NX-10X00 Series

DIGITAL HYBRID SENSOR

PRODUCT BRIEF

Revision D

CONTENTS

1. **GENERAL DESCRIPTION** 3
2. **FEATURES** 3
3. **MARKETS** 3
4. **ORDERING INFORMATION** 4
5. **PIN CONFIGURATION** 4
6. **PIN DESCRIPTION** 4
7. **ABSOLUTE MAXIMUM RATINGS** 5
8. **APPLICATION INFORMATION** 5
   8.1 TYPICAL OPERATING CIRCUIT 5
   8.2 POWER-UP SEQUENCE 6
   8.3 DIGITAL INTERFACE - I^2C SLAVE COMMUNICATIONS AND INTERRUPTS 6
9. **SOLUTION STACK-UP** 8
10. **ELECTRICAL DESIGN, LAYOUT, PLACEMENT, HANDLING & PACKAGING INFORMATION** 8
    10.1 ELECTRICAL DESIGN AND BOARD LAYOUT CONSIDERATIONS 8
    10.2 FOOTPRINT AND SMT DETAILS 10
    10.3 DEVICE HANDLING – BEST PRACTICES 10
    10.4 SMT PICK & PLACE GUIDELINES 11
    10.4.1 NOZZEL CONSIDERATIONS 11
    10.4.2 PICK & PLACE OPERATION 12
    10.5 ASSEMBLY INSTRUCTIONS 13
    10.6 PACKAGING INFORMATION laser mark 14
    10.7 SENSOR TOP MARK CODING 15
    10.8 TAPE-AND-REEL (T&R) DETAILS/DIMENSIONS 15
11. **RELIABILITY & EnvironmentalINFORMATION** 16
12. **GLOSSARY (ALPHABETICAL ORDER)** 16
13. **REVISION HISTORY** 17

1. GENERAL DESCRIPTION

The NX-10x00 series is the world's first digital hybrid sensor. This device can track a force sensor, an NIR detector, plus a CMOS device temperature sensor. The digital output allows a direct connection to a host processor via an industry standard I^2C interface.

The NX-10x00 series digital hybrid sensor enables voting capability by tracking two different sensors when deciding on a valid button press, the combination of one force sensor plus one NIR detector. The NX-10x00's NIR sensor allows proximity detection such as in-ear detection applications.

The NX-10x00 series sensor is designed for "host-free" applications requiring autonomous sensing from power-up, without the need for any I^2C commands to initialize the part. To achieve this, a dual function pin allows for a sensor trigger threshold to be set using an external resistor. In Always-On applications, this sensor offloads the host, allowing it to remain in a low-power state until woken up by an interrupt when a pre-defined sensor threshold is achieved.

The NX-10x00 series includes factory calibration for sensitivity, automatic sensor offset correction, and programmable temperature correction in conjunction with an on-board temperature sensor. It is the world's smallest CSP digital hybrid sensor and uses standard pick-and-place assembly and reflow soldering onto PCB/FPCB substrates.

2. FEATURES

- Digital Hybrid Sensor with built-in Analog Front-End
- Two Simultaneous Sensors with Automatic Offset Correction
- Ultra-Low Power, 7 µA @ 15Hz
- Built-in CMOS Temperature Sensor
- Excellent Force and NIR Sensitivity, Linearity and Reliability
- Built-in Programmable Threshold Detection and Voting Operation
- Fast Response – Max sampling 1ksps
- Force Range, 0 N to 15 N (~ 1.5 kg)
- Excellent Electrical and Thermal Stability
- Supply Voltage, 1.62 V to 1.98 V
- 6-pin CSP Package, 1.33 x 1.43 x 0.22 mm

3. MARKETS

- Smart Phones and Tablets
- Automotive
- Industrial
- IoT, Weight Scales
- Wearables
- Gaming
- Stylus, Touchpads, Smart Home, AR/VR

4. ORDERING INFORMATION

PART	OPERATING TEMP. RANGE	FEATURES	DESCRIPTION
NX-10000A00	-20°C to +70°C	Consumer	5000pc 7-inch reel
NX-10000A00SR	-20°C to +70°C	Consumer	300pc sample reel
NX-10000A00SQ	-20°C to +70°C	Consumer	25pc sample bag
NX-10500B00	-40°C to +85°C	Automotive Grade 3	5000pc 7-inch reel
NX-10500B00SR	-40°C to +85°C	Automotive Grade 3	300pc sample reel
NX-10500C00	-40°C to +105°C	Automotive Grade 2	5000pc 7-inch reel
NX-10500C00SR	-40°C to +105°C	Automotive Grade 2	300pc sample reel
NX-10000DK	-20°C to +70°C	Consumer	Full Design Kit
NX-10000PCK	-20°C to +70°C	Consumer	Design Kit, Sensor module only

