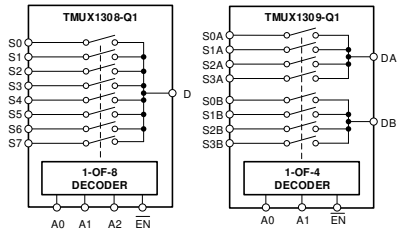
TMUX13xx-Q1 車載用 5V、双方向 8：1、1 チャネルおよび 4：1、2 チャネル・マルチプレクサ、インジェクション電流制御機能付き

1 特長

- 車載アプリケーション用に AEC-Q100 認定済み
  - デバイス温度グレード 1：–40℃～125℃の動作時周囲温度範囲
- インジェクション電流制御
- 逆電力供給保護
  - V_{DD} への ESD ダイオード・パスがない
- 広い電源電圧範囲：1.62V～5.5V
- 低い静電容量
- 双方向の信号パス
- レール・ツー・レール動作
- 1.8V ロジック互換
- フェイルセーフ・ロジック
- ブレイク・ビフォー・メイクのスイッチング動作
- バッテリ短絡保護
- 機能安全対応
  - 機能安全システムの設計に役立つ資料を利用可能
- TMUX1308-Q1 - 以下のデバイスとピン互換：
  - 業界標準の 4051 および 4851 マルチプレクサ
- TMUX1309-Q1 - 以下のデバイスとピン互換：
  - 業界標準の 4052 および 4852 マルチプレクサ

2 アプリケーション

- アナログおよびデジタルの多重化 / 多重分離
- 診断および監視
- ゾーン・アーキテクチャ
- 車体制御モジュール
- バッテリ管理システム (BMS)
- HVAC (エアコン) 制御モジュール
- 車載用ヘッド・ユニット
- テレマティクス
- オンボード・チャージャ (OBC) とワイヤレス充電



TMUX1308-Q1 と TMUX1309-Q1 のブロック図

3 概要

TMUX1308-Q1 および TMUX1309-Q1 は、汎用の CMOS (相補型金属酸化膜半導体) マルチプレクサ (MUX) です。TMUX1308-Q1 は 8：1、1 チャネル (シングルエンド) MUX、TMUX1309-Q1 は 4：1、2 チャネル (差動) MUX です。このデバイスは、ソース (Sx) およびドレイン (Dx) ピンで、GND から V_{DD} までの範囲の双方向アナログおよびデジタル信号をサポートします。

TMUX13xx-Q1 デバイスは、内部インジェクション電流制御機能を備えています。この機能のおかげで、スイッチを保護し入力信号を電源電圧内に維持するために通常使用される外付けのダイオードおよび抵抗ネットワークは不要です。内部インジェクション電流制御回路により、ディセーブルされた信号パスの信号が電源電圧を上回っても、イネーブルされた信号パスの信号に影響を与えません。また、TMUX13xx-Q1 デバイスには電源ピンへの内部ダイオード・パスがないため、電源ピンに接続された部品が損傷し、または電源レールに意図しない電力が供給される危険性がありません。

すべてのロジック入力のスレッショルドは 1.8V ロジック互換で、有効な電源電圧で動作していれば、TTL と CMOS の両方のロジックと互換性が保証されます。フェイルセーフ・ロジック回路により、電源ピンよりも先に制御ピンに電圧が印加されるため、デバイスへの損傷の可能性が避けられます。

製品情報

部品番号	構成(1)	パッケージ(2)	本体サイズ (公称) (3)
TMUX1308-Q1 TMUX1309-Q1	チャネル 8：1 チャネル 4：1	PW (TSSOP、16)	5mm × 4.4mm
		DYY (SOT-23-THIN、16)	4.2mm × 2mm
		BQB (WQFN、16)	3.5mm × 2.5mm

(1) 製品比較表を参照してください。
(2) 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パッケージ・オプションについての付録を参照してください。
(3) 本体サイズ (長さ × 幅) は公称値であり、ピンは含まれていません。

Table of Contents

4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision E (September 2022) to Revision F (July 2023) — **Page**

- 「特長」セクションにバッテリ短絡保護を追加 ... 1
- 「アプリケーション」セクションにゾーン・アーキテクチャを追加 ... 1
- チャネル・カウントを含めるよう「製品情報」表を更新 ... 1
- Added the *Short To Battery Protection* section ... 31

Changes from Revision D (November 2020) to Revision E (September 2022) — **Page**

- Updated the *Injection Current Control* section ... 24

Changes from Revision C (August 2020) to Revision D (November 2020) — **Page**

- TMUX1309 デバイスのステータスをプレビューから量産に変更 ... 1
- Changed ΔR_{ON} test condition to V_{DD} / 2 ... 10
- Changed max ΔR_{ON} spec limit for 1.8 V and 2.5 V supply ... 10

Changes from Revision B (July 2020) to Revision C (August 2020) — **Page**

- ドキュメント全体にわたって表、図、相互参照の採番方法を更新 ... 1
- Added the Typical Characteristics ... 14

Changes from Revision A (June 2020) to Revision B (July 2020) — **Page**

- Added thermal information for TMUX1309-Q1 ... 9

Changes from Revision * (December 2019) to Revision A (June 2020) **Page**

- ステータスを次のように変更:「事前情報」から「*量産データ*」へ 1

5 Device Comparison Table

PRODUCT	DESCRIPTION
TMUX1308-Q1	8:1, 1-channel, single-ended multiplexer
TMUX1309-Q1	4:1, 2-channel, differential multiplexer

6 Pin Configuration and Functions

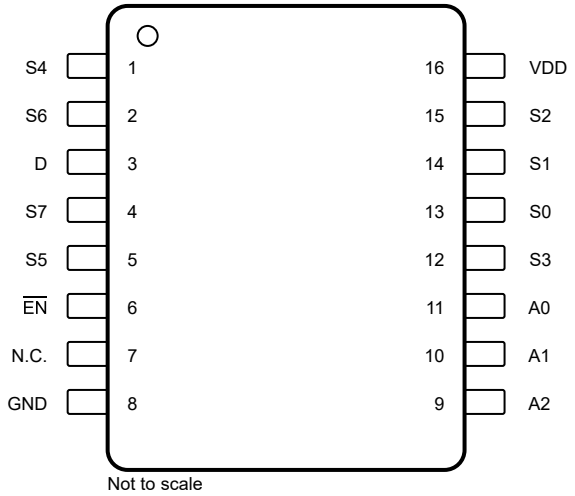


図 6-1. TMUX1308-Q1: PW Package, 16-Pin TSSOP (Top View)

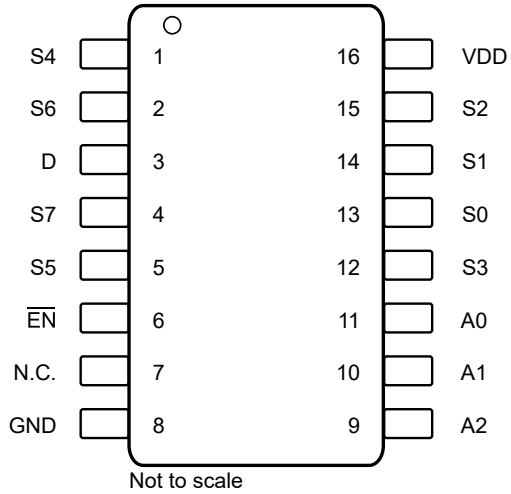


図 6-2. TMUX1308-Q1: DYY Package, 16-Pin SOT-23-THIN (Top View)

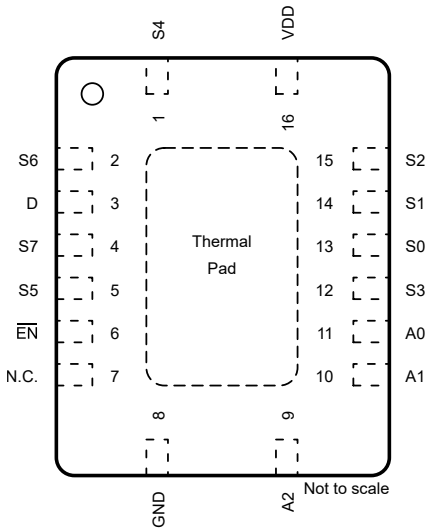


図 6-3. TMUX1308-Q1: BQB Package, 16-Pin WQFN (Top View)

表 6-1. Pin Functions TMUX1308-Q1

PIN		TYPE(1)	DESCRIPTION(2)
NAME	NO.		
S4	1	I/O	Source pin 4. Signal path can be an input or output.
S6	2	I/O	Source pin 6. Signal path can be an input or output.
D	3	I/O	Drain pin (common). Signal path can be an input or output.
S7	4	I/O	Source pin 7. Signal path can be an input or output.
S5	5	I/O	Source pin 5. Signal path can be an input or output.
$\overline{EN}$	6	I	Active low logic input. When this pin is high, all switches are turned off. When this pin is low, the A[2:0] address inputs determine which switch is turned on as listed in 表 9-1.
N.C.	7	Not Connected	Not internally connected.
GND	8	P	Ground (0 V) reference
A2	9	I	Address line 2. Controls the switch configuration as listed in 表 9-1.
A1	10	I	Address line 1. Controls the switch configuration as listed in 表 9-1.
A0	11	I	Address line 0. Controls the switch configuration as listed in 表 9-1.
S3	12	I/O	Source pin 3. Signal path can be an input or output.
S0	13	I/O	Source pin 0. Signal path can be an input or output.
S1	14	I/O	Source pin 1. Signal path can be an input or output.
S2	15	I/O	Source pin 2. Signal path can be an input or output.
VDD	16	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 µF to 10 µF between V_{DD} and GND.
Thermal pad		—	Exposed thermal pad with conductive die attached. No requirement to solder this pad. If connected, then it should be left floating or tied to GND.

(1) I = input, O = output, I/O = input and output, P = power.
(2) For what to do with unused pins, refer to セクション 9.4.

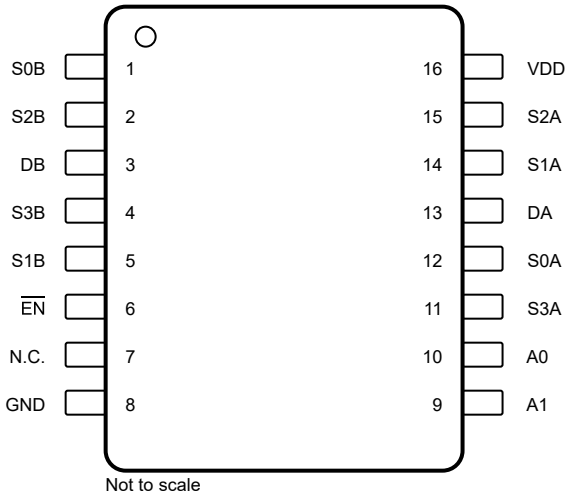


図 6-4. TMUX1309-Q1: PW Package, 16-Pin TSSOP (Top View)

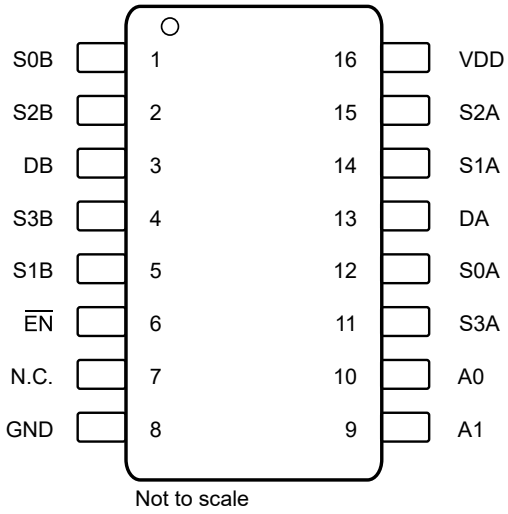


図 6-5. TMUX1309-Q1: DYY Package, 16-Pin SOT-23-THIN (Top View)

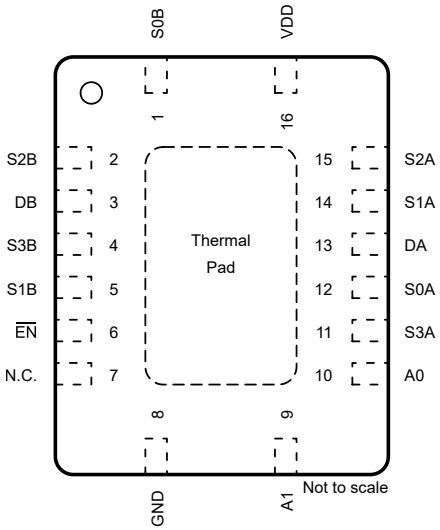


図 6-6. TMUX1309-Q1: BQB Package, 16-Pin WQFN (Top View)

表 6-2. Pin Functions TMUX1309-Q1

PIN		TYPE[1]	DESCRIPTION[2]
NAME	NO.		
S0B	1	I/O	Source pin 0 of mux B. Can be an input or output.
S2B	2	I/O	Source pin 2 of mux B. Can be an input or output.
DB	3	I/O	Drain pin (Common) of mux B. Can be an input or output.
S3B	4	I/O	Source pin 3 of mux B. Can be an input or output.
S1B	5	I/O	Source pin 1 of mux B. Can be an input or output.
$\overline{EN}$	6	I	Active low logic input. When this pin is high, all switches are turned off. When this pin is low, the A[1:0] address inputs determine which switch is turned on.
N.C.	7	Not Connected	Not internally connected.
GND	8	P	Ground (0 V) reference
A1	9	I	Address line 1. Controls the switch configuration as listed in 表 9-2.
A0	10	I	Address line 0. Controls the switch configuration as listed in 表 9-2.
S3A	11	I/O	Source pin 3 of mux A. Can be an input or output.
S0A	12	I/O	Source pin 0 of mux A. Can be an input or output.
DA	13	I/O	Drain pin (Common) of mux A. Can be an input or output.
S1A	14	I/O	Source pin 1 of mux A. Can be an input or output.
S2A	15	I/O	Source pin 2 of mux A. Can be an input or output.
VDD	16	P	Positive power supply. This pin is the most positive power-supply potential. For reliable operation, connect a decoupling capacitor ranging from 0.1 µF to 10 µF between V_{DD} and GND.
Thermal pad		—	Exposed thermal pad with conductive die attached. No requirement to solder this pad. If connected, then it should be left floating or tied to GND.

(1) I = input, O = output, I/O = input and output, P = power.
(2) For what to do with unused pins, refer to セクション 9.4.

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1) (2) (3)

		MIN	MAX	UNIT
V_{DD}	Supply voltage	–0.5	6	V
V_{SEL} or V_{EN}	Logic control input pin voltage ($\overline{EN}$, A0, A1, A2)	–0.5	6	
V_S or V_D	Source or drain voltage (Sx, D)	–0.5	V_{DD}+1.0	
I_{SEL} or I_{EN}	Logic control input pin current ($\overline{EN}$, A0, A1, A2)	–30	30	mA
I_S or $I_{D\ (CONT)}$	Continuous current through switch (Sx, D pins) –40°C to +85°C	–50	50	
I_S or $I_{D\ (CONT)}$	Continuous current through switch (Sx, D pins) –40°C to +125°C	–25	25	
I_{GND}	Continuous current through GND	–100	100	
P_{tot}	Total power dissipation(4)		500	mW
T_{stg}	Storage temperature	–65	150	°C
T_J	Junction temperature		150	

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If briefly operating outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum.
(3) All voltages are with respect to ground, unless otherwise specified.
(4) For TSSOP package: P_{tot} derates linearly above T_A = 80°C by 7.2mW/°C.
For SOT-23-THIN package: P_{tot} derates linearly above T_A = 66°C by 6mW/°C.
For BQB package: P_{tot} derates linearly above T_A = 102°C by 10.6mW/°C.

7.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002(1)	All pins	±2000	V
		Charged device model (CDM), per AEC Q100-011	All pins	±750	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{DD}	Supply voltage	1.62		5.5	V
V_S or V_D	Signal path input/output voltage (source or drain pin) (Sx, D)	0		V_{DD}	V
V_{SEL} or V_{EN}	Logic control input pin voltage ($\overline{EN}$, A0, A1, A2)	0		5.5	V
I_S or $I_{D\ (CONT)}$	Continuous current through switch (Sx, D pins) –40°C to +85°C	–50		50	mA
I_S or $I_{D\ (CONT)}$	Continuous current through switch (Sx, D pins) –40°C to +125°C	–25		25	mA
I_{OK}	Current per input into source or drain pins when singal voltage exceeds recommended operating voltage (1)	–50		50	mA
I_{INJ}	Injected current into single off switch input	–50		50	mA
I_{INJ_ALL}	Total injected current into all off switch inputs combined	–100		100	mA
T_A	Ambient temperature	–40		125	°C

(1) If source or drain voltage exceeds VDD, or goes below GND, the pin will be shunted to GND through an internal FET, the current must be limited within the specified value. If $V_{signal} > V_{DD}$ or if $V_{signal} <$ GND.

