

## Rad-hard plastic quad 2-input NAND gate

TSSOP-20



### Features

- NAND gate
- 6 V max. operating
- 7 V max. rating
- 8 ns propagation delay
- Nickel/palladium/gold-lead-finished (NiPdAu), whisker-free
- Gold-wires
- RML <1% and CVCM <0.1% guaranteed outgassing
- 50 krad (Si) total ionizing dose
- SEL-free up to 62.5 MeV.cm<sup>2</sup>/mg
- Mass: 80 mg
- Compliant with ST-LEO-specification

### Application

- Low earth orbit (LEO) applications

### Description

The **LEOAC00** is a CMOS low power quad 2-input NAND gate qualified for use in aerospace environments. It operates from 2 V to 6 V power supply (7 V absolute maximum ratings).

The **LEOAC00** can operate over a large temperature range of -40 °C to +125 °C and it is housed in plastic TSSOP-20, thin-shrink small outline package, 20 leads, using gold-wires and nickel/palladium/golden-lead-finishing to prevent from whiskers.

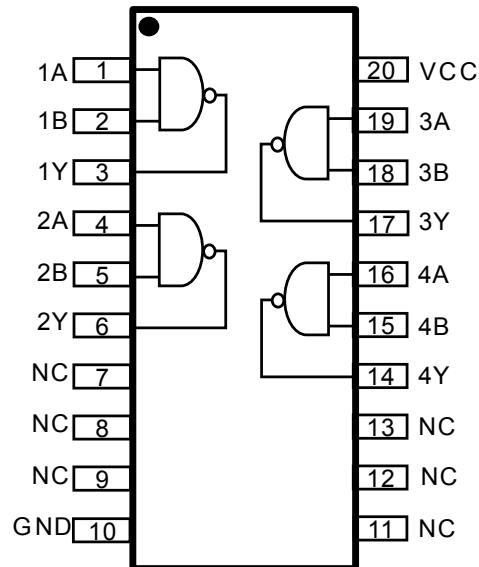
The **LEOAC00** is compliant with ST-LEO-specification, dedicated specification for space-ready rad-hard plastic products. This AEC-Q100-based specification offers a specific trade-off between footprint size savings, cost of ownership and quality assurance together with radiation hardness and large quantity capability.

Product status link

[LEOAC00](#)

## 1 Functional description

**Figure 1.** Pin connections (top view)



NC: not internally connected.  
The pin can be externally connected to any potential.

**Table 1.** Truth table

| Each gate |           |            |
|-----------|-----------|------------|
| INPUT (A) | INPUT (B) | OUTPUT (Y) |
| L         | L         | H          |
| L         | H         | H          |
| H         | L         | H          |
| H         | H         | L          |

with: L = low level, H = high Level.

For all inputs,  $V_{IN} = V_{IH}$  minimum or  $V_{IL}$  maximum, verify output  $V_{OUT}$ .

## 2 Maximum ratings and operating conditions

**Table 2. Absolute maximum ratings**

| Symbol                        | Parameter                                                 | Value                          | Unit |
|-------------------------------|-----------------------------------------------------------|--------------------------------|------|
| VCC <sup>(1)</sup>            | Maximum power supply between VCC and GND                  | -0.5 to 7                      | V    |
| VIN                           | DC input voltage range                                    | -0.5 to VCC+0.5 (and 7 V max.) | V    |
| VOUT                          | DC output voltage range                                   | -0.5 to VCC+0.5 (and 7 V max.) | V    |
| IK                            | I/O clamp diode current                                   | +/-20                          | mA   |
| T <sub>stg</sub>              | Maximum temperature storage                               | -65 to 150                     | °C   |
| T <sub>j</sub> <sup>(2)</sup> | Maximum junction temperature                              | +150                           | °C   |
| Rth <sup>(3)</sup>            | Junction-to-ambient thermal resistance (Θ <sub>ja</sub> ) | 80                             | °C/W |
|                               | Junction-to-case thermal resistance (Θ <sub>jc</sub> )    | 17                             | °C/W |
| ESD                           | HBM (human body model)                                    | 2 k                            | V    |
|                               | CDM (charged device model)                                | 1 k                            |      |

1. All voltages, except differential I/O bus voltage, are with respect to the network ground terminal.
2. Maximum junction temperature shall not be exceeded except for allowable short duration burn-in screening conditions as per the method 5004 of MIL-STD-883.
3. Short-circuits can cause excessive heating. Destructive dissipation can result from short-circuits on the amplifiers.

