

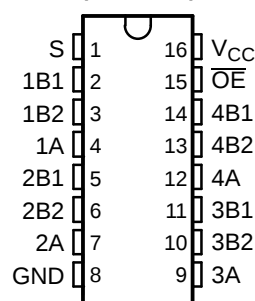
FEATURES

- Low and Flat ON-State Resistance (r_{on}) Characteristics Over Operating Range ($r_{on} = 3\ \Omega$ Typ)
- 0- to 10-V Switching on Data I/O Ports
- Bidirectional Data Flow With Near-Zero Propagation Delay
- Low Input/Output Capacitance Minimizes Loading and Signal Distortion ($C_{io(OFF)} = 20\text{ pF}$ Max, B Port)
- V_{CC} Operating Range From 4.75 V to 5.25 V
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
 - 2000-V Human-Body Model (A114-B, Class II)
 - 1000-V Charged-Device Model (C101)
- Supports Both Digital and Analog Applications

APPLICATIONS

- PCI Interface
- Differential Signal Interface
- Memory Interleaving
- Bus Isolation
- Low-Distortion Signal Gating

DBQ OR PW PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

The TS5N412 is a high-bandwidth FET bus switch utilizing a charge pump to elevate the gate voltage of the pass transistor, providing a low and flat ON-state resistance (r_{on}). The low and flat ON-state resistance allows for minimal propagation delay and supports rail-to-rail switching on the data input/output (I/O) ports. The device also features low data I/O capacitance to minimize capacitive loading and signal distortion on the data bus. Specifically designed to support high-bandwidth applications, the TS5N412 provides an optimized interface solution ideally suited for broadband communications, networking, and data-intensive computing systems.

The TS5N412 is a 4-bit 1-of-2 multiplexer/demultiplexer with a single output-enable ($\overline{OE}$) input. The select (S) inputs control the data path of the multiplexer/demultiplexer. When $\overline{OE}$ is low, the multiplexer/demultiplexer is enabled and the A port is connected to the B port, allowing bidirectional data flow between ports. When $\overline{OE}$ is high, the multiplexer/demultiplexer is disabled and a high-impedance state exists between the A and B ports.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} circuitry prevents damaging current backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down, $\overline{OE}$ should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

ORDERING INFORMATION

T_A	PACKAGE ⁽¹⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	SSOP (QSOP) – DBQ	Tape and reel	TS5N412DBQR	YB412
	TSSOP – PW	Tape and reel	TS5N412PWR	