7.4 Thermal Information: TMUX1308-Q1

THERMAL METRIC[1]		TMUX1308-Q1			UNIT
		PW (TSSOP)	DYY (SOT)	BQB (WQFN)	
		PINS	PINS	PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	139.6	167.1	94.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	77.2	106.3	92.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	84.2	90.0	64.5	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	26.5	17.2	13.3	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	83.8	90.0	64.4	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	42.7	°C/W

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

7.5 Thermal Information: TMUX1309-Q1

THERMAL METRIC[1]		TMUX1309-Q1			UNIT
		PW (TSSOP)	DYY (SOT)	BQB (WQFN)	
		PINS	PINS	PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	139.6	172.4	94.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	77.2	107.0	92.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	84.2	96.1	64.5	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	26.5	19.7	13.3	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	83.8	95.9	64.4	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	42.7	°C/W

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

7.6 Electrical Characteristics

At specified V_{DD} ±10%
Typical values measured at nominal V_{DD}

PARAMETER		TEST CONDITIONS	V_{DD}	Operating free-air temperature (T_A)									UNIT
				25°C			–40°C to 85°C			–40°C to 125°C			
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
ANALOG SWITCH													
R_{ON}	On-state switch resistance	V_S = 0 V to V_{DD} I_{SD} = 0.5 mA	1.8 V		650	1500			1700			1700	Ω
			2.5 V		230	600			670			670	
			3.3 V		120	330			350			370	
			5 V		75	195			220			270	
Δ_{RON}	On-state switch resistance matching between inputs	V_S = V_{DD} / 2 I_{SD} = 0.5 mA	1.8 V		10	38			45			45	Ω
			2.5 V		3	20			22			22	
			3.3 V		2	8			11			15	
			5 V		1	7			10			14	
$I_{S(OFF)}$	Source off-state leakage current	Switch Off V_D = 0.8 x V_{DD}/ 0.2 x V_{DD} V_S = 0.2 x V_{DD}/ 0.8 x V_{DD}	1.8 V		±1			–25	25		–800	800	nA
			2.5 V		±1			–25	25		–800	800	
			3.3 V		±1			–25	25		–800	800	
			5 V		±1			–25	25		–800	800	
$I_{D(OFF)}$	Drain off-state leakage current (common drain pin)	Switch Off V_D = 0.8 x V_{DD}/ 0.2 x V_{DD} V_S = 0.2 x V_{DD}/ 0.8 x V_{DD}	1.8 V		±1			–45	45		–800	800	nA
			2.5 V		±1			–45	45		–800	800	
			3.3 V		±1			–45	45		–800	800	
			5 V		±1			–45	45		–800	800	
$I_{D(ON)}$ $I_{S(ON)}$	Channel on-state leakage current	Switch On V_D = V_S = 0.8 x V_{DD} or V_D = V_S = 0.2 x V_{DD}	1.8 V		±1			–45	45		–800	800	nA
			2.5 V		±1			–45	45		–800	800	
			3.3 V		±1			–45	45		–800	800	
			5 V		±1			–45	45		–800	800	
C_{SOFF}	Source off capacitance	V_S = V_{DD} / 2 f = 1 MHz	1.8 V		2	14			14			14	pF
			2.5 V		2	14			14			14	
			3.3 V		2	14			14			14	
			5 V		2	14			14			14	
C_{DOFF}	Drain off capacitance	V_S = V_{DD} / 2 f = 1 MHz	1.8 V		7	37			37			37	pF
			2.5 V		7	37			37			37	
			3.3 V		7	37			37			37	
			5 V		7	37			37			37	
C_{SON} C_{DON}	On capacitance	V_S = V_{DD} / 2 f = 1 MHz	1.8 V		11	40			40			40	pF
			2.5 V		11	40			40			40	
			3.3 V		11	40			40			40	
			5 V		11	40			40			40	
POWER SUPPLY													
I_{DD}	V_{DD} supply current	Logic inputs = 0 V or V_{DD}	1.8 V			1			1			1.2	µA
			2.5 V			1			1			1.5	
			3.3 V			1			1			2	
			5 V			1			1.5			3	

7.7 Logic and Dynamic Characteristics

At specified V_{DD} ±10%
Typical values measured at nominal V_{DD} and T_A = 25°C.

PARAMETER		TEST CONDITIONS	V_{DD}	Operating free-air temperature (T_A) –40°C to 125°C			UNIT
				MIN	TYP	MAX	
LOGIC INPUTS ($\overline{EN}$, A0, A1, A2)							
V_{IH}	Input logic high		1.8 V	0.95		5.5	V
			2.5 V	1.1		5.5	
			3.3 V	1.15		5.5	
			5 V	1.25		5.5	
V_{IL}	Input logic low		1.8 V	0		0.6	V
			2.5 V	0		0.7	
			3.3 V	0		0.8	
			5 V	0		0.95	
I_{IH}	Logic high input leakage current	V_{LOGIC} = 1.8 V or V_{DD}	All			1	µA
I_{IL}	Logic low input leakage current	V_{LOGIC} = 0 V	All	–1			µA
C_{IN}	Logic input capacitance	V_{LOGIC} = 0 V, 1.8 V, V_{DD} f = 1 MHz	All		1	2	pF
DYNAMIC CHARACTERISTICS							
Q_{INJ}	Charge Injection	V_S = V_{DD} / 2 R_S = 0 Ω, C_L = 100 pF	1.8 V		–0.5		pC
			2.5 V		–0.5		
			3.3 V		–1		
			5 V		–6.5		
O_{ISO}	Off Isolation	V_{BIAS} = V_{DD} / 2 V_S = 200 mVpp R_L = 50 Ω, C_L = 5 pF f = 100 kHz	1.8 V		–110		dB
			2.5 V		–110		
			3.3 V		–110		
			5 V		–110		
O_{ISO}	Off Isolation	V_{BIAS} = V_{DD} / 2 V_S = 200 mVpp R_L = 50 Ω, C_L = 5 pF f = 1 MHz	1.8 V		–90		dB
			2.5 V		–90		
			3.3 V		–90		
			5 V		–90		
X_{TALK}	Crosstalk	V_{BIAS} = V_{DD} / 2 V_S = 200 mVpp R_L = 50 Ω, C_L = 5 pF f = 100 kHz	1.8 V		–110		dB
			2.5 V		–110		
			3.3 V		–110		
			5 V		–110		
X_{TALK}	Crosstalk	V_{BIAS} = V_{DD} / 2 V_S = 200 mVpp R_L = 50 Ω, C_L = 5 pF f = 1 MHz	1.8 V		–90		dB
			2.5 V		–90		
			3.3 V		–90		
			5 V		–90		
BW	Bandwidth	V_{BIAS} = V_{DD} / 2 V_S = 200 mVpp RL = 50 Ω, CL = 5 pF	1.8 V		350		MHz
			2.5 V		450		
			3.3 V		500		
			5 V		500		

7.8 Timing Characteristics

At specified V_{DD} ±10%
Typical values measured at nominal V_{DD}.

PARAMETER		TEST CONDITIONS	V_{DD}	Operating free-air temperature (T_A)									UNIT
				25°C			–40°C to 85°C			–40°C to 125°C			
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SWITCHING CHARACTERISTICS													
t_{PD}	Propagation delay	C_L = 50 pF Sx to D, D to Sx	1.8 V		15	30			30			30	ns
			2.5 V		8	15			20			20	
			3.3 V		5	11			15			15	
			5 V		4	9			10			10	
		CL = 15 pF	5 V		1.5	4			5			5	
t_{TRAN}	Transition-time between inputs	R_L = 10 kΩ, C_L = 50 pF Ax to D, Ax to Sx	1.8 V		44	94			103			103	ns
			2.5 V		30	63			67			67	
			3.3 V		23	51			54			54	
			5 V		18	43			46			46	
		R_L = 10 kΩ, C_L = 15 pF	5 V		15	39			43			43	
$t_{ON(EN)}$	Turnon-time from enable	R_L = 10 kΩ, C_L = 50 pF EN to D, EN to Sx	1.8 V		39	64			75			75	ns
			2.5 V		30	45			50			50	
			3.3 V		26	38			42			42	
			5 V		24	32			37			37	
		R_L = 10 kΩ, C_L = 15 pF	5 V		22	31			35			35	
$t_{OFF(EN)}$	Turnoff time from enable	R_L = 10 kΩ, C_L = 50 pF EN to D, EN to Sx	1.8 V		58	80			85			85	ns
			2.5 V		21	70			72			72	
			3.3 V		15	65			70			70	
			5 V		11	40			45			45	
		R_L = 10 kΩ, C_L = 15 pF	5 V		8	15			20			20	
t_{BBM}	Break before make time	R_L = 10 kΩ, C_L = 15 pF Sx to D, D to Sx	1.8 V	1	16		1			1			ns
			2.5 V	1	22		1			1			
			3.3 V	1	24		1			1			
			5 V	1	33		1			1			

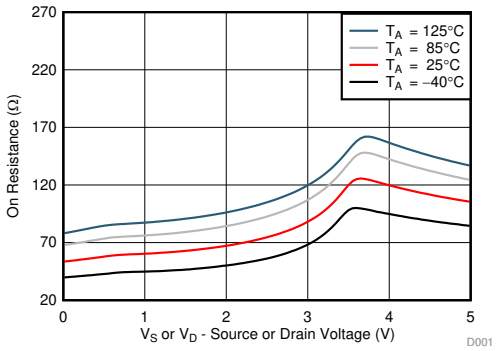
7.9 Injection Current Coupling

At specified V_{DD} ±10%
Typical values measured at nominal V_{DD} and T_A = 25°C.

PARAMETER		V_{DD}	TEST CONDITIONS		-40°C to 125°C			UNIT
					MIN	TYP	MAX	
INJECTION CURRENT COUPLING								
ΔV_{OUT}	Maximum shift of output voltage of enabled analog input	1.8 V	R_S ≤ 3.9 kΩ	I_{INJ} ≤ 1 mA		0.01	1	mV
		3.3 V				0.05	1	
		5 V				0.1	1	
		1.8 V	R_S ≤ 3.9 kΩ	I_{INJ} ≤ 10 mA		0.01	2	
		3.3 V				0.3	3	
		5 V				0.06	4	
		1.8 V	R_S ≤ 20 kΩ	I_{INJ} ≤ 1 mA		0.05	2	
		3.3 V				0.05	2	
		5 V				0.1	2	
		1.8 V	R_S ≤ 20 kΩ	I_{INJ} ≤ 10 mA		0.05	15	
		3.3 V				0.05	15	
		5 V				0.02	15	

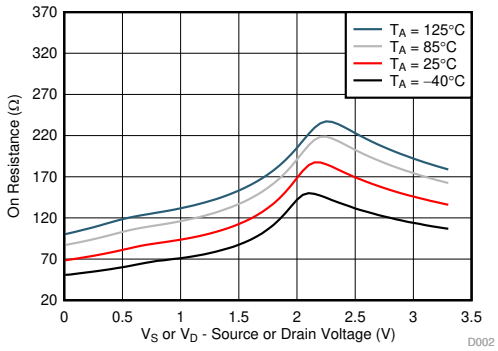
7.10 Typical Characteristics

at T_A = 25°C, V_{DD} = 5 V (unless otherwise noted)



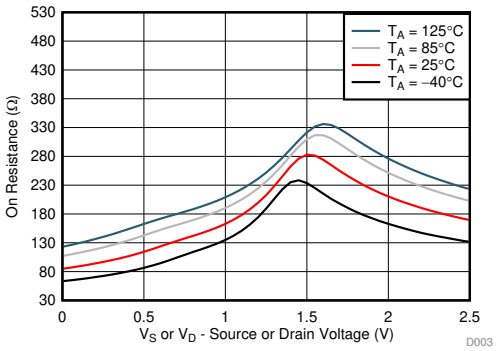
V_{DD} = 5 V

図 7-1. On-Resistance vs Temperature



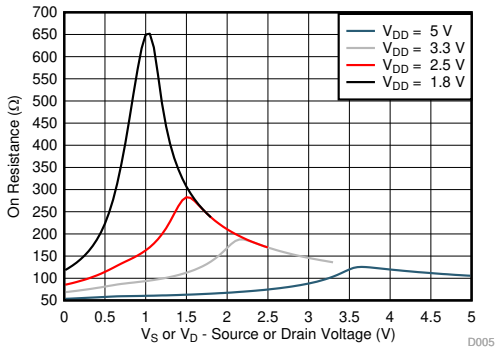
V_{DD} = 3.3 V

図 7-2. On-Resistance vs Temperature



V_{DD} = 2.5 V

図 7-3. On-Resistance vs Temperature



T_A = 25°C

図 7-4. On-Resistance vs Source or Drain Voltage

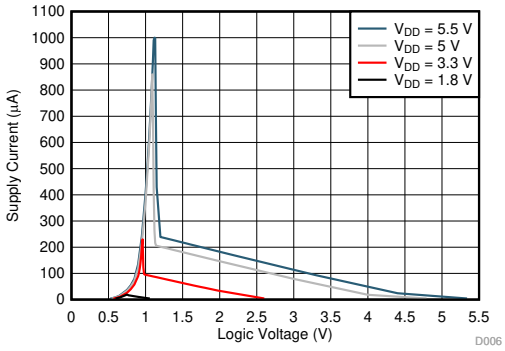
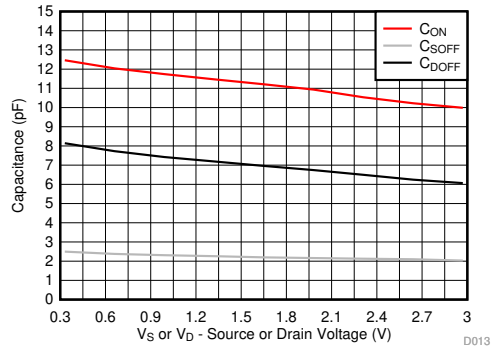


図 7-5. Supply Current vs Logic Voltage

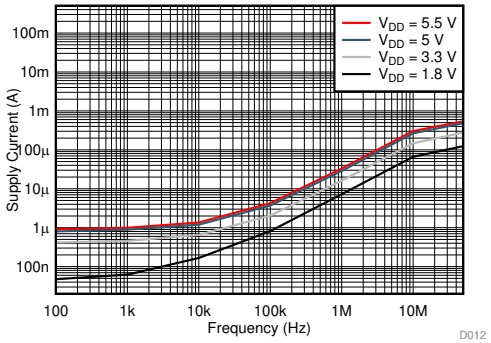


V_{DD} = 3.3 V

図 7-6. Capacitance vs Source Voltage

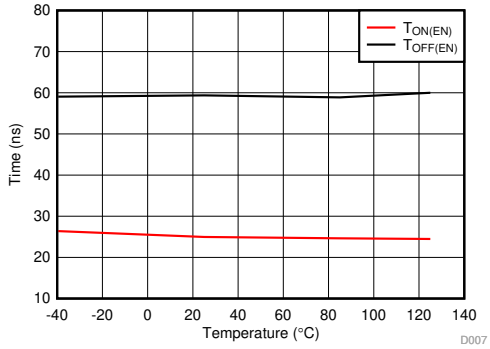
7.10 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = 5 V (unless otherwise noted)