Table 1: Ordering Information

5. PIN CONFIGURATION

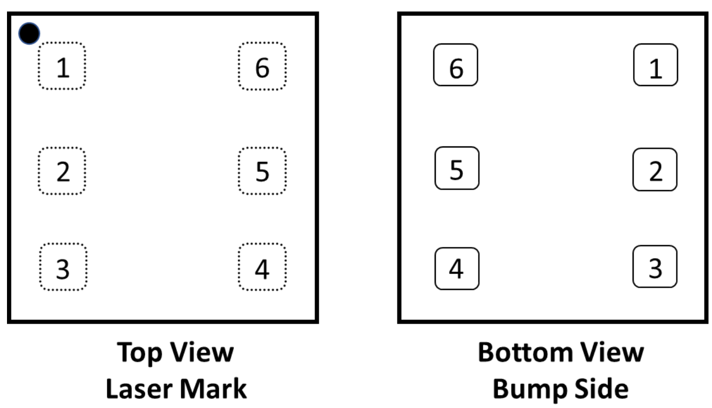


Figure 1: Pin Configuration

6. PIN DESCRIPTION

SOLDER	PIN NAME	PIN DESCRIPTION
1	THR_ADR	I²C Address Selection and hardware programmed threshold setting on boot up. See sections *8.3* for setting device address, interupt threshold, and IR LED current.
2	INTB	Interrupt Output. This pin allows the NX-10x00 to wake-up the host.
3	SCL	Serial Clock Input. Serial I²C clock input connecting the master clock.
4	SDA	Serial Data I/O. Serial I²C data pin allowing communications to/from the master.
5	VDD	Power Supply. This pin accepts supply voltage levels from 1.62 V to 1.98 V.
6	GND	Ground. Ground terminal. All signals are referred to this terminal

Table 2: Pin Description

7. ABSOLUTE MAXIMUM RATINGS

VDD to GND (Power)........ -0.3 V to +2 V
SCL, SDA to GND (Digital Input/output)........ -0.3 V to +3.63 V
INTB to GND (Digital Output)........ -0.3 V to + 3.63 V
THR_ADR to GND .... -0.3 V to VDD + 0.3V
Applied Force (directly applied on top of sensor) ....20 N
Operating Temperature Range .... See Ordering Information
Storage Temperature........-65°C to +150°C
Lead Temperature (soldering 10s)........ +260°C
Electrostatic Discharge Protection (ESD) .... 2000 V (HBM), 500 V (CDM)

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

8. APPLICATION INFORMATION

8.1 TYPICAL OPERATING CIRCUIT

Figure 2 shows a typical circuit for a button application utilizing the NX-10x00. The sensor generates an interrupt when the programmed threshold is exceeded. The host processor can change the threshold by writing to the sensor registers using the I^{2}C interface.

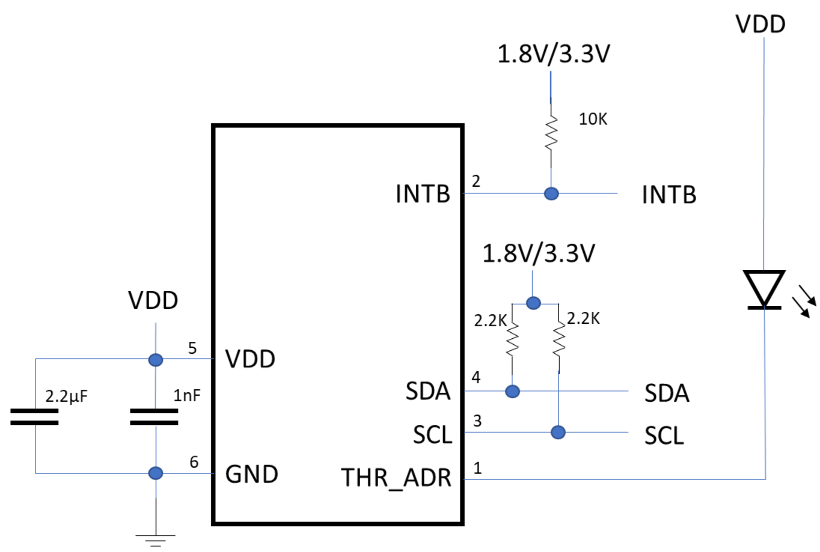


Figure 2: Typical Circuit for Button Application

8.2 POWER-UP SEQUENCE

The NX-10x00 will be fully operational 10 ms after power is initially applied to the chip. After power-up, it enters active mode by default, see Figure 3. VDD needs to meet 90% of nominal value within 2 ms after power up for correct operation.

