SN3257-Q1 5-V, Low Propagation Delay, 2:1 (SPDT), 4-Channel Switch with 1.8 V Logic

1 Features

- AEC-Q100 qualified for automotive application
  - Temperature grade 1: -40°C to +125°C, T_A
- Wide supply range: 1.5 V to 5.5 V
- Low propagation delay: 78 ps
- Low on-resistance: 5 Ω
- High bandwidth: 1.2 GHz
- Bidirectional Signal Path
- Supports Input Voltage Beyond Supply
- 1.8 V Logic Compatible
- Integrated Pull Down Resistor on Logic Pins
- Fail-Safe Logic
- Powered-off Protection up to 3.6 V Signals

2 Applications

- SPI multiplexing
- I2S multiplexing
- eSIM multiplexing
- eMMC multiplexing
- Flash memory sharing
- Battery management system (BMS)
- Telematics control unit (TCU)
- Smart telematics gateway
- Rear seat entertainment
- Digital cockpit processing unit
- Automotive head unit
- Automotive navigation
- ADAS domain controller
- Surround view system ECU
- On-board (OBC) & wireless charger

3 Description

The SN3257-Q1 is an automotive grade complementary metal-oxide semiconductor (CMOS) switch that supports high speed signals with low propagation delay. The SN3257-Q1 offers a 2:1 (SPDT) switch configuration with 4-channels making it ideal for multi-lane protocols such as SPI and I2S. The device supports bidirectional analog and digital signals on the source (SxA, SxB) and drain (Dx) pins and can pass signals above supply up to V_{DD} x 2, with a maximum input and output voltage of 5.5 V.

The SN3257-Q1 has an active low $\overline{EN}$ pin that is used to enable and disable all channels simultaneously. When the $\overline{EN}$ pin is LOW, one of the two switch paths is selected based on the state of SEL pin.

Powered-off protection up to 3.6 V on the signal path of the SN3257-Q1 provides isolation when the supply voltage is removed (V_{DD} = 0 V). Without this protection feature, switches can back-power the supply rail through an internal ESD diode and cause potential damage to the system.

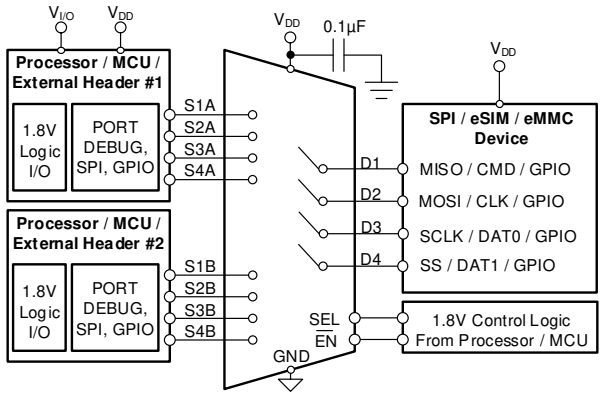
Fail-safe logic circuitry allows voltages on the logic control pins to be applied before the supply pin, protecting the device from potential damage. Both logic control inputs have 1.8 V logic compatible thresholds, ensuring both TTL and CMOS logic compatibility. Integrated pull down resistor on the logic pins removes external components to reduce system size and cost.

Device Information(1)

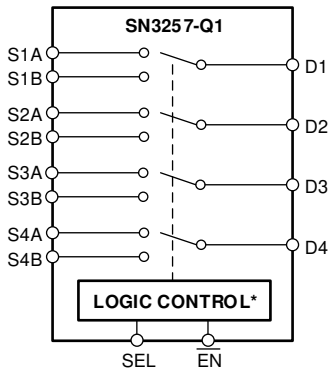
PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN3257-Q1	TSSOP (16)	5.00 mm × 4.40 mm
	SOT-23-THIN (16)	4.20 mm x 2.00 mm

(1) For all available packages, see the package option addendum at the end of the data sheet.

Application Example



Block Diagram



*Internal 6MΩ Pull-Down on Logic Pins

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Table of Contents

4 Revision History

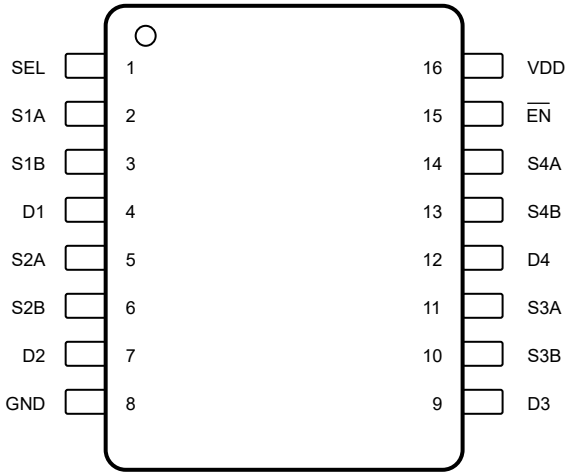
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (August 2016) to Revision B	Page
• Changed the document status From: *Advanced Information* To: *Production Data*	1

Copyright © 2019–2020, Texas Instruments Incorporated

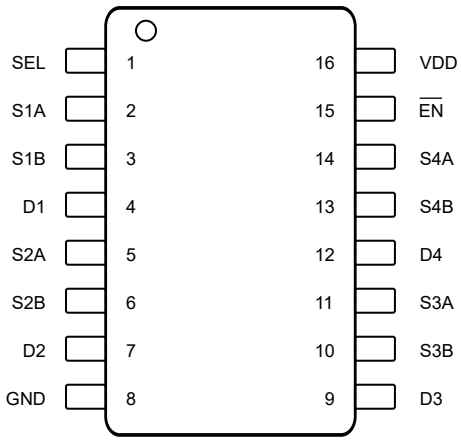
5 Pin Configuration and Functions

PW Package
16-Pin TSSOP
Top View



Not to scale

DYY Package
16-Pin SOT-23
Top View



Not to scale

Pin Functions

PIN		TYPE(1)	DESCRIPTION(2)
NAME	NO.		
SEL	1	I	Select pin: controls state of switches according to Table 1. Internal 6 MΩ pull-down to GND.
S1A	2	I/O	Source pin 1A. Can be an input or output.
S1B	3	I/O	Source pin 1B. Can be an input or output.
D1	4	I/O	Drain pin 1. Can be an input or output.
S2A	5	I/O	Source pin 2A. Can be an input or output.
S2B	6	I/O	Source pin 2B. Can be an input or output.
D2	7	I/O	Drain pin 2. Can be an input or output.
GND	8	P	Ground (0 V) reference
D3	9	I/O	Drain pin 3. Can be an input or output.
S3B	10	I/O	Source pin 3B. Can be an input or output.
S3A	11	I/O	Source pin 3A. Can be an input or output.
D4	12	I/O	Drain pin 4. Can be an input or output.
S4B	13	I/O	Source pin 4B. Can be an input or output.
S4A	14	I/O	Source pin 4A. Can be an input or output.
$\overline{EN}$	15	I	Active low enable: When this pin is high, all switches are turned off. When this pin is low, SEL pin controls the signal path selection. Internal 6 MΩ pull-down to GND.
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.

(1) I = input, O = output, I/O = input and output, P = power
(2) Refer to Device Functional Modes for what to do with unused pins.

Copyright © 2019–2020, Texas Instruments Incorporated

6 Specifications

6.1 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 (SEL or $\overline{EN}$)	–0.5	6	V
I_{SEL} or I_{EN}	Logic control input pin current (SEL or $\overline{EN}$)	–30	30	mA
V_S or V_D	Source or drain pin voltage	–0.5	6	V
I_S or $I_{D\ (CONT)}$	Source and drain pin continuous current: (SxA, SxB, Dx)	–25	25	mA
T_{stg}	Storage temperature	–65	150	°C
T_J	Junction temperature		150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(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.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002(1) HBM ESD Classification Level 2	±2000	V
		Charged device model (CDM), per AEC Q100-011 CDM ESD Classification Level C4B	±750	

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

6.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V_{DD}	Supply voltage	1.5	5.5	V
V_S or V_D	Signal path input or output voltage (source or drain pin), $V_{DD} \geq 1.5$ V(1)	0	V_{DD} x 2	V
V_{S_off} or V_{D_off}	Signal path input or output voltage (source or drain pin), $V_{DD} < 1.5$ V(2)	0	3.6	V
V_{SEL} or V_{EN}	Logic control input voltage ($\overline{EN}$, SEL)	0	5.5	V
I_S or $I_{D\ (CONT)}$	Source and drain pin continuous current: (SxA, SxB, Dx)	–25	25	mA
T_A	Ambient temperature	–40	125	ºC

(1) Device input/output can operate up to V_{DD} x 2, with a maximum input/output voltage of 5.5 V.
(2) V_{S_off} and V_{D_off} refers to the voltage at the source or drain pins when supply is less than 1.5 V.

6.4 Thermal Information

THERMAL METRIC(1)		DEVICE PW (TSSOP) 16 PINS	DEVICE DYY (SOT-23) 16 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	117.4	123.0	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	47.9	70.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	63.7	50.4	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	6.9	5.0	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	63.1	50.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

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

Copyright © 2019–2020, Texas Instruments Incorporated

6.5 Electrical Characteristics

V_{DD} = 1.5 V to 5.5 V, GND = 0V, T_A = –40°C to +125°C
Typical values are at V_{DD} = 3.3 V, T_A = 25°C, (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
V_{DD}	Power supply voltage		1.5		5.5	V
I_{DD}	Active supply current	V_{SEL} = 0 V, 1.4 V or V_{DD} V_S = 0 V to 5.5 V		40	68	µA
$I_{DD\_STANDBY}$	Supply current when disabled	V_{EN} = 1.4 V or V_{DD} V_S = 0 V to 5.5 V		7.5	15	µA
DC CHARACTERISTICS						
R_{ON}	On-resistance	V_S = 0 V to V_{DD}×2 $V_{S(max)}$ = 5.5 V I_{SD} = 8 mA Refer to ON-State Resistance Figure		2	5	Ω
ΔR_{ON}	On-resistance match between channels	V_S = V_{DD} I_{SD} = 8 mA Refer to ON-State Resistance Figure		0.07	0.8	Ω
$R_{ON\ (FLAT)}$	On-resistance flatness	V_S = 0 V to V_{DD} I_{SD} = 8 mA Refer to ON-State Resistance Figure		1	2.5	Ω
I_{POFF}	Powered-off I/O pin leakage current	V_{DD} = 0 V V_S = 0 V to 3.6 V V_D = 0 V Refer to Ipoff Leakage Figure	–8	0.01	8	µA
$I_{S(OFF)}$ $I_{D(OFF)}$	OFF leakage current	Switch Off V_D = 0.8×V_{DD} / 0.2×V_{DD} V_S = 0.2×V_{DD} / 0.8×V_{DD} Refer to Off Leakage Figure	–900	0.03	900	nA
$I_{D(ON)}$ $I_{S(ON)}$	ON leakage current	Switch On V_D = 0.8×V_{DD} / 0.2×V_{DD}, S pins floating or V_S = 0.8×V_{DD} / 0.2×V_{DD}, D pins floating Refer to On Leakage Figure	–900	0.01	900	nA
LOGIC INPUTS						
V_{IH}	Input logic high		1.2		5.5	V
V_{IL}	Input logic low		0		0.45	V
I_{IH}	Input high leakage current	V_{SEL} = 1.8 V, V_{DD}		1	±2	µA
I_{IL}	Input low leakage current	V_{SEL} = 0 V		0.2	±2	µA
R_{PD}	Internal pull-down resistor on logic pins			6		MΩ
C_I	Logic input capacitance	V_{SEL} = 0 V, 1.8 V or V_{DD} f = 1 MHz		3		pF