**Note:** Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. All values are referred to GND.

**Table 3. Operating conditions**

| Symbol         | Parameter                 | Min. | Max. | Unit |
|----------------|---------------------------|------|------|------|
| VCC            | Analog supply voltage     | 2    | 6    | V    |
| VIN            | Input voltage range       | 0    | VCC  | V    |
| VOUT           | Output voltage range      | 0    | VCC  | V    |
| T <sub>a</sub> | Ambient temperature range | -40  | +125 | °C   |

**Note:** All unused inputs must be held at VCC or GND to ensure proper device operation.

### 3 Electrical characteristics

VCC = 3 V to 5.5 V, typical values are at ambient  $T_a = +25\text{ }^{\circ}\text{C}$ , minimum and maximum values are at  $T_a = -40\text{ }^{\circ}\text{C}$  and  $+125\text{ }^{\circ}\text{C}$ , unless otherwise specified.

**Table 4. Electrical characteristics**

| Symbol             | Parameter                    | Test conditions                                                                                                                         | VCC   | Min. | Typ. | Max. | Unit |
|--------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|------|
| VOH <sup>(1)</sup> | High level output voltage    | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOH = -50 $\mu$ A | 3 V   | 2.9  |      |      | V    |
|                    |                              |                                                                                                                                         | 4.5 V | 4.4  |      |      |      |
|                    |                              |                                                                                                                                         | 5.5 V | 5.4  |      |      |      |
|                    |                              | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOH = -12 mA      | 3 V   | 2.4  |      |      |      |
|                    |                              |                                                                                                                                         | 4.5 V | 3.7  |      |      |      |
|                    |                              | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOH = -24 mA      | 5.5 V | 4.7  |      |      |      |
| VOL <sup>(1)</sup> | Low level output voltage     | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOL = +50 $\mu$ A | 3 V   |      |      | 0.1  | V    |
|                    |                              |                                                                                                                                         | 4.5 V |      |      | 0.1  |      |
|                    |                              |                                                                                                                                         | 5.5 V |      |      | 0.1  |      |
|                    |                              | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOL = +12 mA      | 3 V   |      |      | 0.5  |      |
|                    |                              |                                                                                                                                         | 4.5 V |      |      | 0.5  |      |
|                    |                              | For all inputs affecting output under test, VIN = VIH minimum or VIL maximum. For all other inputs, VIN = VCC or GND, IOL = +24 mA      | 5.5 V |      |      | 0.5  |      |
| IOH                | High level output current    |                                                                                                                                         | 3 V   | -12  |      |      | mA   |
|                    |                              |                                                                                                                                         | 4.5 V | -24  |      |      |      |
|                    |                              |                                                                                                                                         | 5.5 V | -24  |      |      |      |
| IOL                | Low level output current     |                                                                                                                                         | 3 V   |      |      | 12   |      |
|                    |                              |                                                                                                                                         | 4.5 V |      |      | 24   |      |
|                    |                              |                                                                                                                                         | 5.5 V |      |      | 24   |      |
| VIH                | High level input voltage     |                                                                                                                                         | 3 V   | 2.1  |      |      | V    |
|                    |                              |                                                                                                                                         | 4.5 V | 3.15 |      |      |      |
|                    |                              |                                                                                                                                         | 5.5 V | 3.85 |      |      |      |
| VIL                | Low level input voltage      |                                                                                                                                         | 3 V   |      |      | 0.9  |      |
|                    |                              |                                                                                                                                         | 4.5 V |      |      | 1.35 |      |
|                    |                              |                                                                                                                                         | 5.5 V |      |      | 1.65 |      |
| VIC+               | Positive input clamp voltage | For input under test, IIN = 1 mA                                                                                                        | 0 V   | 0.4  |      | 1.5  | V    |

