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 チャネル、2：1 スイッチ

1 特長

- 高速 I^3C 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、$\overline{EN}$)
- 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

- I^3C (SenseWire)
- I^3C および I^2C 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

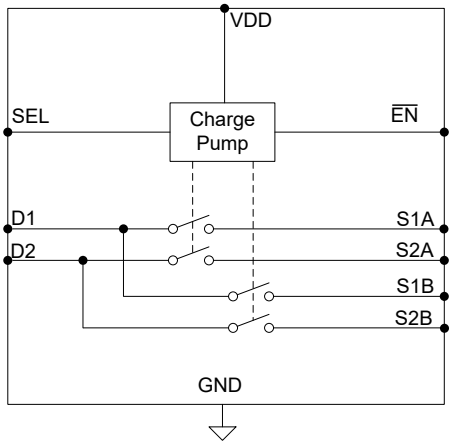
TMUX121 は、高性能双方向 2 チャネルの 2:1 (SPDT) スイッチで、差動およびシングル・エンドの両方の信号をサポートします。TMUX121 は、電源オフ保護機能を備えたアナログ・パッシブ・スイッチで、V_{DD} ピンに電力が供給されていないときは、すべての I/O ピンが強制的に高インピーダンス・モードになります。TMUX121 の選択ピンとイネーブル・ピンは、1.8V および 3.3V 制御電圧と互換性があるため、低電圧プロセッサからの汎用 I/O (GPIO) と直接インターフェイスが可能です。このデバイスはオン抵抗が低くオン静電容量が小さいため、TMUX121 は I^3C 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

(1) 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。
(2) 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

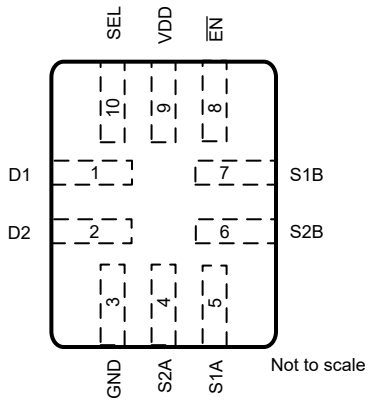


図 5-1. TMUX121 NKG Package, 10-Pin UQFN (Top View)

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.
$\overline{EN}$	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

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.

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°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 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

6.7 Typical Characteristics

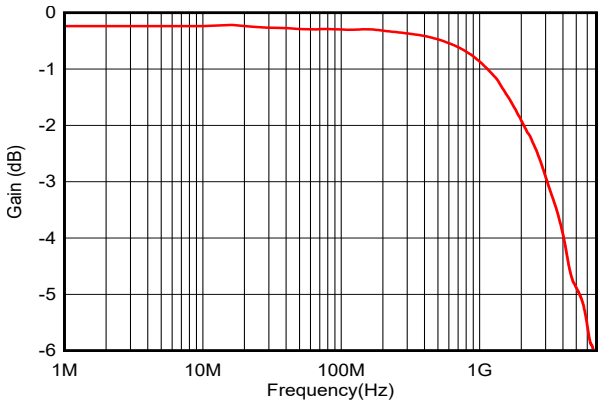


図 6-1. Typical Differential Bandwidth vs Frequency

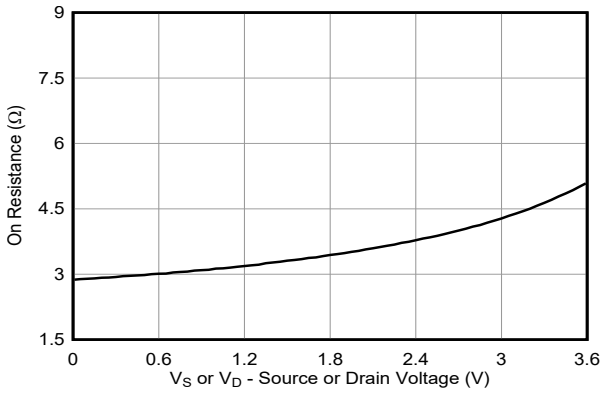


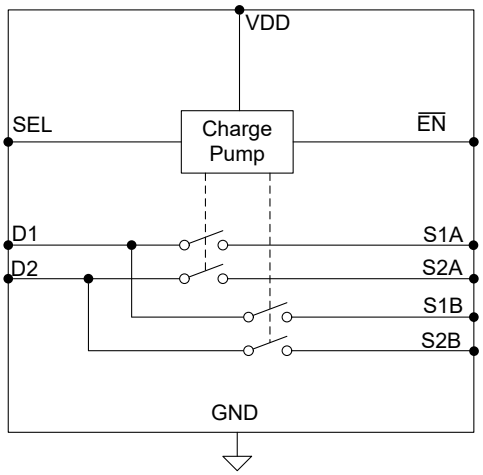
図 6-2. R_{ON} vs Common Mode Voltage VCM

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 $\overline{EN}$ 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.