Copyright © 2019–2020, Texas Instruments Incorporated

6.6 Dynamic Characteristics

V_{DD} = 1.5 V to 5.5 V, GND = 0 V, T_A = –40°C to +125°C
Typical values are at V_{DD} = 3.3 V, T_A = 25°C, (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
C_{OFF}	Source and drain off capacitance	V_S = 2.5 V V_{SEL}= 0 V f = 1 MHz Refer to Capacitance Figure	Switch OFF		4		pF
C_{ON}	Source and drain on capacitance	V_S = 2.5 V V_{SEL}= 0 V f = 1 MHz Refer to Capacitance Figure	Switch ON		8		pF
Q_C	Charge Injection	V_S = V_{DD}/2 R_S = 0 Ω, C_L =1 nF Refer to Charge Injection Figure	Switch ON		3.5		pC
O_{ISO}	Off isolation	R_L = 50 Ω f = 100 kHz Refer to Off Isolation Figure	Switch OFF		–90		dB
		R_L = 50 Ω f = 1 MHz Refer to Off Isolation Figure	Switch OFF		–75		dB
X_{TALK}	Channel to Channel crosstalk	R_L = 50 Ω f = 100 kHz Refer to Crosstalk Figure	Switch ON		–90		dB
BW	Bandwidth	R_L = 50 Ω Refer to Bandwidth Figure	Switch ON		1.2		GHz
I_{LOSS}	Insertion loss	R_L = 50 Ω f = 1 MHz Refer to Bandwidth Figure	Switch ON		–0.12		dB

Copyright © 2019–2020, Texas Instruments Incorporated

6.7 Timing Requirements

V_{DD} = 1.5 V to 5.5 V, GND = 0V, T_A = –40°C to +125°C
Typical values are at V_{DD} = 3.3 V, T_A = 25°C, (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
t_{TRAN}	Transition time from control input	V_{DD} = 2.5 V to 5.5 V V_S = V_{DD} R_L = 200 Ω, C_L = 15 pF Refer to Transition Timing Figure		160	350	ns
t_{TRAN}	Transition time from control input	V_{DD} < 2.5 V V_S = V_{DD} R_L = 200 Ω, C_L = 15 pF Refer to Transition Timing Figure		180	580	ns
$t_{ON(EN)}$	Device turn on time from enable pin	V_S = V_{DD} R_L = 200 Ω, C_L = 15 pF Refer to Ton(EN) & Toff(EN) Figure		12	35	µs
$t_{OFF(EN)}$	Device turn off time from enable pin	V_S = V_{DD} R_L = 200 Ω, C_L = 15 pF Refer to Ton(EN) & Toff(EN) Figure		50	95	ns
$t_{ON(VDD)}$	Device turn on time (V_{DD} to output)	V_S = 3.6 V V_{DD} rise time = 1us R_L = 200 Ω, C_L = 15 pF Refer to Ton(vdd) & Toff(vdd) Figure		20	60	µs
$t_{OFF(VDD)}$	Device turn off time (V_{DD} to output)	V_S = 3.6 V V_{DD} fall time = 1us R_L = 200 Ω, C_L = 15 pF Refer to Ton(vdd) & Toff(vdd) Figure		1.2	2.7	µs
$t_{OPEN\ (BBM)}$	Break before make time	V_S = 1 V R_L = 200 Ω, C_L = 15 pF Refer to Topen(BBM) Figure	0.5			ns
$t_{SK(P)}$	Inter - channel skew - SOT-23 (DYY)	Refer to Tsk Figure		10		ps
$t_{SK(P)}$	Inter - channel skew - TSSOP (PW)	Refer to Tsk Figure		18		ps
t_{PD}	Propagation delay - SOT-23 (DYY)	Refer to Tpd Figure		78		ps
t_{PD}	Propagation delay - TSSOP (PW)	Refer to Tpd Figure		95		ps

Copyright © 2019–2020, Texas Instruments Incorporated

6.8 Typical Characteristics

At T_A = 25°C, V_{DD} = 3.3 V (unless otherwise noted).

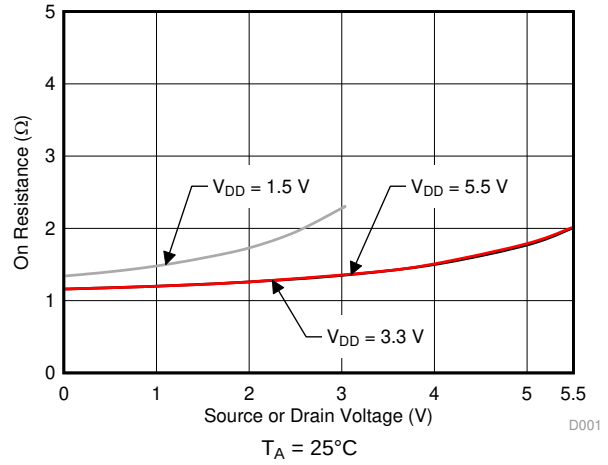


Figure 1. On-Resistance vs Source or Drain Voltage

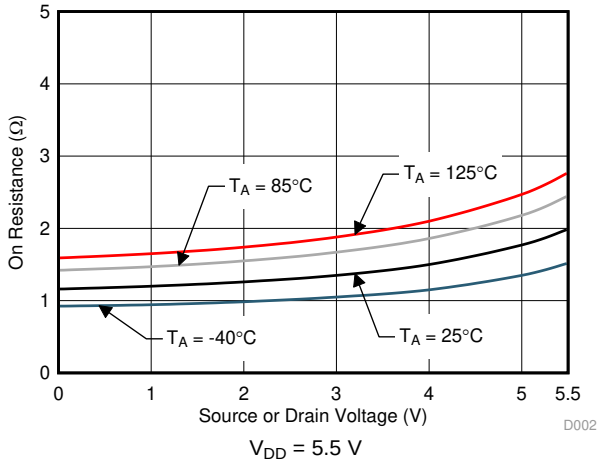


Figure 2. On-Resistance vs Source or Drain Voltage

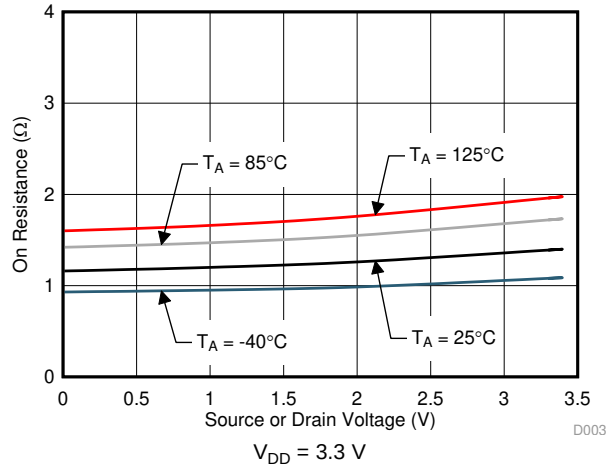


Figure 3. On-Resistance vs Source or Drain Voltage

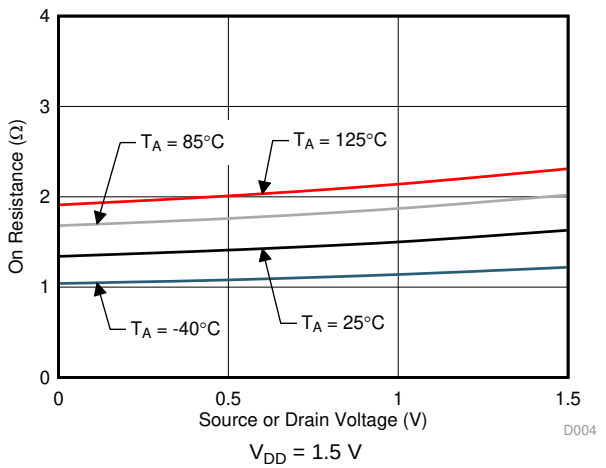


Figure 4. On-Resistance vs Source or Drain Voltage

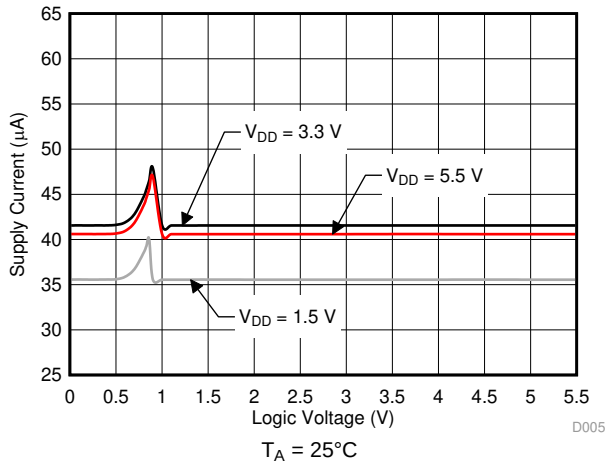


Figure 5. Supply Current vs Logic Voltage

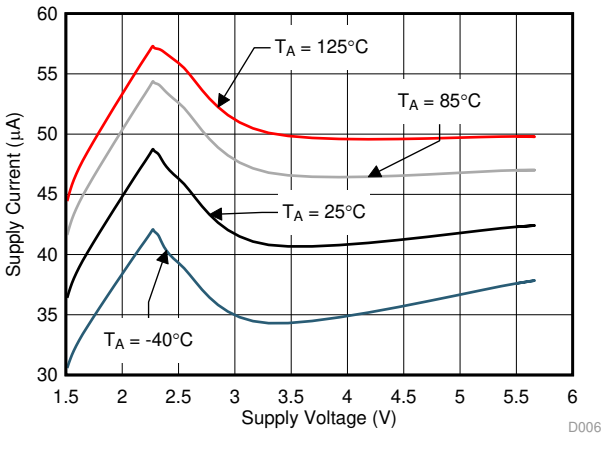
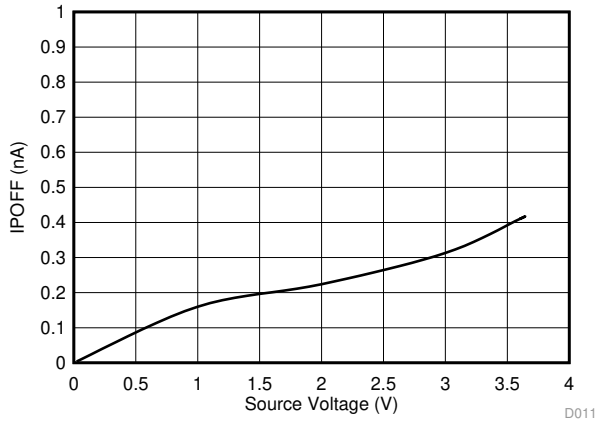


Figure 6. Supply Current vs Supply Voltage

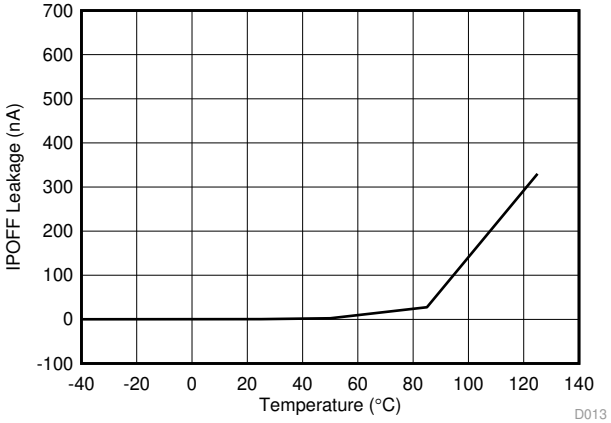
Copyright © 2019–2020, Texas Instruments Incorporated

Typical Characteristics (continued)