| Symbol                | Parameter                                       | Test conditions                                                              | VCC   | Min. | Typ. | Max. | Unit |
|-----------------------|-------------------------------------------------|------------------------------------------------------------------------------|-------|------|------|------|------|
| VIC-                  | Negative input clamp voltage                    | For input under test, IIN = -1.0 mA                                          | Open  | -0.4 |      | -1.5 | V    |
| IIH                   | Input current high                              | For input under test, VIN = VCC<br>For all other inputs,<br>VIN = VCC or GND | 5.5 V |      |      | 1    | μA   |
| IIL                   | Input current low                               | For input under test, VIN = GND<br>For all other inputs,<br>VIN = VCC or GND | 5.5 V |      |      | -1   | μA   |
| ICCH                  | Quiescent supply current, output high           | For all inputs, VIN = VCC or GND<br>IOUT = 0 A                               | 5.5 V |      |      | 40   | μA   |
| ICCL                  | Quiescent supply current, output low            | For all inputs, VIN = VCC or GND<br>IOUT = 0 A                               | 5.5 V |      |      | 40   | μA   |
| CIN <sup>(2)</sup>    | Input capacitance                               | Ta=+25°C                                                                     | 5 V   |      |      | 10   | pF   |
| CPD <sup>(2)(3)</sup> | Power dissipation capacitance                   | Ta=+25°C, F = 1 MHz                                                          | 5 V   |      |      | 50   | pF   |
| Tr, Tf                | Output rise time and fall time                  | CL = 2 pF, RL = 500 ohm,<br>see <a href="#">Figure 2. Waveform</a>           | 3 V   |      | 3.3  |      | ns   |
|                       |                                                 |                                                                              | 4.5   |      | 2.7  |      |      |
|                       |                                                 | CL = 2 pF, RL = 500 ohm,<br>see <a href="#">Figure 2. Waveform</a>           | 3 V   |      | 4.6  |      |      |
|                       |                                                 |                                                                              | 4.5 V |      | 3.3  |      |      |
| tPHL <sup>(4)</sup>   | Propagation delay time<br>An to Yn, high to low | CL = 50 pF, RL = 500 ohm<br>See <a href="#">Figure 2. Waveform</a>           | 3 V   | 1    |      | 9.5  | ns   |
|                       |                                                 |                                                                              | 4.5 V | 1    |      | 8    |      |
| tPLH <sup>(4)</sup>   | Propagation delay time<br>An to Yn, low to high | CL = 50 pF, RL = 500 ohm<br>See <a href="#">Figure 2. Waveform</a>           | 3 V   | 1    |      | 9.5  |      |
|                       |                                                 |                                                                              | 4.5 V | 1    |      | 8    |      |

1. The VOH and VOL tests shall be tested at VCC = 3.0 V and 4.5 V. The VOH and VOL tests are guaranteed, if not tested, for other values of VCC. Limits shown apply to operation at VCC = 3.3 V ±0.3 V and VCC = 5.0 V ±0.5 V. Tests with input current at +50 mA and -50 mA are performed on only one input at a time with duration not to exceed 10 ms. Transmission driving tests may be performed using VIN = VCC or GND. When VIN = VCC or GND is used, the test is guaranteed for VIN = VIH minimum and VIL maximum.
2. CIN and CPD shall be measured only for initial qualification and after process or design changes which may affect capacitance. CIN shall be measured between the designated terminal and GND at a frequency of 1 MHz. CPD shall be tested in accordance with the latest revision of JEDEC standard JESD20 and table 1A herein. For CIN and CPD, test all applicable pins on five devices with zero failures.
3. Power dissipation capacitance (CPD) determines both the power consumption (PD) and dynamic current consumption (IS). Where:  $PD = (CPD + CL) (VCC \times VCC) f + (ICC \times VCC)$  and  $IS = (CPD + CL) VCC \times f + ICC$ , and f is the frequency of the input signal and CL is the external output load capacitance.
4. The AC limits at VCC = 5.5 V are equal to the limits at VCC = 4.5 V and guaranteed by testing at VCC = 4.5 V. The AC limits at VCC = 3.6 V are equal to the limits at VCC = 3.0 V and guaranteed by testing at VCC = 3.0 V. Minimum AC limits for VCC = 5.5 V and VCC = 3.6 V are 1.0 ns and guaranteed by guard banding the VCC = 4.5 V and VCC = 3.0 V minimum limits, respectively, to 1.5 ns. For propagation delay tests, all paths must be tested.