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 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 図 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.

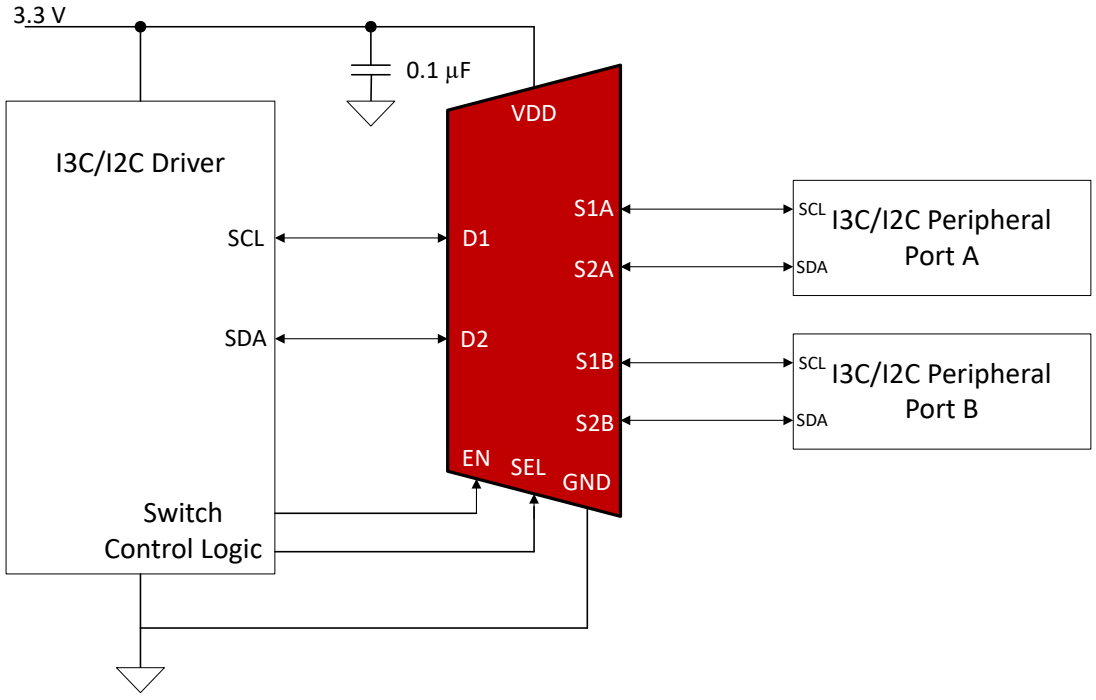


図 8-1. Typical Application

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

図 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.

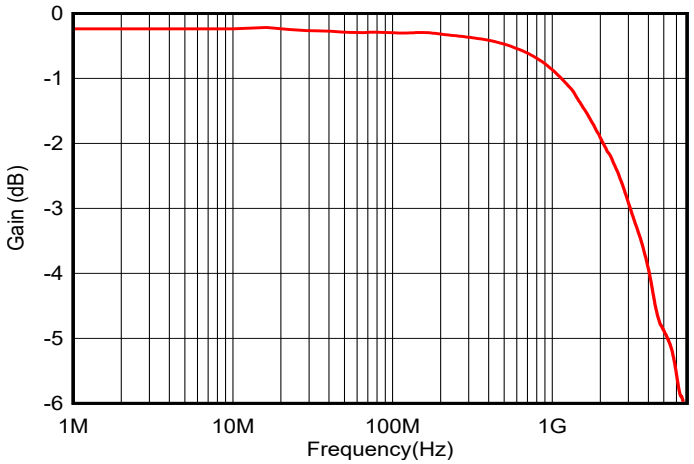


図 8-2. Typical Differential Bandwidth vs Frequency

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 図 8-3.

