TMUX121 具有断电隔离功能和 1.8V 逻辑的低电容双通道 2:1 开关

1 特性

- 与高速 I^3C 信号兼容
- 高性能开关特性：
  - 带宽（–3dB）：3.0GHz
  - R_{ON}（典型值）：3Ω
  - C_{ON}（典型值）：1.7pF
  - T_{PD}（典型值）：60 ps
  - T_{SWEK}（典型值）：2ps
- 低电流消耗：12μA（典型值）
- 专有特性：
  - I_{POFF} 保护可防止在断电状态下产生漏电流
  - 1.8V 和 3.3V 兼容控制输入（SEL，$\overline{EN}$）
- 3.3V 电源电压
- 工业温度范围：–40 至 125° C
- 紧凑型 10 引脚 1.4mm × 1.8mm，UQFN 封装

2 应用

- I^3C (SenseWire)
- I^3C 和 I^2C 外设开关
- 服务器
- 手持终端：智能电话
- 笔记本电脑
- 平板电脑：多媒体
- 电子销售终端
- 现场仪器
- 便携式监视器

3 说明

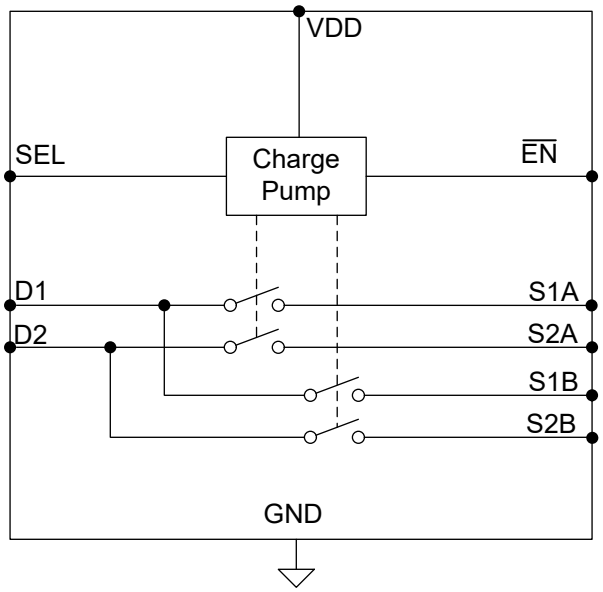
TMUX121 是一款高性能双向 2 通道 2:1 (SPDT) 开关，同时支持差分和单端信号。TMUX121 是一款具有断电保护功能的模拟无源开关，当 V_{DD} 引脚断电时，强制所有 I/O 引脚进入高阻抗模式。TMUX121 的选择引脚和使能引脚与 1.8V 和 3.3V 控制电压兼容，因而能够直接与低电压处理器的通用 I/O (GPIO) 相连。凭借这一特性以及器件的低导通电阻和低导通电容，TMUX121 成为支持切换各种模拟信号和数字通信协议标准（包括 I^3C 等高速标准）的理想选择。

TMUX121 采用小型 10 引脚 UQFN 封装，尺寸仅为 1.8mm × 1.4mm，非常适合 PCB 面积有限的情况。

封装信息

器件型号	封装(1)	封装尺寸(2)
TMUX121	NKG（UQFN，10）	1.8mm × 1.4mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。
(2) 封装尺寸（长 × 宽）为标称值，并包括引脚（如适用）。



应用用例

本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。有关适用的官方英文版本的最新信息，请访问 www.ti.com，其内容始终优先。TI 不保证翻译的准确性和有效性。在实际设计之前，请务必参考最新版本的英文版本。

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4 Revision History

DATE	REVISION	NOTES
August 2023	*	Initial Release

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5 Pin Configuration and Functions

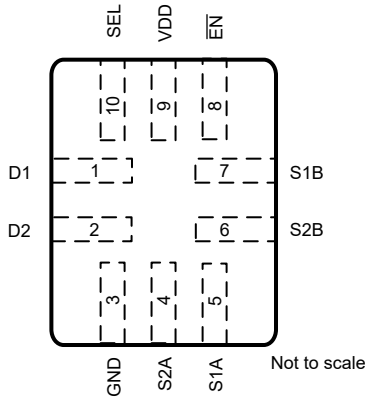


图 5-1. TMUX121 NKG Package, 10-Pin UQFN (Top View)