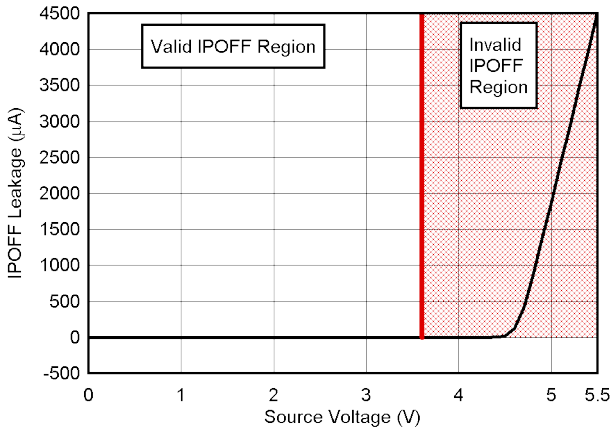
T_A = 25°C

Figure 7. IPOFF Leakage vs Source or Drain Voltage



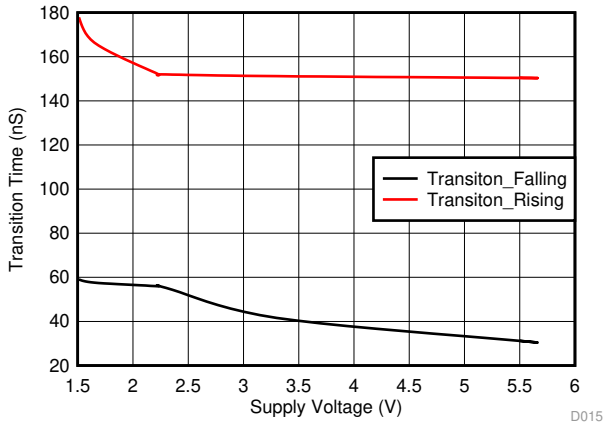
V_{Source} = 3.6 V
V_{Drain} = 0 V

Figure 8. IPOFF Leakage vs Temperature



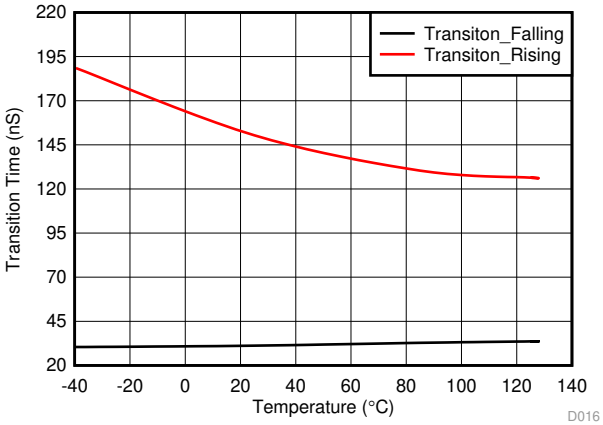
T_A = 25°C
R_L = 200 Ω

Figure 9. IPOFF Leakage vs Source or Drain Voltage



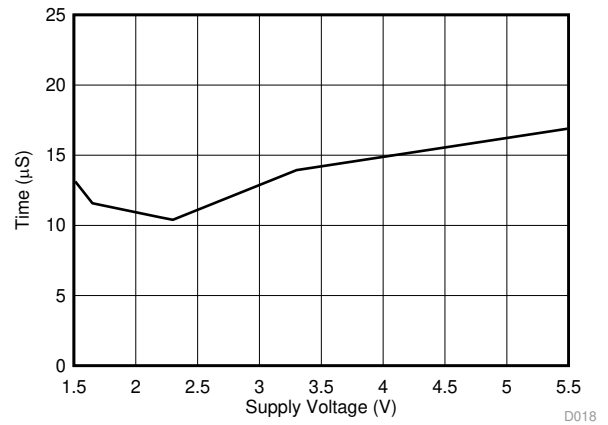
T_A = 25°C

Figure 10. $T_{TRANSITION}$ vs Supply Voltage



V_{DD} = 5.5 V

Figure 11. $T_{TRANSITION}$ vs Temperature

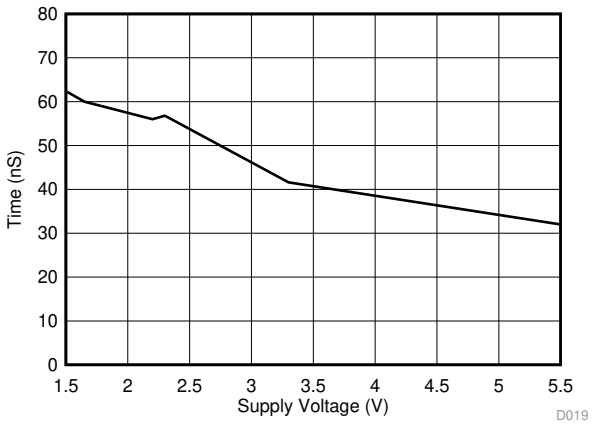


T_A = 25°C

Figure 12. $T_{ON\ (EN)}$ vs Supply Voltage

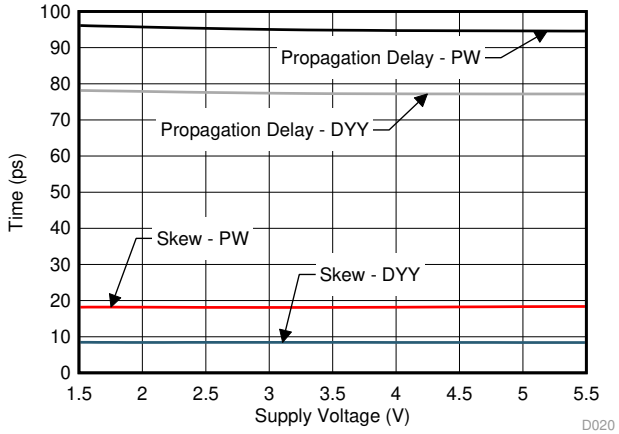
Copyright © 2019–2020, Texas Instruments Incorporated

Typical Characteristics (continued)



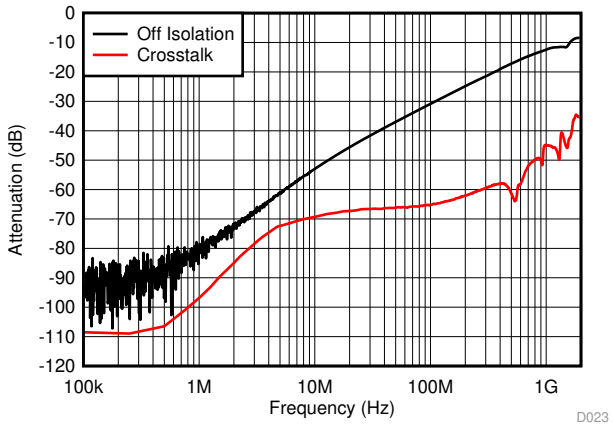
T_A = 25°C

Figure 13. $T_{OFF\ (EN)}$ vs Supply Voltage



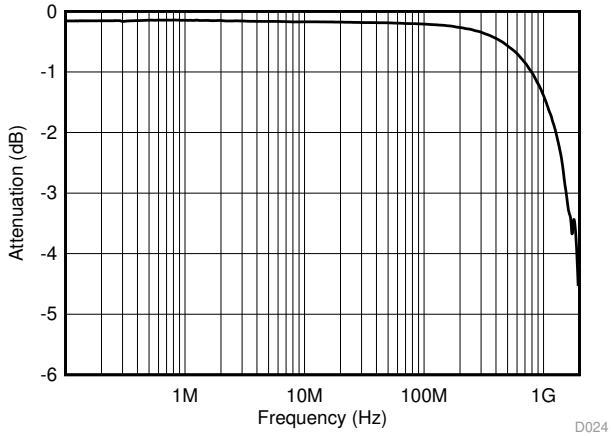
T_A = 25°C

Figure 14. Skew and Propagation Delay vs Supply Voltage



T_A = 25°C
V_{DD} = 3.3 V

Figure 15. Off Isolation and Crosstalk vs Frequency



T_A = 25°C
V_{DD} = 1.5 V to 5.5 V

Figure 16. On-Response vs Frequency

Copyright © 2019–2020, Texas Instruments Incorporated

7 Parameter Measurement Information

7.1 On-Resistance

The on-resistance of a device is the ohmic resistance between the source (Sx) and drain (Dx) 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 in Figure 17. Voltage (V) and current (I_{SD}) are measured using this setup, and R_{ON} is computed as shown below with $R_{ON} = V / I_{SD}$:

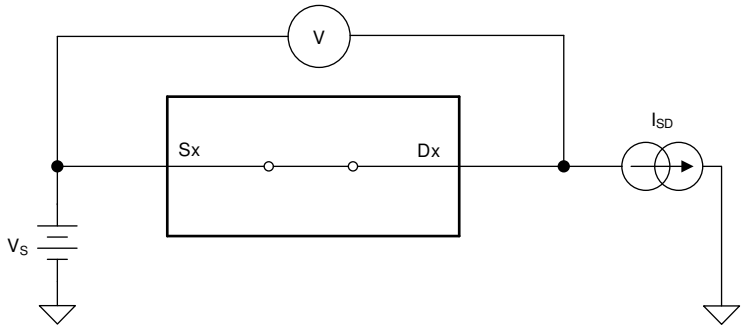


Figure 17. On-Resistance Measurement Setup

7.2 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 $I_{D\ (OFF)}$.

The setup used to measure both off-leakage currents is shown in Figure 18.

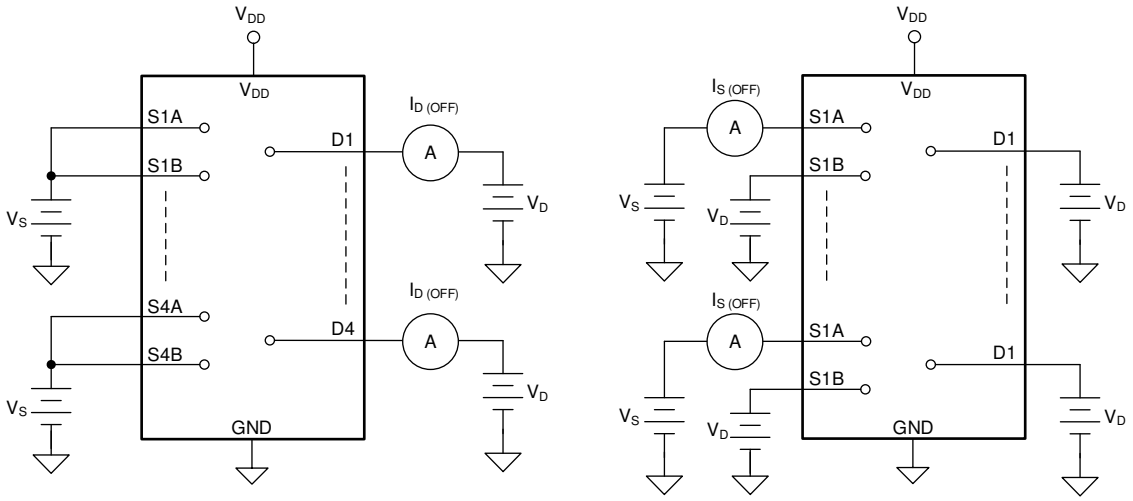


Figure 18. Off-Leakage Measurement Setup

7.3 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. Figure 19 shows the circuit used for measuring the on-leakage current, denoted by $I_{S(ON)}$ or $I_{D(ON)}$.

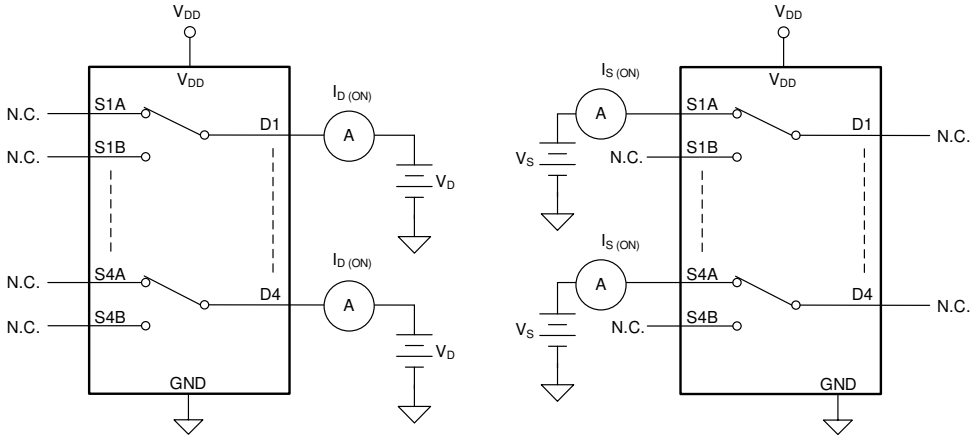


Figure 19. On-Leakage Measurement Setup

7.4 I_{POFF} Leakage Current

I_{POFF} leakage current is defined as the leakage current flowing into or out of the source pin when the device is powered off. This current is denoted by the symbol I_{POFF}.

The setup used to measure both I_{POFF} leakage current is shown in Figure 20.

