

TMUX121 電源オフ絶縁機能搭載、1.8V ロジック対応、低静電容量、2 チャンネル、2 : 1 スイッチ

1 特長

- 高速 I³C 信号と互換
- 高性能スイッチ特性:
 - 帯域幅 (−3dB): 3.0GHz
 - R_{ON} (標準値): 3Ω
 - C_{ON} (標準値): 1.7pF
 - T_{PD} (標準値): 60ps
 - T_{SWEK} (標準値): 2ps
- 低消費電流: 12μA (標準値)
- 特別な機能:
 - I_{POFF} 保護により、パワーダウン状態でのリーク電流を防止
 - 1.8V および 3.3V 互換の制御入力 (SEL, EN)
- 電源電圧: 3.3V
- 産業用温度範囲: −40~125°C
- 小型の 10 ピン、1.4mm × 1.8mm の UQFN パッケージ

2 アプリケーション

- I³C (SenseWire)
- I³C および I²C ペリフェラル・スイッチング
- サーバー
- 携帯電話: スマートフォン
- ノート PC
- タブレット: マルチメディア
- レジ用電子機器
- 現場用計測機器
- ポータブル・モニタ

3 概要

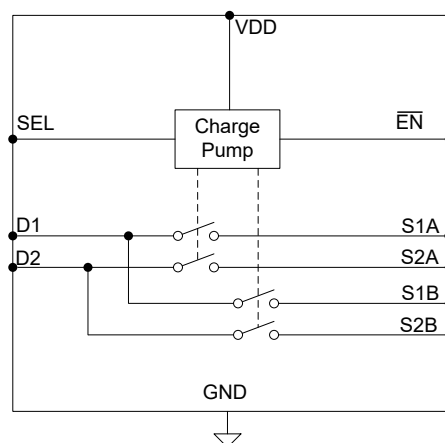
TMUX121 は、高性能双方向 2 チャンネルの 2:1 (SPDT) スイッチで、差動およびシングル・エンドの両方の信号をサポートします。TMUX121 は、電源オフ保護機能を備えたアナログ・パッシブ・スイッチで、V_{DD} ピンに電力が供給されていないときは、すべての I/O ピンが強制的に高インピーダンス・モードになります。TMUX121 の選択ピンとイネーブル・ピンは、1.8V および 3.3V 制御電圧と互換性があるため、低電圧プロセッサからの汎用 I/O (GPIO) と直接インターフェイスが可能です。このデバイスはオン抵抗が低くオン静電容量が小さいため、TMUX121 は I³C などの高速規格を含め、幅広いアナログ信号およびデジタル通信プロトコル規格のスイッチングをサポートするのに優れた選択肢です。

TMUX121 は、小型の 10 ピン UQFN パッケージで供給されており、そのサイズはわずか 1.8mm × 1.4mm であることから、PCB 面積が限られている場合に便利です。

パッケージ情報

部品番号	パッケージ (1)	パッケージ・サイズ (2)
TMUX121	NKG (UQFN, 10)	1.8mm × 1.4mm

- 利用可能なすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。
- パッケージ・サイズ (長さ×幅) は公称値であり、該当する場合はピンも含まれます。



アプリケーション使用事例



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4 Revision History

DATE	REVISION	NOTES
August 2023	*	Initial Release

5 Pin Configuration and Functions

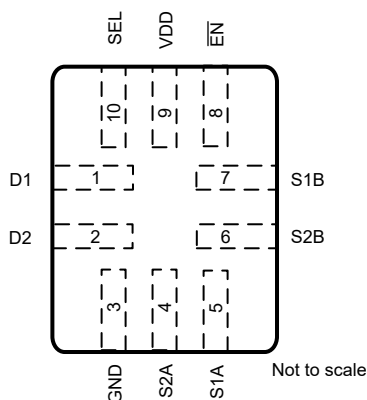


図 5-1. TMUX121 NKG Package, 10-Pin UQFN (Top View)

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.
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

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
		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
V _{DD}	Power Supply voltage	3.0	3.3	3.6	V
V _{DD} 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	UNIT
		NKG (UQFN)	
		10 PINS	
R _{θJA}	Junction-to-ambient thermal resistance - High K	225.9	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	93.5	°C/W
R _{θJB}	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.