表 5-1. Pin Functions

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
D1	1	I/O	Drain pin 1. Can be an input or output.
D2	2	I/O	Drain pin 2. Can be an input or output.
S1A	5	I/O	Source pin 1A. Can be an input or output.
S2A	4	I/O	Source pin 2A. Can be an input or output.
S1B	7	I/O	Source pin 1B. Can be an input or output.
S2B	6	I/O	Source pin 2B. Can be an input or output.
SEL	10	IN	Switch logic control input. Controls the switch connection as provided in 表 7-1.
$\overline{EN}$	8	IN	Active low enable input. Controls the switch connection as provided in 表 7-1.
VDD	9	P	3.3 V power supply
GND	3	G	Ground

(1) IN = input, I/O = input or output, P = power, G = ground

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6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{DD}	Supply voltage	–0.5	4.0	V
V_{EN} or V_{SEL}	Logic control input pin current (SEL, EN)	–0.5	4.0	V
V_D or V_S	Source or drain voltage (Sx, Dx)	–0.5	5.5	V
T_{stg}	Storage temperature	–65	150	°C
T_J	Junction temperature	–40	125	°C

(1) Operation outside the *Absolute Maximum Rating* may cause permanent device damage. *Absolute Maximum Rating* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Condition*. If used outside the *Recommended Operating Condition* but within the *Absolute Maximum Rating*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

			VALUE	UNIT
V_{ESD}	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±5000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	TYP	MAX	UNIT
VDD	Power Supply voltage	3.0	3.3	3.6	V
VDD_{RAMP}	Power Supply voltage ramp time	0.1		100	ms
V_D or V_S	Source or drain voltage (Sx, Dx)	0		3.6	V
V_{EN} or V_{SEL}	Logic control input pin current (SEL, EN)	0		3.6	V
I_S or I_D (cont)	Source or drain continuous current (Sx, Dx)			90	mA
T_A	Operating free-air/ambient temperature	-40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TMUX121 NKG (UQFN) 10 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance - High K	225.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	93.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	147.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	3.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	147.1	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

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6.5 Electrical Characteristics

Over operating free-air temperature and supply voltage range (unless otherwise noted)
Typical at V_{DD} = 3.3 V T_A = 25℃ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DDQ}	V_{DD} quiescent supply current	EN = V_{DD}		1.3	4	µA
I_{DD}	V_{DD} supply current	EN = 0 V		11	30	µA
R_{ON}	On-resistance	V_S = 0 V , I_S = –8 mA		3	5.4	Ω
		V_S = 2.4 V , I_S = –8 mA		3.9	8	Ω
ΔR_{ON}	On-resistance mismatch between channels	V_S = 0 V , I_S = –8 mA			0.5	Ω
		V_S = 2.4 V , I_S = –8 mA			0.5	Ω
$R_{ON\ FLAT}$	On-resistance flatness	V_S = 0 V and V_S = 2.4 V; I_S = –8 mA		1		Ω
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current (Sx, Dx)	Switch state is on V_D = V_S = 3.6 V			2	µA
		Switch state is on V_D = V_S = 0 V			0.2	µA
$I_{S(OFF)}$	Source off leakage current (Sx)	Switch state is off V_S = 3.6 V			2	µA
$I_{D(OFF)}$	Drain off leakage current (Dx)	Switch state is off V_D = 3.6 V			2	µA
$I_{(POFF)}$	Powered-off leakage current (Sx, Dx)	V_{CC} = 0 V, V_D or V_S = 3.6 V			10	µA
V_{IH}	Logic voltage high (EN, SEL)		1.4		3.6	V
V_{IL}	Logic voltage low (EN, SEL)		0		0.4	
I_{IL}	Input leakage current (EN, SEL)				0.2	µA
I_{IH}	Input leakage current (EN, SEL)				1	µA
I_{IH}	Failsafe Input leakage current (EN, SEL)	V_{CC} = 0 V, V_{EN} or V_{SEL} = 3.6 V			10	µA

6.6 Switching Characteristics

over operating free-air temperature and supply voltage range (unless otherwise noted)