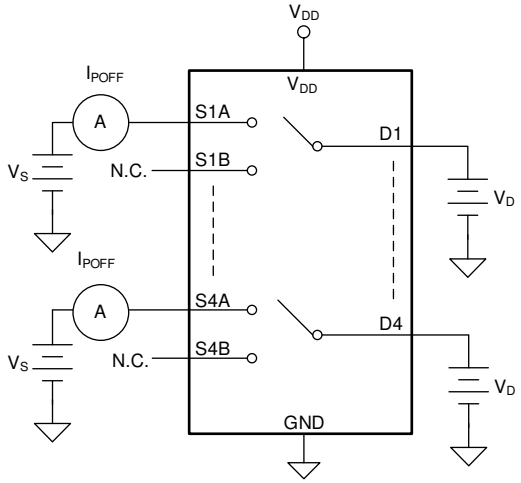


Figure 20. I_{POFF} Leakage Measurement Setup

Copyright © 2019–2020, Texas Instruments Incorporated

7.5 Transition Time

Transition time is defined as the time taken by the output of the device to rise or fall 10% after the select signal has risen or fallen past the logic threshold. The 10% transition measurement is utilized to provide the timing of the device. The time constant from the load resistance and load capacitance can be added to the transition time to calculate system level timing. Figure 21 shows the setup used to measure transition time, denoted by the symbol $t_{TRANSITION}$.

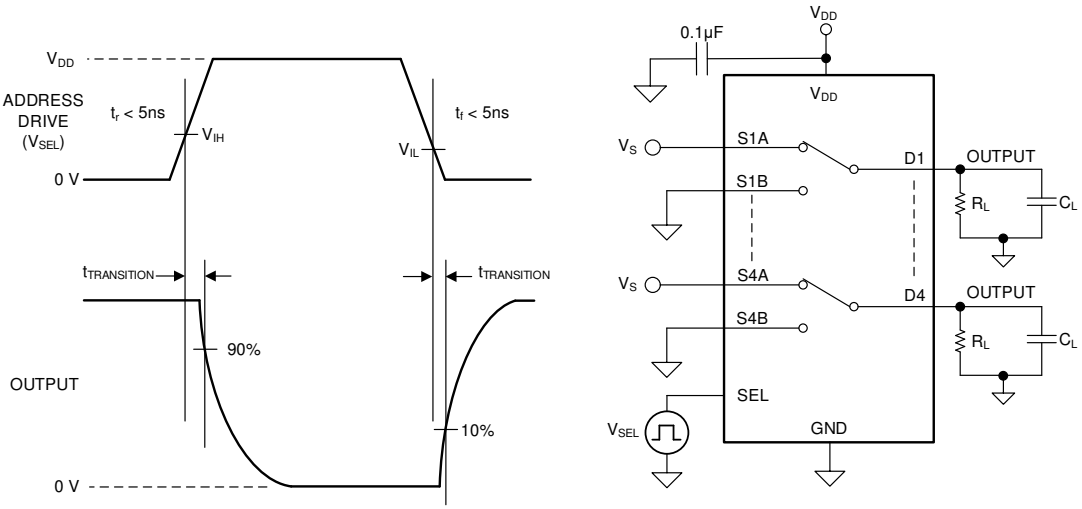


Figure 21. Transition-Time Measurement Setup

7.6 $t_{ON\ (EN)}$ and $t_{OFF\ (EN)}$ Time

The $t_{ON\ (EN)}$ time is defined as the time taken by the output of the device to rise to 90% after the enable has fallen past the logic threshold. The 90% measurement is used to provide the timing of the device being enabled in the system. Figure 22 shows the setup used to measure the enable time, denoted by the symbol $t_{ON\ (EN)}$.

The $t_{OFF\ (EN)}$ time is defined as the time taken by the output of the device to fall to 90% after the enable has fallen past the logic threshold. The 90% measurement is used to provide the timing of the device being disabled in the system. Figure 22 shows the setup used to measure enable time, denoted by the symbol $t_{OFF\ (EN)}$.

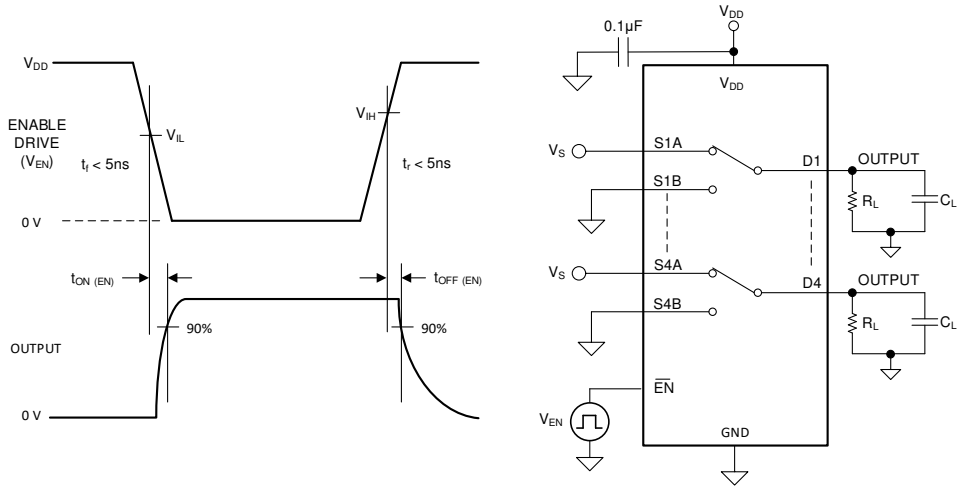


Figure 22. $t_{ON\ (EN)}$ and $t_{OFF\ (EN)}$ Time Measurement Setup

7.7 $t_{ON\ (VDD)}$ and $t_{OFF\ (VDD)}$ Time

The $t_{ON\ (VDD)}$ time is defined as the time taken by the output of the device to rise to 90% after the supply has risen past the supply threshold. The 90% measurement is used to provide the timing of the device turning on in the system. Figure 23 shows the setup used to measure turn on time, denoted by the symbol $t_{ON\ (VDD)}$.

The $t_{OFF\ (VDD)}$ time is defined as the time taken by the output of the device to fall to 90% after the supply has fallen past the supply threshold. The 90% measurement is used to provide the timing of the device turning off in the system. Figure 23 shows the setup used to measure turn off time, denoted by the symbol $t_{OFF\ (VDD)}$.

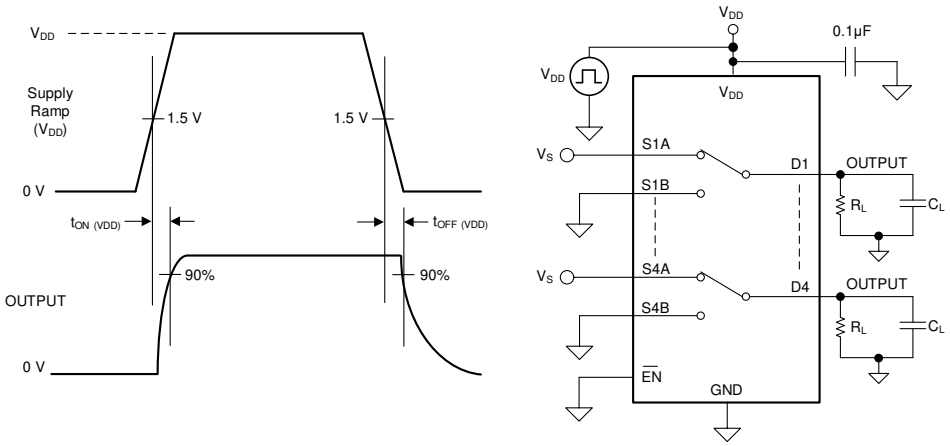


Figure 23. $t_{ON\ (VDD)}$ and $t_{OFF\ (VDD)}$Time Measurement Setup

7.8 Break-Before-Make Delay

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. Figure 24 shows the setup used to measure break-before-make delay, denoted by the symbol $t_{OPEN(BBM)}$.

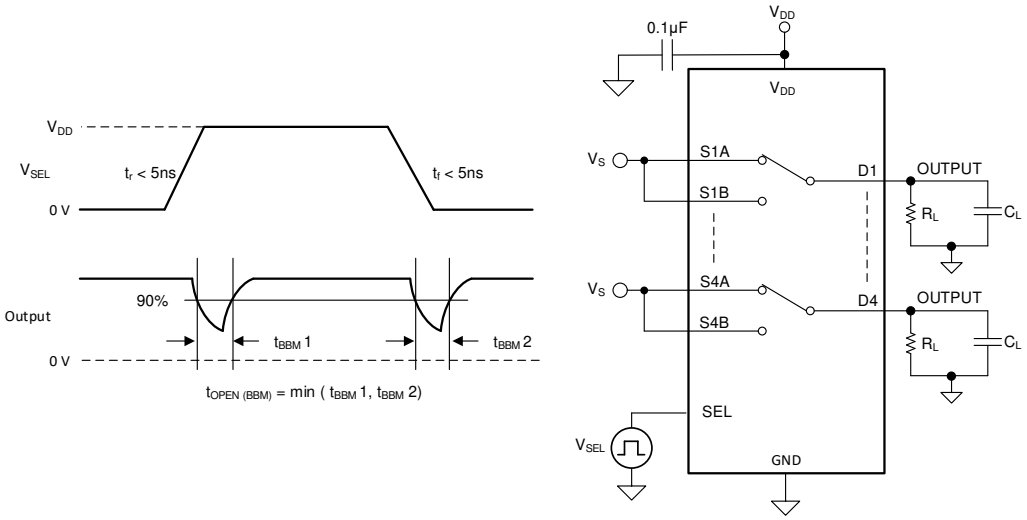


Figure 24. Break-Before-Make Delay Measurement Setup

Copyright © 2019–2020, Texas Instruments Incorporated

7.9 Propagation Delay

Propagation delay is defined as the time taken by the output of the device to rise or fall 50% after the input signal has risen or fallen past the 50% threshold. Figure 25 shows the setup used to measure propagation delay, denoted by the symbol t_{PD}.

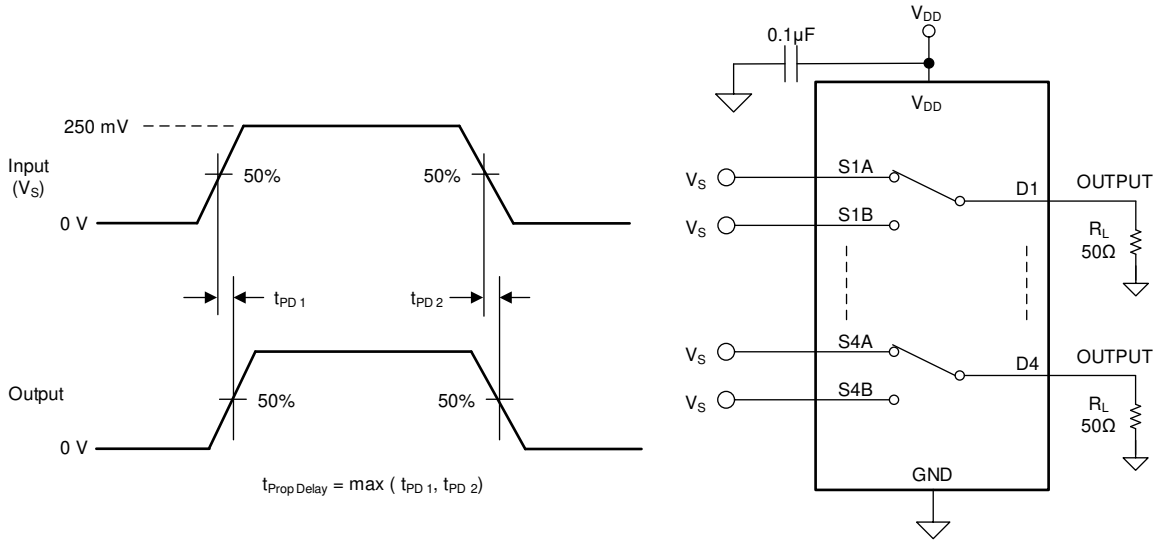


Figure 25. Propagation Delay Measurement Setup

7.10 Skew

Skew is defined as the difference between propagation delays of any two outputs of the same device. The skew measurement is taken from the output of one channel rising or falling past 50% to a second channel rising or falling past the 50% threshold when the input signals are switched at the same time. Figure 26 shows the setup used to measure skew, denoted by the symbol t_{SK}.