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TS5N412

4-BIT 1-OF-2 FET MULTIPLEXER/DEMULTIPLEXER

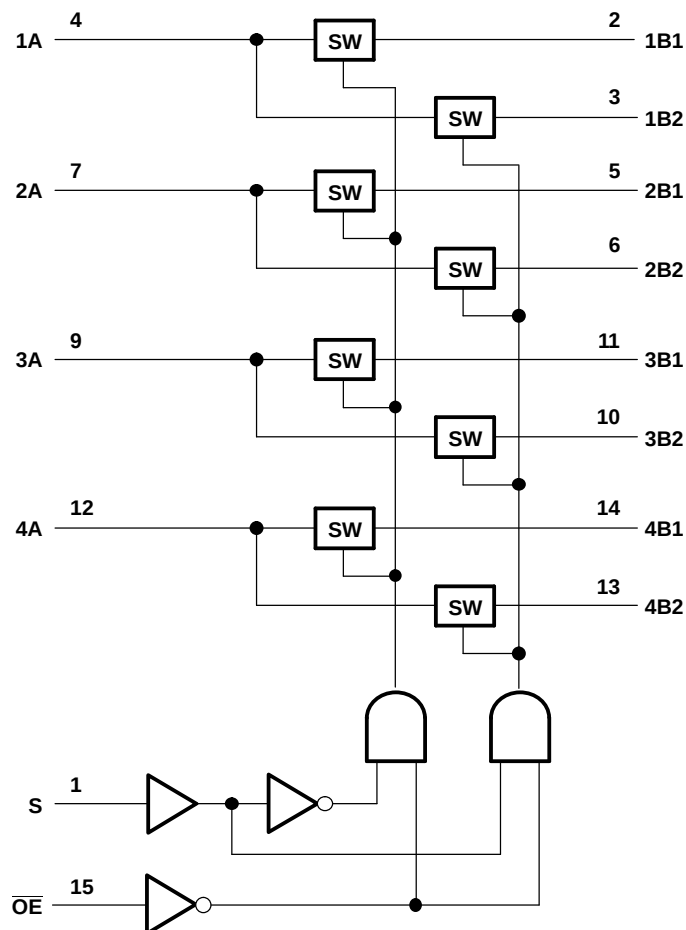
HIGH-BANDWIDTH BUS SWITCH

SCDS207–AUGUST 2005

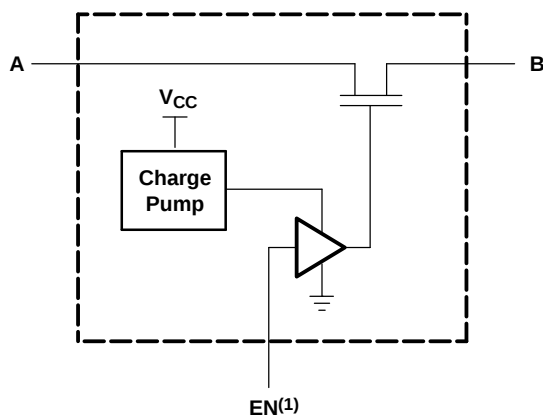
FUNCTION TABLE

INPUTS		INPUT/OUTPUT A	FUNCTION
$\overline{OE}$	S		
L	L	B1	A port = B1 port
L	H	B2	A port = B2 port
H	X	Z	Disconnect

LOGIC DIAGRAM (POSITIVE LOGIC)



SIMPLIFIED SCHEMATIC, EACH FET SWITCH (SW)



(1) EN is the internal enable signal applied to the switch.

Absolute Maximum Ratings⁽¹⁾

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage range	–0.5	7	V
V_{IN}	Control input voltage range ⁽²⁾⁽³⁾	–0.5	7	V
$V_{I/O}$	Switch I/O voltage range ⁽²⁾⁽³⁾⁽⁴⁾	–0.5	11	V
$I_{I/O}$	ON-state switch current ⁽⁵⁾		±100	mA
	Continuous current through V_{CC} or GND		±100	mA
θ_{JA}	Package thermal impedance ⁽⁶⁾	DBQ package		90
		PW package		108
				°C/W
T_{stg}	Storage temperature range	–65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to ground, unless otherwise specified.
- (3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (4) V_I and V_O are used to denote specific conditions for $V_{I/O}$.
- (5) I_I and I_O are used to denote specific conditions for $I_{I/O}$.
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions⁽¹⁾

		MIN	MAX	UNIT
V_{CC}	Supply voltage	4.75	5.25	V
V_{IH}	High-level control input voltage	2	5.25	V
V_{IL}	Low-level control input voltage	0	0.8	V
$V_{I/O}$	Data input/output voltage	0	10	V
T_A	Operating free-air temperature	–40	85	°C

- (1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

TS5N412

4-BIT 1-OF-2 FET MULTIPLEXER/DEMULTIPLEXER

HIGH-BANDWIDTH BUS SWITCH

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Electrical Characteristics⁽¹⁾

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

PARAMETER		TEST CONDITIONS		MIN	TYP ⁽²⁾	MAX	UNIT
I_{IN}	Control inputs	$V_{CC} = 5.25\text{ V}$,	$V_{IN} = 0\text{ to }V_{CC}$			10	μA
I_{OZ} ⁽³⁾		$V_{CC} = 5.25\text{ V}$,	$V_O = 0\text{ to }10\text{ V}$, $V_I = 0$,			10	μA
		$V_{CC} = 0\text{ V}$,	$V_O = \text{Open}$,			10	
I_{CC}		$V_{CC} = 5.25\text{ V}$,	$I_{I/O} = 0$, Switch ON or OFF,			10	mA
C_{in}	Control inputs	$V_{CC} = 5\text{ V}$,	$V_{IN} = 10\text{ V or }0$			10	pF
$C_{io(OFF)}$	A port	$V_{CC} = 5\text{ V}$,	Switch OFF, $V_{IN} = V_{CC}\text{ or GND}$,			35	pF
	B port	$V_{CC} = 5\text{ V}$,	Switch OFF, $V_{IN} = V_{CC}\text{ or GND}$,			20	
$C_{io(ON)}$		$V_{CC} = 5\text{ V}$,	Switch ON, $V_{IN} = V_{CC}\text{ or GND}$,			80	pF
r_{on} ⁽⁴⁾		$V_{CC} = 4.75\text{ V}$, TYP at $V_{CC} = 5\text{ V}$	$V_I = 0$,			3	Ω
			$V_I = 8\text{ V}$,			7.5	
			$V_I = 10\text{ V}$,			12.5	