PARAMETER			MIN	TYP	MAX	UNIT
t_{TRAN}	Transition time from control input (SEL)	R_L = 50 Ω, C_L = 10 pF			1	µs
t_{ON}	Turn-on time from control input (EN)	R_L = 50 Ω, C_L = 10 pF			16	µs
t_{OFF}	Turn-off time from control input (EN)	R_L = 50 Ω, C_L = 10 pF			0.5	µs
t_{PD}	Switch propagation delay (Sx to Dx or Dx to Sx)			60	80	ps
t_{SKEW_INTRA}	Intra-pair propagation delay skew for same channel			2	10	ps
t_{SKEW_INTER}	Inter-pair propagation delay skew between channels			2	10	ps
BW	–3-dB bandwidth			3		GHz
I_L	Differential insertion loss	f = 10 MHz		-0.3		dB
O_{ISO}	Differential OFF isolation (D to SA/SB)	f = 10 MHz		-56		dB
X_{TALK}	Differential cross-talk (SA to SB or SB to SA)	f = 10 MHz		-64		dB
$C_{S(ON)}$ $C_{D(ON)}$	On capacitance	f = 10 MHz		1.7		pF

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6.7 Typical Characteristics

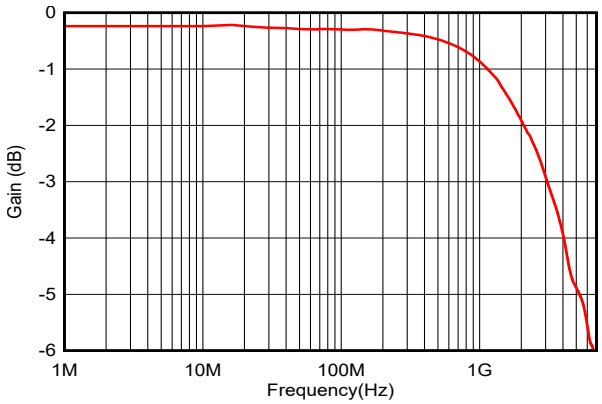


图 6-1. Typical Differential Bandwidth vs Frequency

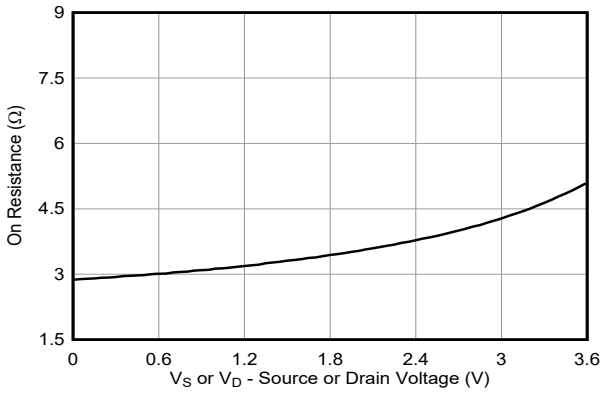


图 6-2. R_{ON} vs Common Mode Voltage VCM

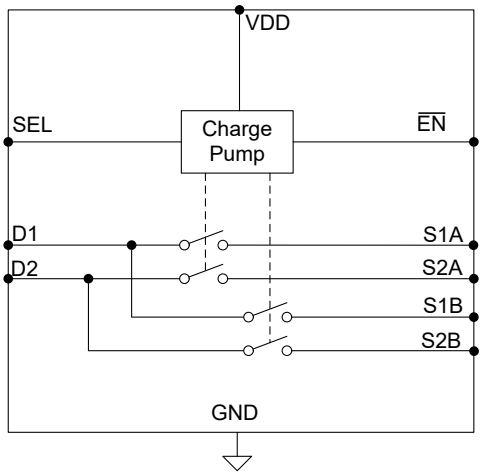
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7 Detailed Description

7.1 Overview

The TMUX121 is an analog passive 2 channel 2:1 (SPDT) that can work for any low-speed, high-speed, differential or single ended signals. Excellent low capacitance characteristics of the device allow signal switching with minimal attenuation and very little added jitter. The signals must be within the allowable voltage range of 0 to 3.6 V.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Enable and Low Power Mode

The TMUX121 can be placed in a power saving mode by pulling $\overline{EN}$ high. This reduces the supply power consumption from 12 µA to 1.5 µA. which is extremely beneficial for systems where saving power is critical.

7.4 Device Functional Modes

表 7-1. Mux Configuration Control Logic for TMUX121 (1)

SEL	$\overline{EN}$	Mux Configuration
L	L	D to SA
H	L	D to SB
X	H	All channels are disabled and Hi-Z

(1) The TMUX121 can tolerate polarity inversions for differential signals. Keep the polarity consistent for all differential pairs.