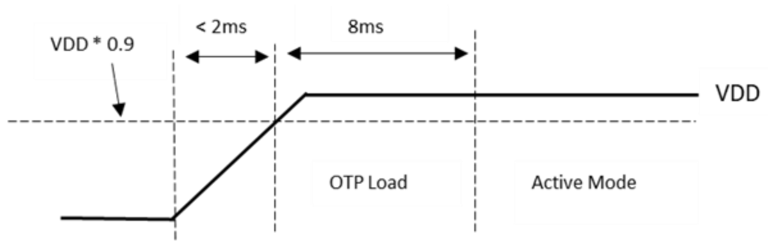


Figure 3: Power-up Ramp and Full Operation

8.3 DIGITAL INTERFACE - I^{2}C SLAVE COMMUNICATIONS AND INTERRUPTS

The I²C slave interface on the NX-10x00 series consists of a pair of open-drain lines comprising of a serial data line (SDA) and a serial clock line (SCL). SDA and SCL facilitate bidirectional communications with the master at rates up to 1 MHz clocking. Standard Mode (100 kHz), Full-Speed Mode (400 kHz) and Fast Mode (< 1 MHz) are supported. The master initiates data transfer on the bus and generates the SCL signal to permit that transfer.

The THR_ADR is used to choose between four I²C slave addresses at power-up to ensure that each device has a designated address. The four different addresses can be achieved by pulling the THR_ADR pin to either VDD directly, GND directly, connect it to VDD via a resistor or connect it to GND via a resistor, see Figure 4. Two different configurations are shown as force plus IR and force only. The four addresses and the associated THR_ADR connection is shown in Table 3. Use 10kΩ if only for address assignment.

THR_ADR CONNECTION	Sensor I²C ADDRESS
THR_ADR = 3.3 kΩ - 100 kΩ Resistor to GND	0x70
THR_ADR = 3.3 kΩ - 100 kΩ Resistor to VDD	0x71
THR_ADR = GND	0x72
THR_ADR = VDD	0x73

Table 3: I²C Address Selection using THR_ADR

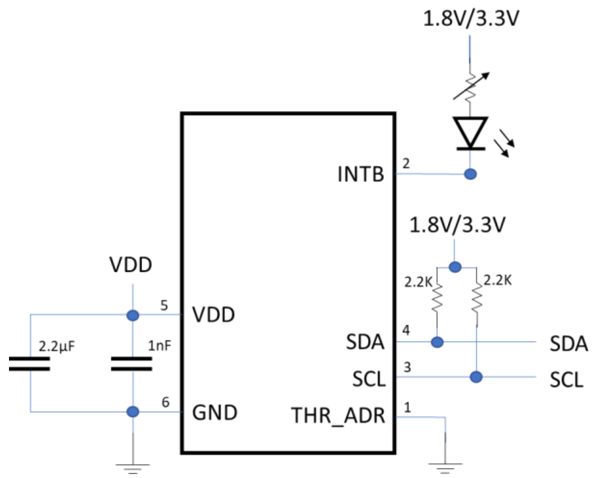


Figure 4a: Force and IR on same I²C bus

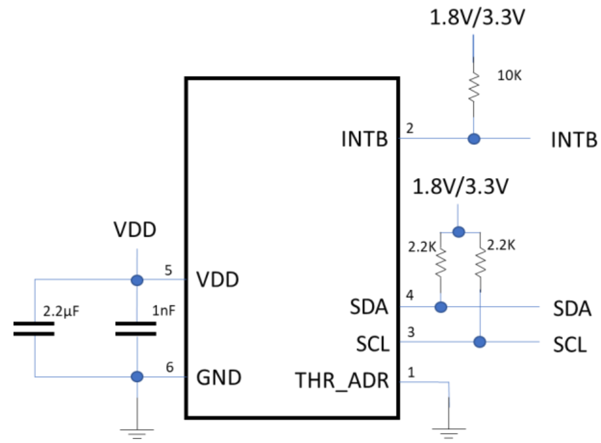


Figure 4b: Force only on I²C bus

When configuring according to the Typical Circuit shown in Figure 2, note that the THR_ADR pin is connected to VDD via IR LED. In this case, device address is set to 0x73 (THD_ADR = VDD) and IR LED current is controlled with LEDCTL[1:0] register.

The NX-10x00 I²C addresses are 7-bit. Note that support for 10-bit I²C slave addressing and General-Call (broadcast) addressing are not supported.

The supply voltage to the sensor should be less or equal to the pull-up voltage for the I²C and INTB, see Figure 2.

SDA and SCL signals are open-drain and must be pulled high for the bus to operate. This is typically done with ≥ 2 kΩ pull-up resistors (or greater for lower power operation), see Figure 2. Series resistors in the signal path are optional to protect the sensor input architecture from high-voltage spikes on the bus lines, minimize crosstalk, and undershoot events of the bus signals.

9. SOLUTION STACK-UP

The device is soldered onto a PCB, which is then bonded to the back of the surface where the force is to be detected. The NX-10x00 series digital hybrid sensor can detect forces as light as a few grams. Figure 5 shows the stack-up for a single button application utilizing one sensor mounted to a PCB.