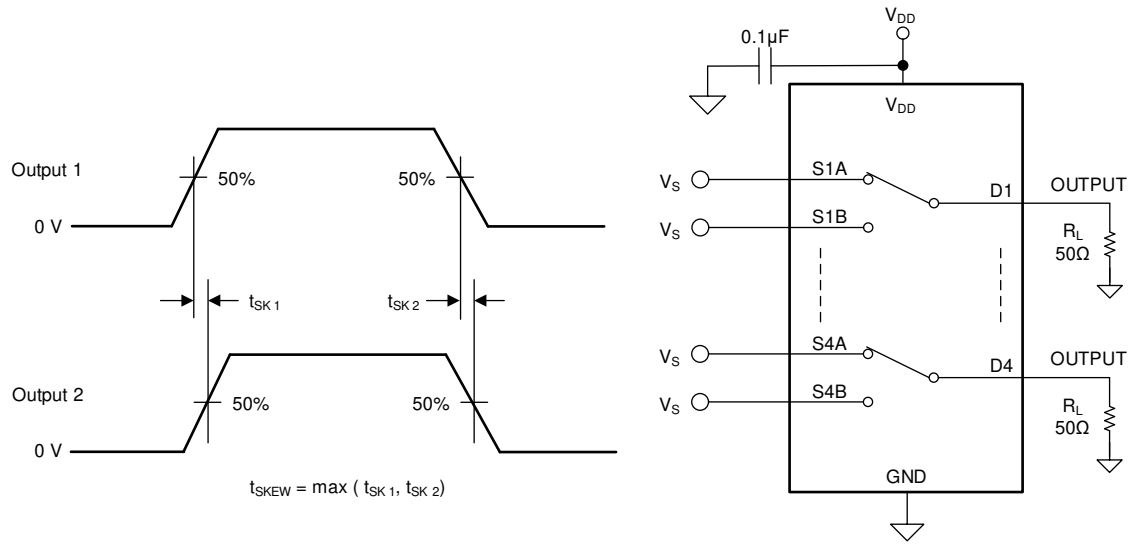


Figure 26. Skew Measurement Setup

7.11 Charge Injection

The amount of charge injected into the source or drain of the device during the falling or rising edge of the gate signal is known as charge injection, and is denoted by the symbol Q_C. Figure 27 shows the setup used to measure charge injection from source (Sx) to drain (Dx).

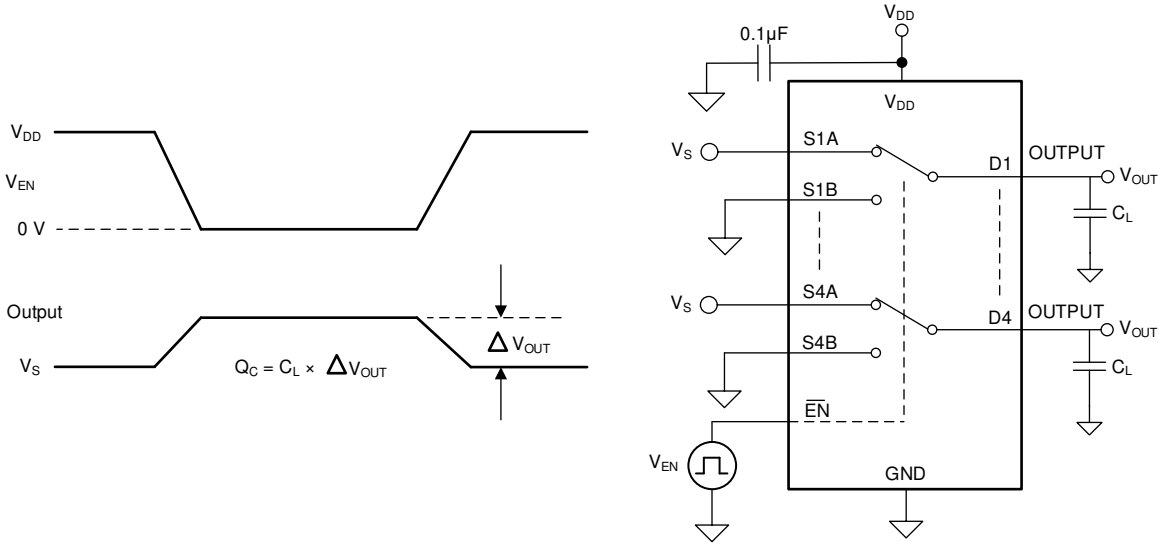


Figure 27. Charge-Injection Measurement Setup

7.12 Capacitance

The parasitic capacitance of the device is captured at the source (Sx), drain (Dx), and select (SELx) pins. The capacitance is measured in both the ON and OFF state and is denoted by the symbol C_{ON} and C_{OFF}. Figure 28 shows the setup used to measure capacitance.

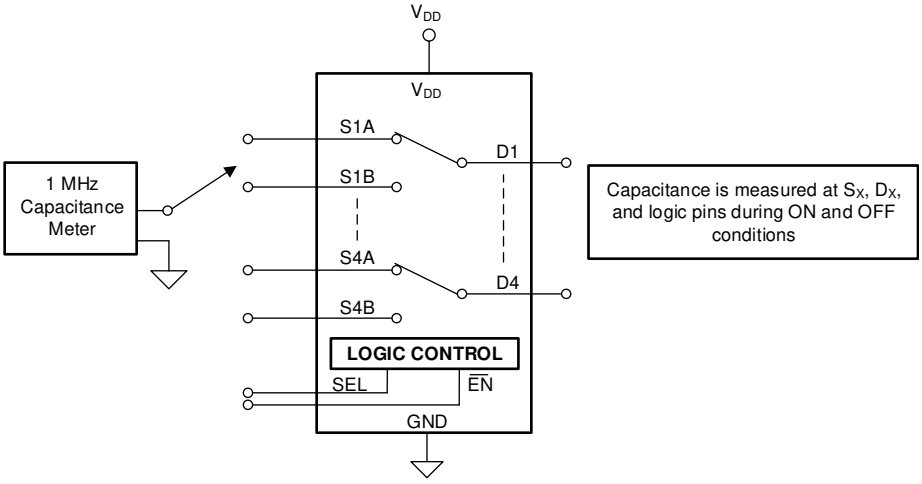


Figure 28. Capacitance Measurement Setup

Copyright © 2019–2020, Texas Instruments Incorporated

7.13 Off Isolation

Off isolation is defined as the ratio of the signal at the drain pin (Dx) of the device when a signal is applied to the source pin (Sx) of an off-channel. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 29 shows the setup used to measure off isolation. Use off isolation equation to compute off isolation.

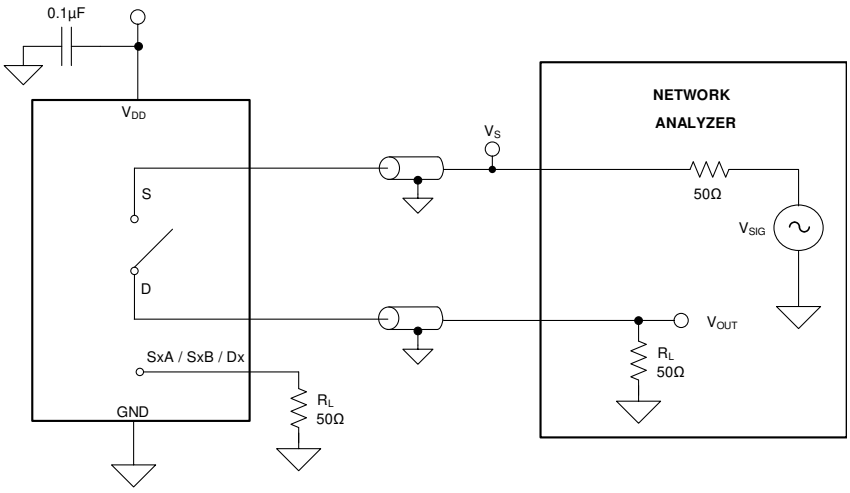


Figure 29. Off Isolation Measurement Setup

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

7.14 Channel-to-Channel Crosstalk

Crosstalk is defined as the ratio of the signal at the drain pin (Dx) of a different channel, when a signal is applied at the source pin (Sx) of an on-channel. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 30 shows the setup used to measure, and the equation used to compute crosstalk.

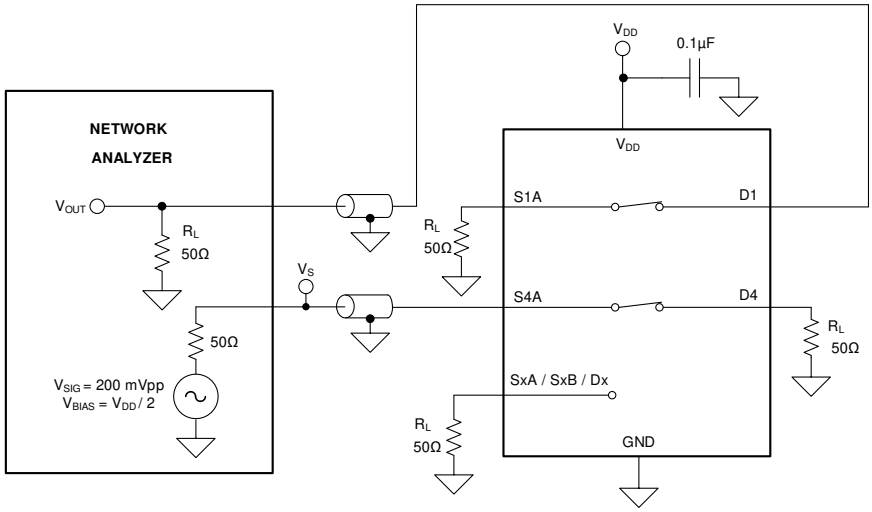


Figure 30. Channel-to-Channel Crosstalk Measurement Setup

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

Copyright © 2019–2020, Texas Instruments Incorporated

7.15 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 (Dx) of the device. The characteristic impedance, Z_0, for the measurement is 50 Ω. Figure 31 shows the setup used to measure bandwidth.

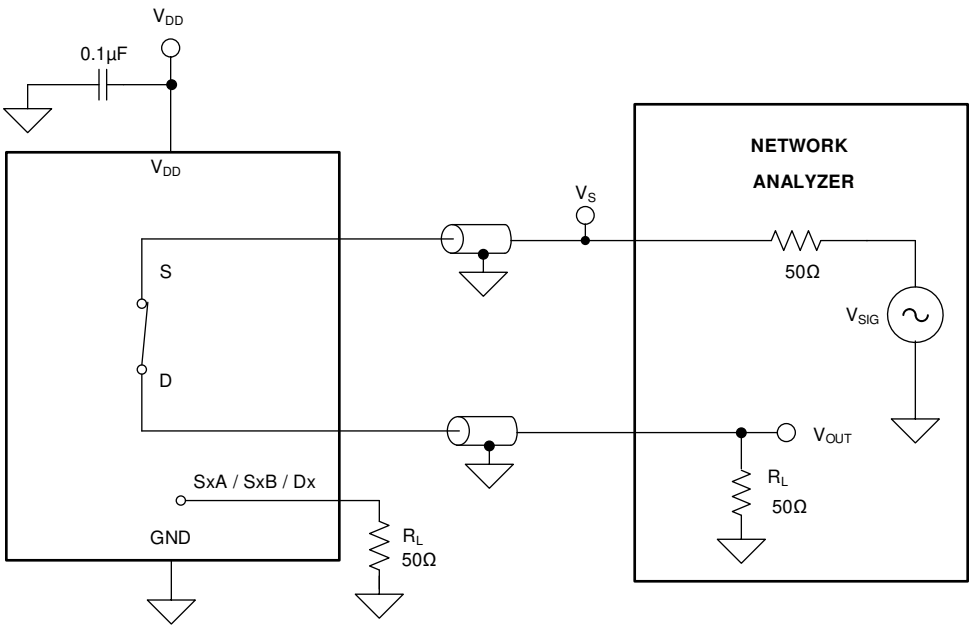


Figure 31. Bandwidth Measurement Setup

$$Attenuation = 20 \times Log\left(\frac{V_{OUT}}{V_S}\right) \quad (3)$$

Copyright © 2019–2020, Texas Instruments Incorporated

8 Detailed Description

8.1 Overview

The SN3257-Q1 is an automotive qualified 2:1 (SPDT) 4-channel switch with powered-off protection up to 3.6 V. Wide operating supply of 1.5 V to 5.5 V allows for use in applications where different supply voltages are available. The device supports bidirectional analog and digital signals on the source (SxA, SxB) and drain (Dx) pins. The wide bandwidth of this switch allows little or no attenuation of high-speed signals with minimum propagation delay.