6.5 Electrical Characteristics

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

Typical at $V_{DD} = 3.3\text{ V}$ $T_A = 25^\circ\text{C}$ (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	$EN = 0\text{ V}$		11	30	μA
R_{ON}	On-resistance	$V_S = 0\text{ V}$, $I_S = -8\text{ mA}$		3	5.4	Ω
		$V_S = 2.4\text{ V}$, $I_S = -8\text{ mA}$		3.9	8	Ω
ΔR_{ON}	On-resistance mismatch between channels	$V_S = 0\text{ V}$, $I_S = -8\text{ mA}$			0.5	Ω
		$V_S = 2.4\text{ V}$, $I_S = -8\text{ mA}$			0.5	Ω
$R_{ON\text{ FLAT}}$	On-resistance flatness	$V_S = 0\text{ V}$ and $V_S = 2.4\text{ V}$; $I_S = -8\text{ mA}$		1		Ω
$I_{S(ON)}$ $I_{D(ON)}$	Channel on leakage current (S_x , D_x)	Switch state is on $V_D = V_S = 3.6\text{ V}$			2	μA
		Switch state is on $V_D = V_S = 0\text{ V}$			0.2	μA
$I_{S(OFF)}$	Source off leakage current (S_x)	Switch state is off $V_S = 3.6\text{ V}$			2	μA
$I_{D(OFF)}$	Drain off leakage current (D_x)	Switch state is off $V_D = 3.6\text{ V}$			2	μA
$I_{(POFF)}$	Powered-off leakage current (S_x , D_x)	$V_{CC} = 0\text{ V}$, V_D or $V_S = 3.6\text{ V}$			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)	$V_{CC} = 0\text{ V}$, V_{EN} or $V_{SEL} = 3.6\text{ V}$			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)	$R_L = 50\text{ }\Omega$, $C_L = 10\text{ pF}$			1	μs
t_{ON}	Turn-on time from control input (EN)	$R_L = 50\text{ }\Omega$, $C_L = 10\text{ pF}$			16	μs
t_{OFF}	Turn-off time from control input (EN)	$R_L = 50\text{ }\Omega$, $C_L = 10\text{ pF}$			0.5	μs
t_{PD}	Switch propagation delay (S_x to D_x or D_x to S_x)			60	80	ps
$t_{\text{SKEW_INTRA}}$	Intra-pair propagation delay skew for same channel			2	10	ps
$t_{\text{SKEW_INTER}}$	Inter-pair propagation delay skew between channels			2	10	ps
BW	–3-dB bandwidth			3		GHz
I_L	Differential insertion loss	$f = 10\text{ MHz}$		–0.3		dB
O_{ISO}	Differential OFF isolation (D to SA/SB)	$f = 10\text{ MHz}$		–56		dB
X_{TALK}	Differential cross-talk (SA to SB or SB to SA)	$f = 10\text{ MHz}$		–64		dB
$C_{S(ON)}$ $C_{D(ON)}$	On capacitance	$f = 10\text{ MHz}$		1.7		pF