- (1) V_{IN} and I_{IN} refer to control inputs. V_I , V_O , I_I , and I_O refer to data pins
- (2) All typical values are at $V_{CC} = 5\text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.
- (3) For I/O ports, the parameter I_{OZ} includes the I/O leakage current.
- (4) Measured by the voltage drop between the A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.

Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see [Figure 3](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 5\text{ V}$ $\pm 0.25\text{ V}$		UNIT
			MIN	MAX	
t_{pd} ⁽¹⁾	A or B	B or A		3	ns
$t_{pd(s)}$	S	A		200	ns
t_{en}	S	B		200	ns
	$\overline{OE}$	A or B		200	
t_{dis}	S	B		200	ns
	OE	A or B		200	

- (1) The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).

Dynamic Characteristics

over recommended operating free-air temperature range, $V_{CC} = 5\text{ V} \pm 5\%$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Bandwidth (BW) ⁽²⁾	$R_L = 50\ \Omega$, $V_I = 0.632\text{ V (P-P)}$, See Figure 4		25		MHz
OFF isolation (O_{ISO})	$R_L = 50\ \Omega$, $V_I = 0.632\text{ V (P-P)}$, $f = 25\text{ MHz}$, See Figure 5		–50		dB
Crosstalk (X_{TALK})	$R_L = 50\ \Omega$, $V_I = 0.632\text{ V (P-P)}$, $f = 25\text{ MHz}$, See Figure 6 and Figure 7		–50		dB

- (1) All typical values are at $V_{CC} = 5\text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.
- (2) Bandwidth is the frequency at which the gain is –3 dB below the DC gain.

TYPICAL PERFORMANCE

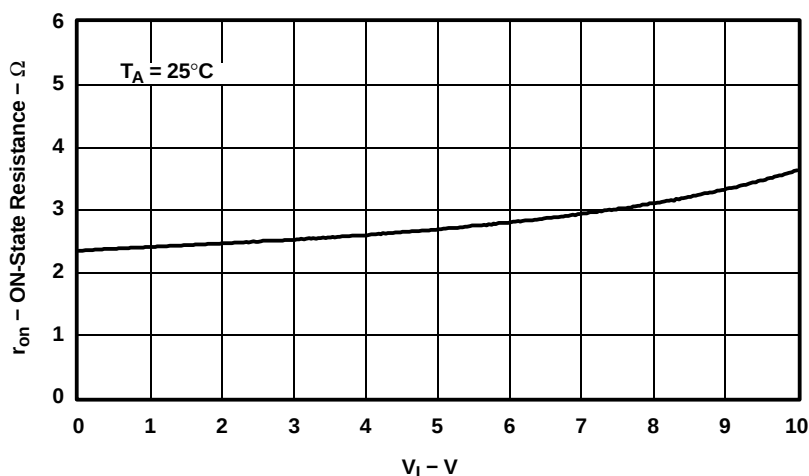


Figure 1. Typical r_{on} vs V_I , $V_{CC} = 5\text{ V}$ and $I_O = -50\text{ mA}$