A 0.4mm thick FR4 PCB is recommended. For other PCB options and recommended adhesives, please contact Qorvo.

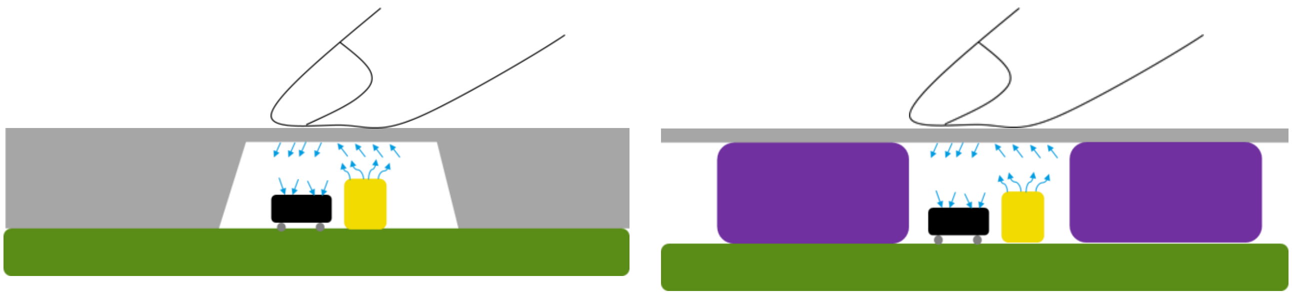
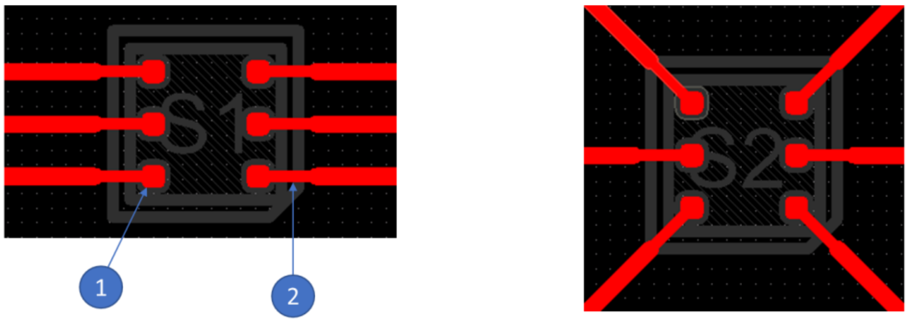


Figure 5: Stack-Up

10. ELECTRICAL DESIGN, LAYOUT, PLACEMENT, HANDLING & PACKAGING INFORMATION

10.1 ELECTRICAL DESIGN AND BOARD LAYOUT CONSIDERATIONS

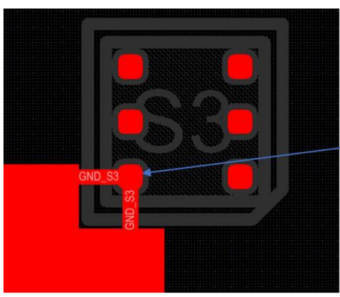
- Two bypass capacitors required, 2.2uF & 1nF, to reduce noise on the power supply. Use higher value bypass capacitors for noisy power supplies. Ensure that both capacitors are placed close to the NX-10x00 – ***REQUIRED***.
- Symmetrical routing improves sensor self-alignment (Figure 6-a) during assembly – ***REQUIRED***.
- Place the nearest components at least 0.3 mm (RECOMMENDED) away from the NX-10x00 series sensor.
- Do not use vias directly under the NX-10x00 solder balls. (Figure 6-b)
- Keep signal lines short (**REQUIRED**) and free of 90° turns (steep angles/corners can cause undesired acid traps during the manufacturing process). Use 45° turns or rounded-edge-turns for all signal/power lines.
- Do not use glue/epoxy under or around the sensor – ***REQUIRED***.
- The sensor edge should be at least 0.25 mm from all edges of the PCB – ***RECOMMENDED***.
- If using a flexible PCB, a top hatched ground plane is required.
- Under-fill is not recommended. For harsh environments like salt spray please contact Qorvo for recommendations for materials for under-fill and glob top.
- For additional stability consider implementing "teardrop" routing into vias, pin pads and T-junctions; this increases the copper area and avoids steep angles in areas where multiple traces meet in a common point.
- It is recommended to run the sensor from an on-board analog power supply (e.g. low-noise LDO) for lowest noise.
- Make the traces to all the pins the same width. Qorvo recommends greater than (or equal) 6 mils traces for all signals except the traces directly connected to bumps of NX-10000. These should be 4 mils traces for better reflow result.



1 → Pad Size: 0.2mm square pad with rounder corner.
Solder Mask: 0.05mm wider on all four sides of pad.
Copper defined, not solder mask defined pad.