## 4 Waveform and test circuit

Figure 2. Waveform

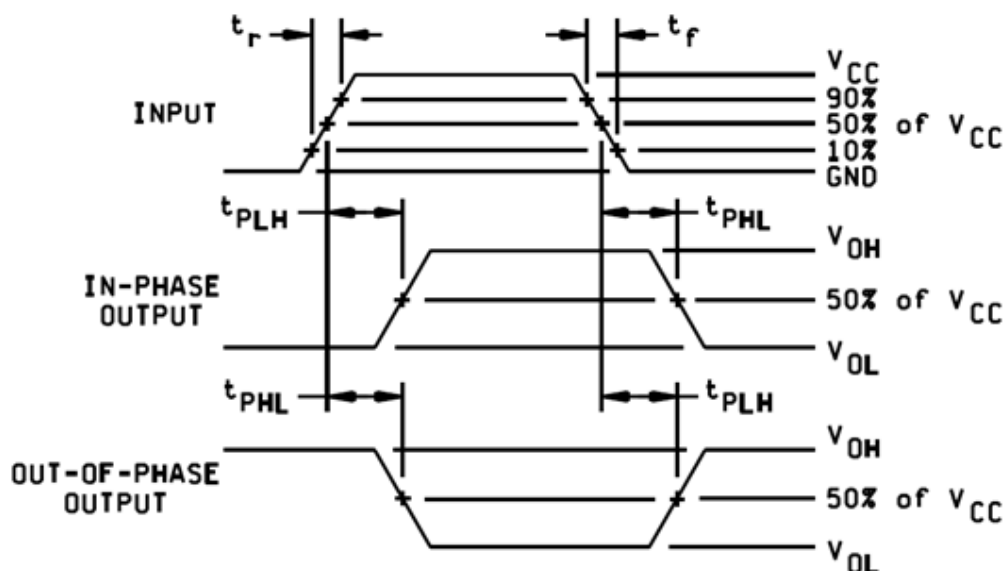
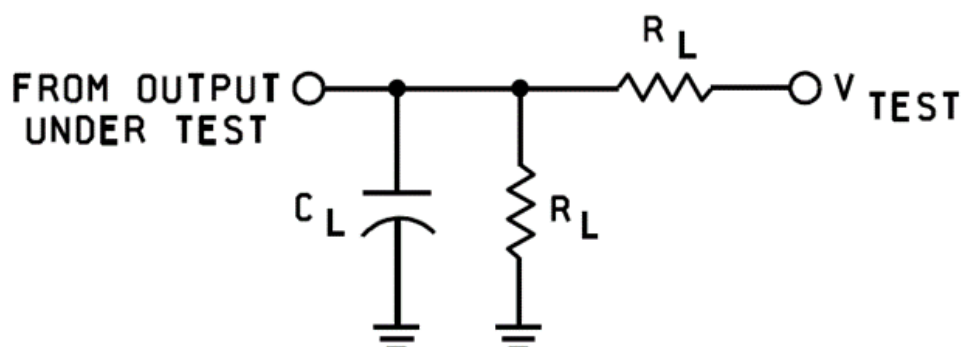


Figure 3. Test circuit



Note:

- When measuring  $t_{PHL}$  or  $t_{PLH}$ :  $V_{TEST} = \text{open}$ .
- $C_L = 50 \text{ pF}$  minimum or equivalent (includes probe and jig capacitance).
- $R_L = 500 \Omega$  or equivalent.
- Input signal from pulse generator:  $V_{IN} = 0.0 \text{ V to } V_{CC}$ ;  $PRR \leq 1 \text{ MHz}$ ;  $Z_O = 50 \Omega$ ;  $t_r \leq 3.0 \text{ ns}$ ;  $t_f \leq 3.0 \text{ ns}$ ;  $t_r$  and  $t_f$  shall be measured from 10% of  $V_{CC}$  to 90% of  $V_{CC}$  and from 90% of  $V_{CC}$  to 10% of  $V_{CC}$ , respectively; duty cycle = 50 percent.
- Timing parameters shall be tested at a minimum input frequency of 1 MHz.
- The outputs are measured one at a time with one transition per measurement.

## 5 Radiations

### Total ionizing dose (TID):

For the qualification, the product is characterized in TID as per MIL-STD-883 TM 1019 up to 50 krad (Si) on 5 biased parts at high dose rate, such a rate being the worst condition for a pure CMOS technology.

All parameters provided in [Table 4. Electrical characteristics](#) apply to both pre- and post-irradiation.

Each new production lot is tested at high dose rate as per MIL-STD-883 TM 1019 on 5 parts.

### Heavy-ions:

Single event latchup (SEL) is characterized at 125 °C at a LET of 62.5 MeV.cm<sup>2</sup>/mg. The test shows the product is immune to heavy ions at this LET. Heavy-ion trials are performed on qualification lots only.