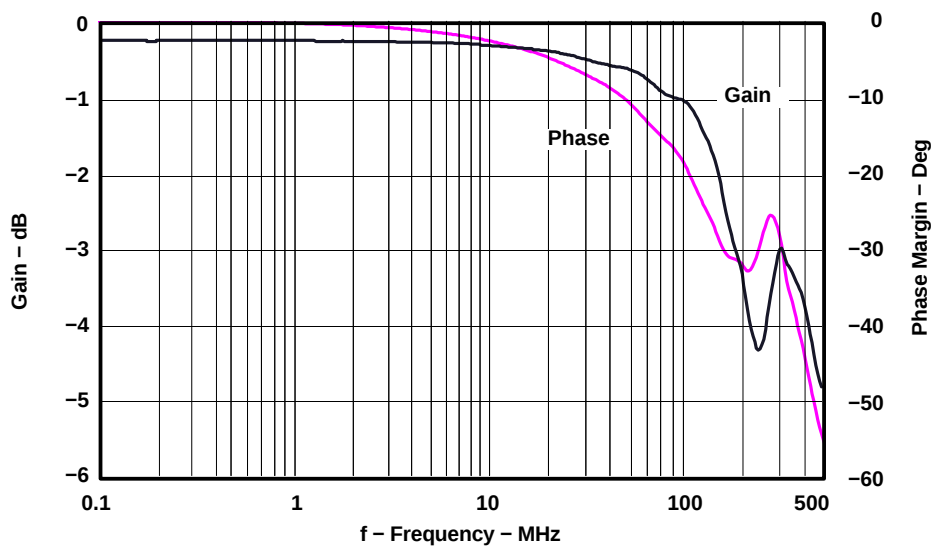


Figure 2. Frequency Response vs Bandwidth

TYPICAL PERFORMANCE

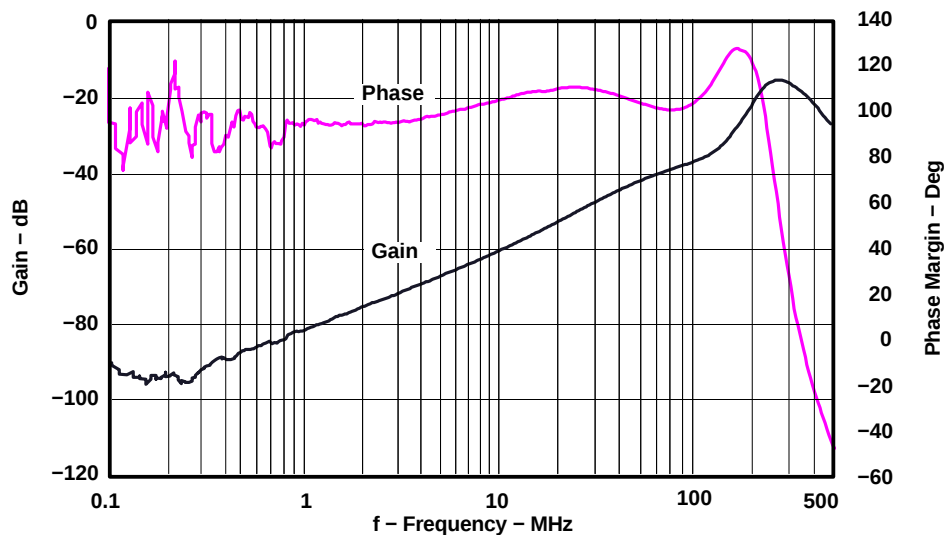


Figure 3. Frequency Response vs OFF Isolation

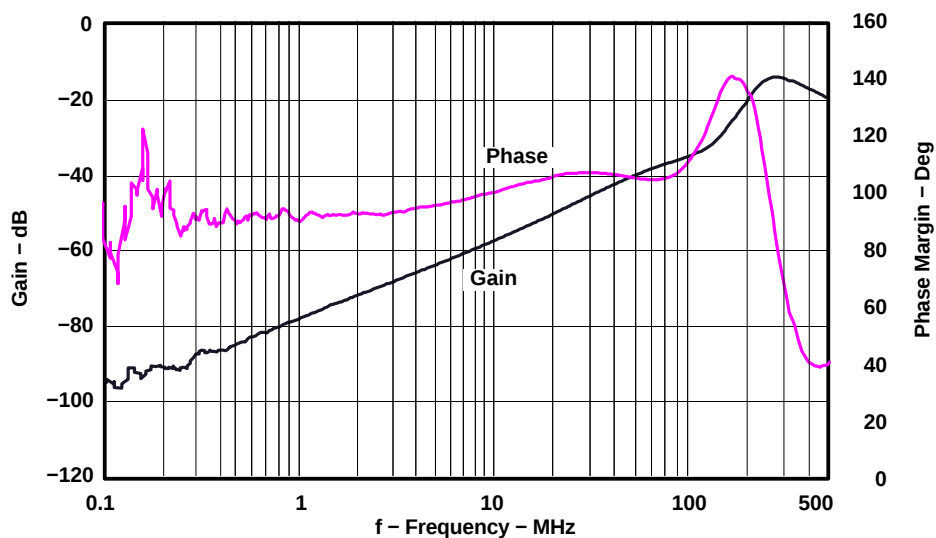
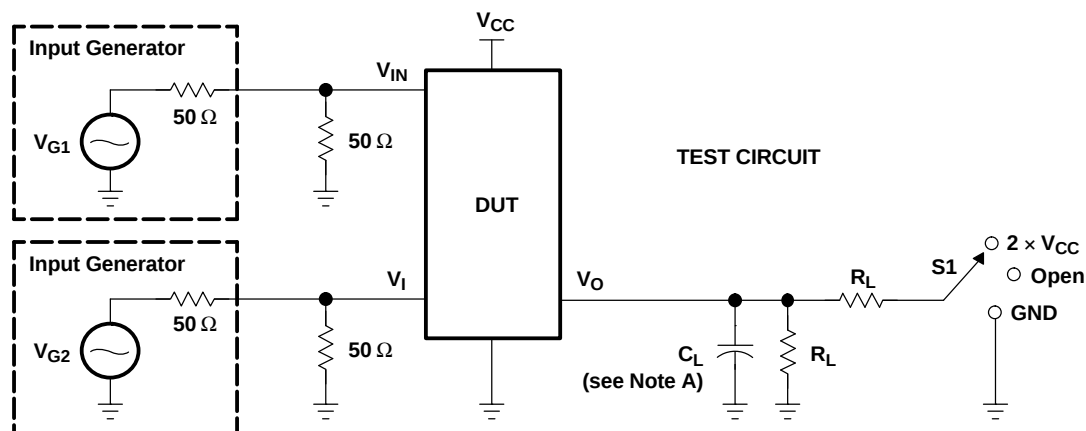