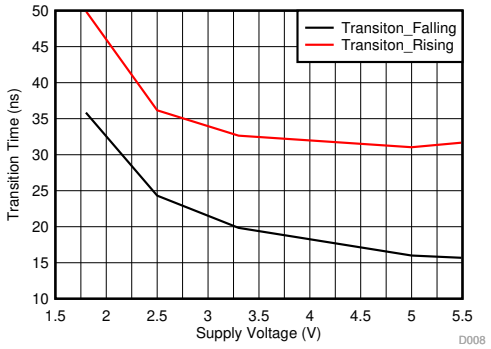
T_A = 25°C

図 7-7. Supply Current vs Input Switching Frequency



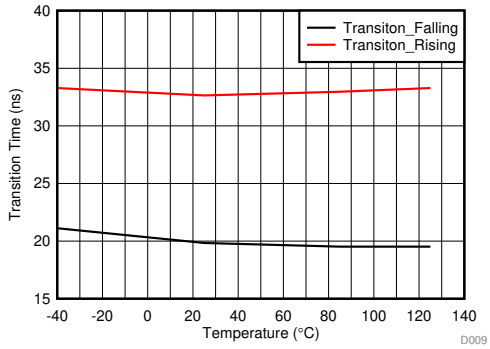
V_{DD} = 3.3 V

図 7-8. $T_{ON(EN)}$ and $T_{OFF(EN)}$ vs Temperature



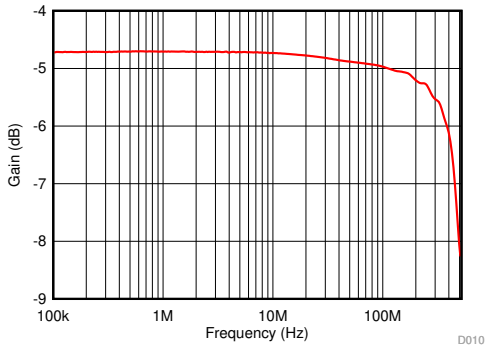
T_A = 25°C

図 7-9. $T_{TRANSITION}$ vs Supply Voltage



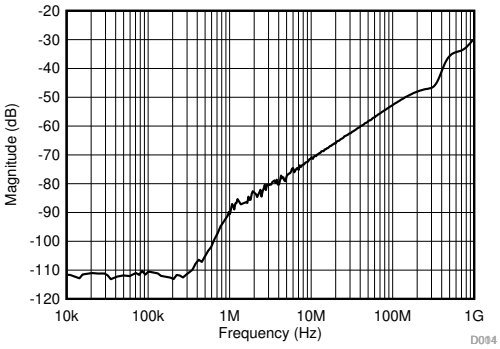
T_A = 25°C

図 7-10. $T_{TRANSITION}$ vs Temperature



T_A = 25°C

図 7-11. On Response vs Frequency

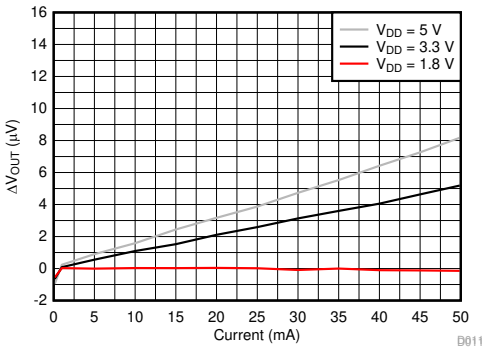


T_A = 25°C , V_{DD} = 3.3 V

図 7-12. Xtalk and Off-Isolation vs Frequency

7.10 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = 5 V (unless otherwise noted)



V_S = (V_{DD}/2), T_A = 25°C

図 7-13. Injection Current vs Maximum Output Voltage Shift

8 Parameter Measurement Information

8.1 On-Resistance

The on-resistance of a device is the ohmic resistance between the source (Sx) and drain (D) pins of the device. The on-resistance varies with input voltage and supply voltage. The symbol R_{ON} is used to denote on-resistance. The measurement setup used to measure R_{ON} is shown below. Voltage (V) and current (I_{SD}) are measured using this setup, and R_{ON} is computed as shown in 図 8-1 with R_{ON} = V / I_{SD}:

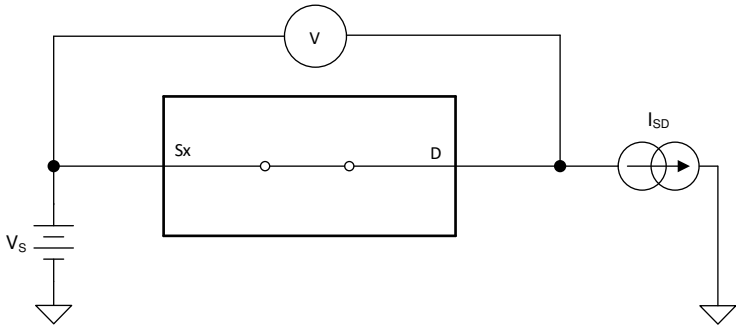


図 8-1. On-Resistance Measurement Setup

8.2 Off-Leakage Current

There are two types of leakage currents associated with a switch during the off state:

1. Source off-leakage current.
2. Drain off-leakage current.

Source leakage current is defined as the leakage current flowing into or out of the source pin when the switch is off. This current is denoted by the symbol $I_{S(OFF)}$.

Drain leakage current is defined as the leakage current flowing into or out of the drain pin when the switch is off. This current is denoted by the symbol $I_{D(OFF)}$.

図 8-2 shows the setup used to measure both off-leakage currents.

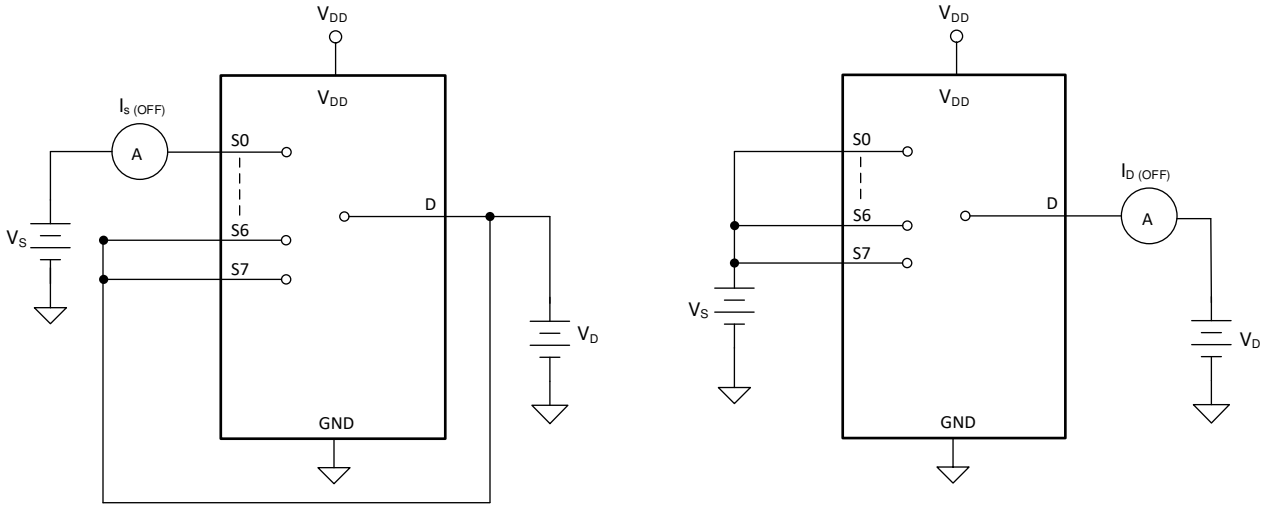


図 8-2. Off-Leakage Measurement Setup

8.3 On-Leakage Current

Source on-leakage current is defined as the leakage current flowing into or out of the source pin when the switch is on. This current is denoted by the symbol $I_{S(ON)}$.

Drain on-leakage current is defined as the leakage current flowing into or out of the drain pin when the switch is on. This current is denoted by the symbol $I_{D(ON)}$.

Either the source pin or drain pin is left floating during the measurement. 図 8-3 shows the circuit used for measuring the on-leakage current, denoted by $I_{S(ON)}$ or $I_{D(ON)}$.

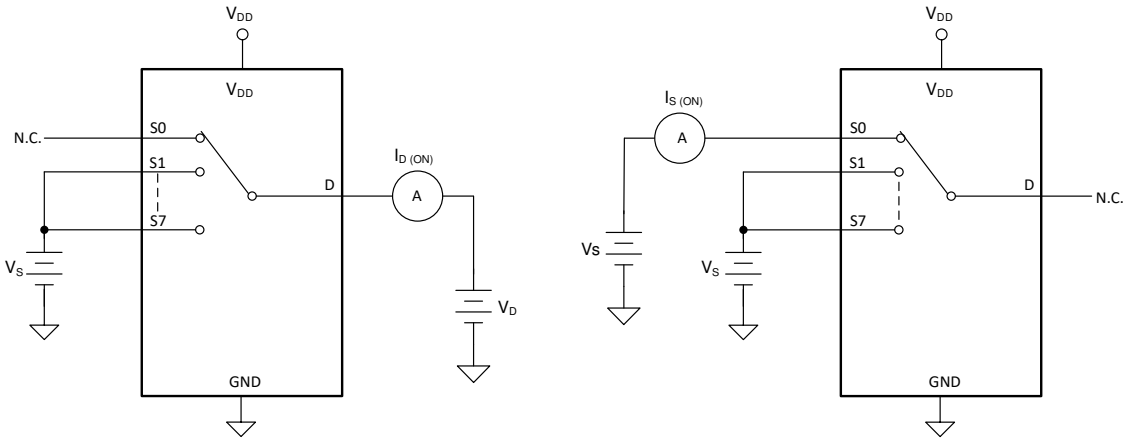


図 8-3. On-Leakage Measurement Setup

8.4 Transition Time

Transition time is defined as the time taken by the output of the device to rise or fall 50% after the address signal has risen or fallen past the 50% threshold. 図 8-4 shows the setup used to measure transition time, denoted by the symbol $t_{TRANSITION}$.

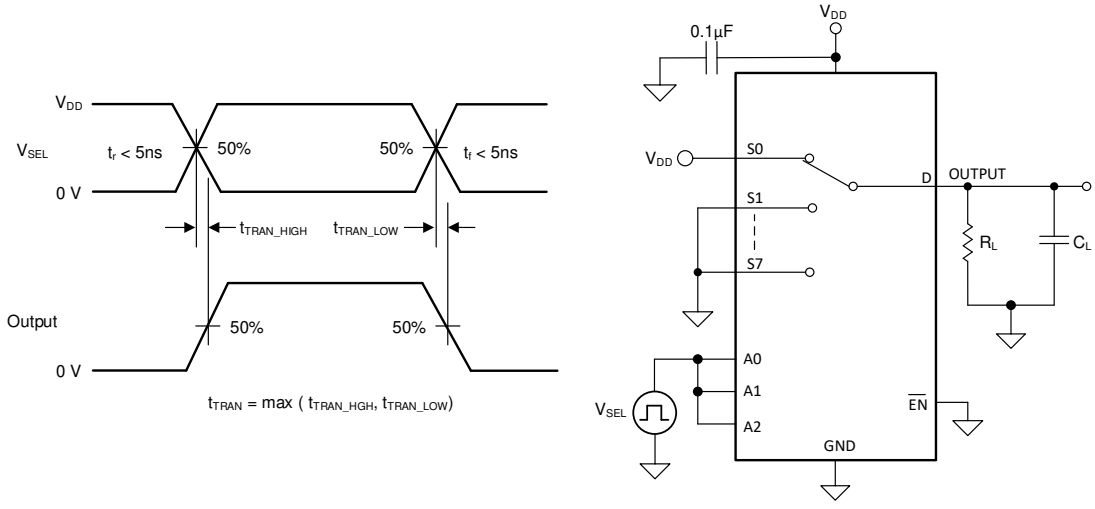


図 8-4. Transition-Time Measurement Setup

8.5 Break-Before-Make

Break-before-make delay is a safety feature that prevents two inputs from connecting when the device is switching. The output first breaks from the on-state switch before making the connection with the next on-state switch. The time delay between the *break* and the *make* is known as break-before-make delay. 図 8-5 shows the setup used to measure break-before-make delay, denoted by the symbol $t_{OPEN(BBM)}$.

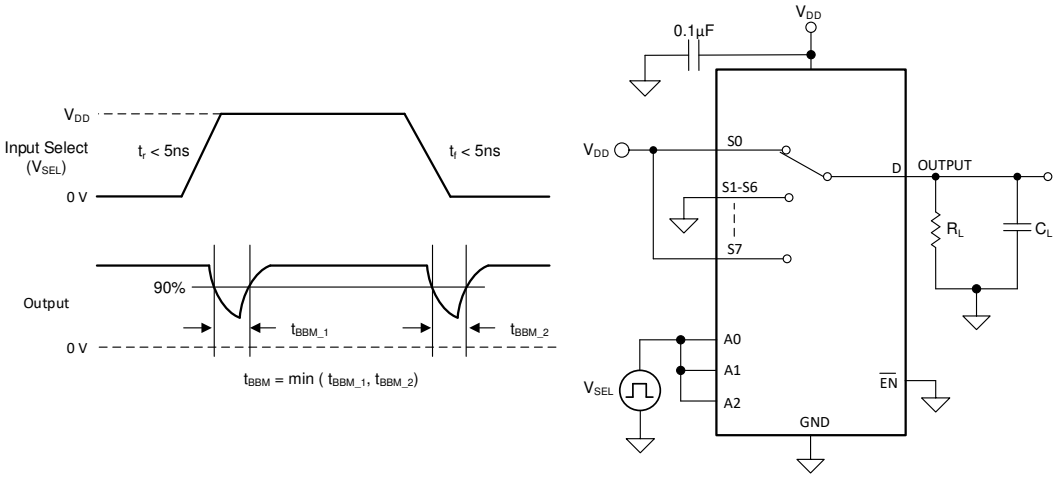


図 8-5. Break-Before-Make Delay Measurement Setup

8.6 $t_{ON(EN)}$ and $t_{OFF(EN)}$

Turn-on time is defined as the time taken by the output of the device to rise to 10% after the enable has risen past the 50% threshold. The 10% measurement is utilized to provide the timing of the device, system level timing can then account for the time constant added from the load resistance and load capacitance. 図 8-6 shows the setup used to measure transition time, denoted by the symbol $t_{ON(EN)}$.

Turn-off time is defined as the time taken by the output of the device to fall to 90% after the enable has fallen past the 50% threshold. The 90% measurement is utilized to provide the timing of the device, system level timing can then account for the time constant added from the load resistance and load capacitance. 図 8-6 shows the setup used to measure transition time, denoted by the symbol $t_{OFF(EN)}$.

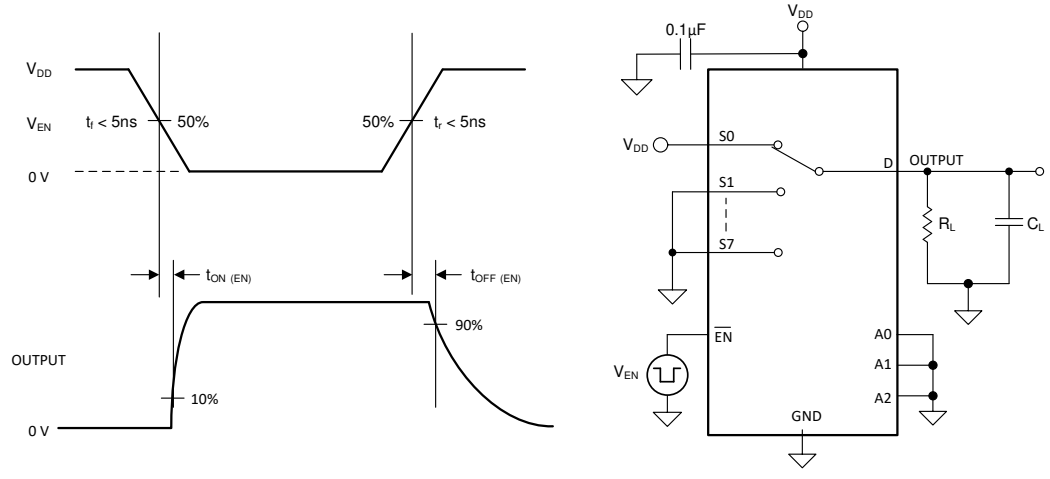


図 8-6. Turn-On and Turn-Off Time Measurement Setup

8.7 Charge Injection

The TMUX1308-Q1 and TMUX1309-Q1 device have a transmission-gate topology. Any mismatch in capacitance between the NMOS and PMOS transistors results in a charge injected into the drain or source during the falling or rising edge of the gate signal. The amount of charge injected into the source or drain of the device is known as charge injection, and is denoted by the symbol Q_C. 図 8-7 shows the setup used to measure charge injection from source (Sx) to drain (D).