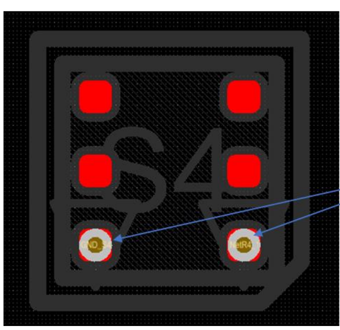
2 → Use 0.1mm trace-width (1/2 of pad size) at pad entry for minimum of 0.25mm length.
After 0.25mm: can increase trace width to 0.15mm.

Figure 6-a: Recommended Design/Layout Practice



Do not use multiple traces on same pads.
Do not use copper pouring or plane direct on device pad.

This will make routing non-symmetrical with other pads.



Do not use Via in pad or micro via (Blind via) direct on land area.

Figure 6-b: Avoid in Layout/Routing

10.2 FOOTPRINT AND SMT DETAILS

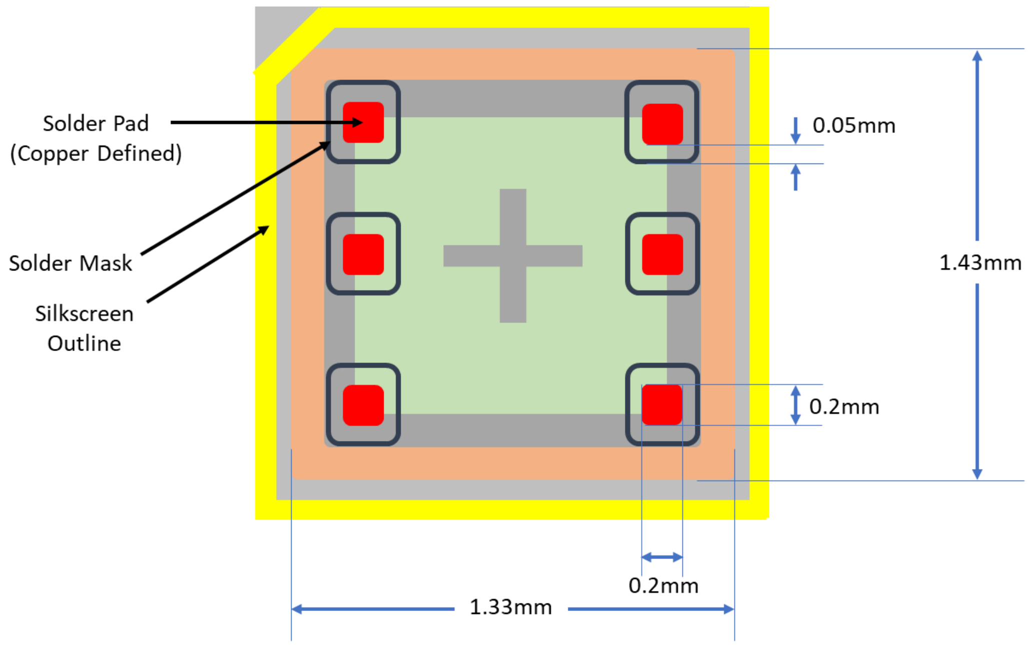


Figure 7: Must-Have Footprint

Figure 7 depicts the ***must-have*** footprint drawing for the NX-10x00 series and the details below must be followed for the SMT of the sensor onto a PCB/FPCB

1. Pad dimensions and type
    a. Rounded rectangle with dimensions **7.874 mil x 7.874 mil** (0.2 mm x 0.2 mm)
    b. Radius of the rounded square pad: **Corner radius of 0.05mm (not a circular pad)**
    c. Copper defined, ***not* solder-mask defined**
2. Solder paste stencil thickness: **4 mil** (100 µm)
3. Solder mask: **2 mil (50 µm) wider on all sides of the pad**
4. Solder Paste: **Alpha OM 550 HRL1 (to reduce solution offset and TCO), SAC305 or SAC405**

10.3 DEVICE HANDLING – BEST PRACTICES

- **<u>Do not pick up the device with metal tweezers. Use vacuum pickup head.</u>**
- Do not "snap" panelized, assembled PCBs
- Follow ESD-safe handling recommendations
    - Store sensors in ESD sensitive containers (e.g. T&R, moisture-sealed)
    - Handle devices only in ESD-safe work areas
    - Persons /machines handling the sensor must be grounded to avoid potential ESD damage

10.4 SMT PICK & PLACE GUIDELINES

10.4.1 NOZZEL CONSIDERATIONS

SMT assembly machines typically employ a vacuum nozzle for Pick & Place (P&P) operations. Not all equipment is the same, but there are some general guidelines to follow, for optimal performance/yield.