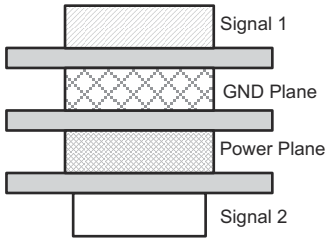


図 8-3. Four-Layer Board Stack-Up

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

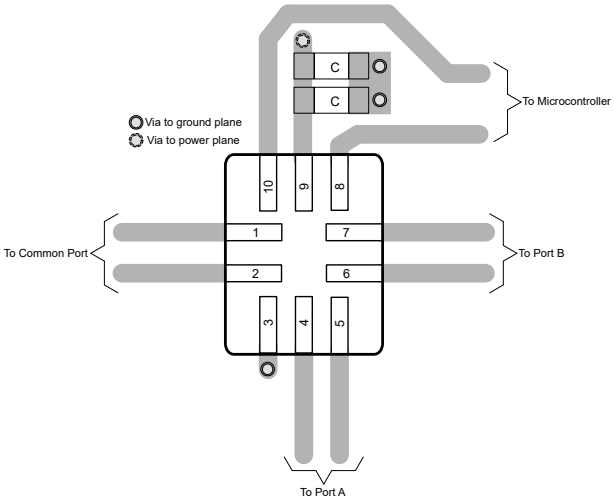


図 8-4. TMUX121 Layout Example

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、設計で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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すべての商標は、それぞれの所有者に帰属します。

9.5 静電気放電に関する注意事項

この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMUX121NKGR	ACTIVE	UQFN	NKG	10	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	OJ	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

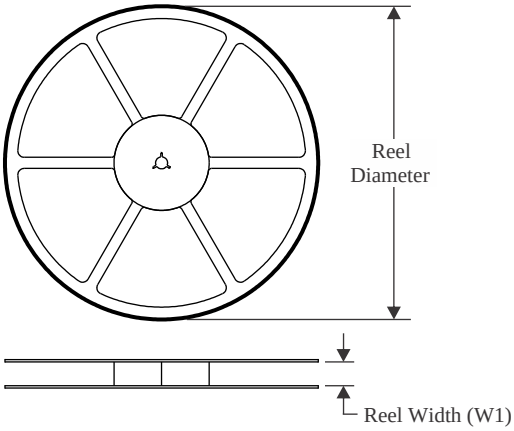
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

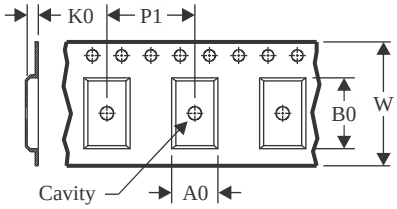
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

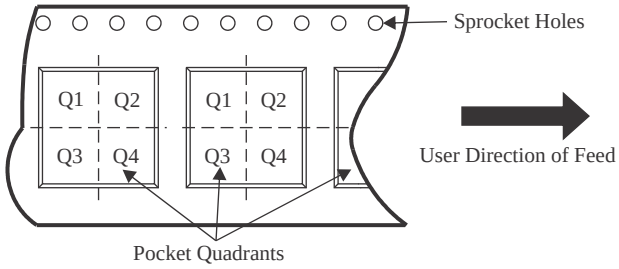


TAPE DIMENSIONS



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

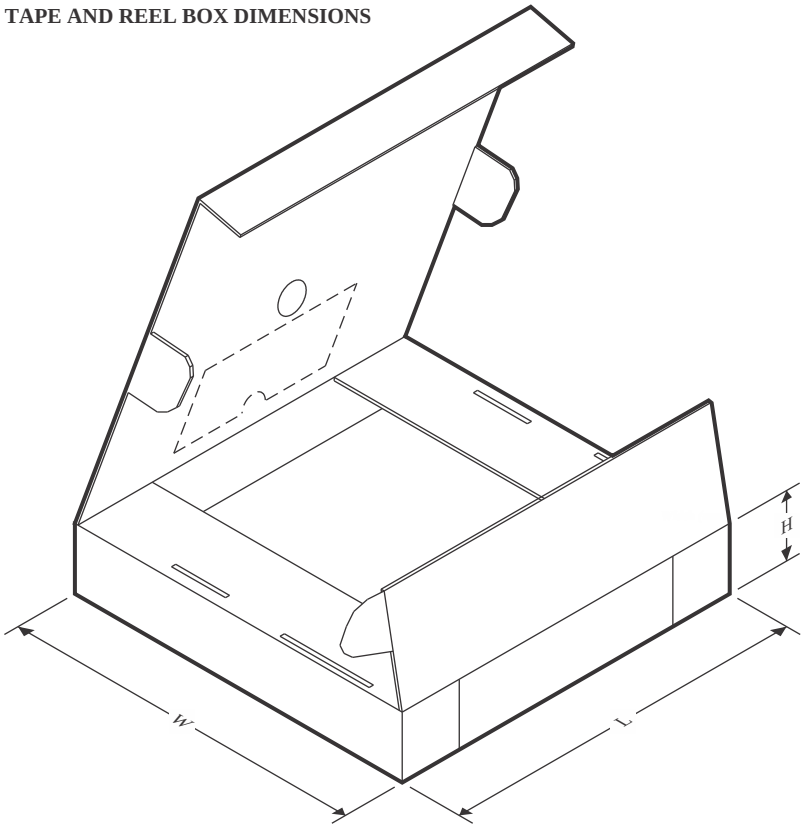
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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