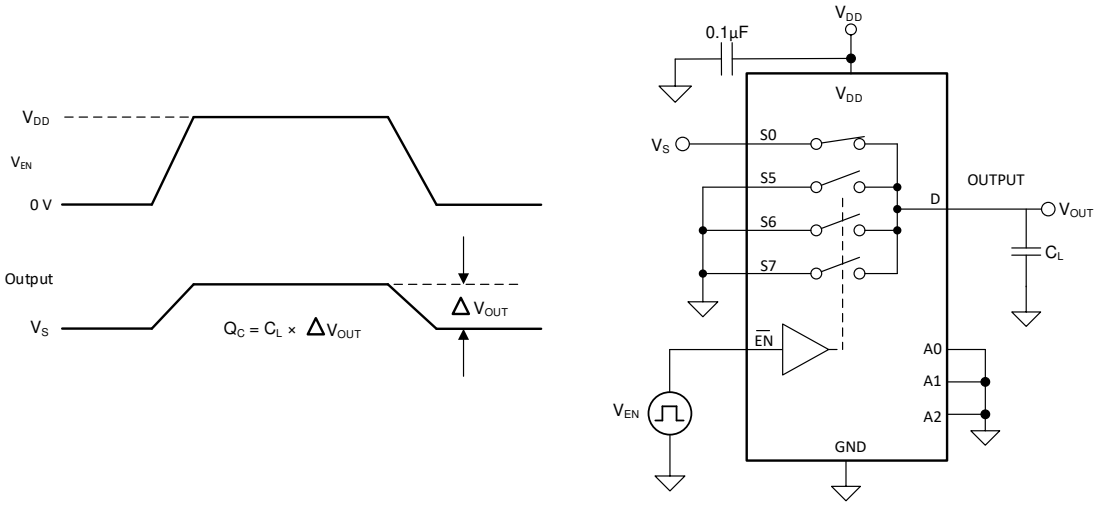


図 8-7. Charge-Injection Measurement Setup

8.8 Off Isolation

Off isolation is defined as the ratio of the signal at the drain pin (D) of the device when a signal is applied to the source pin (Sx) of an off-channel. 図 8-8 shows the setup used to measure, and the equation to compute off isolation.

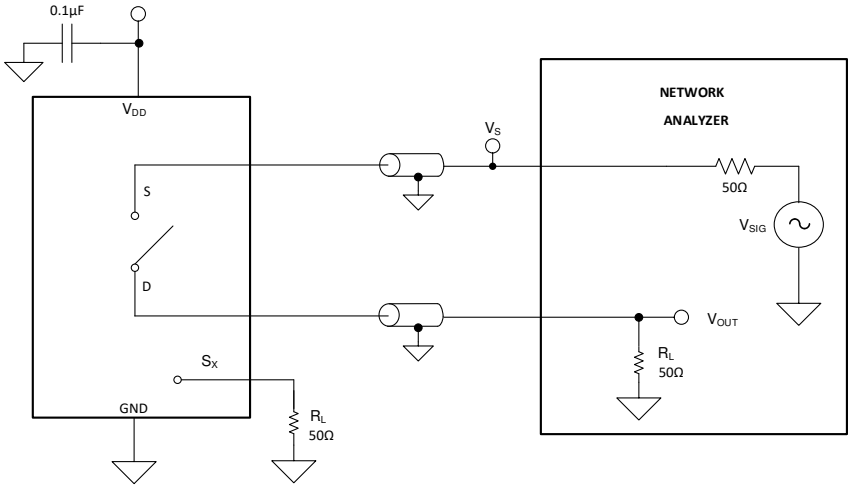


図 8-8. Off Isolation Measurement Setup

$$\text{Off Isolation} = 20 \cdot \text{Log}\left(\frac{V_{OUT}}{V_S}\right) \quad (1)$$

8.9 Crosstalk

Crosstalk is defined as the ratio of the signal at the drain pin (D) of a different channel, when a signal is applied at the source pin (Sx) of an on-channel. 図 8-9 shows the setup used to measure, and the equation used to compute crosstalk.

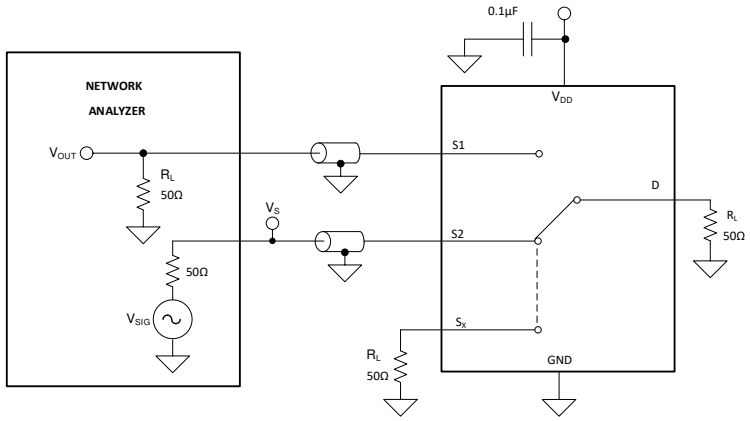


図 8-9. Channel-to-Channel Crosstalk Measurement Setup

$$\text{Channel-to-Channel Crosstalk} = 20 \cdot \text{Log}\left(\frac{V_{OUT}}{V_S}\right) \quad (2)$$

8.10 Bandwidth

Bandwidth is defined as the range of frequencies that are attenuated by less than 3 dB when the input is applied to the source pin (Sx) of an on-channel, and the output is measured at the drain pin (D) of the device. 図 8-10 shows the setup used to measure bandwidth.

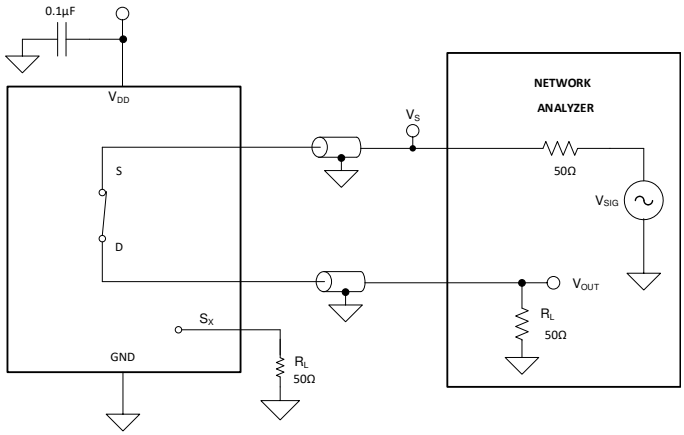


図 8-10. Bandwidth Measurement Setup

$$\text{Attenuation} = 20 \cdot \text{Log}\left(\frac{V_2}{V_1}\right) \quad (3)$$

8.11 Injection Current Control

Injection current is measured at the change in output of the enabled signal path when a current is injected into a disabled signal path. 図 8-11 shows the setup used to measure injection current control.

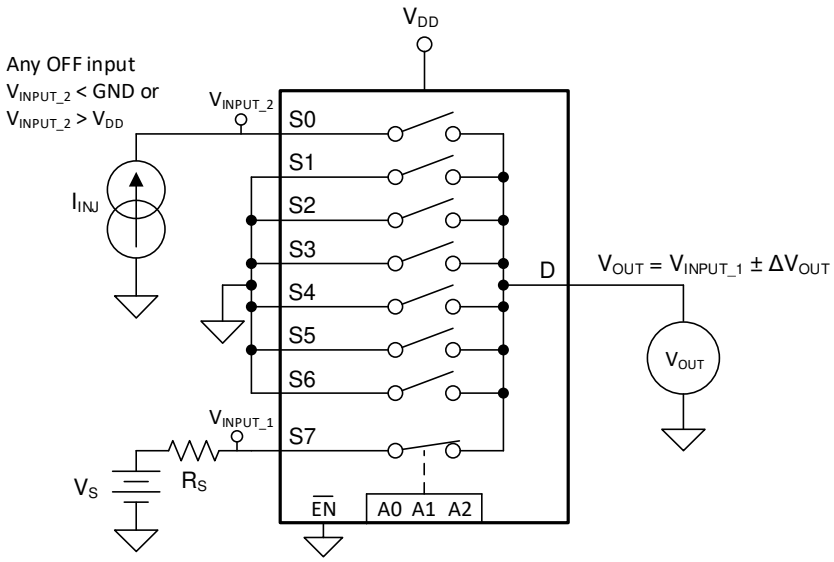


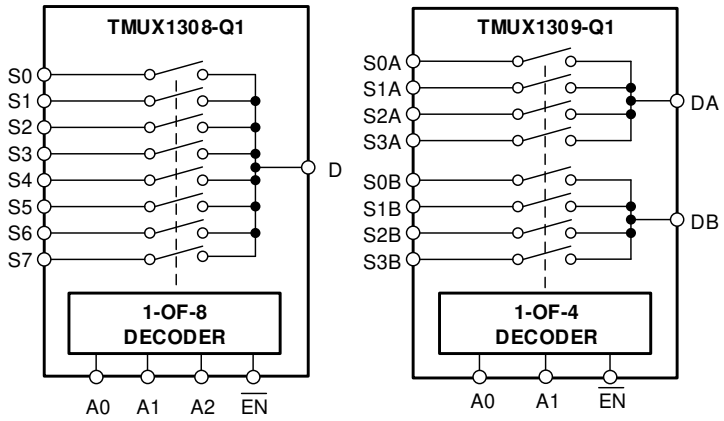
図 8-11. Injection Current Measurement Setup

9 Detailed Description

9.1 Overview

The TMUX1308-Q1 is an 8:1, single-ended (1-channel), mux. The TMUX1309-Q1 is a 4:1, differential (2-channel) mux. Each channel is turned on or turned off based on the state of the address lines and enable pin.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 Bidirectional Operation

The TMUX1308-Q1 and TMUX1309-Q1 devices conduct equally well from source (Sx) to drain (Dx) or from drain (Dx) to source (Sx). Each signal path has very similar characteristics in both directions so they can be used as both multiplexers and demultiplexer to support both analog and digital signals.

9.3.2 Rail-to-Rail Operation

The valid signal path input and output voltage for the TMUX1308-Q1 and TMUX1309-Q1 ranges from GND to V_{DD}.

9.3.3 1.8 V Logic Compatible Inputs

The TMUX1308-Q1 and TMUX1309-Q1 support 1.8-V logic compatible control for all logic control inputs. The logic input thresholds scale with supply but still provide 1.8-V logic control when operating at 5.5-V supply voltage. 1.8-V logic level inputs allows the multiplexers to interface with processors that have lower logic I/O rails and eliminates the need for an external voltage translator, which saves both space and BOM cost. The current consumption of the TMUX1308-Q1 and TMUX1309-Q1 devices increase when using 1.8-V logic with higher supply voltage. For more information on 1.8-V logic implementations, refer to *Simplifying Design with 1.8 V logic Muxes and Switches*.

9.3.4 Fail-Safe Logic

The TMUX1308-Q1 and TMUX1309-Q1 device have Fail-Safe Logic on the control input pins (EN, A0, A1, and A2) allowing for operation up to 5.5-V, regardless of the state of the supply pin. This feature allows voltages on the control pins to be applied before the supply pin, protecting the device from potential damage. Fail-Safe Logic minimizes system complexity by removing the need for power supply sequencing on the logic control pins. For example, the Fail-Safe Logic feature allows the select pins of the TMUX1308-Q1 and TMUX1309-Q1 to be ramped to 5.5-V while V_{DD} = 0-V. Additionally, the feature enables operation of the multiplexers with V_{DD} = 1.8-V while allowing the select pins to interface with a logic level of another device up to 5.5-V, eliminating the potential need for an external voltage translator.

9.3.5 Injection Current Control

Injection current is the current that is being forced into a pin by an input voltage (V_{IN}) higher than the positive supply (V_{DD} + ΔV) or lower than ground (V_{SS}). The current flows through the input protection diodes into whichever supply of the device is potentially compromising the accuracy and reliability of the system. Injected currents can come from various sources depending on the application.

- Harsh environments and applications with long cabling, such as in factory automation and automotive systems, may be susceptible to injected currents from switching or transient events.
- Other self-contained systems can also be subject to injected current if the input signal is coming from various sensors or current sources.

Injected Current Impact: typical CMOS switches have ESD protection diodes on the inputs and outputs. These diodes not only serve as ESD protection but also provide a voltage clamp to prevent the inputs or outputs going above V_{DD} or below GND and V_{SS}. When current is injected into the pin of a disabled signal path, a small amount of current goes through the ESD diode but most of the current goes through conduction to the drain. If forward diode voltage of the ESD diode (VF) is greater than the PMOS threshold voltage (VT), then the PMOS of all OFF switches turns ON and there would be undesirable subthreshold leakage between the source and the drain that can lift the OFF source pins up also. 図 9-1 shows a simplified diagram of a typical CMOS switch and associated injected current path.

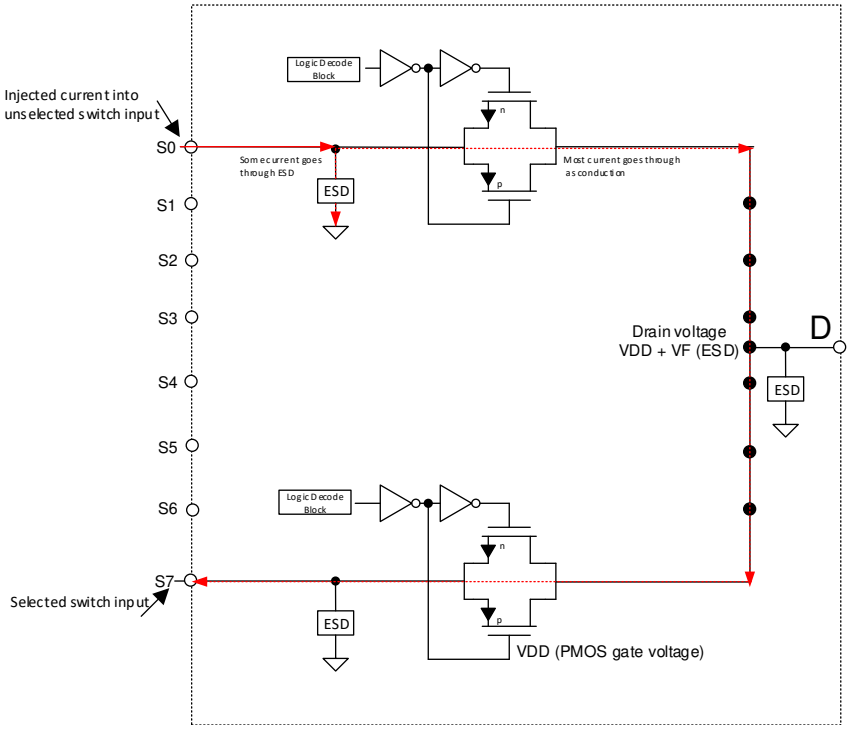


図 9-1. Simplified Diagram of Typical CMOS Switch and Associated Injected Current Path

It is quite difficult to cut off these current paths. The drain pin can never be allowed to exceed the voltage above V_{DD} by more than a VT. Analog pins can be protected against current injection by adding external components like a Schottky diode from the drain pin to ground to clamp the drain voltage at < V_{DD} + VT and cut off the current path.

Change in R_{ON} due to Current Injection: because the ON resistance of the enabled FET switch is impacted by the change in the supply rail, when the drain pin voltage exceeds the supply voltage by more than a VT, an error in the output signal voltage can be expected. This undesired change in the output can cause issues related to false trigger events and incorrect measurement readings, potentially compromising the accuracy and reliability of the system. As shown in 図 9-2, S2 is the enabled signal path that is conducting a signal from S2 pin to D pin. Because there is an injected current at the disabled S1 pin, the voltage at that pin increases above the supply voltage and the ESD protection diode is forward biased, shifting the power supply rail. This shift in supply voltage alters the R_{ON} of the internal FET switches, causing a ΔV error on the output at the D pin.