The results in radiation are summarized in [Table 5](#) as follows:

**Table 5. Radiations**

| Symbol | Characteristics                                                                                                                                                                                                                                             | Value                                             |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| TID    | <ul style="list-style-type: none"> <li>High-dose rate (40 krad (Si) / h)</li> <li>Temperature: 25 °C</li> <li>Performed on 5 biased parts</li> </ul>                                                                                                        | Within <a href="#">Table 4</a> up to 50 krad (Si) |
| SEL    | <ul style="list-style-type: none"> <li>LET: 62.5 MeV.cm<sup>2</sup>/mg (Xenon ions)</li> <li>Temperature: 125 °C</li> <li>Fluence: 1 x 10<sup>7</sup> ions/cm<sup>2</sup> (10 million of particles per cm<sup>2</sup>)</li> <li>Normal incidence</li> </ul> | Immune to SEL up to 62.5 MeV.cm <sup>2</sup> /mg  |

1. A total ionizing dose (TID) of 50 krad(Si) is equivalent to 500 Gy(Si), (1 gray = 100 rad).

2. SEL: single event latch-up.

## 6 Outgassing

| Specification (tested per ASTM E 595)                         | Value | Unit |
|---------------------------------------------------------------|-------|------|
| Recovered mass loss (RML) <sup>(1)</sup>                      | 0.06  | %    |
| Collected volatile condensable material (CVCM) <sup>(2)</sup> | 0.00  | %    |

1. RML < 1%.

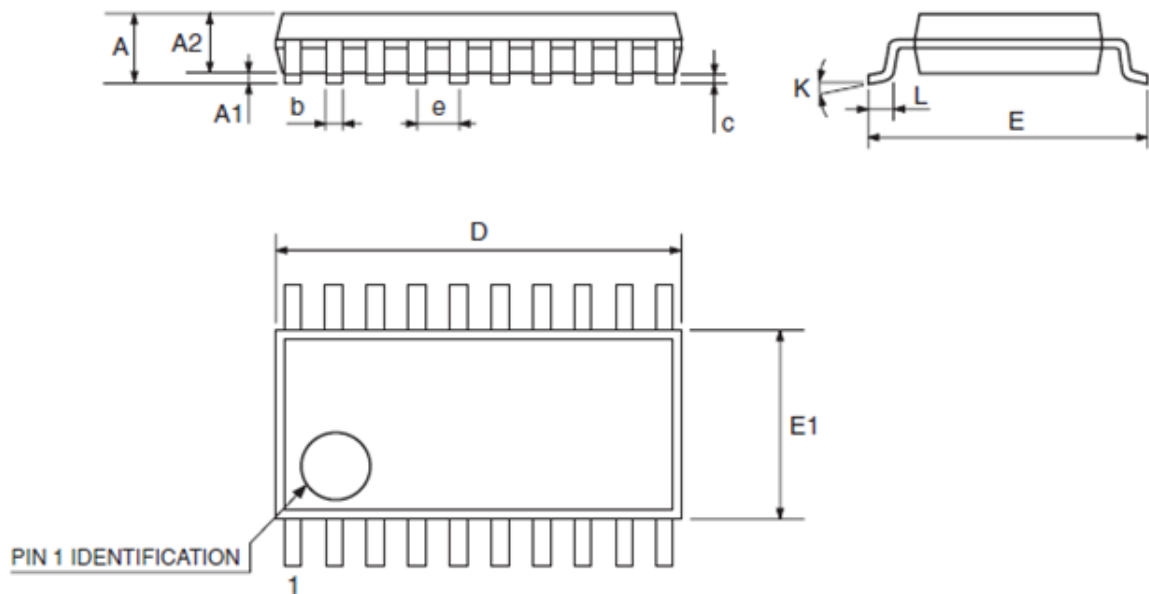
2. CVCM < 0.1%.