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8 Application and Implementation

备注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI’s customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TMUX121 is an analog high-speed mux or demux that can be used for routing differential as well as single ended signals through it. The device can be used for many interfaces including I^2C and I^3C.

An available GPIO pin of a controller or hard tie to voltage level H or L can easily control the mux or demux selection pin (SEL) of the device as an application requires. The switch path is passive and therefore bidirectional.

8.2 Typical Applications

8.2.1 Signal Expansion (I^3C and I^2C)

There are many applications in which microprocessors or controllers have a limited number of I/Os. The TMUX121 solution can effectively expand the limited I/Os by switching between multiple buses to interface them to a single microprocessor or controller. A common application where the TMUX121 is as a I^3C 1:2 multiplexer. In this application, the TMUX121 is used to route communicating between different peripherals from a single controller or driver within a server, as shown in 图 8-1. The high bandwidth of the TMUX121 will preserve signal integrity at even the fastest communication protocols that may be used in server applications, such as I^3C. Also, because I^3C is backwards compatible, any of the peripherals can also be I^2C, and the TMUX121 will still support it.

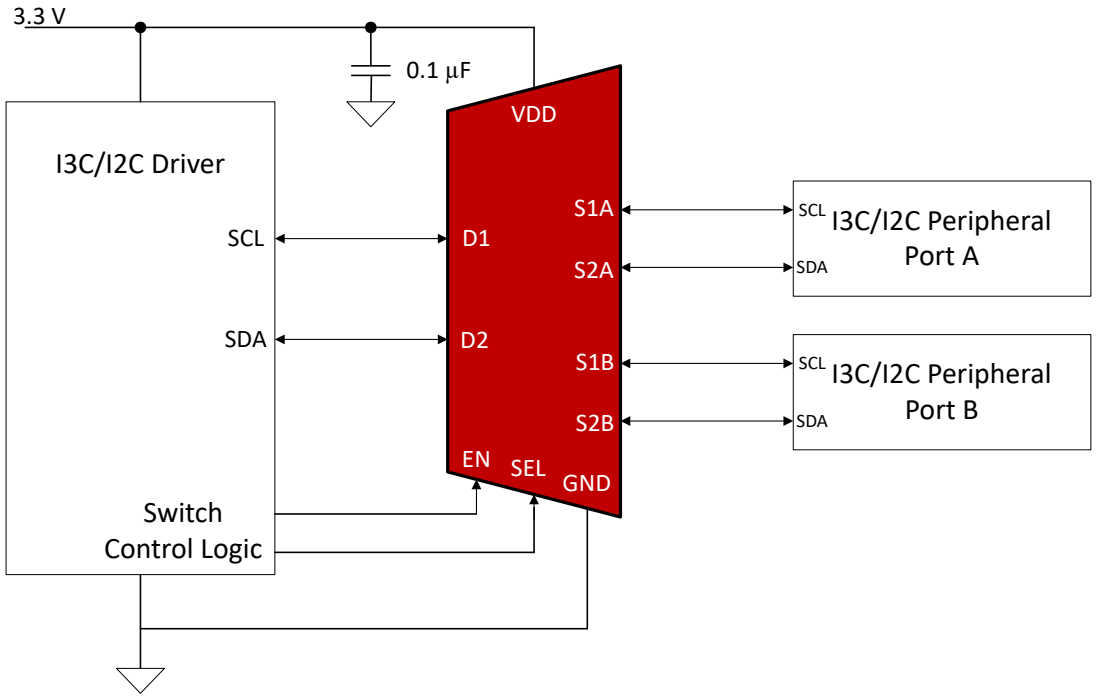


图 8-1. Typical Application

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8.2.1.1 Design Requirements

表 8-1. TMUX121 I3C Compatibility

	I3C Requirements	TMUX121 Specification
Voltage	1.0 V, 1.2 V, 1.8 V, 3.3 V	0-3.6 V
Frequency	Up to 12.5 MHz	3 GHz Bandwidth
Capacitance	50 pF maximum bus capacitance	< 2 pF On or Off Capacitance

8.2.1.2 Detailed Design Procedure

The TMUX121 supports I3C standard by maintaining signal integrity through the switch. 表 8-1 details how the TMUX121 specifications make this device optimal for switching I3C signals. Choosing a multiplexer with very low capacitance helps reduces the impact to your total capacitance budget. This can enable more design flexibility keeping the total bus capacitance under 50 pF such as: longer traces, more ICs, multiple buses, and so forth.