6.7 Typical Characteristics

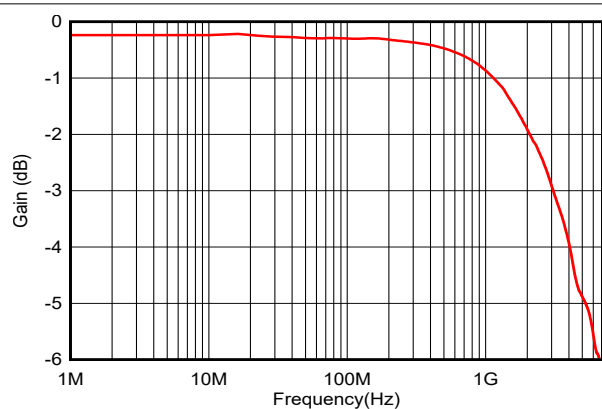


Figure 6-1. Typical Differential Bandwidth vs Frequency

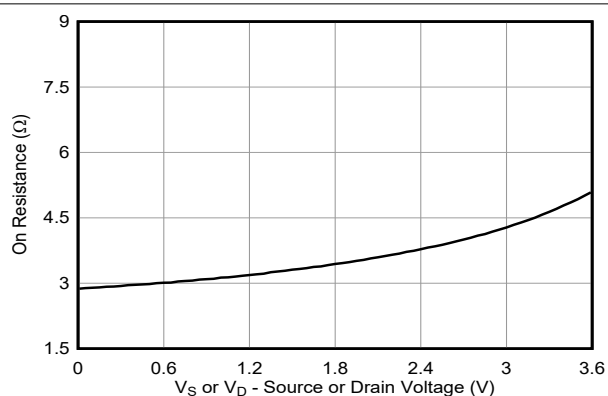


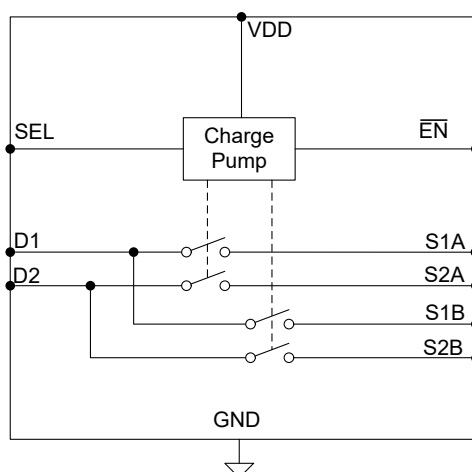
Figure 6-2. R_{ON} vs Common Mode Voltage VCM

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 $\overline{\text{EN}}$ 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	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.

8 Application and Implementation

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 I²C and I³C.

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 (I³C and I²C)

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 I³C 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 [Figure 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 I³C. Also, because I³C is backwards compatible, any of the peripherals can also be I²C, and the TMUX121 will still support it.