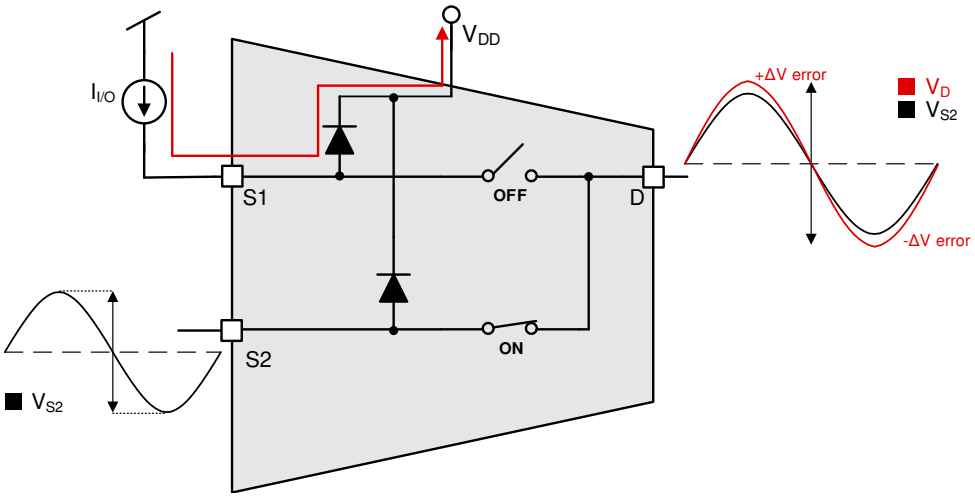


図 9-2. Injected Current Impact on R_{ON}

To avoid the complications of added external protection to your system, the TMUX1308-Q1 and TMUX1309-Q1 devices have an internal injection current control feature which eliminates the need for external diode and resistor networks typically used to protect the switch and keep the input signals within the supply voltage. The internal injection current control circuitry allows the signals on the disabled signal paths to exceed the supply voltage without affecting the signal of the enabled signal path. The injection current control circuitry also protects the TMUX13xx-Q1 from currents injected into disabled signal paths without impacting the enabled signal path, which typical CMOS switches do not support. Additionally, the TMUX1308-Q1 and TMUX1309-Q1 do not have any internal diode paths to the supply pin, which eliminates the risk of damaging components connected to the supply pin or providing unintended power to the system supply rail. For a simplified diagram that shows one signal path for the TMUX13xx-Q1 devices and the associated injection current circuit, refer to セクション 9.2.

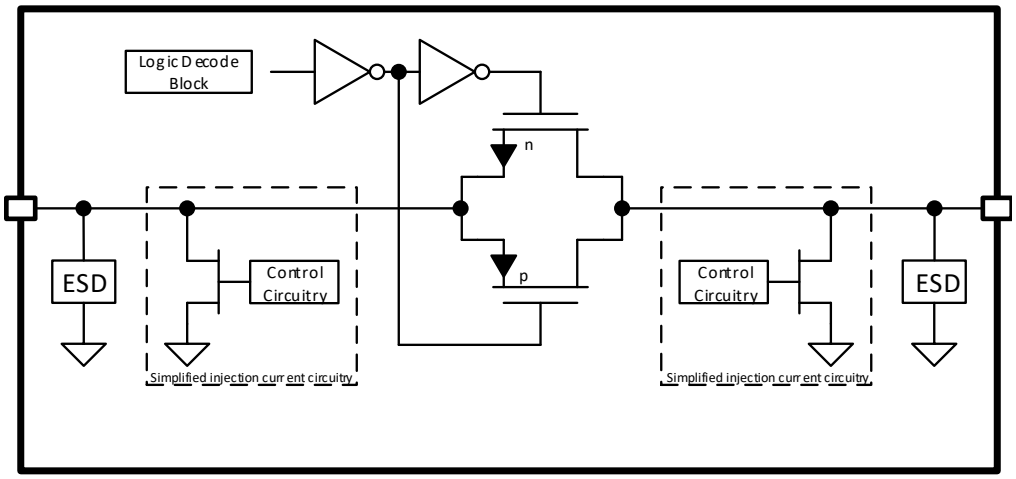


図 9-3. Simplified Diagram of Injection Current Control

The injection current control circuitry is independently controlled for each source or drain pin (Sx or D). The control circuitry for a particular pin is enabled when that input is disabled by the logic pins and the injected current causes the voltage at the pin to be above V_{DD} or below GND. The injection current circuit includes an FET to shunt the undesired current to GND in the case of overvoltage or injected current events. Each injection current circuit is rated to handle up to 50 mA; the device, however, can support a maximum current of 100 mA at any given time. Depending on the system application, a series limiting resistor may be needed and must be sized appropriately. 図 9-3 shows the TMUX13xx-Q1 protection circuitry with an injected current at an input pin.

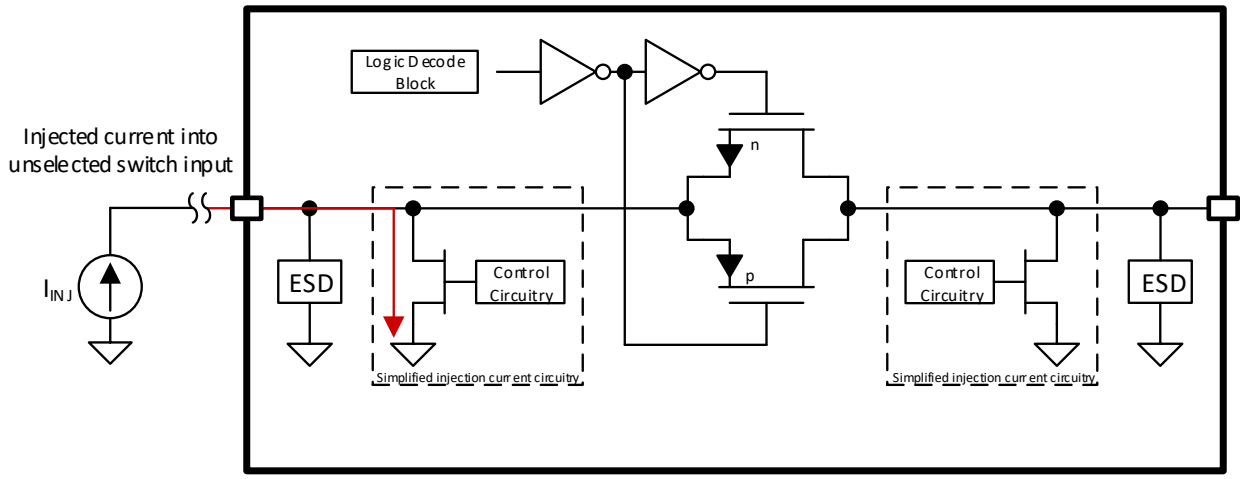


図 9-4. Injected Current at Input Pin

図 9-5 shows an example of using a series limiting resistor in the case of an overvoltage event.

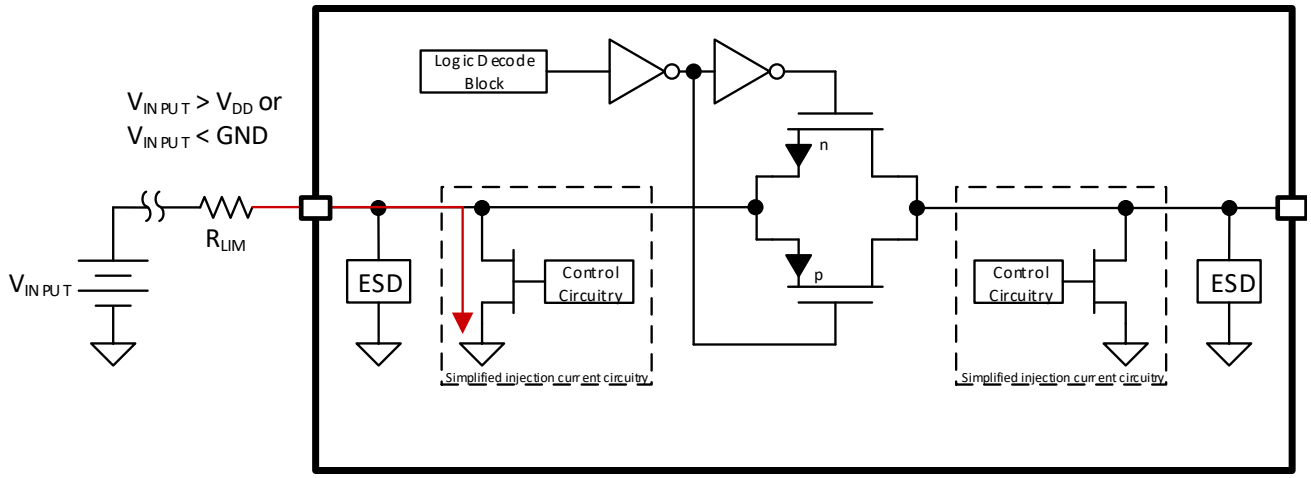


図 9-5. Over-Voltage Event with Series Resistor

For the injection current control circuitry to be active, two conditions must be present. First, the voltage at the source or drain pins is greater than V_{DD}, or less than GND. Next, the channel must be unselected. With those two requirements met, the protection FET will be turned on for any disabled signal path and shunt the pin to GND. In this event, a series resistor is needed to limit the total current injected into the device to be less than 100 mA. Three example scenarios are outlined in the following sections.

9.3.5.1 TMUX13xx-Q1 is Powered, Channel is Unselected, and the Input Signal is Greater Than V_{DD} (V_{DD} = 5 V, V_{INPUT} = 5.5 V)

A typical CMOS switch would have an internal ESD diode to the supply pin rated for ≅30 mA that would be turned on and a series limited resistor would be needed. However, any conducted current would be injected into the supply rail potentially damaging the system, unexpectedly turning on other devices on the same supply rail, or requiring additional components for protection. The TMUX13xx-Q1 implementation also handles this scenario with a series limiting resistor; the current path, however, is now to GND which does not have the same issues as the current injected into the supply rail.

9.3.5.2 TMUX13xx-Q1 is Powered, Channel is Selected, and the Input Signal is Greater Than V_{DD} (V_{DD} = 5 V, V_{INPUT} = 5.5 V)

The injection current control circuitry is fully active when the channel is unselected and an overvoltage event is present (overvoltage being defined as 0.5 V above the supply rail). However, in situations where the channel is selected and an overvoltage event occurs, this protection circuitry will still be partially active. In this instance, a portion of the injected current will be redirected through the protection circuitry to GND, but will not be a full shunt. So, some current will also flow through the source to drain path. This allows the device to tolerate overvoltage conditions in the event of the channel being selected, but precautions are still necessary to protect the device from overcurrent events such as implementing a current limiting resistor to keep the device below the maximum continuous source and drain current specification.

9.3.5.3 TMUX13xx-Q1 is Unpowered and the Input Signal has a Voltage Present (V_{DD} = 0 V, V_{INPUT} = 3 V)

Many CMOS switches are unable to support a voltage at the input without a valid supply voltage present, otherwise the voltage will be coupled from input to output and could damage downstream devices or impact power-sequencing. The TMUX13xx-Q1 circuitry can handle an input signal present without a supply voltage while minimizing power transfer from the input to output of the switch. By limiting the output voltage coupling to 400 mV the TMUX1308-Q1 and TMUX1309-Q1 help reduce the chance of conduction through any downstream ESD diodes.

9.4 Device Functional Modes

When the $\overline{EN}$ pin of the TMUX1308-Q1 is pulled low, one of the switches is closed based on the state of the address lines. Similarly, when the $\overline{EN}$ pin of the TMUX1309-Q1 is pulled low, two of the switches are closed based on the state of the address lines. When the $\overline{EN}$ pin is pulled high, all the switches are in an open state regardless of the state of the address lines.

Unused logic control pins must be tied to GND or V_{DD} so that the device does /not consume additional current as highlighted in *Implications of Slow or Floating CMOS Inputs*. Unused signal path inputs (Sx and Dx) should be connected to GND.

9.5 Truth Tables

表 9-1 and 表 9-2 provides the truth tables for the TMUX1308-Q1 and TMUX1309-Q1 respectively.

表 9-1. TMUX1308-Q1 Truth Table

$\overline{EN}$	A2	A1	A0	Selected Signal Path Connected To Drain (D) Pin
0	0	0	0	S0
0	0	0	1	S1
0	0	1	0	S2
0	0	1	1	S3
0	1	0	0	S4
0	1	0	1	S5
0	1	1	0	S6
0	1	1	1	S7

表 9-1. TMUX1308-Q1 Truth Table (continued)

$\overline{EN}$	A2	A1	A0	Selected Signal Path Connected To Drain (D) Pin
1	X(1)	X(1)	X(1)	All channels are off

(1) X denotes *do not care*.

表 9-2. TMUX1309-Q1 Truth Table

$\overline{EN}$	A1	A0	Selected Signal Path Connected To Drain (DA and DB) Pins
0	0	0	S0A to DA S0B to DB
0	0	1	S1A to DA S1B to DB
0	1	0	S2A to DA S2B to DB
0	1	1	S3A to DA S3B to DB
1	X(1)	X(1)	All channels are off

(1) X denotes *do not care*.

10 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. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The TMUX13xx-Q1 family offers protection against injection current events across a wide operating supply range (1.62 V to 5.5 V). These devices include 1.8 V logic compatible control input pins that enable operation in systems with 1.8 V I/O rails. Additionally, the control input pins support Fail-Safe Logic which allows for operation up to 5.5 V, regardless of the state of the supply pin. This feature stops the logic pins from back-powering the supply rail while the injection current circuitry prevents the signal path from back-powering the supply. These features make the TMUX13xx-Q1 a family of general purpose multiplexers and switches that can reduce system complexity, board size, and overall system cost.

10.2 Typical Application

One useful application that takes advantage of the TMUX13xx-Q1 features is multiplexing various physical switches in a body control module (BCM) or electronic control unit (ECU). Automotive BCMs are complex systems designed to manage numerous functions such as lighting, door locks, windows, wipers, turn signals, and many more inputs. The BCM monitors these physical switches and controls power to various loads within the vehicle. A CMOS multiplexer can be used to multiplex the inputs and minimize the number of GPIO or ADC inputs needed by an onboard MCU. 図 10-1 shows a typical BCM system using the TMUX1308-Q1 to multiplex system inputs.

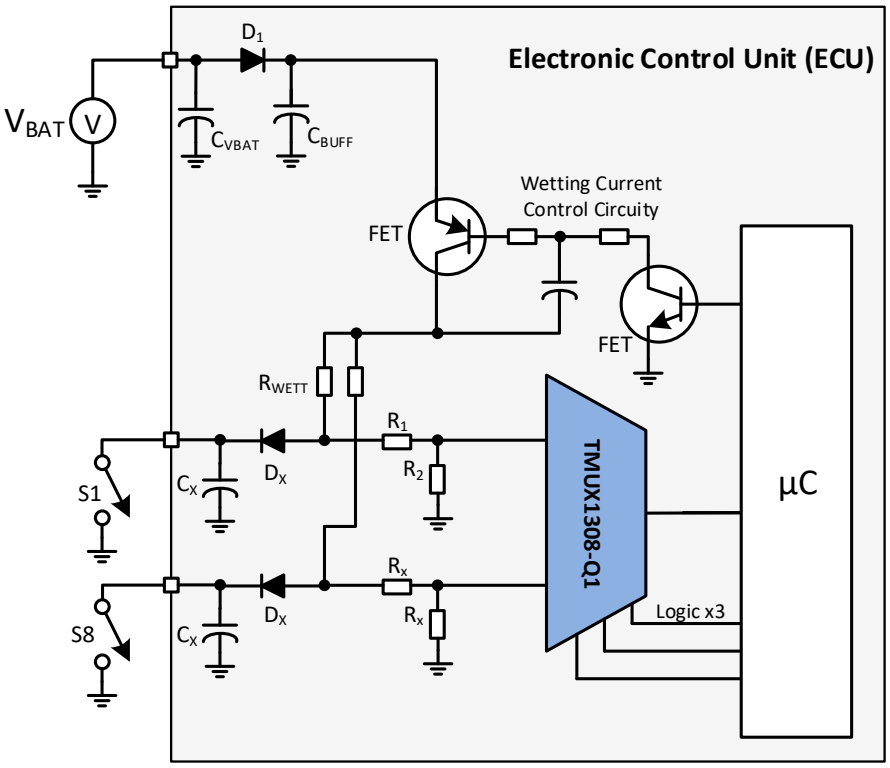


図 10-1. Multiplexing BCM Inputs

10.2.1 Design Requirements

For this design example, use the parameters listed in 表 10-1.