8.2.1.3 Application Curves

图 8-2 shows bandwidth of the TMUX121. This can easily support the max data rate of the I3C standard. A combination of low on-resistance, low capacitance, and low added jitter from the device allows it to be used for I3C.

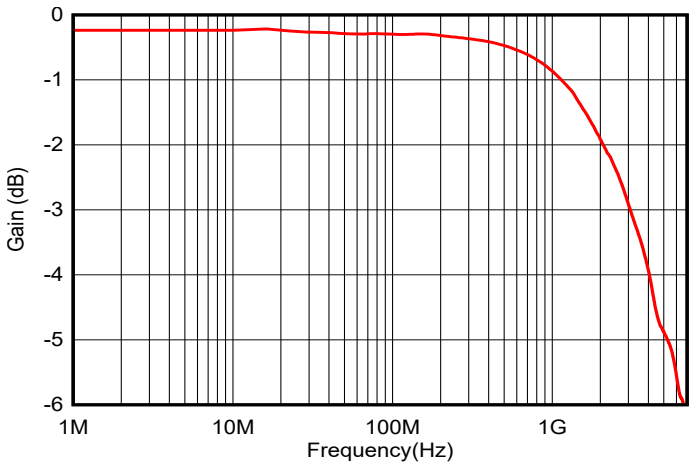


图 8-2. Typical Differential Bandwidth vs Frequency

8.3 Power Supply Recommendations

The TMUX121 does not require a power supply sequence. However, TI recommends to enable the device after VDD is stable and in specification. TI also recommends placing a bypass capacitor as close to the supply pin VDD as possible to help smooth out lower frequency noise to provide better load regulation across the frequency spectrum.

8.4 Layout

8.4.1 Layout Guidelines

Place supply bypass capacitors as close to VDD pin as possible and avoid placing the bypass capacitors near the high speed traces.

Route the high-speed signals using a minimum of vias and corners which reduces signal reflections and impedance changes. When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal’s transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points on twisted pair lines; through-hole pins are not recommended.

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When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn. Doing this reduces reflections on the signal traces by minimizing impedance discontinuities. Avoid stubs on the high-speed signals because they cause signal reflections. Route all high-speed signal traces over continuous planes (VDD or GND) with no interruptions.

Due to high frequencies, a printed circuit board with at least four layers is recommended; two signal layers separated by a ground and power layer as shown in 图 8-3.

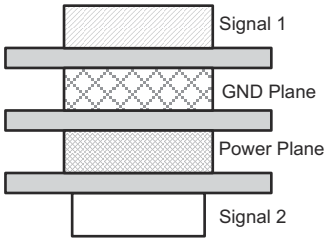


图 8-3. Four-Layer Board Stack-Up

The majority of signal traces must run on a single layer, preferably Signal 1. Immediately next to this layer must be the GND plane, which is solid with no cuts. Avoid running signal traces across a split in the ground or power plane. When running across split planes is unavoidable, sufficient decoupling must be used. Minimizing the number of signal vias reduces EMI by reducing inductance at high frequencies.

For high speed layout guidelines, refer to *High-Speed Layout Guidelines* application note.

8.4.2 Layout Example

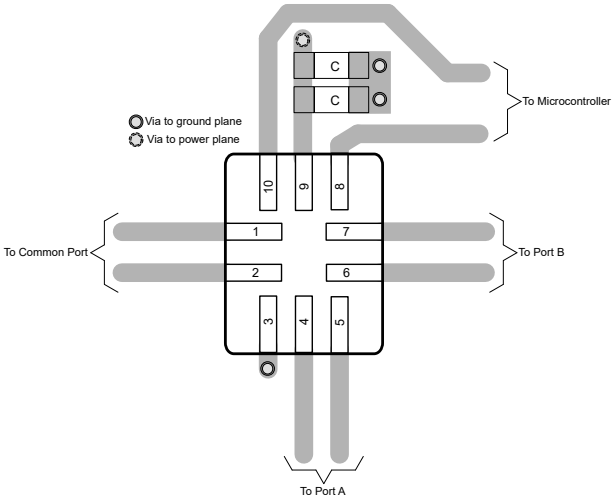


图 8-4. TMUX121 Layout Example

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9 Device and Documentation Support

9.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *High-Speed Layout Guidelines* application note