## 7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

### 7.1 TSSOP-20 package information

**Figure 4. TSSOP-20 package outline**



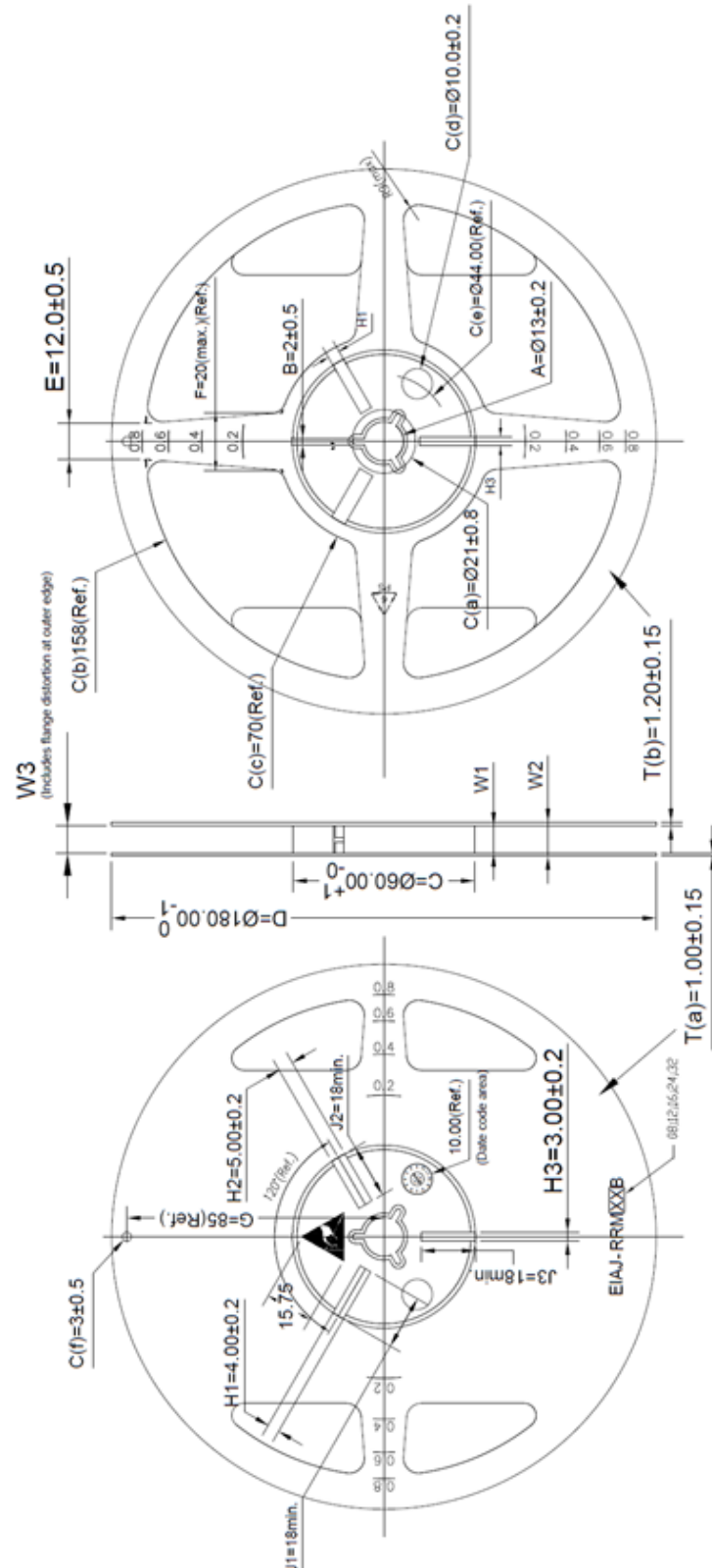
**Table 6. TSSOP-20 package mechanical data**

| Symbol | Millimeters |          |      | Inches <sup>(1)</sup> |            |       |
|--------|-------------|----------|------|-----------------------|------------|-------|
|        | Min.        | Typ.     | Max. | Min.                  | Typ.       | Max.  |
| A      |             |          | 1.2  |                       |            | 0.047 |
| A1     | 0.05        |          | 0.15 | 0.002                 | 0.004      | 0.006 |
| A2     | 0.8         | 1        | 1.05 | 0.031                 | 0.039      | 0.041 |
| b      | 0.19        |          | 0.30 | 0.007                 |            |       |
| c      | 0.09        |          | 0.20 | 0.004                 |            |       |
| D      | 6.4         | 6.5      | 6.6  | 0.252                 | 0.256      | 0.260 |
| E      | 6.2         | 6.4      | 6.6  | 0.244                 | 0.252      | 0.260 |
| E1     | 4.3         | 4.4      | 4.48 | 0.169                 | 0.173      | 0.176 |
| e      |             | 0.65 BSC |      |                       | 0.0256 BSC |       |
| K      | 0°          |          | 8°   | 0°                    |            | 8°    |
| L      | 0.45        | 0.60     | 0.75 | 0.018                 | 0.024      | 0.030 |