1. Select a vacuum nozzle only.
    a. DO NOT use mechanical grippers or collets, that contact the edges/sides of a WLCSP.
    b. DO NOT handle WLCSP parts with metal tweezers.
2. Prefer softer nozzle materials.
    a. Nozzle materials can vary (metal, ceramic, plastic, rubber), and certain equipment requires certain nozzle materials. If there's a choice, try to select a softer material, to avoid potential damage from mechanical shocks.
3. Select an appropriate nozzle tip shape.
    a. Nozzle tip shape can affect the amount of pressure applied to a single point on a WLCSP part.
    b. Nozzle tips should be circular, square/rectangular, and preferably with a vertical separator.
    c. The nozzle tip surface should be a single plane; do not use a nozzle with a protruded edge

Figure 8: Acceptable vs. NOT Acceptable Tip Shapes

4. Select an appropriate nozzle tip size, for the part being placed.
    a. The largest tip dimension should be smaller than the size of the WLCSP part.
    b. The tip should account for the tolerance of the pick accuracy, so that it's not possible for the nozzle tip to contact the edge or the corner of a part.
    c. The tip size should be as large as possible, while satisfying the above 2 points.

10.4.2 PICK & PLACE OPERATION

The P&P operation consists of two key steps: picking a part out of the carrier tape pocket, and placement of that part onto a circuit board. Both operations are performed with some alignment tolerance: nozzle-to-part tolerance during the pick, and part-to-board alignment during the placement. Additionally, the placement should occur with as little force as possible, to press the die into place on the board.

WLCSP parts are shipped to customers in standard carrier tape & reel packaging. Parts sit in a pocket that is slightly larger than the size of the part. A part can move laterally inside the pocket, typically by less than 0.1 mm, but this varies by product.

1. If available, the P&P equipment should use a vision detection system to align the P&P nozzle to the center of the die, for every part picked.
2. If a vision alignment system isn't available, the nozzle size selection should account for the positional tolerance of the WLCSP part in the carrier tape pocket.

The die placement operation should be performed with a placement accuracy of better than 0.1 mm, but accuracies smaller than 0.05 mm are typical. The placement force should be as small as possible to make contact of the WLCSP solder bumps with the solder paste on the board.

1. A force contactless pickup is preferred, using only light physical contact, and allowing the vacuum to pick the part.
2. Prefer to use a "air-ejection" placement over a contact placement. A typical air-ejection pressure is 150 mbar.
3. If air placement isn't available, use a contact mode for the part placement. Ensure that both the pick and placement force is not larger than 2 N (200 gram). Placement forces should be measured periodically using a calibrated load, to ensure parts aren't placed with a force over this specification.

10.5 ASSEMBLY INSTRUCTIONS

The NX-10x00 can be reflow-soldered using direct-chip-attachment (DCA) techniques to the circuit substrate (e.g. FR-4 or FPC). The chip should be soldered at normal reflow (Table 4) temperatures designed to support RoHS and Pb-free compliance (Figure 9). Reflow assembly houses should follow this profile closely but can chose more conservative ramp-up/down rates. To avoid damage to the sensor do not exceed maximum ratings of the qualification profile (e.g. T_{PMAX} = 260°C @ the top side of the CSP). Customers should consult with their assembly house/vendor for the appropriate temperature/reflow soldering profile.