表 10-1. Design Parameters

PARAMETERS	VALUES
Supply (V_{DD})	5.0 V
I/O signal range	0 V to V_{DD} (Rail to Rail)
Control logic thresholds	1.8 V compatible
Switch inputs	Eight

10.2.2 Detailed Design Procedure

The TMUX1308-Q1 has an internal injection current control feature which eliminates the need for external diode or resistor networks typically used to protect the switch and keep the input signals within the supply voltage. The internal injection current control circuitry allows signals on disabled signal paths to exceed the supply voltage without affecting the signal of the enabled signal path. Injected currents can come from various sources such as from long cabling in automotive systems that may be susceptible to induced currents from switching or transient events. Another momentary source of injected currents in BCMs are wetting currents, which are small currents used to prevent oxidation on metal switch contacts or wires. A switch without injection current control can have the measured output of the enabled signal path impacted if a current is injected into a disabled signal path. This undesired change in the output can cause issues related to false trigger events and incorrect measurement readings which can compromise the accuracy and reliability of the BCM system. 図 10-2 shows a detailed BCM application.

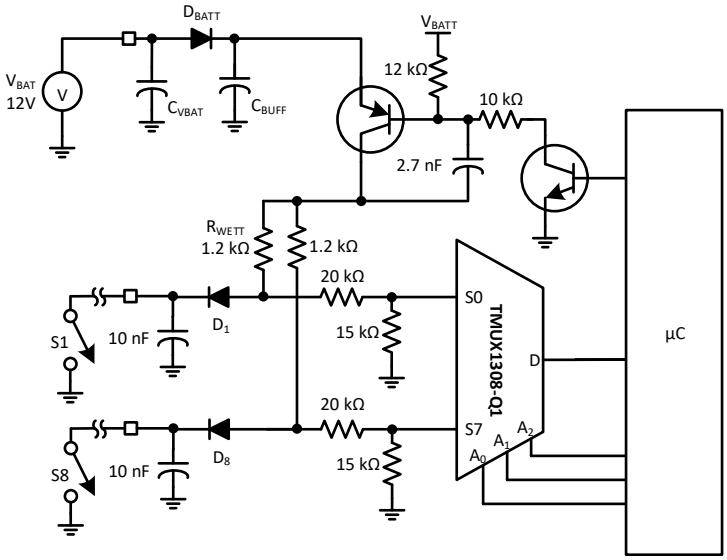


図 10-2. Detailed BCM Application

The BCM uses the 12 V battery voltage to provide a wetting current to each switch when the associated control circuitry is enabled by the micro controller. The wetting current is sized by the R_{WETT} and the required value may vary depending on the type of physical switch being monitored. The 20 kΩ and 15 kΩ resistors are used in addition to the wetting resistor to create a voltage divider before the input of the multiplexer in case of a short to battery condition. The resistor values are selected to maintain the voltage at the switch signal path below VDD. The 20 kΩ series resistor also limits the amount of injected current into the switch if an overvoltage event occurs. Diodes D1 through D8 are used to prevent back flow of current in case a secondary system is monitoring the same physical switches for backup or redundancy reasons. The 10 nF capacitors are used for initial ESD protection in the system and must be sized based on system level requirements.

The logic address pins are controlled by the micro controller to cycle between the eight switch inputs in the system. If the parts desired power-up state is disabled, then the enable pin should have a weak pull-up resistor and be controlled by the MCU through the GPIO.

10.2.3 Short To Battery Protection

When evaluating the safety and reliability of an automotive grade multiplexer, it is important to note their performance under various operating conditions. In the case of TMUX13xx-Q1, we examine it's response to various short-to-battery conditions to provide insight on system level design for automotive optimization. It is important to design around short-to-battery as failure to do so can result in operational issues. The following section shows a deep dive into three scenarios to demonstrate the behavior of the TMUX1308-Q1 under short-to-battery conditions using a 5V supply voltage.

We begin with the following setup to explore our first scenario with channel S7 selected and channel S0 experiencing a short-to-battery condition.

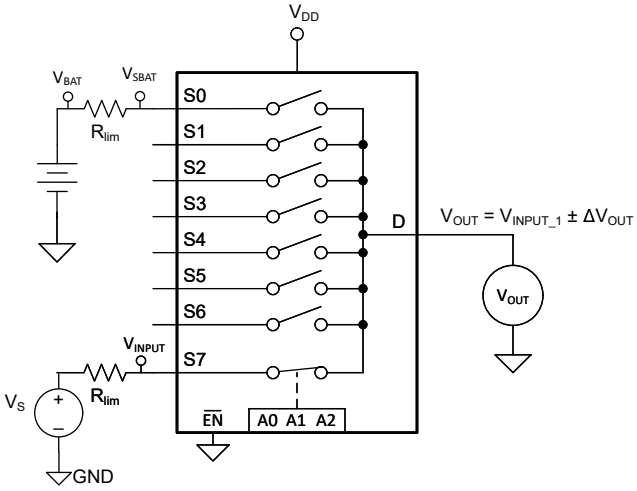


図 10-3. Channel S7 selected, Channel S0 experiencing a short-to-battery condition

表 10-2 indicates values of ΔV_{OUT}, V_{SBAT} and minimum R_{LIM} for various V_{BAT} cases when considering a maximum allotment of 25mA for I_S/I_D. Choosing too large of an R_{LIM} will negatively affect ΔV_{OUT} as well as substantially limit current flow. Choosing too small of an R_{LIM} can damage the device.

表 10-2. R_{Lim} Values for 25mA Through the Switch

V_{BAT}	R_{LIM}	ΔV_{OUT} (typ)	V_{SBAT}
12V	470	< 10 uV	5.6V
19V	750	< 10 uV	5.6V
24V	1K	< 10 uV	5.6V
36V	1.5K	< 10 uV	5.6V
48V	2K	< 10 uV	5.6V
60V	2.4K	< 10 uV	5.6V

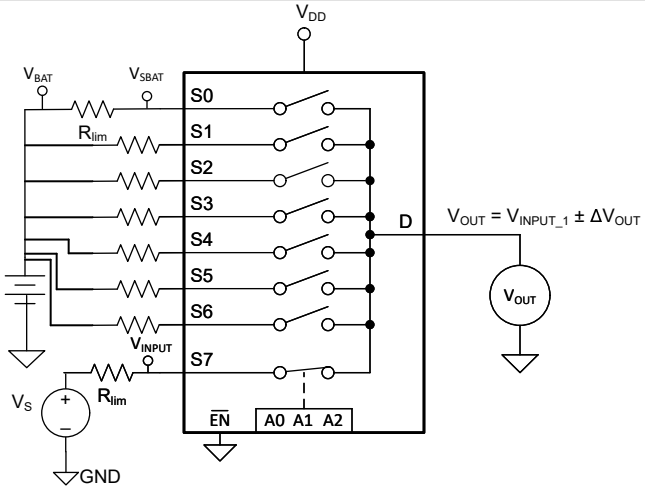


図 10-4. All Unselected Channels Experiencing a Short-to-Battery Condition

We then evaluate the scenario of seeing a short to battery condition on all unselected channels at the same time. The below table indicates values when considering a maximum allotment of 12.5mA for I_S/I_D. If you have the potential to see short to battery on all channels at the same time, then 12.5 mA is the limiting factor. Here again choosing too large of an R_{LIM} will negatively affect ΔV_{OUT} as well as substantially limit current flow. Choosing too small of an R_{LIM} can also damage the device.

表 10-3. R_{Lim} Values for 12.5mA Through the Switch

V_{BAT}	R_{LIM}	ΔV_{OUT} (typ)	V_{SBAT}
12V	1K	< 10 uV	5.6V
19V	1.5K	< 10 uV	5.6V
24V	2K	< 10 uV	5.6V
36V	3K	< 10 uV	5.6V
48V	3.9K	< 10 uV	5.6V
60V	4.7K	< 10 uV	5.6V

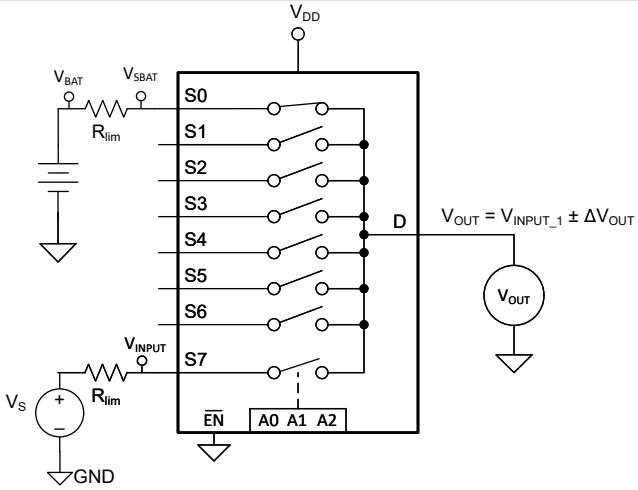


図 10-5. Short-to-Battery Condition Only on a Single Selected Channel

We then evaluate the scenario of a short to battery occurring when the switch is closed using a 5V supply. As such, input voltage needs to be limited to 6V. The below table indicates values of R_{LIM} needed to keep the voltage of a selected channel under 6V using a standard 5V V_{DD} for all short to battery cases. Choosing too large of an R_{LIM} will negatively affect ΔV_{OUT} as well as substantially limit current flow. Choosing too small of an R_{LIM} can also damage the device.

表 10-4. R_{Lim} Values for <6V Through the Switch

V_{BAT}	R_{LIM}	ΔV_{OUT} (typ)	V_{SBAT}
12V	1.6K	< 10 uV	5.9V
18V	3K	< 10 uV	5.9V
19V	3.3K	< 10 uV	5.9V
24V	4.7K	< 10 uV	5.9V
36V	10K	< 10 uV	5.9V
48V	13K	< 10 uV	5.9V
60V	15K	< 10 uV	5.9V

In conclusion, several short-to-battery case studies were observed using a 5V supply. Note that if using a lower supply voltage, the R_{Lim} values will change for optimal current flow. It is important to protect against short to battery conditions as a failure to do so can result in system level issues. Caution must be observed to design around these conditions and the electrical characteristics of the device such that proper operation of the device is guaranteed.

10.3 Power Supply Recommendations

The TMUX1308-Q1 and TMUX1309-Q1 devices operate across a wide supply range of 1.62 V to 5.5 V. Note: do not exceed the absolute maximum ratings because stresses beyond the listed ratings can cause permanent damage to the devices.

Power-supply bypassing improves noise margin and prevents switching noise propagation from the V_{DD} supply to other components. Good power-supply decoupling is important to achieve optimum performance. For improved supply noise immunity, use a supply decoupling capacitor ranging from 0.1 µF to 10 µF from V_{DD} to ground. Place the bypass capacitors as close to the power supply pins of the device as possible using low-impedance connections. TI recommends using multi-layer ceramic chip capacitors (MLCCs) that offer low equivalent series resistance (ESR) and inductance (ESL) characteristics for power-supply decoupling purposes. For very sensitive systems, or for systems in harsh noise environments, avoiding the use of vias for connecting

the capacitors to the device pins may offer superior noise immunity. The use of multiple vias in parallel lowers the overall inductance and is beneficial for connections to ground planes.

10.4 Layout

10.4.1 Layout Guidelines

When a PCB trace turns a corner at a 90° angle, a reflection can occur. A reflection occurs primarily because of the change of width of the trace. At the apex of the turn, the trace width increases to 1.414 times the width. This increase upsets the transmission-line characteristics, especially the distributed capacitance and self-inductance of the trace which results in the reflection. Not all PCB traces can be straight; therefore, some traces must turn corners. 図 10-6 shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

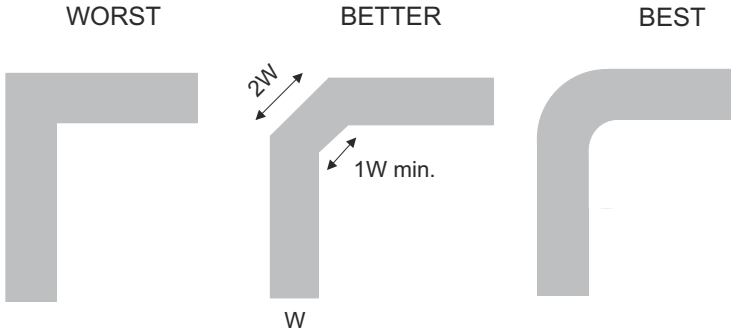


図 10-6. Trace Example

Route 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, through-hole pins are not recommended at high frequencies.

図 10-7 shows an example of a PCB layout with the TMUX1308-Q1 and TMUX1309-Q1. Some key considerations are as follows:

- Decouple the V_{DD} pin with a 0.1-µF capacitor, placed as close to the pin as possible. Make sure that the capacitor voltage rating is sufficient for the V_{DD} supply.
- Keep the input lines as short as possible.
- Use a solid ground plane to help reduce electromagnetic interference (EMI) noise pickup.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible, and only make perpendicular crossings when necessary.

10.4.2 Layout Example

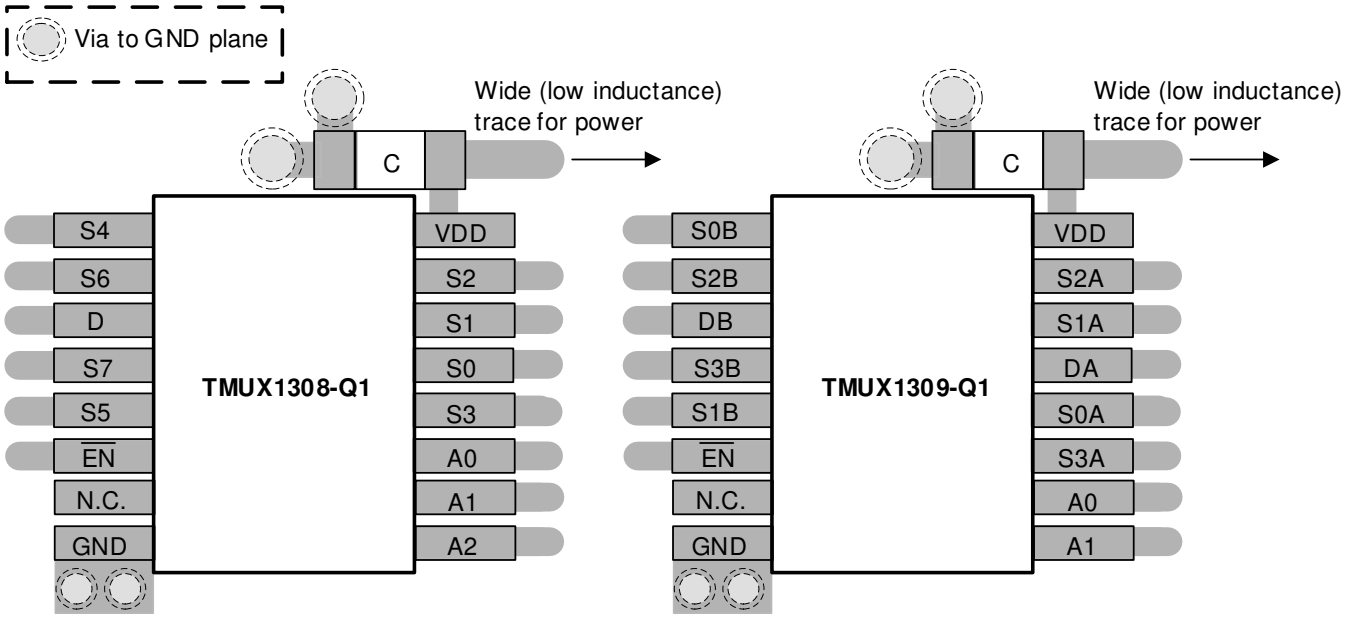


図 10-7. TMUX1308-Q1 and TMUX1309-Q1 Layout Example

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *Simplifying Design with 1.8 V logic Muxes and Switches*
- Texas Instruments, *QFN/SON PCB Attachment*
- Texas Instruments, *Quad Flatpack No-Lead Logic Packages*

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 サポート・リソース

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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。

11.6 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。

12 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)
TMUX1308QBQBRQ1	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	1308Q
TMUX1308QBQBRQ1.A	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	1308Q
TMUX1308QDYYRQ1	Active	Production	SOT-23-THIN (DYY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX1308Q
TMUX1308QDYYRQ1.A	Active	Production	SOT-23-THIN (DYY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX1308Q
TMUX1308QPWRQ1	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1308Q
TMUX1308QPWRQ1.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1308Q
TMUX1309QBQBRQ1	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	1309Q
TMUX1309QBQBRQ1.A	Active	Production	WQFN (BQB) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	1309Q
TMUX1309QDYYRQ1	Active	Production	SOT-23-THIN (DYY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX1309Q
TMUX1309QDYYRQ1.A	Active	Production	SOT-23-THIN (DYY) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TMUX1309Q
TMUX1309QPWRQ1	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1309Q
TMUX1309QPWRQ1.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TM1309Q