The enable ($\overline{EN}$) pin is an active-low logic pin that controls the connection between the source (SxA, SxB) and drain (Dx) pins of the device. The select pin (SEL) controls the state of all four channels of the SN3257-Q1 and determines which source pin is connected to the drain. Fail-Safe Logic circuitry allows voltages on the logic control pins to be applied before the supply pin, protecting the device from potential damage. All logic control inputs have 1.8 V logic compatible thresholds, ensuring both TTL and CMOS logic compatibility when operating in the valid supply voltage range.

Powered-off protection up to 3.6 V on the signal path of the SN3257-Q1 provides isolation when the supply voltage is removed (V_{DD} = 0 V). Without this protection feature, the system can back-power the supply rail through an internal ESD diode and cause potential damage to the system.

8.2 Functional Block Diagram

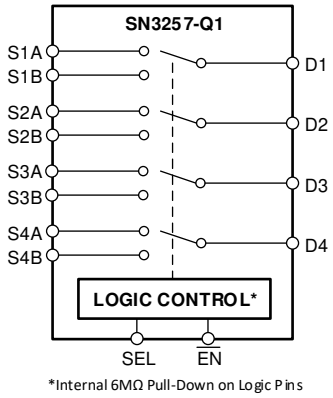


Figure 32. SN3257-Q1 Functional Block Diagram

8.3 Feature Description

8.3.1 Bidirectional Operation

The SN3257-Q1 conducts equally well from source (SxA, SxB) to drain (Dx) or from drain (Dx) to source (SxA, SxB). Each channel has very similar characteristics in both directions and supports both analog and digital signals.

8.3.2 Beyond Supply Operation

When the SN3257-Q1 is powered from 1.5 V to 5.5 V, the valid signal path input or output voltage ranges from GND to V_{DD} x 2, with a maximum input or output voltage of 5.5 V.

Example 1: If the SN3257-Q1 is powered at 1.5 V, the signal range is 0 V to 3 V.

Example 2: If the SN3257-Q1 is powered at 2.5 V, the signal range is 0 V to 5.0 V.

Example 2: If the SN3257-Q1 is powered at 3.6 V, the signal range is 0 V to 5.5 V.

Example 3: If the SN3257-Q1 is powered at 5.5 V, the signal range is 0 V to 5.5 V.

Other voltage levels not mentioned in the examples support Beyond Supply Operation as long as the supply voltage falls within the recommended operation conditions of 1.5 V to 5.5 V.

Copyright © 2019–2020, Texas Instruments Incorporated

Feature Description (continued)

8.3.3 1.8 V Logic Compatible Inputs

The SN3257-Q1 has 1.8-V logic compatible control inputs. Regardless of the V_{DD} voltage, the control input thresholds remain fixed, allowing a 1.8-V processor GPIO to control the SN3257-Q1 without the need for an external translator. This saves both space and BOM cost. For more information on 1.8 V logic implementations, refer to *Simplifying Design with 1.8 V logic Muxes and Switches.*

8.3.4 Powered-off Protection

Powered-off protection up to 3.6 V on the signal path of the SN3257-Q1 provides isolation when the supply voltage is removed (V_{DD} = 0 V). When the SN3257-Q1 is powered-off, the I/Os of the device remain in a high-Z state. Powered-off protection minimizes system complexity by removing the need for power supply sequencing on the signal path. The device performance remains within the leakage performance mentioned in the Electrical Specifications. For more information on powered-off protection, refer to *Eliminate Power Sequencing with Powered-off Protection Signal Switches*.

8.3.5 Fail-Safe Logic

The SN3257-Q1 has Fail-Safe Logic on the control input pins (SELx) which allows 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 SN3257-Q1 to be ramped to 5.5 V while V_{DD} = 0 V. Additionally, the feature enables operation of the SN3257-Q1 with V_{DD} = 1.5 V while allowing the select pins to interface with a logic level of another device up to 5.5 V.

8.3.6 Integrated Pull-Down Resistors

The SN3257-Q1 has internal weak pull-down resistors (6 MΩ) to GND to ensure the logic pins are not left floating. This feature integrates up to four external components and reduces system size and cost.

Copyright © 2019–2020, Texas Instruments Incorporated

8.4 Device Functional Modes

The enable ($\overline{EN}$) pin is an active-low logic pin that controls the connection between the source (SxA, SxB) and drain (Dx) pins of the device. When the enable pin is pulled high, all switches are turned off. When the enable pin is pulled low, the select pin controls the signal path selection. The select pin (SEL) controls the state of all four channels of the SN3257-Q1 and determines which source pin is connected to the drain pins. When the select pin is pulled low, the SxA pin conducts to the corresponding Dx pins. When the select pin is pulled high, the SxB pin conducts to the corresponding Dx pins. The SN3257-Q1 logic pins have internal weak pull-down resistors (6 MΩ) to GND so that it powers-on in a known state.

The SN3257-Q1 can be operated without any external components except for the supply decoupling capacitors. Unused logic control pins should be tied to GND or V_{DD} to ensure the device does not consume additional current as highlighted in *Implications of Slow or Floating CMOS Inputs*. Unused signal path inputs (SxA, SxB, or Dx) should be connected to GND.

8.4.1 Truth Tables

Table 1. SN3257-Q1 Truth Table

INPUTS		Selected Source Pins Connected To Drain Pins (Dx)
$\overline{EN}$	SEL	
0	0	S1A connected to D1 S2A connected to D2 S3A connected to D3 S4A connected to D4
0	1	S1B connected to D1 S2B connected to D2 S3B connected to D3 S4B connected to D4
1	X(1)	Hi-Z (OFF)

(1) X denotes *don't care*.

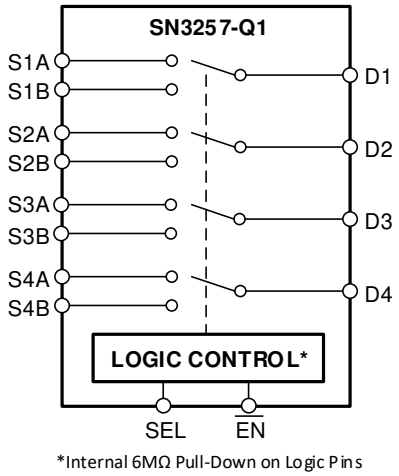


Figure 33. SN3257-Q1 Functional Block Diagram

9 Application and Implementation

NOTE

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.

9.1 Application Information

The SN3257-Q1 operates across a wide supply 1.5 V to 5.5 V and operating temperature range (–40°C to +125°C). The SN3257-Q1 supports a number of features that improve system performance such as 1.8 V logic compatibility, supports input voltages beyond supply, Fail-Safe Logic, and Powered-off Protection up to 3.6 V. These features reduce system complexity, board size, and overall system cost.

9.2 Typical Application

Common applications that require the features of the SN3257-Q1 include multiplexing various protocols from a possessor or MCU such as SPI, eMMC, I2S, or standard GPIO signals. The SN3257-Q1 provides superior isolation performance when the device is powered. The added benefit of powered-off protection allows a system to minimize complexity by eliminating the need for power sequencing in hot-swap and live insertion applications. The example shown in Figure 34 illustrates the use of the SN3257-Q1 to multiplex an SPI bus to multiple flash memory devices.

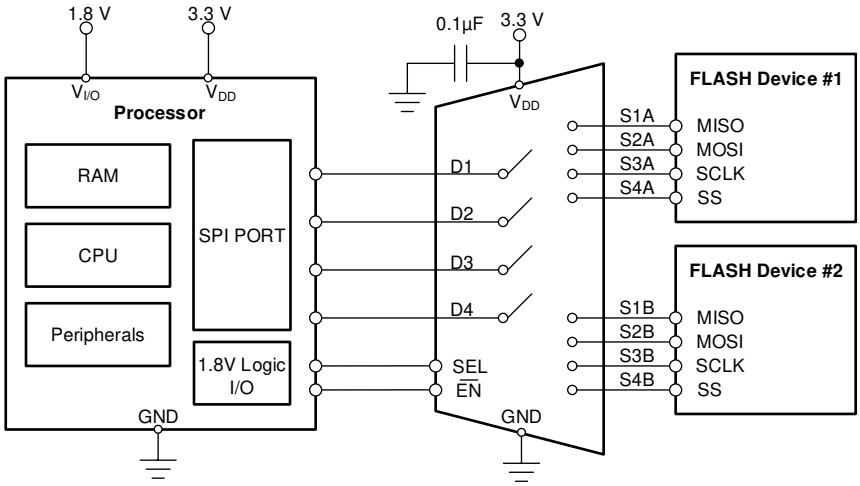


Figure 34. Multiplexing Flash Memory

9.2.1 Design Requirements

For this design example, use the parameters listed in Table 2.

Table 2. Design Parameters

PARAMETERS	VALUES
Supply (V_{DD})	3.3 V
Input and Output signals	0 V to 3.3 V SPI
Control logic thresholds	1.8 V compatible

Copyright © 2019–2020, Texas Instruments Incorporated

9.2.2 Detailed Design Procedure

The SN3257-Q1 can be operated without any external components except for the supply decoupling capacitors. The SN3257-Q1 has internal weak pull-down resistors (6 MΩ) to GND so that it powers-on with the switches in a known state. All inputs signals passing through the switch must fall within the recommended operating conditions of the SN3257-Q1 including signal range and continuous current. This design example can support SPI signals that range from 0 V to 3.3 V when the device is powered. This example can also utilize the Powered-off Protection feature and the inputs can range from 0 V to 3.6 V when V_{DD} = 0 V. The max continuous current can be 25 mA. Due to the voltage range and high speed capability, the SN3257-Q1 example is suitable for use in SPI, JTAG, and I2S applications.

9.2.3 Application Curves

Two important specifications when using a switch or multiplexer to pass signals are the device propagation delay and skew.

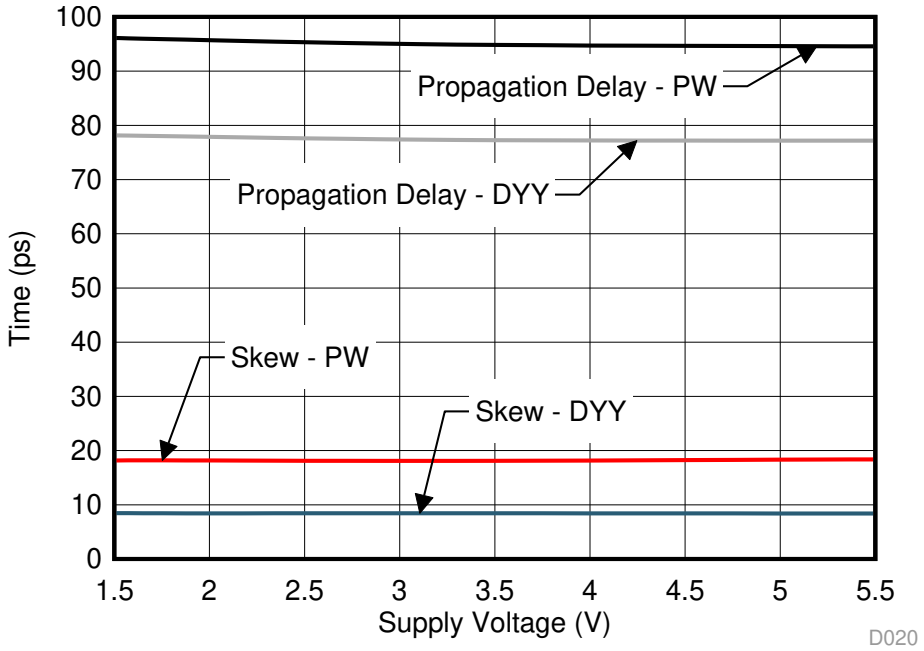


Figure 35. Propagation Delay and Skew Measurement

10 Power Supply Recommendations

The SN3257-Q1 operates across a wide supply range of 1.5 V to 5.5 V. 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 the 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.

Copyright © 2019–2020, Texas Instruments Incorporated

11 Layout

11.1 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 and therefore some traces must turn corners.Figure 36 shows progressively better techniques of rounding corners. Only the last example (BEST) maintains constant trace width and minimizes reflections.