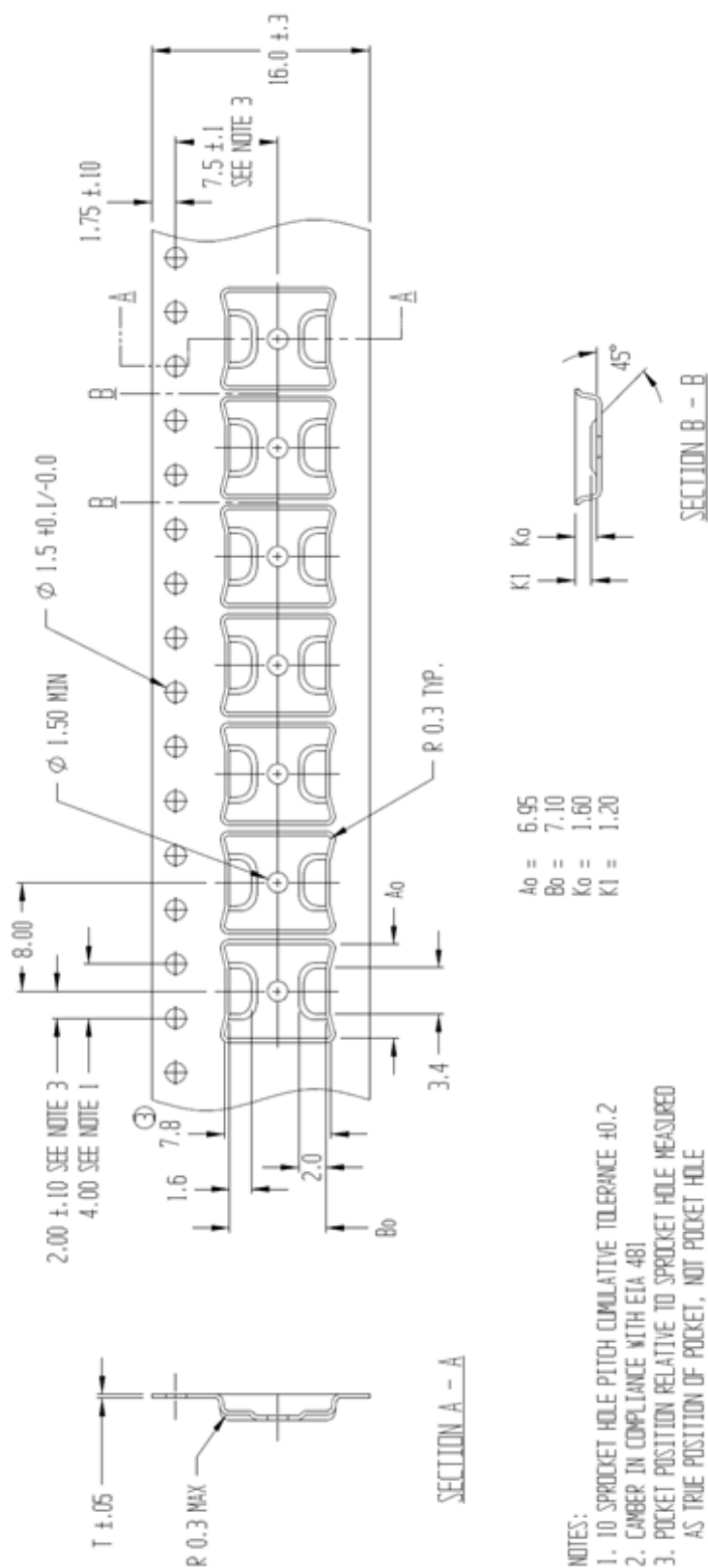
1. Values in inches are converted from mm and rounded to 4 decimal digits.