9.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*订阅更新*进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

9.6 术语表

TI 术语表	本术语表列出并解释了术语、首字母缩略词和定义。

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TMUX121NKGR	Active	Production	UQFN (NKG) | 10	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	OJ

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

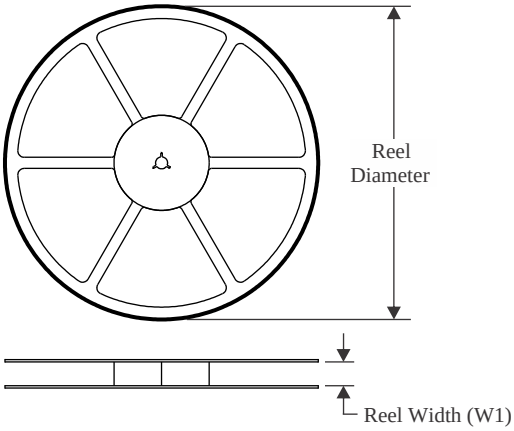
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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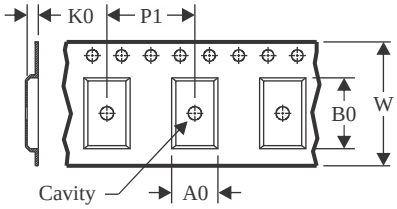
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

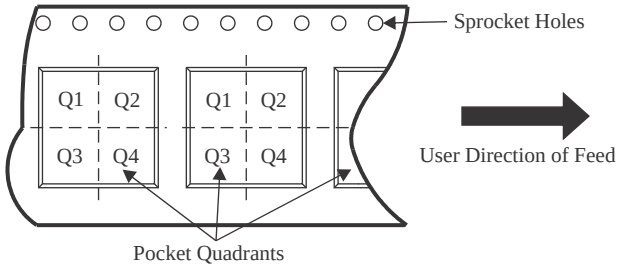


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

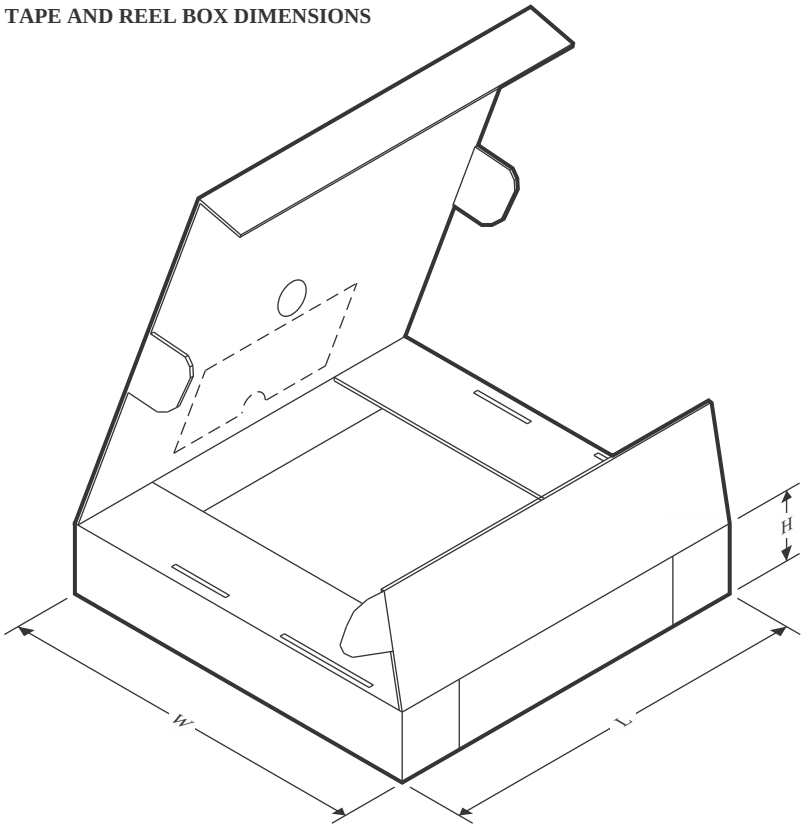
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUX121NKGR	UQFN	NKG	10	3000	180.0	8.4	1.6	2.0	0.7	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