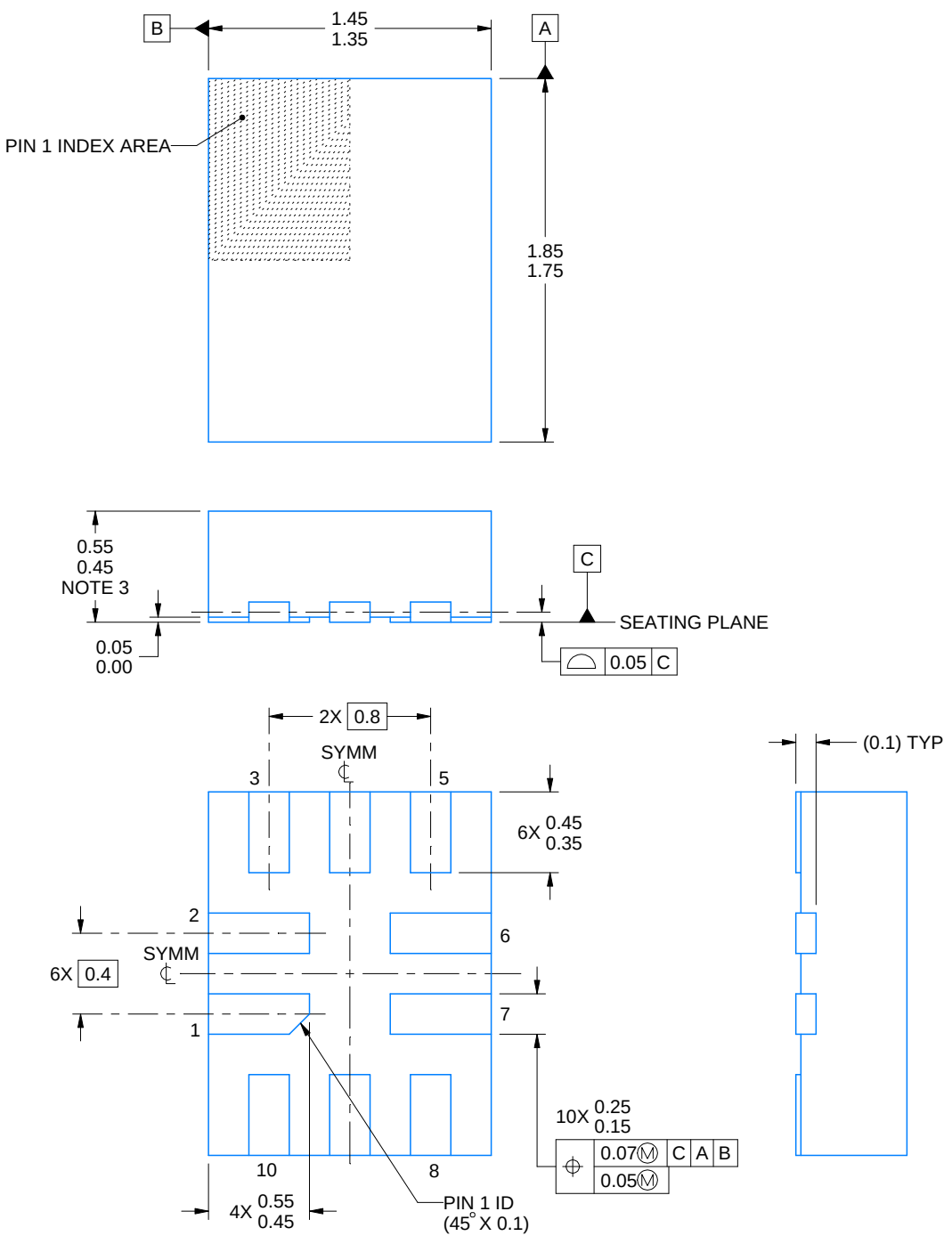
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX121NKGR	UQFN	NKG	10	3000	210.0	185.0	35.0