(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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OTHER QUALIFIED VERSIONS OF TMUX1308-Q1, TMUX1309-Q1 :

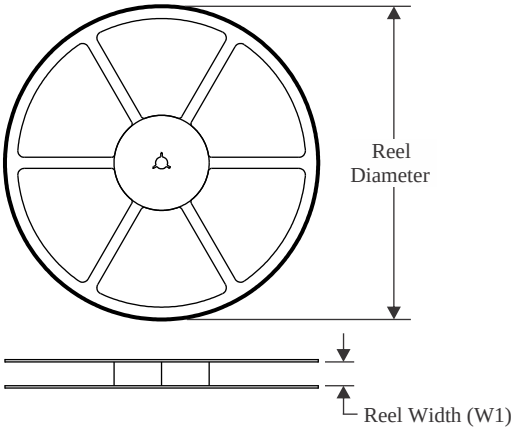
- Catalog : TMUX1308, TMUX1309

NOTE: Qualified Version Definitions:

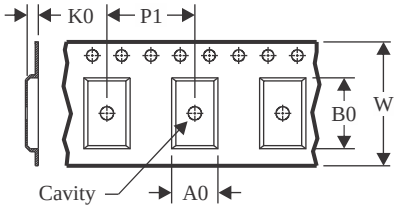
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

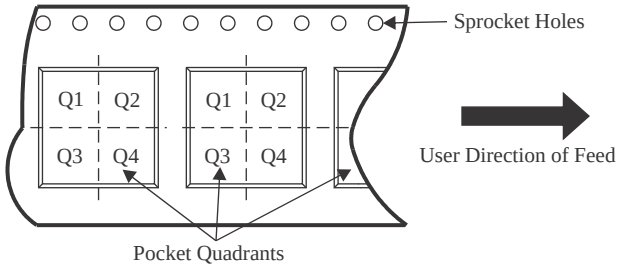


TAPE DIMENSIONS



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

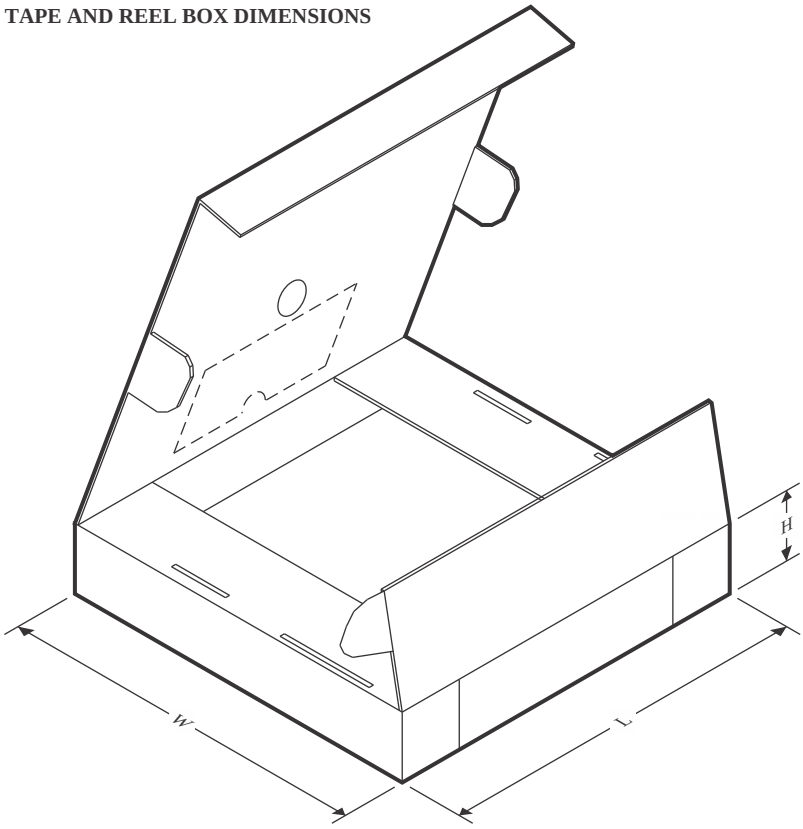
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TMUX1308QBQBRQ1	WQFN	BQB	16	3000	180.0	12.4	2.8	3.8	1.2	4.0	12.0	Q1
TMUX1308QDYYRQ1	SOT-23-THIN	DYY	16	3000	330.0	12.4	4.8	3.6	1.6	8.0	12.0	Q3
TMUX1308QPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TMUX1309QBQBRQ1	WQFN	BQB	16	3000	180.0	12.4	2.8	3.8	1.2	4.0	12.0	Q1
TMUX1309QDYYRQ1	SOT-23-THIN	DYY	16	3000	330.0	12.4	4.8	3.6	1.6	8.0	12.0	Q3
TMUX1309QPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMUX1308QBQBRQ1	WQFN	BQB	16	3000	210.0	185.0	35.0
TMUX1308QDYYRQ1	SOT-23-THIN	DYY	16	3000	336.6	336.6	31.8
TMUX1308QPWRQ1	TSSOP	PW	16	2000	353.0	353.0	32.0
TMUX1309QBQBRQ1	WQFN	BQB	16	3000	210.0	185.0	35.0
TMUX1309QDYYRQ1	SOT-23-THIN	DYY	16	3000	336.6	336.6	31.8
TMUX1309QPWRQ1	TSSOP	PW	16	2000	353.0	353.0	32.0

GENERIC PACKAGE VIEW

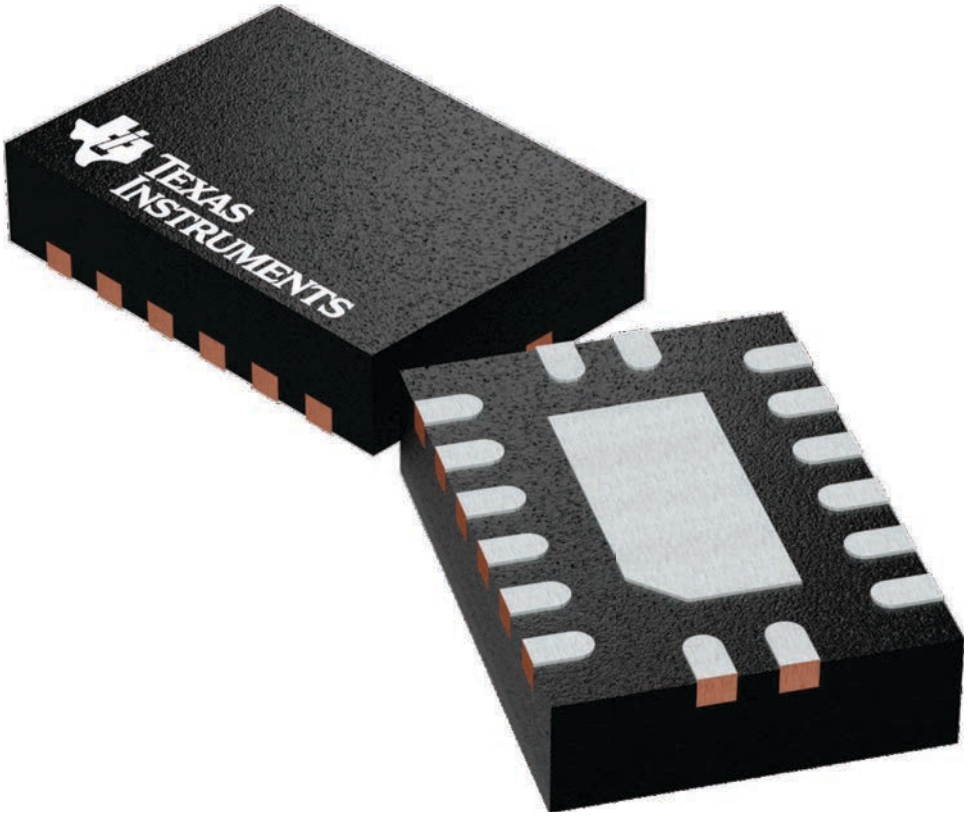
BQB 16

WQFN - 0.8 mm max height

2.5 x 3.5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



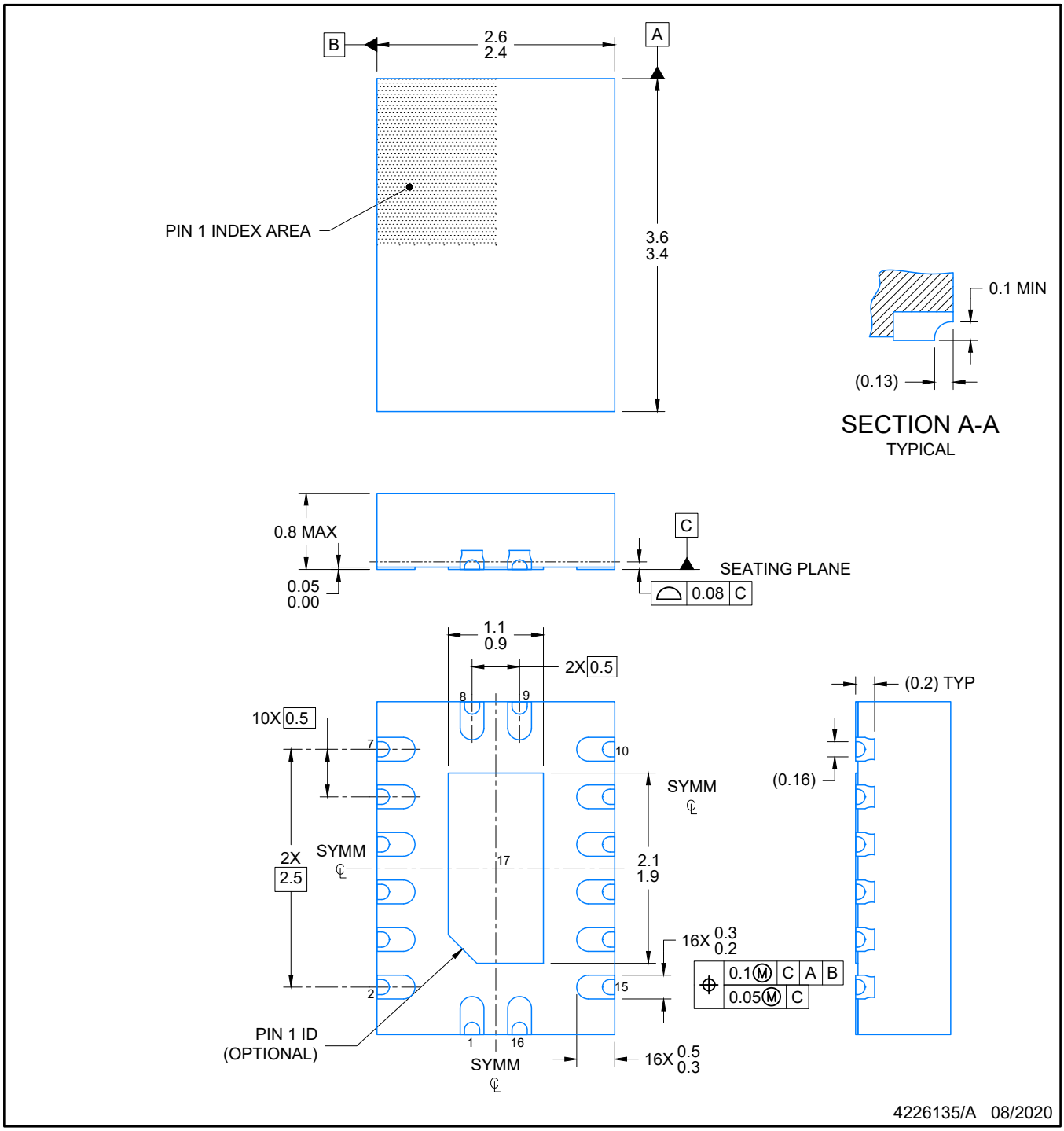
4226161/A

PACKAGE OUTLINE

BQB0016B

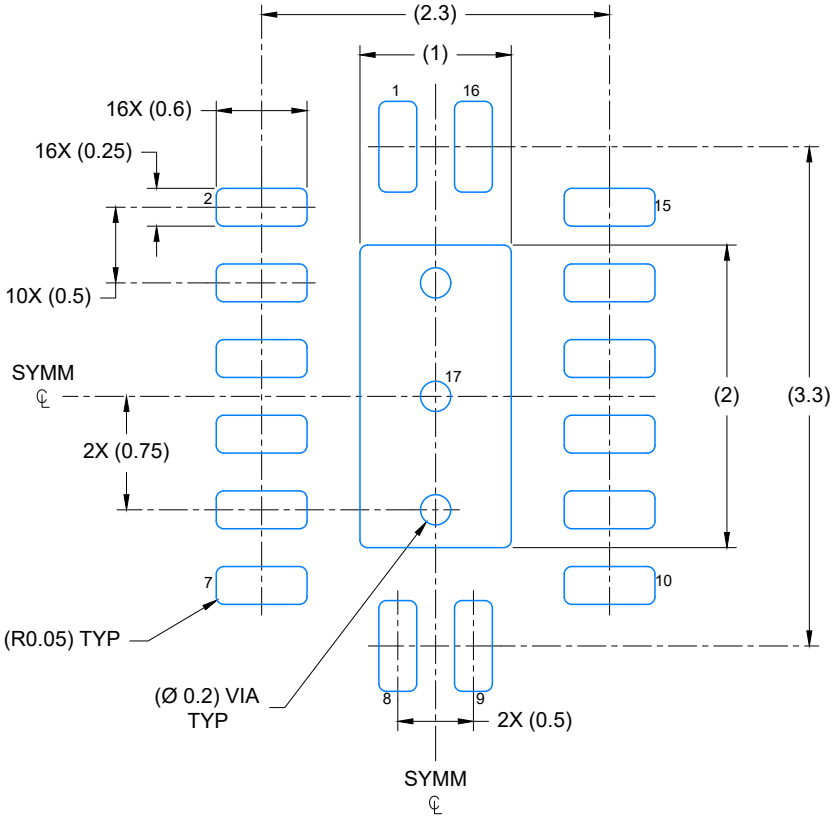
WQFN - 0.8 mm max height

INDSTNAME



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. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

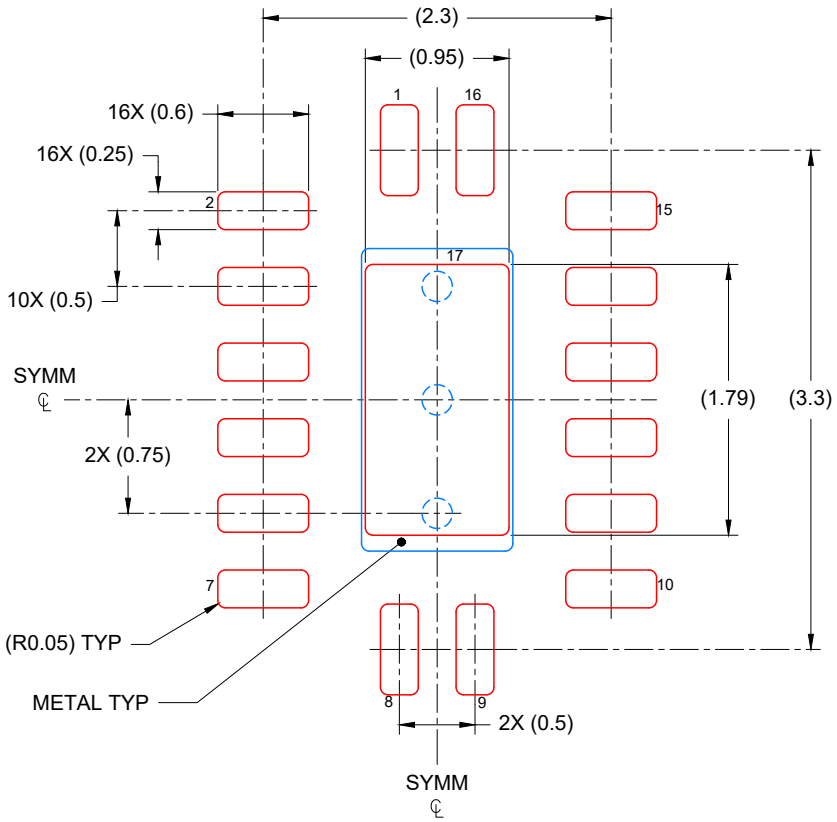


LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X

4226135/A 08/2020

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 0.125 mm THICK STENCIL

EXPOSED PAD
85% PRINTED COVERAGE BY AREA
SCALE: 20X

4226135/A 08/2020

NOTES: (continued)