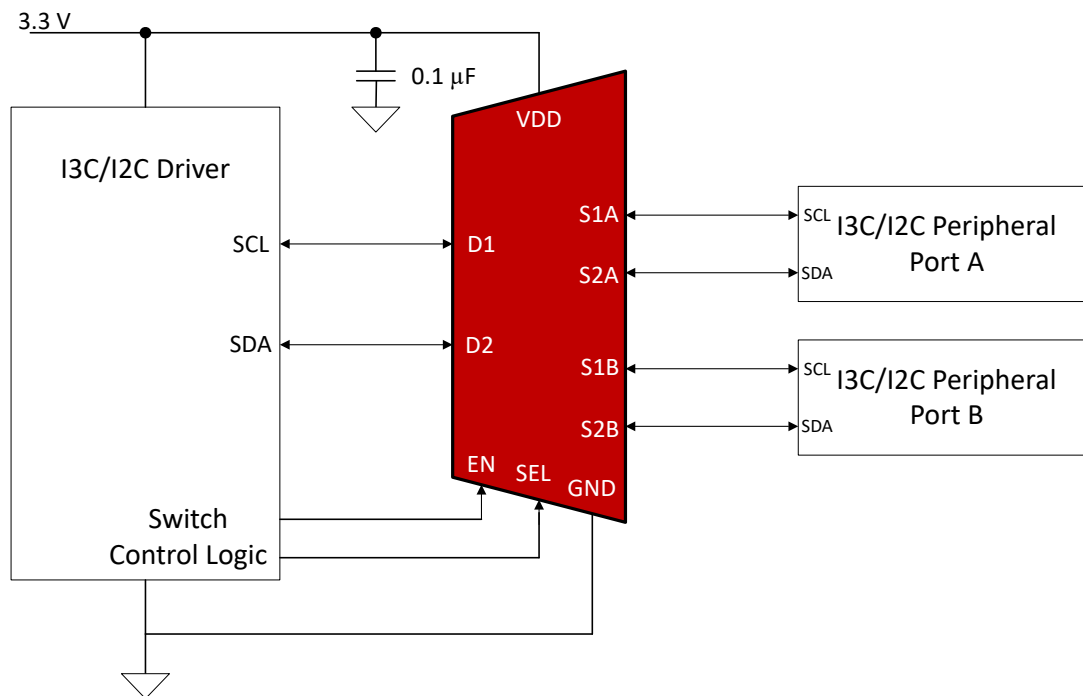


Figure 8-1. Typical Application

8.2.1.1 Design Requirements

表 8-1. TMUX121 I³C Compatibility

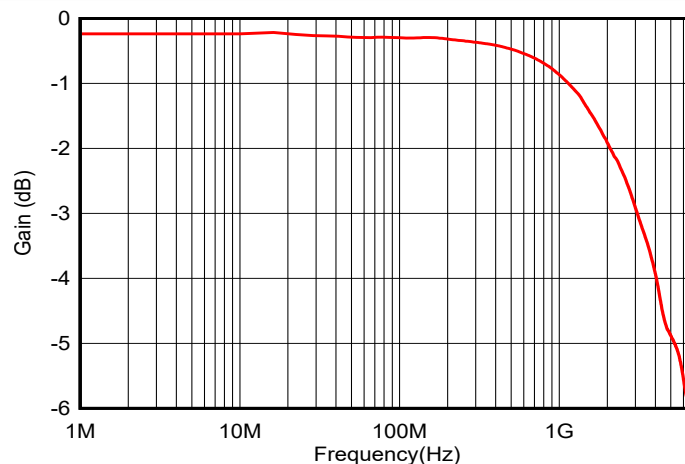
	I ³ C Requirements	TMUX121 Specification
Voltage	1.0 V, 1.2 V, 1.8 V, 3.3 V	0-3.6 V
Frequency	Up to 12.5 MHz	3 GHz Bandwidth
Capacitance	50 pF maximum bus capacitance	< 2 pF On or Off Capacitance

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 reduce 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

☒ 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.



☒ 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.

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 [Figure 8-3](#).

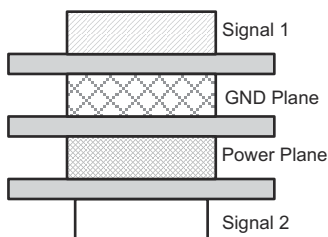


Figure 8-3. Four-Layer Board Stack-Up

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

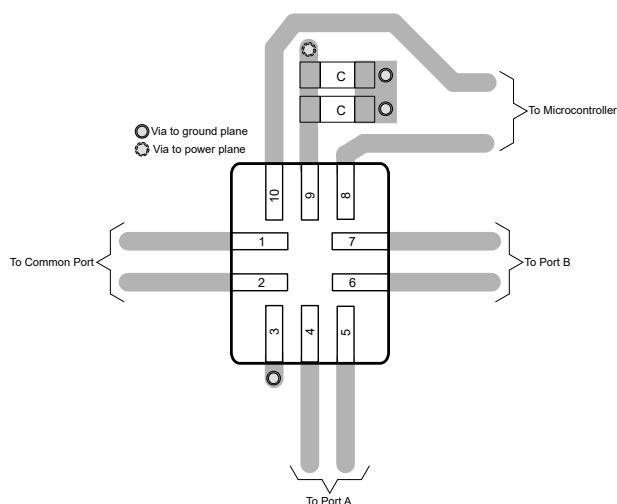


Figure 8-4. TMUX121 Layout Example

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 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[ti.com](#) のデバイス製品フォルダを開いてください。「更新の通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

9.3 サポート・リソース

[TI E2E™ サポート・フォーラム](#)は、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計に必要な支援を迅速に得ることができます。

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9.4 Trademarks

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9.5 静電気放電に関する注意事項



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ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

9.6 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

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.

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
TMUX121NKGR.A	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.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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.