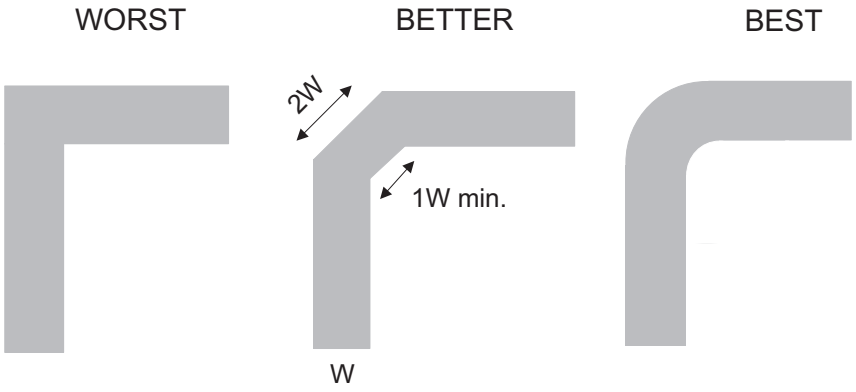


Figure 36. Trace Example

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

Do not route high speed signal traces under or near crystals, oscillators, clock signal generators, switching regulators, mounting holes, magnetic devices or ICs that use or duplicate clock signals.

Avoid stubs on the high-speed signals traces because they cause signal reflections.

Route all high-speed signal traces over continuous GND planes, with no interruptions.

Avoid crossing over anti-etch, commonly found with plane splits.

When working with high frequencies, a printed circuit board with at least four layers is recommended; two signal layers separated by a ground and power layer as shown in Figure 37.

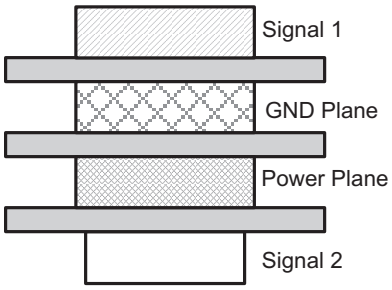


Figure 37. Example Layout

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.

Figure 38 illustrates an example of a PCB layout with the SN3257-Q1. Some key considerations are:

Copyright © 2019–2020, Texas Instruments Incorporated

Layout Guidelines (continued)

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.

High-speed switches require proper layout and design procedures for optimum performance.

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.

11.2 Layout Example

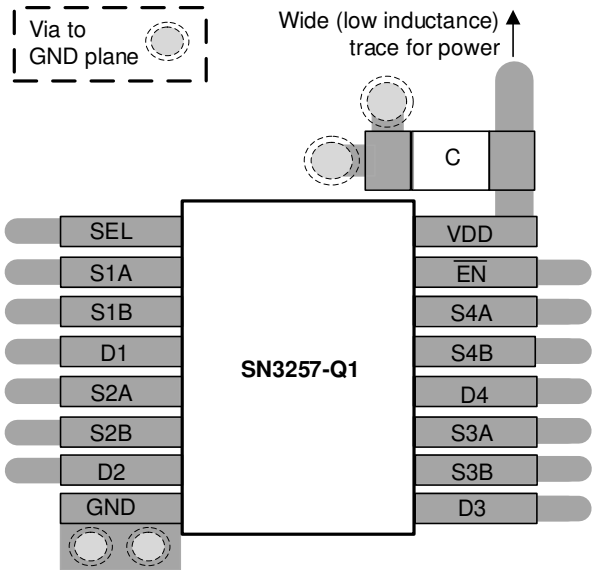


Figure 38. Example Layout

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

Texas Instruments, *Eliminate Power Sequencing with Powered-off Protection Signal Switches*.

Texas Instruments, *Simplifying Design with 1.8 V logic Muxes and Switches*.

Texas Instruments, *System-Level Protection for High-Voltage Analog Multiplexers*.

Texas Instruments, *Improve Stability Issues with Low CON Multiplexers*.

Texas Instruments, *High-Speed Interface Layout Guidelines*.

Texas Instruments, *High-Speed Layout Guidelines*.

12.2 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.

12.3 Community Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

12.4 Trademarks

E2E is a trademark of Texas Instruments.

12.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 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.

Copyright © 2019–2020, Texas Instruments Incorporated

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
SN3257QDYYRQ1	ACTIVE	SOT-23-THN	DYY	16	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	SN3257	Samples
SN3257QPWRQ1	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	SN3257	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.

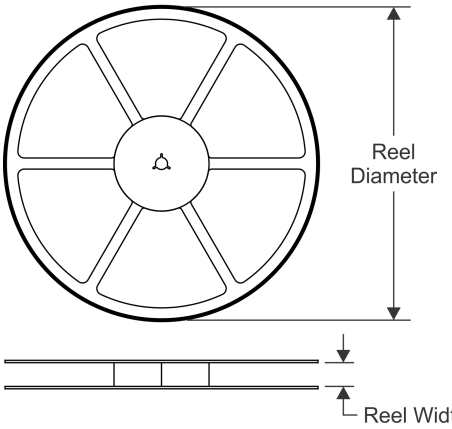
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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

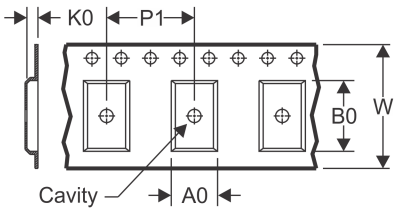
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

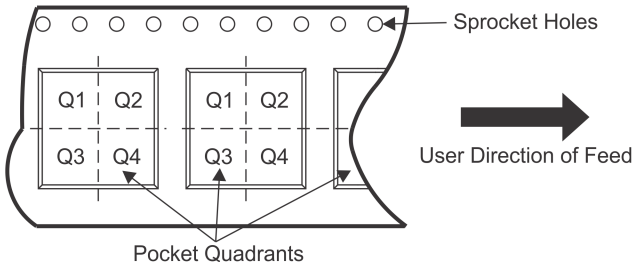


TAPE DIMENSIONS



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

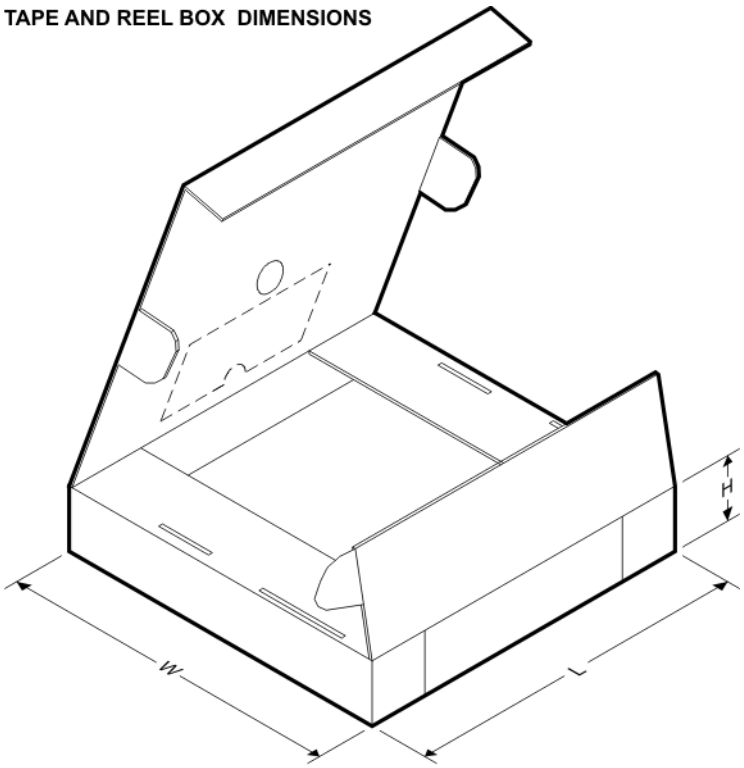
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN3257QDYYRQ1	SOT-23-THN	DYY	16	3000	330.0	12.4	4.8	3.6	1.6	8.0	12.0	Q3
SN3257QPWRQ1	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

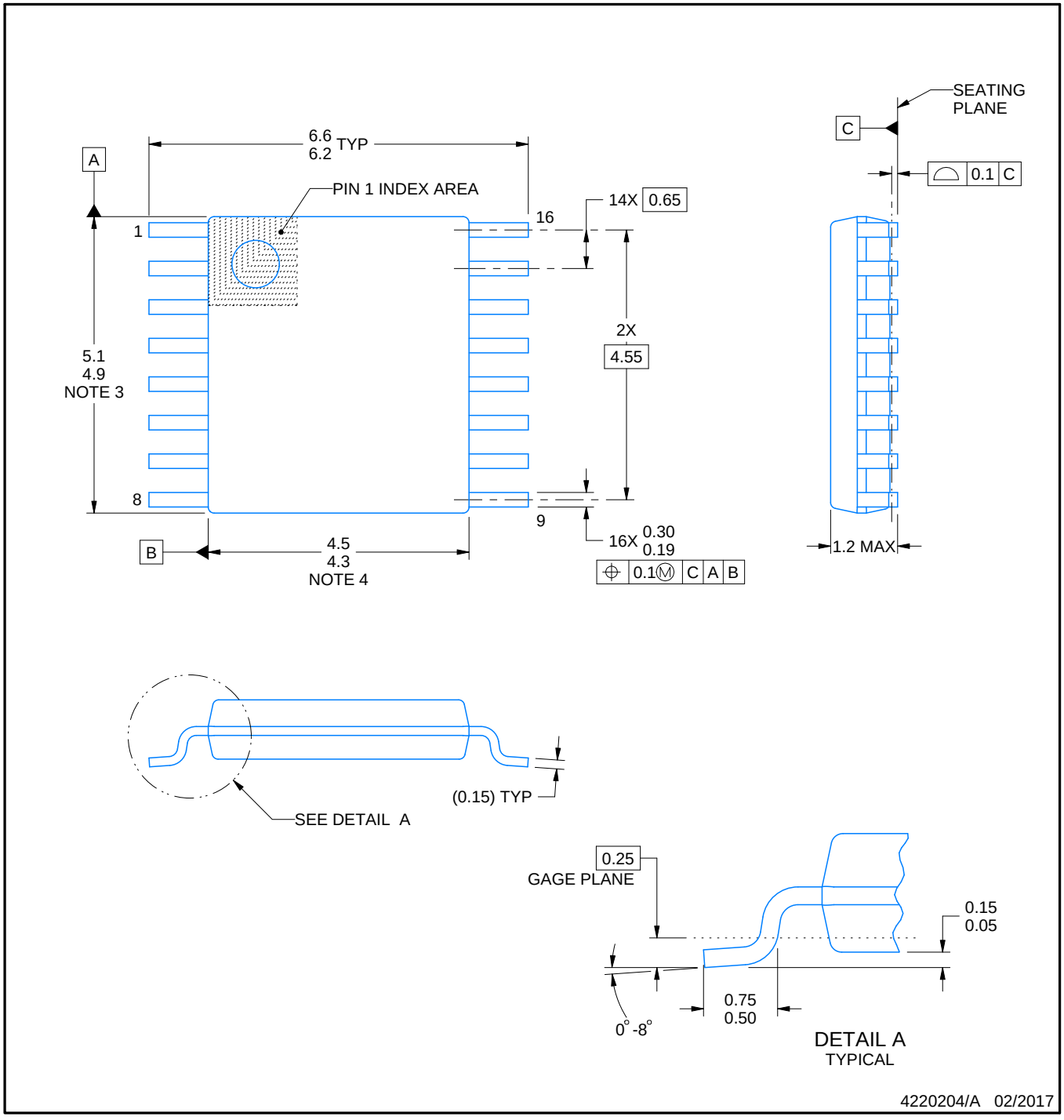
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN3257QDYYRQ1	SOT-23-THN	DYY	16	3000	336.6	336.6	31.8
SN3257QPWRQ1	TSSOP	PW	16	2000	853.0	449.0	35.0

PACKAGE OUTLINE

PW0016A

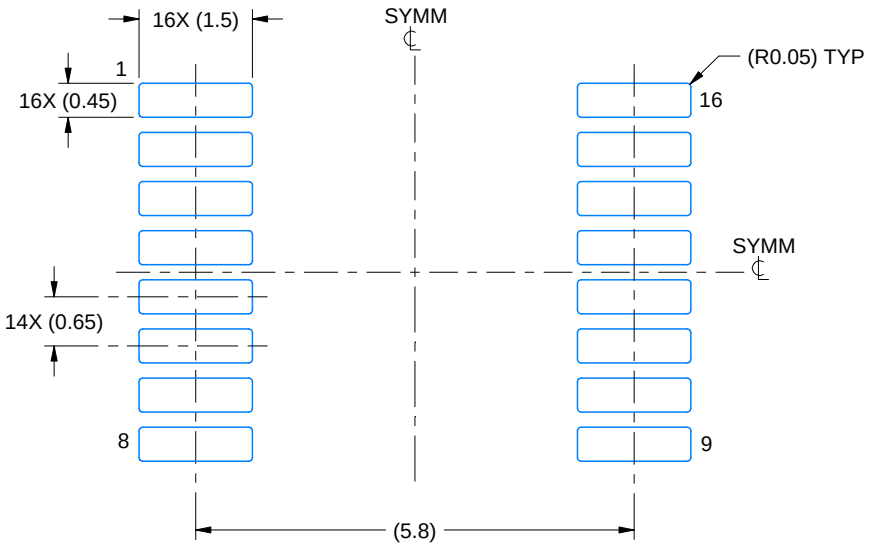
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