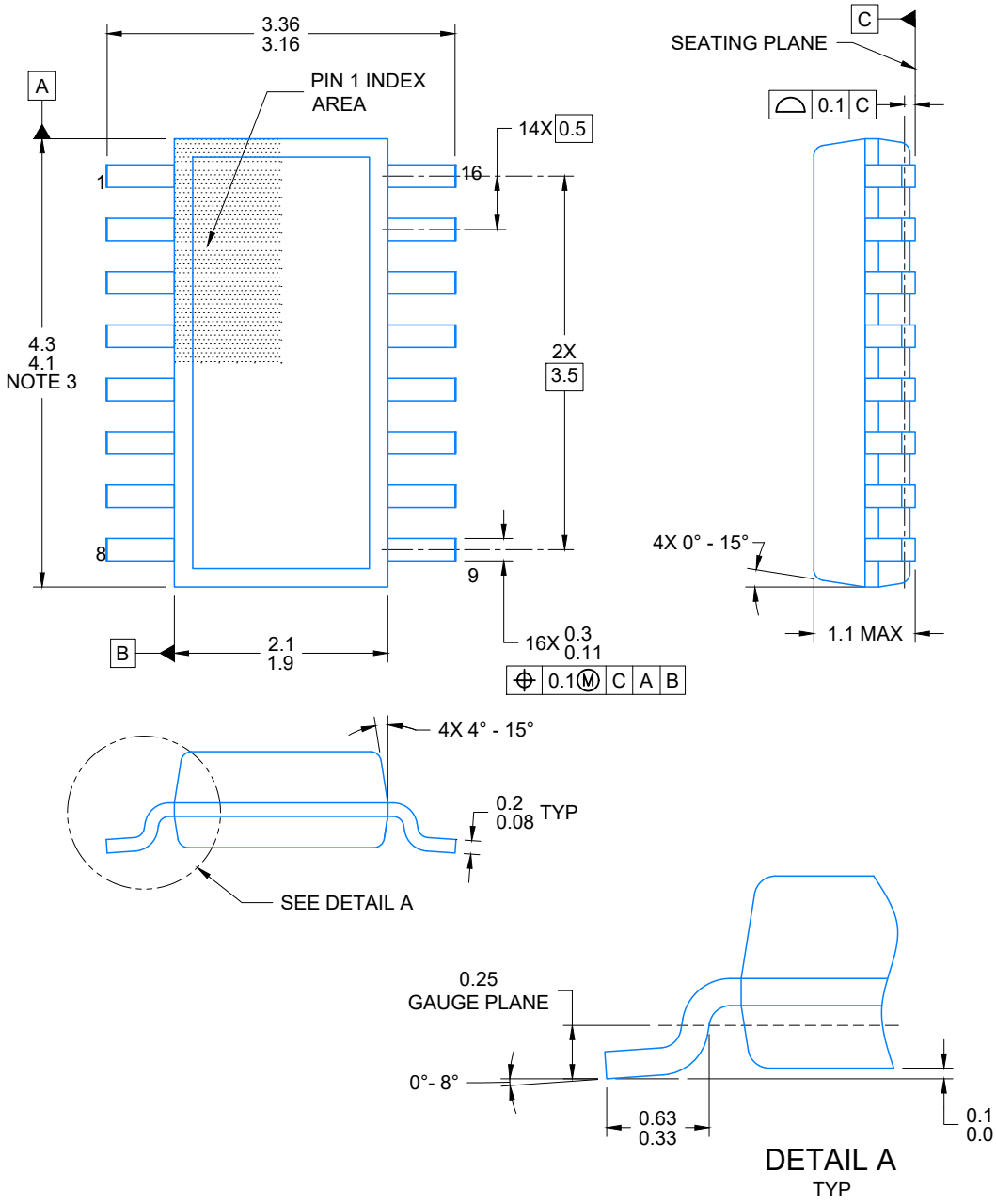
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGE OUTLINE

DYY0016A

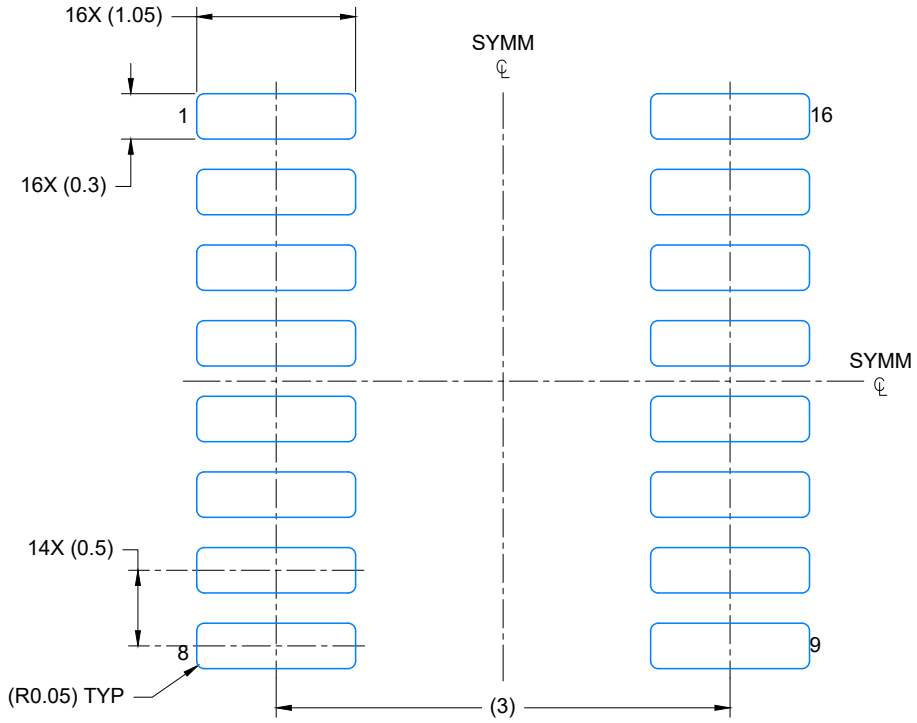
SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE

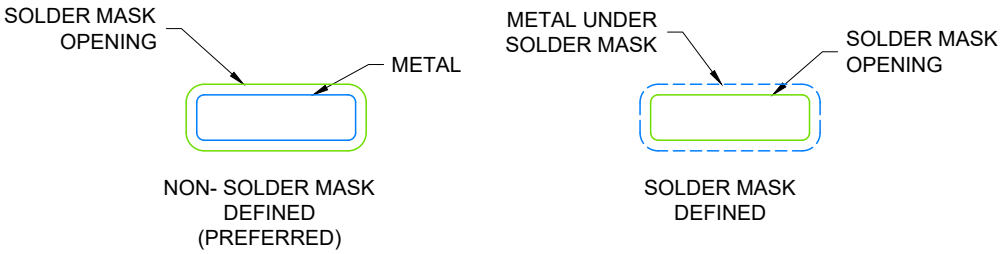


NOTES:

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 dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
5. Reference JEDEC Registration MO-345, Variation AA



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



SOLDER MASK DETAILS

4224642/D 07/2024

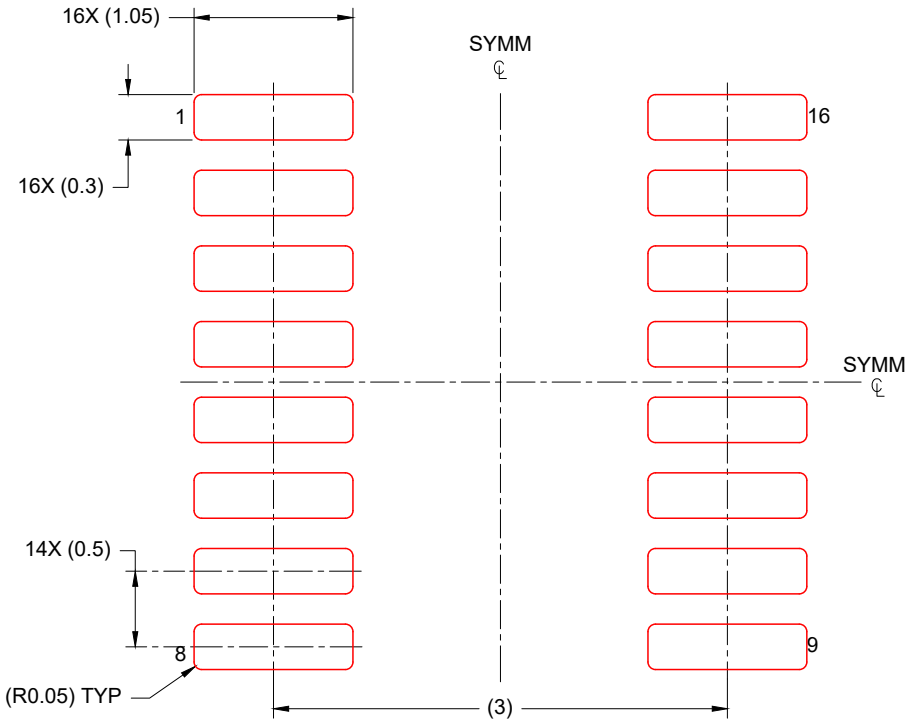
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 20X

4224642/D 07/2024

NOTES: (continued)

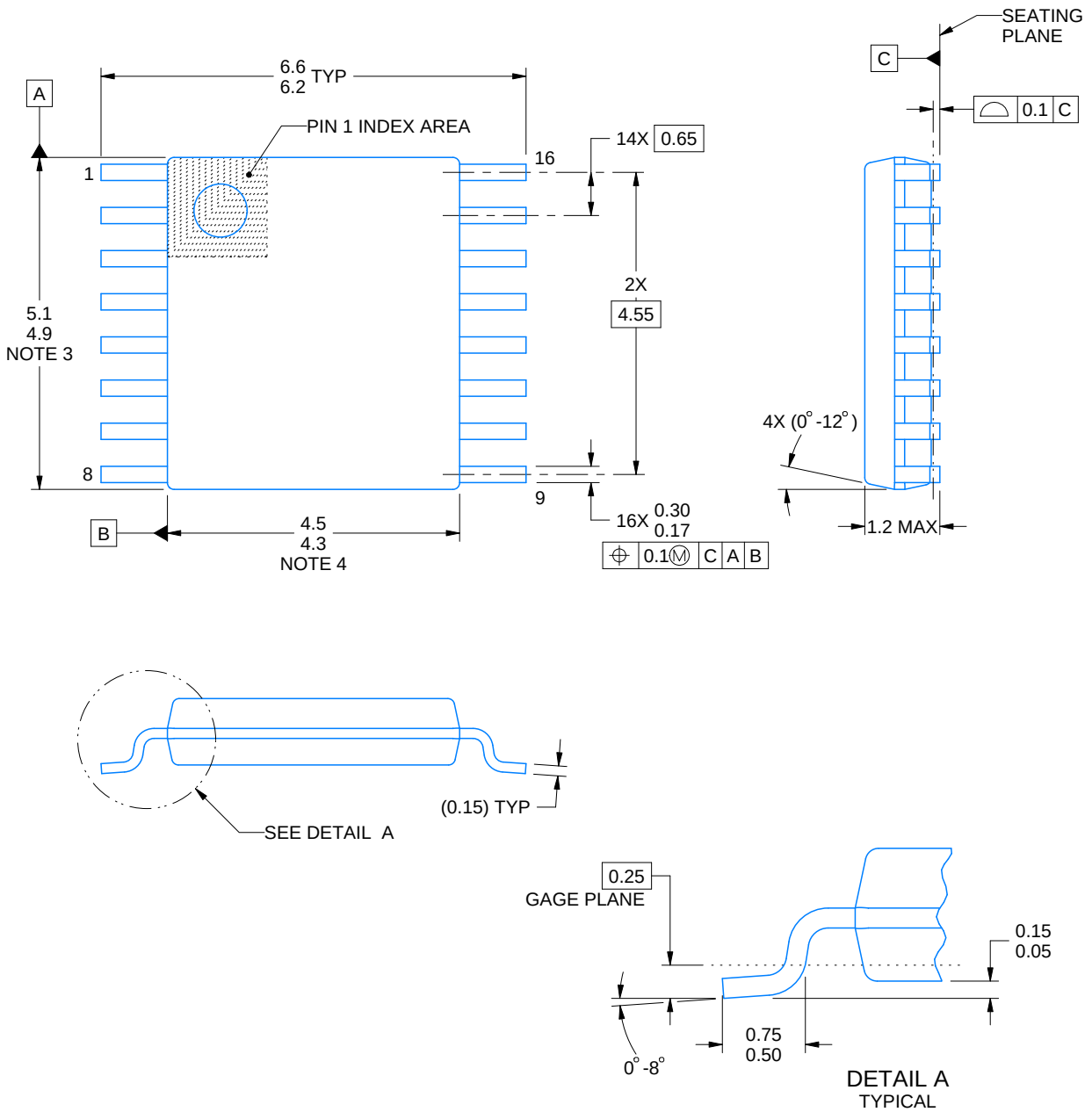
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

PW0016A

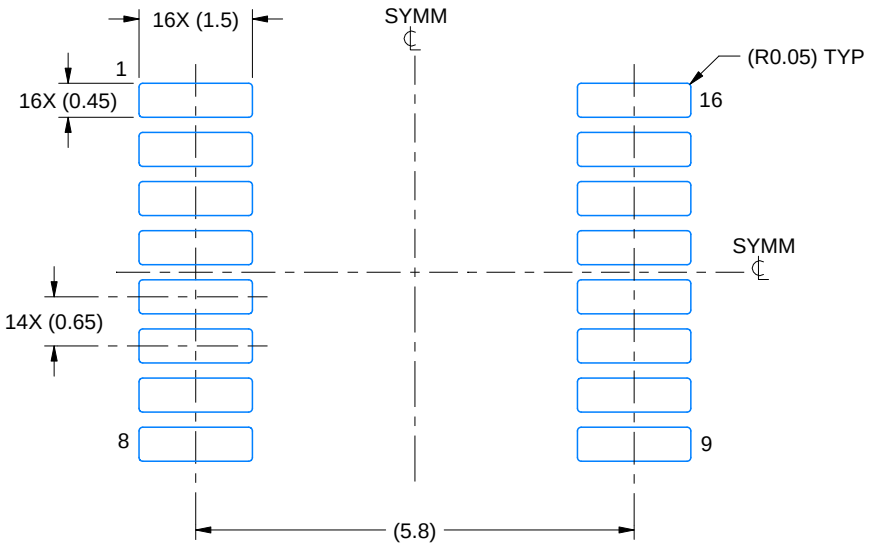
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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 dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



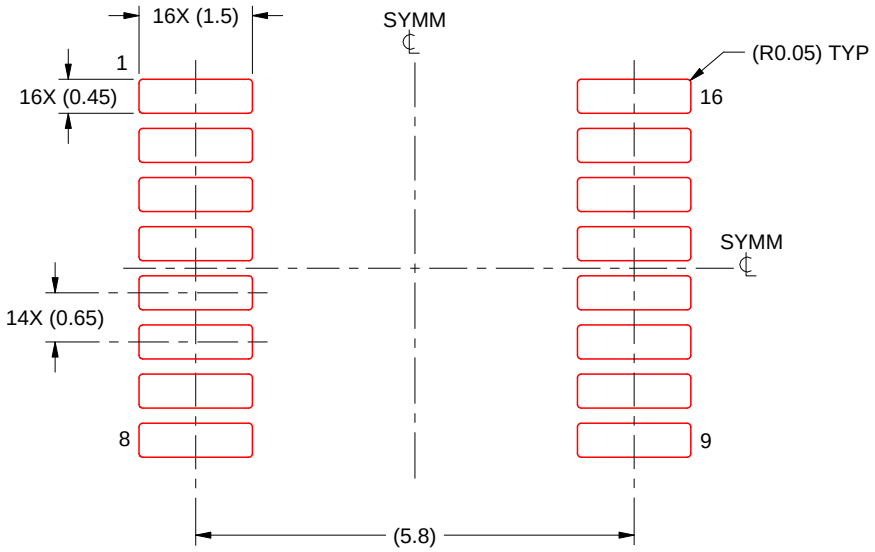
LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

SOLDER MASK DETAILS

4220204/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220204/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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最終更新日：2025 年 10 月