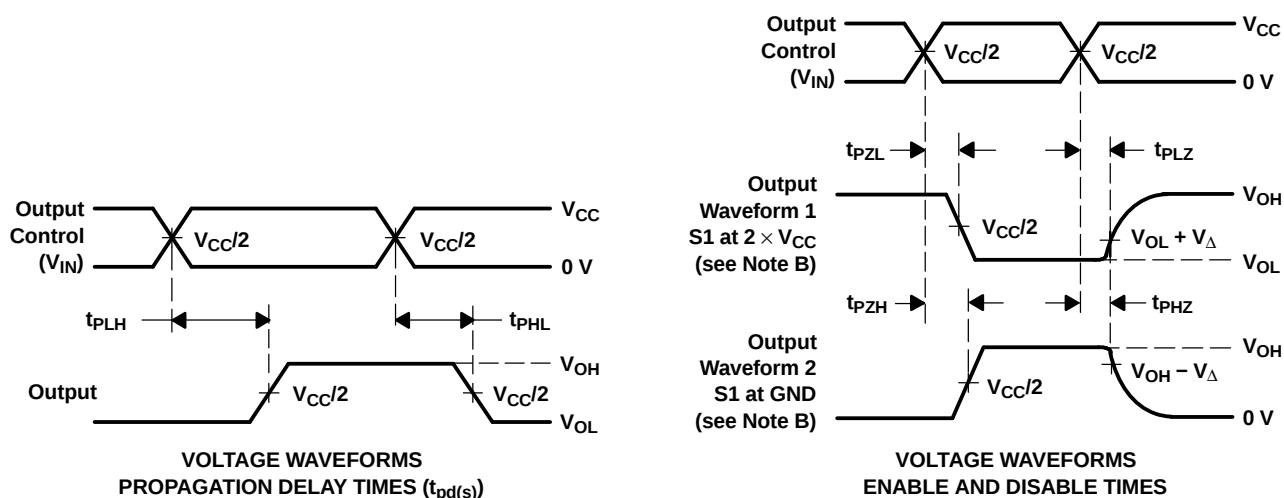
Figure 4. Frequency Response vs Crosstalk

PARAMETER MEASUREMENT INFORMATION



TEST	V _{CC}	S1	R _L	V _I	C _L	V _Δ
t _{pd(s)} [†]	5 V ± 0.25 V	Open	100 Ω	V _{CC}	35 pF	
t _{PLZ} /t _{PZL}	5 V ± 0.25 V	2 × V _{CC}	100 Ω	GND	35 pF	0.3 V
t _{PHZ} /t _{PZH}	5 V ± 0.25 V	GND	100 Ω	V _{CC}	35 pF	0.3 V

[†] t_{pd(s)} is measured with Demux inputs at opposite voltage levels, i.e. V_{B1} = 5 V, V_{B2} = GND.