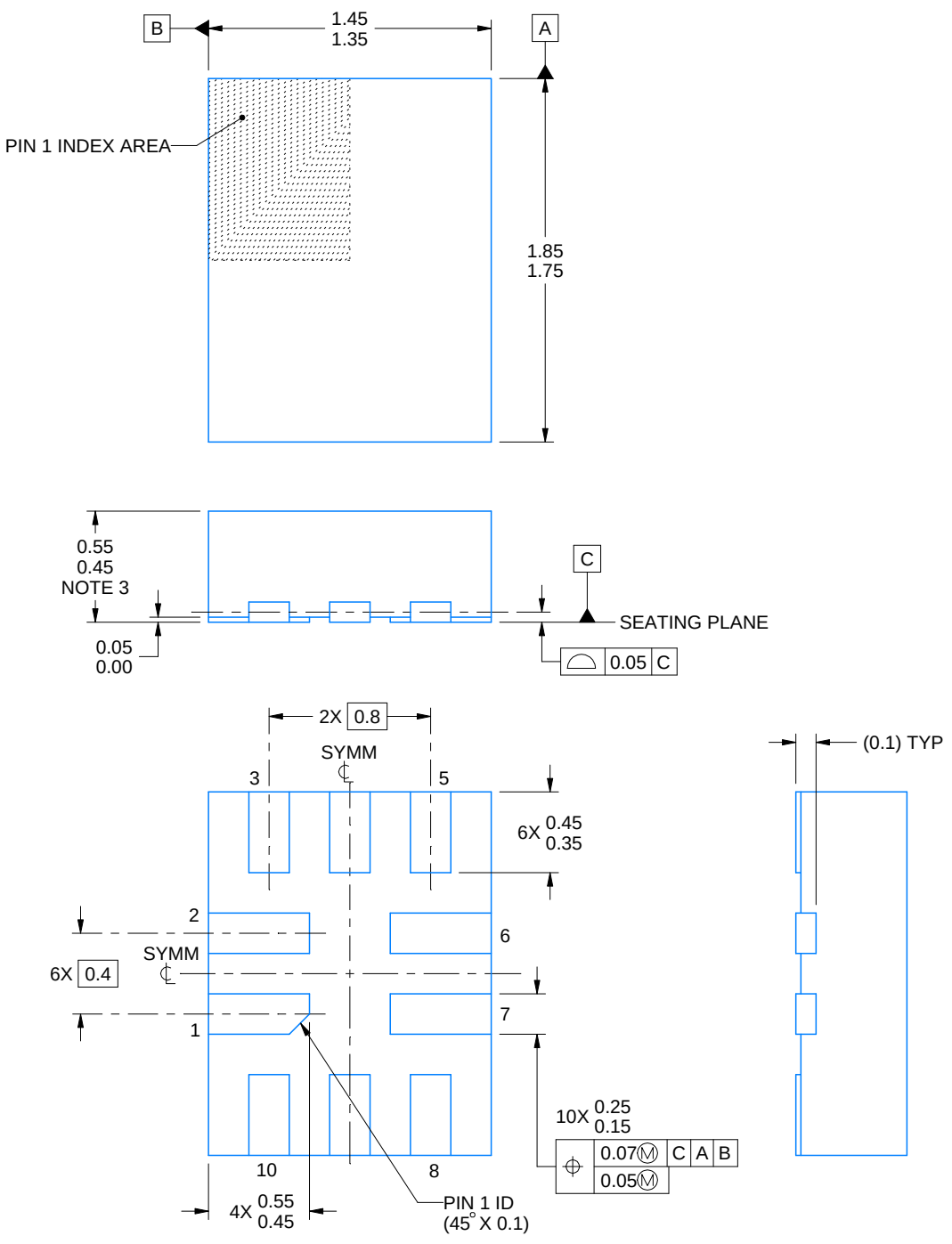
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX121NKGR	UQFN	NKG	10	3000	210.0	185.0	35.0