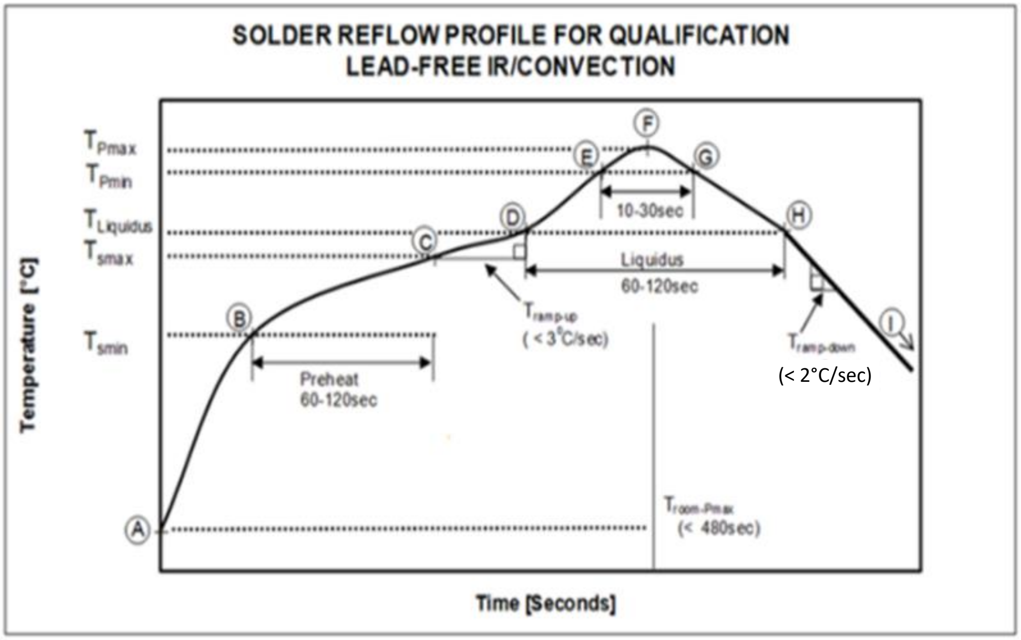


Figure 9: Pb-Free Soldering Profile for Reflow Assembly

Step	Parameter	Temperature [°C]	Time [s]	Maximum Rate [°C/s]
A	T_{ROOM}	25		
B	T_{SMIN}	150		
C	T_{SMAX}	200	$60 < t_{BC} < 120$	
D	$T_{LIQUIDUS}$	217		$r_{(TLIQUIDUS - TPMAX)} < 3$
E	$T_{PMIN\ [255°C,\ 260°]}$	255		$r_{(TLIQUIDUS - TPMAX)} < 3$
F	$T_{PMAX\ [260°C,\ 265°C]}$	260	$t_{AF} < 480$	$r_{(TLIQUIDUS - TPMAX)} < 3$
G	$T_{PMIN\ [255°C,\ 260°]}$	255	$10 < t_{EG} <30$	$r_{(TPMAX-TLIQUIDUS)} < 2$
H	$T_{LIQUIDUS}$	217	$60 < t_{DH} < 120$	
I	T_{ROOM}	25		

Table 4: Reflow Assembly Temperature Profile

10.6 PACKAGING INFORMATION LASER MARK

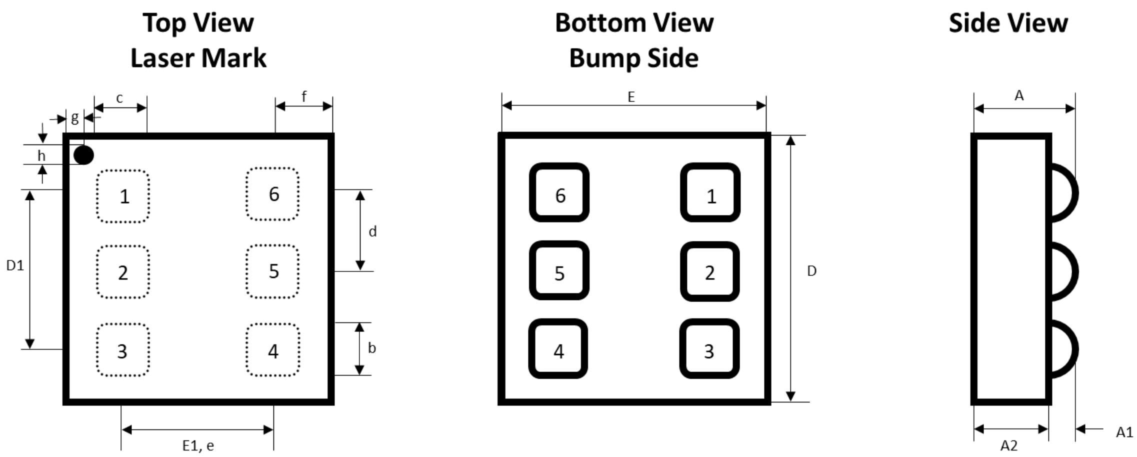


Figure 10: Package Dimensions

Info for 1.33 mm x 1.43 mm x 0.22 mm CSP				
Symbol	**Min.**	**Nom.**	**Max.**	**Notes**
A	0.190	0.220	0.250	Overall height
A1	0.055	0.070	0.085	Solder ball height
A2	0.135	0.150	0.165	Body thickness
D	1.380	1.430	1.480	Body size
D1	0.890	0.900	0.910	Solder ball footprint, Y
E	1.280	1.330	1.380	Body size
E1	0.890	0.900	0.910	Solder ball footprint, X
6				Number of solder balls
b	0.195	0.210	0.225	Solder ball diameter; measured at the maximum solder ball diameter, Y
c	0.195	0.210	0.225	Solder ball diameter; measured at the maximum solder ball diameter, X
d	0.440	0.450	0.460	Solder ball pitch, Y
e	0.890	0.900	0.910	Solder ball pitch, X
f	0.190	0.215	0.240	Package edge to solder ball center
g	0.100	0.150	0.200	Pin 1 ID to package edge
h	0.050	0.100	0.150	Pin 1 ID diameter

All dimensions are in mm unless otherwise specified; dimensions and tolerances conform to ANSI Y14.5M-1982.

Table 5: Package Dimensions

For Must have footprint see Figure 7.

10.7 SENSOR TOP MARK CODING

The top mark coding consists of 3 rows of letters and numbers printed on the top of the CSP package (Figure 11).