PACKAGE OUTLINE

NKG0010A

UQFN - 0.55 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

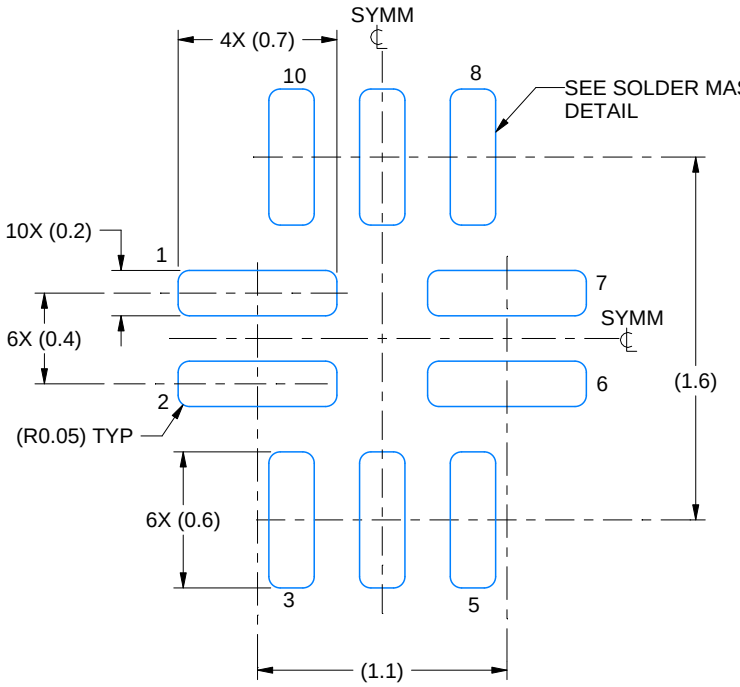
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package complies to JEDEC MO-288 variation UDEE, except minimum package height.

EXAMPLE BOARD LAYOUT

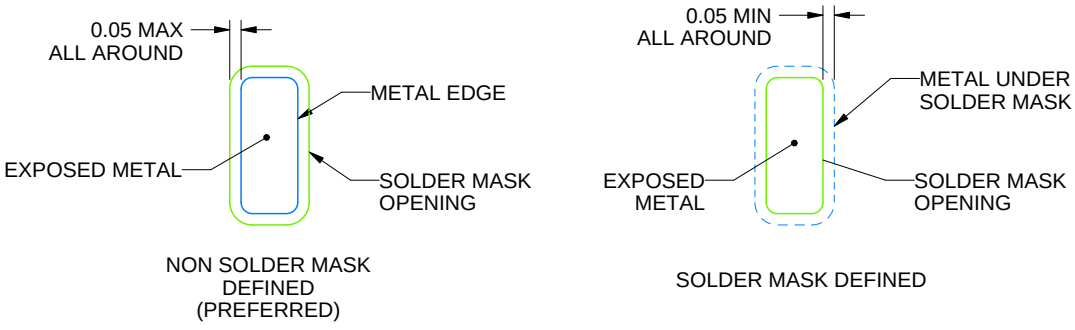
NKG0010A

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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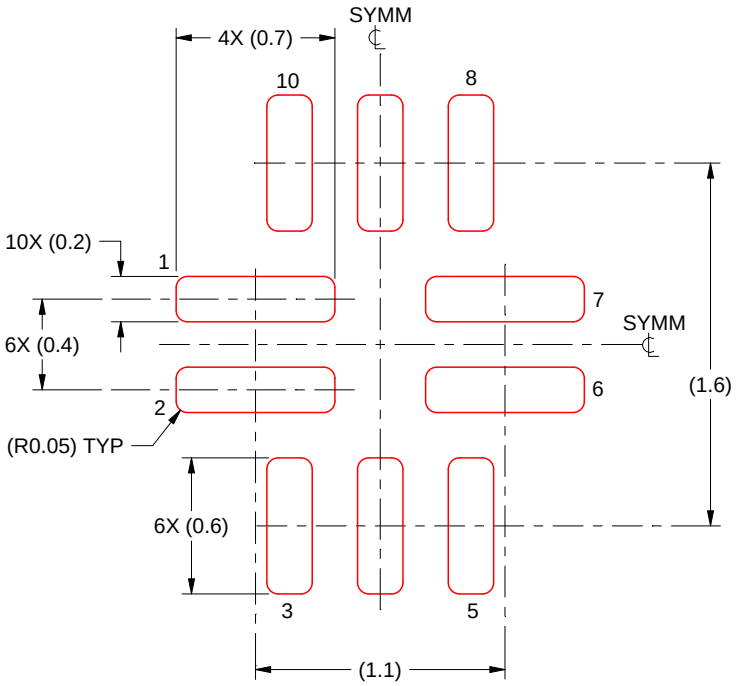
NOTES: (continued)

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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