PACKAGE OUTLINE

NKG0010A

UQFN - 0.55 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

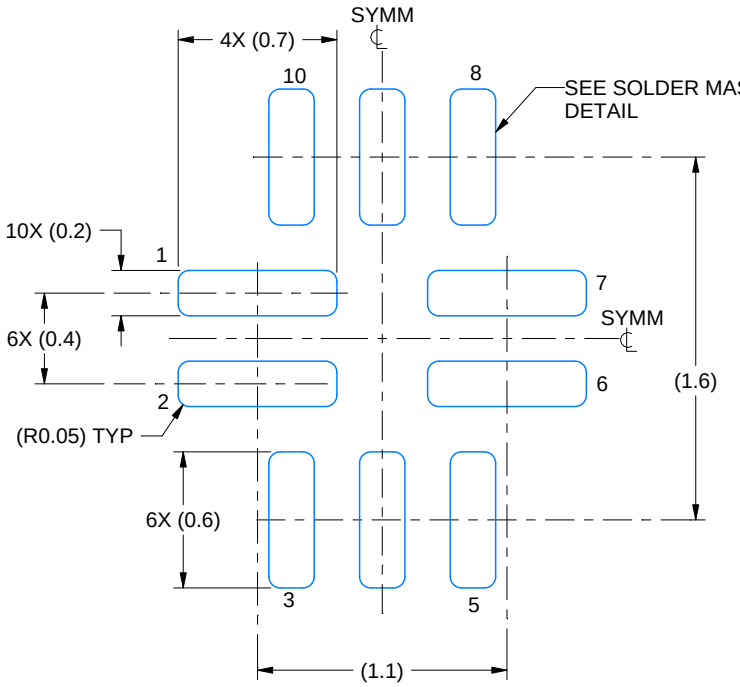
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package complies to JEDEC MO-288 variation UDEE, except minimum package height.

EXAMPLE BOARD LAYOUT

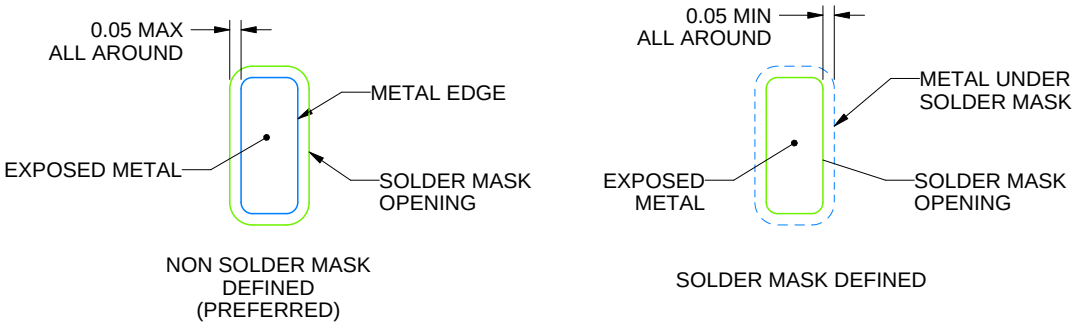
NKG0010A

UQFN - 0.55 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 30X

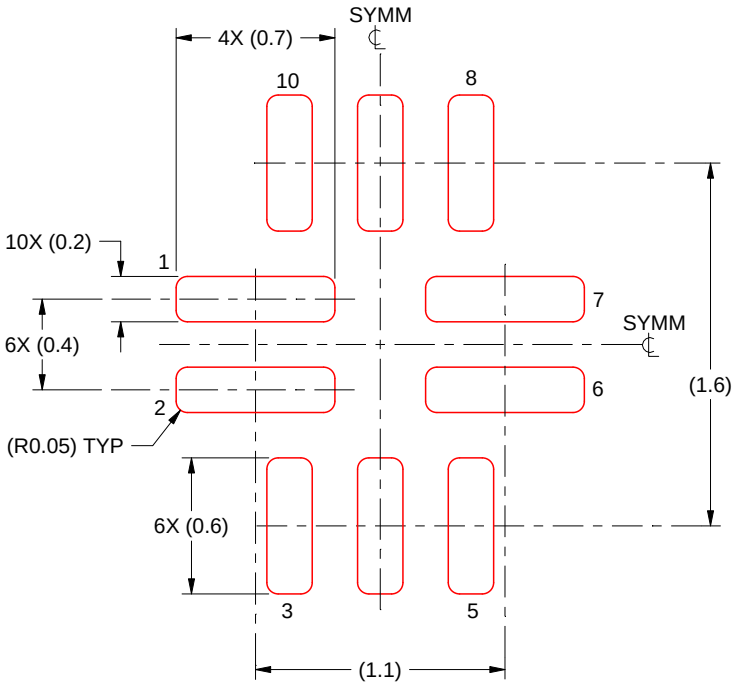


SOLDER MASK DETAILS

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NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.1 MM THICK STENCIL
SCALE: 30X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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