## 7.2 TSSOP-20 packing information

Figure 5. TSSOP-20 Carrier tape (dimensions in mm) outline



**Figure 6. TSSOP-20 tape (dimensions in mm) outline**



## 8 Ordering information

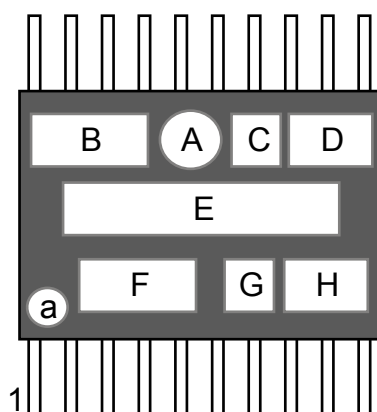
**Table 7. Ordering information**

| Order code  | Quality level      | Package  | Lead-finish | Marking  | Packing       |
|-------------|--------------------|----------|-------------|----------|---------------|
| LEOAC00PT-D | Development sample | TSSOP-20 | NiPdAu      | DLEOAC00 | Tape and reel |
| LEOAC00PT   | Flight model       | TSSOP-20 | NiPdAu      | LEOAC00  | Tape and reel |

**Table 8. Order code**

| LEO               | AC00 | P                | T             |
|-------------------|------|------------------|---------------|
| LEO qualification | Name | TSSOP-20 package | Tape and reel |

**Figure 7. TSSOP-20 marking**



- a: pin-1 reference
- A : Second Level of interconnexion (type of lead-finishing)
- B: ST logo
- C: Assy plant
- D: Lot code
- E: Marking area
- F: Country of origin
- G: Assy year
- H: Assy week

## Revision history

**Table 9. Document revision history**

| Date        | Version | Changes                                                                                                        |
|-------------|---------|----------------------------------------------------------------------------------------------------------------|
| 10-Feb-2021 | 1       | Initial release.                                                                                               |
| 29-Mar-2021 | 2       | Updated Section 8 Ordering information.<br>Removed "product documentation" section.                            |
| 08-Jun-2021 | 3       | Updated T <sub>STG</sub> value in <a href="#">Table 2</a> and TID characteristics in <a href="#">Table 5</a> . |
| 30-Aug-2021 | 4       | Updated <a href="#">Section 5 Radiations</a> .                                                                 |

## Contents

|          |                                                       |           |
|----------|-------------------------------------------------------|-----------|
| <b>1</b> | <b>Functional description .....</b>                   | <b>2</b>  |
| <b>2</b> | <b>Maximum ratings and operating conditions .....</b> | <b>3</b>  |
| <b>3</b> | <b>Electrical characteristics.....</b>                | <b>4</b>  |
| <b>4</b> | <b>Waveform and test circuit.....</b>                 | <b>6</b>  |
| <b>5</b> | <b>Radiations.....</b>                                | <b>7</b>  |
| <b>6</b> | <b>Outgassing.....</b>                                | <b>8</b>  |
| <b>7</b> | <b>Package information.....</b>                       | <b>9</b>  |
| 7.1      | TSSOP-20 package information .....                    | 9         |
| 7.2      | TSSOP-20 packing information.....                     | 10        |
| <b>8</b> | <b>Ordering information .....</b>                     | <b>12</b> |
|          | <b>Revision history .....</b>                         | <b>13</b> |

## List of tables

|                 |                                            |    |
|-----------------|--------------------------------------------|----|
| <b>Table 1.</b> | Truth table . . . . .                      | 2  |
| <b>Table 2.</b> | Absolute maximum ratings . . . . .         | 3  |
| <b>Table 3.</b> | Operating conditions . . . . .             | 3  |
| <b>Table 4.</b> | Electrical characteristics . . . . .       | 4  |
| <b>Table 5.</b> | Radiations . . . . .                       | 7  |
| <b>Table 6.</b> | TSSOP-20 package mechanical data . . . . . | 9  |
| <b>Table 7.</b> | Ordering information. . . . .              | 12 |
| <b>Table 8.</b> | Order code . . . . .                       | 12 |
| <b>Table 9.</b> | Document revision history . . . . .        | 13 |

## List of figures

|                  |                                                           |    |
|------------------|-----------------------------------------------------------|----|
| <b>Figure 1.</b> | Pin connections (top view) . . . . .                      | 2  |
| <b>Figure 2.</b> | Waveform . . . . .                                        | 6  |
| <b>Figure 3.</b> | Test circuit . . . . .                                    | 6  |
| <b>Figure 4.</b> | TSSOP-20 package outline . . . . .                        | 9  |
| <b>Figure 5.</b> | TSSOP-20 Carrier tape (dimensions in mm) outline. . . . . | 10 |
| <b>Figure 6.</b> | TSSOP-20 tape (dimensions in mm) outline . . . . .        | 11 |
| <b>Figure 7.</b> | TSSOP-20 marking . . . . .                                | 12 |

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