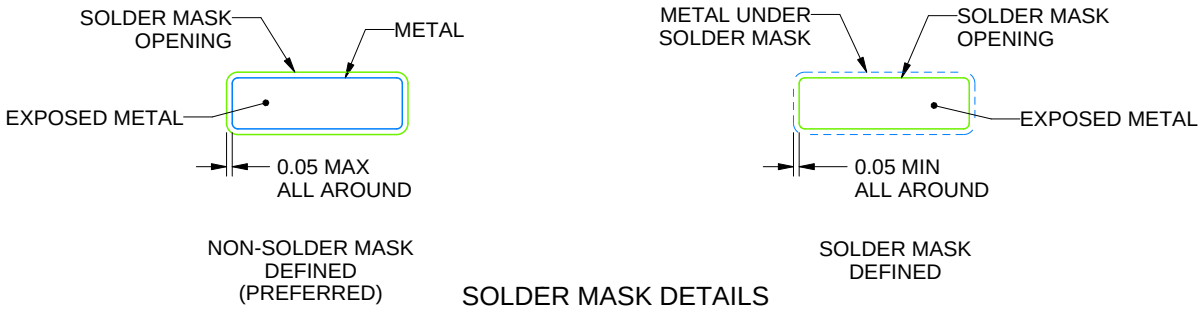


NOTES:

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

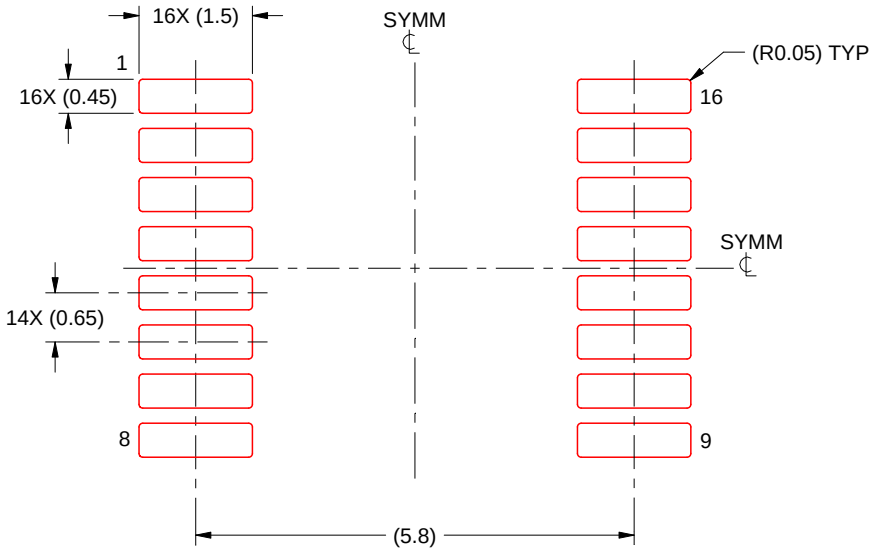


SOLDER MASK DETAILS

4220204/A 02/2017

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/A 02/2017

NOTES: (continued)

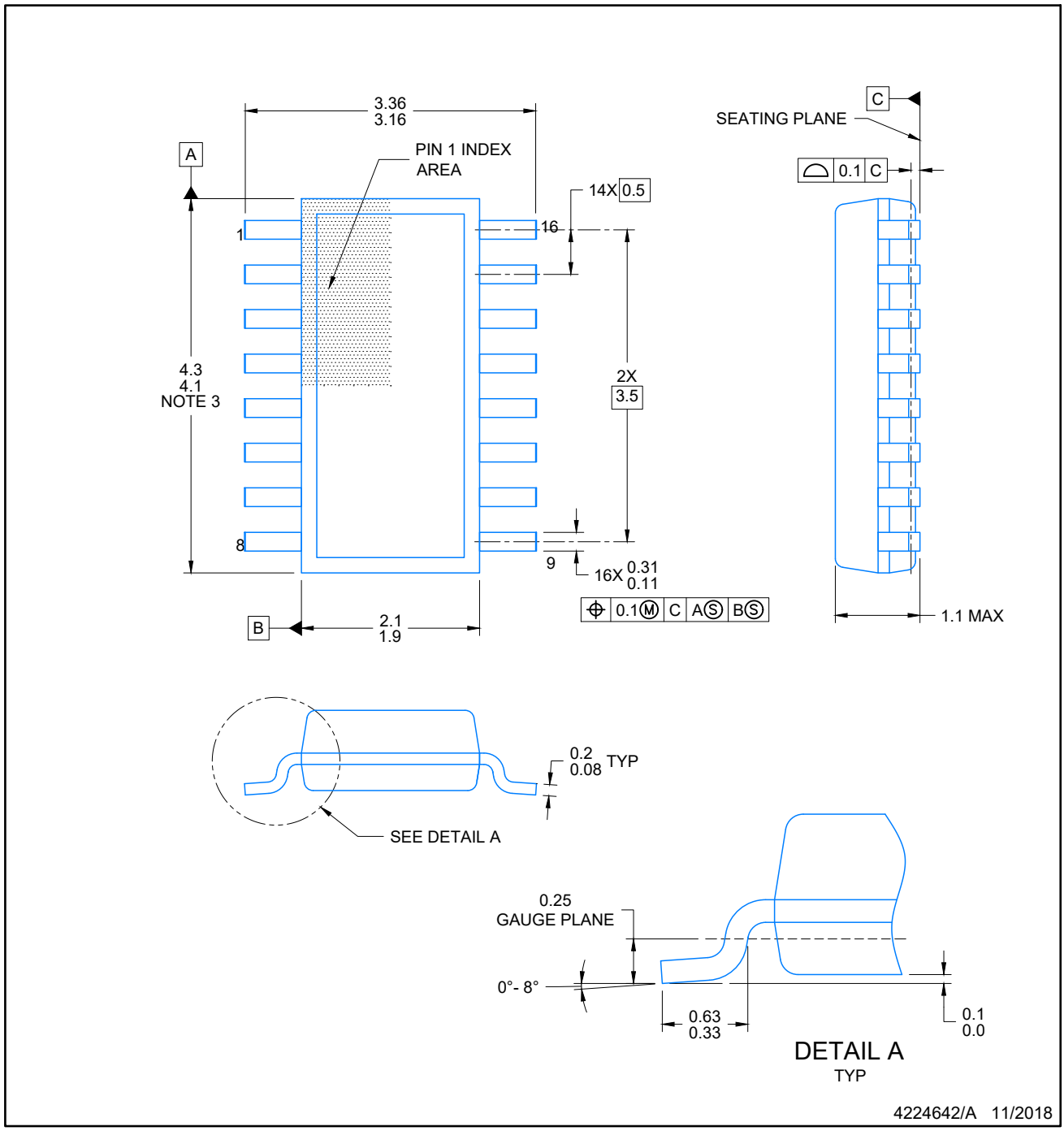
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

DYY0016A

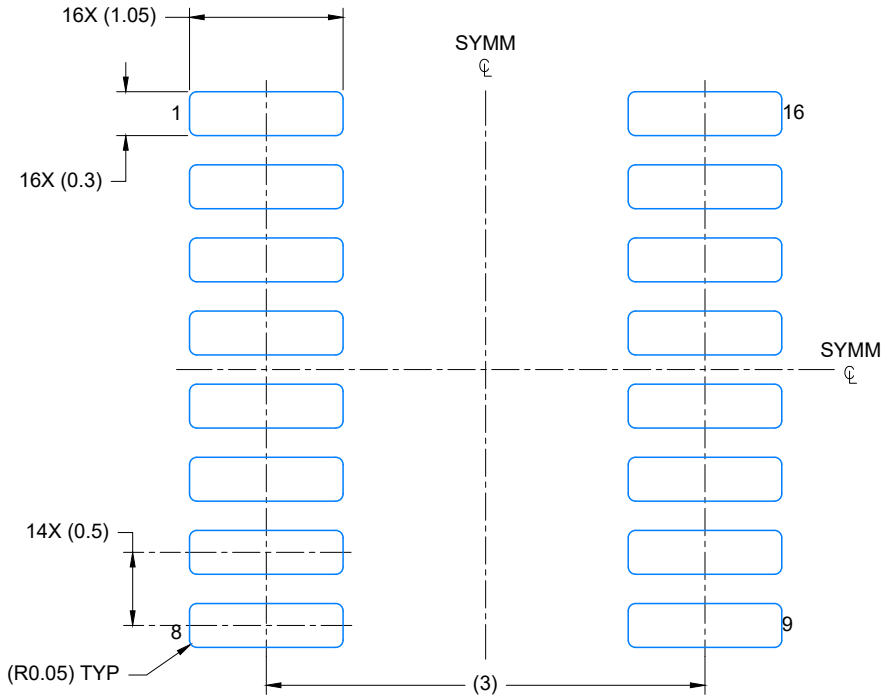
SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE

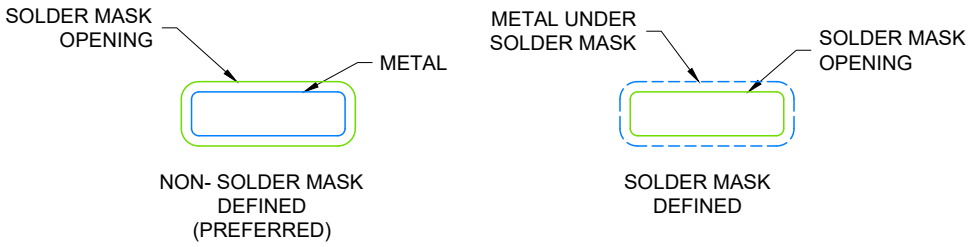


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



SOLDER MASK DETAILS

4224642/A 11/2018

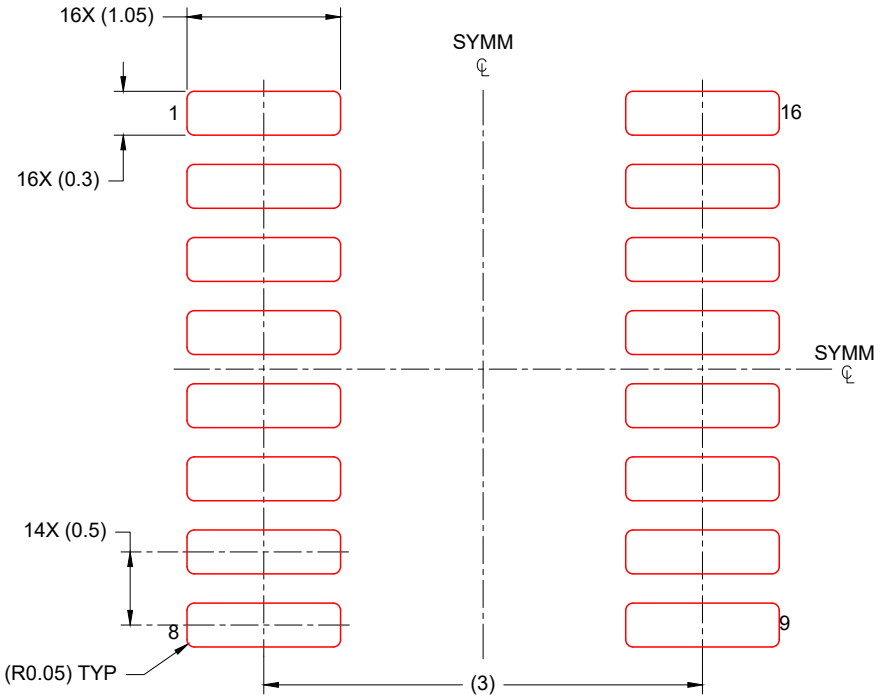
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. 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/A 11/2018

NOTES: (continued)

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2020, Texas Instruments Incorporated