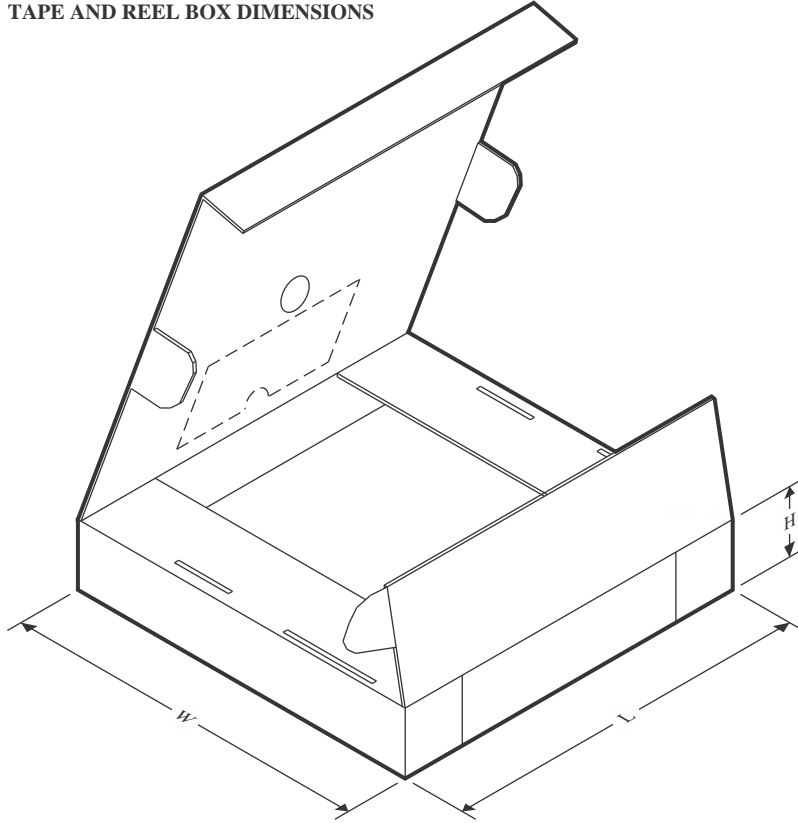
TAPE AND REEL INFORMATION



*All dimensions are nominal

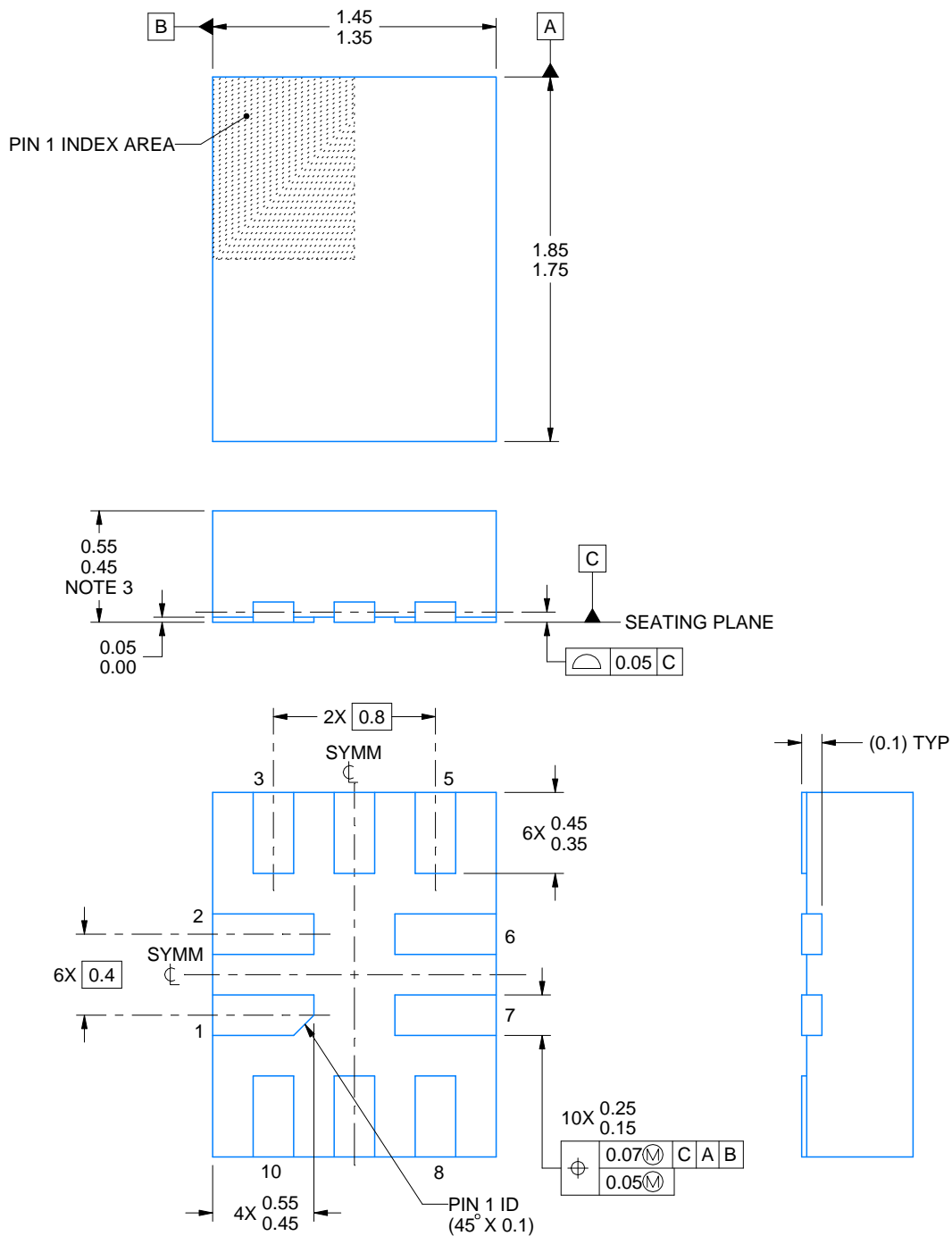
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TMUX121NKGR	UQFN	NKG	10	3000	180.0	8.4	1.6	2.0	0.7	4.0	8.0	Q1

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



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NOTES:

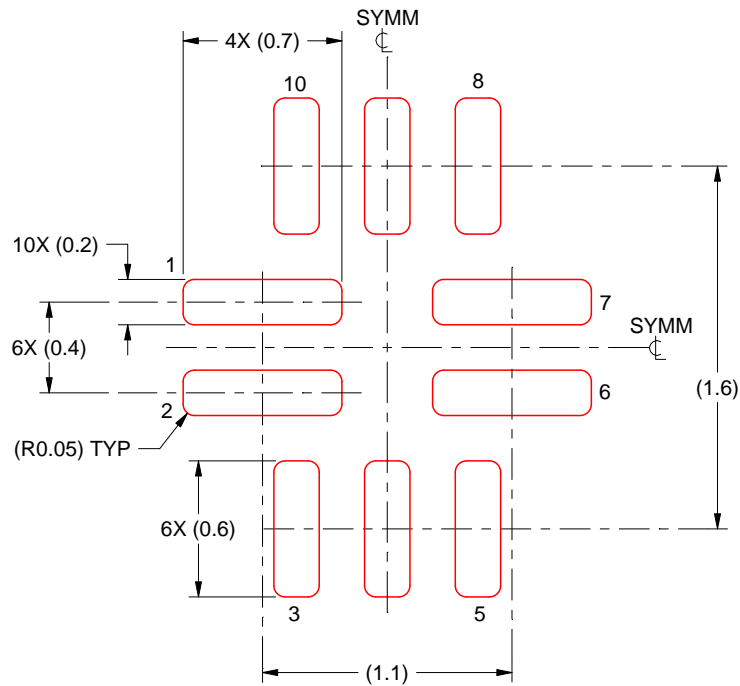
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package complies to JEDEC MO-288 variation UDEE, except minimum package height.

EXAMPLE STENCIL DESIGN

NKG0010A

UQFN - 0.55 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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

4228479/A 02/2022

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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