- NOTES:
- C_L includes probe and jig capacitance.
 - Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 - All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r < 25 ns, t_f < 25 ns.
 - The outputs are measured one at a time, with one transition per measurement.
 - t_{PLZ} and t_{PHZ} are the same as t_{dis}.
 - t_{PZL} and t_{PZH} are the same as t_{en}.
 - t_{PLH} and t_{PHL} are the same as t_{pd(s)}. The t_{pd} propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).
 - All parameters and waveforms are not applicable to all devices.

Figure 5. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION

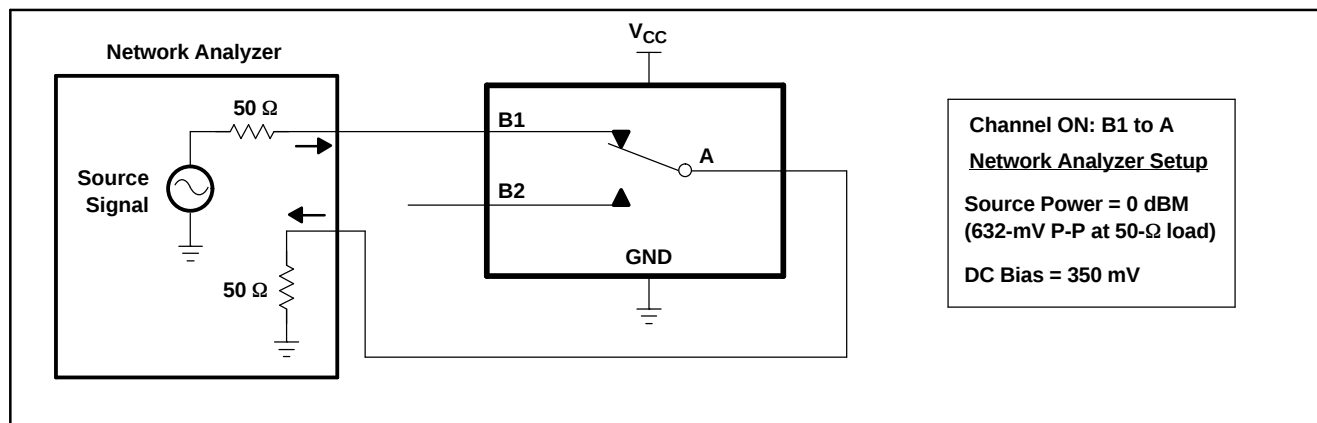


Figure 6. Bandwidth (BW)

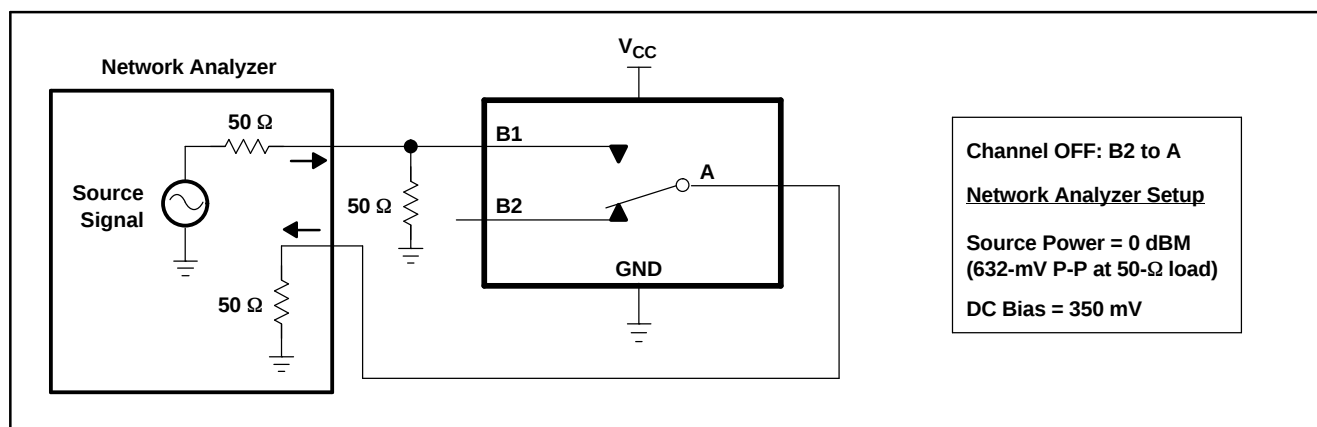


Figure 7. OFF Isolation (O_{ISO})