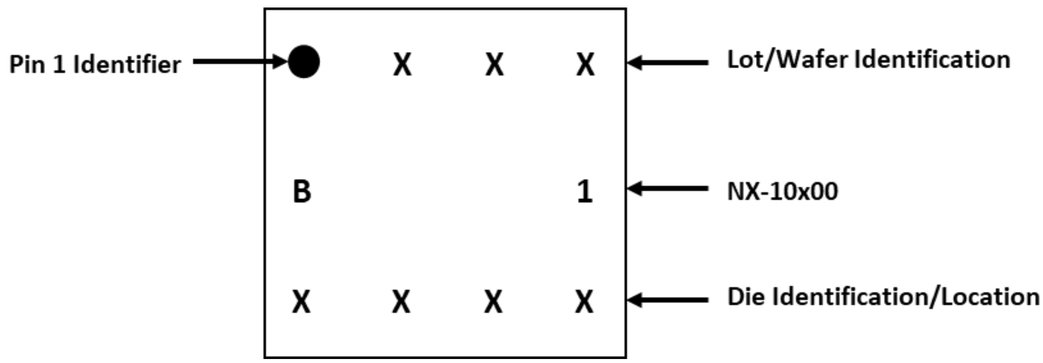


Figure 11: Top Mark

10.8 TAPE-AND-REEL (T&R) DETAILS/DIMENSIONS

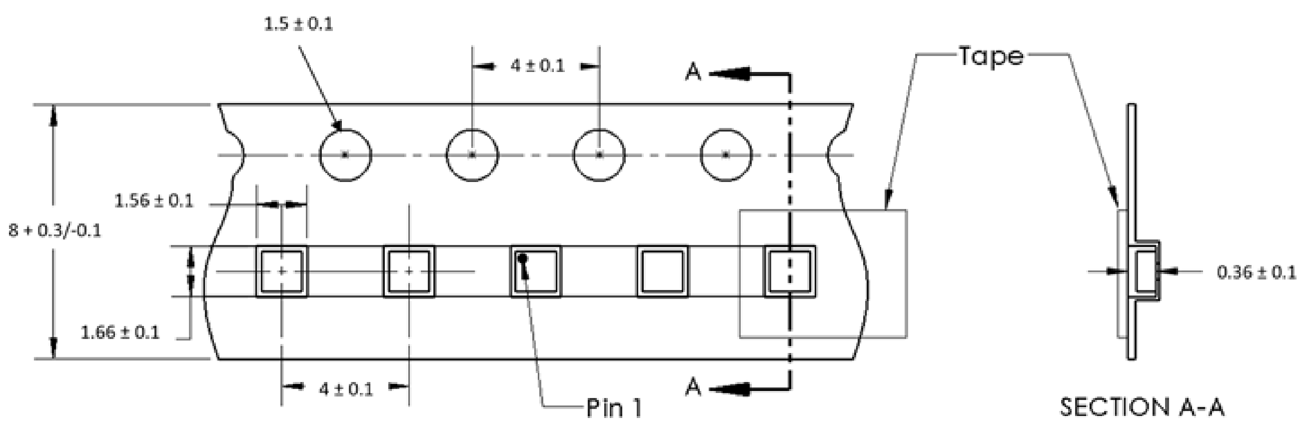


Figure 12: Tape-and-Reel Dimensions

Note that all dimensions and tolerances in this tape-and-reel diagram (Figure 12) are in mm.

Figures 13 depicts a tape reel sealed in an ESD-protective bag. The diameter of the sensor reel measures 7 inches (Radius = 3.5 inches) with reel thickness of 0.25 inches to comfortably host the tape. Each reel is stamped with the company logo, part number, lot number, and date code.

Figure 13: Example of Packaged Reel

11. RELIABILITY & ENVIRONMENTALINFORMATION

The NX-10x00 meets Level 1 (unlimited) Moisture Sensitivity Level (MSL) specifications.

Reliability and Environmental reports are furnished upon request.

12. GLOSSARY (ALPHABETICAL ORDER)

CDM (Charge Device Model) – CDM is a model for characterizing the susceptibility of an electronic device to damage from electrostatic discharge (ESD). CDM is commonly used for semiconductor devices and has been standardized in JEDEC with JESD22-C101E.

HBM (Human Body Model) – HBM is the most commonly used model for characterizing the susceptibility of an electronic device to damage from electrostatic discharge (ESD). The model simulates an ESD discharge that may occur when a human makes contact with an electronic device.

I^{2}C Timeout – This is the time the I^{2}C bus allows for no communications via I^{2}C before it resets the bus

13. REVISION HISTORY

REVISION NUMBER	REVISION DATE	DESCRIPTION/CHANGES	PAGES CHANGED
A	4/6/2022	New Release	N / A
B	5/11/2022	Combined product brief and assembly guidelines. Updated ADR resistor range, added SMT pick & place guidelines	All
C	11/30/2022	New release per RevD of the full datasheet	All
D	6/12/2023	Sensor module image replaced.	9