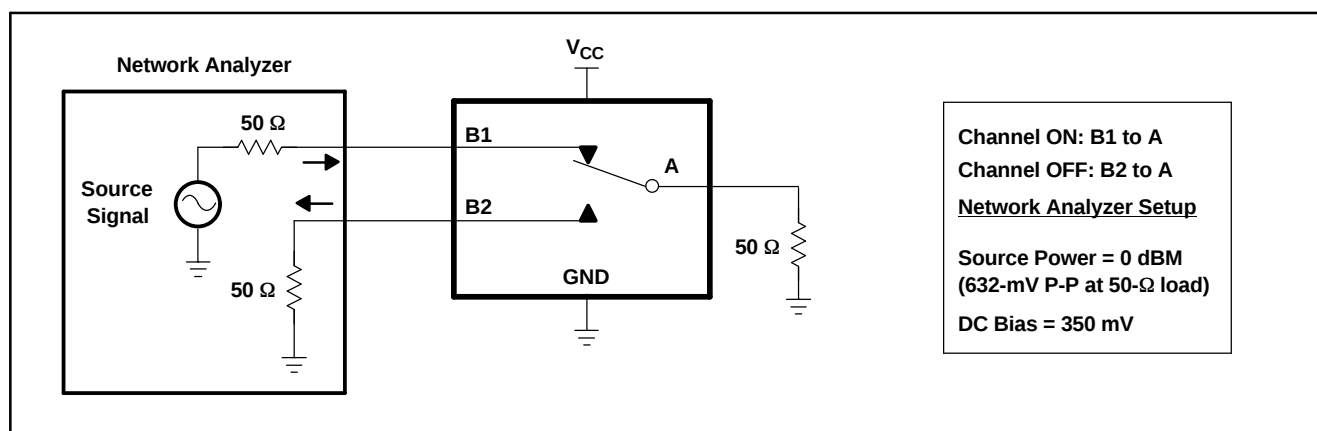


Figure 8. Crosstalk (X_{TALK})

PARAMETER MEASUREMENT INFORMATION (continued)

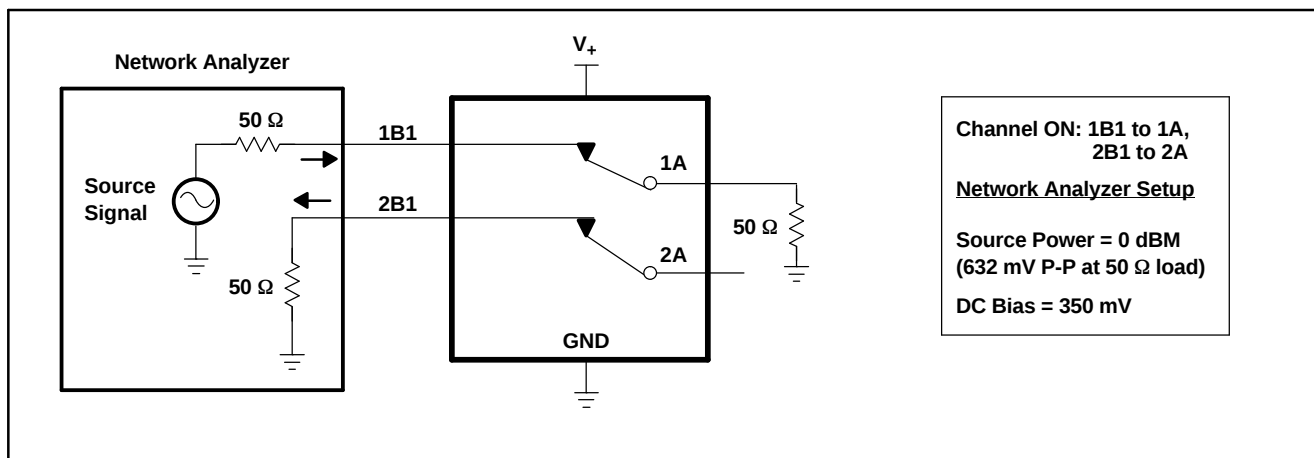


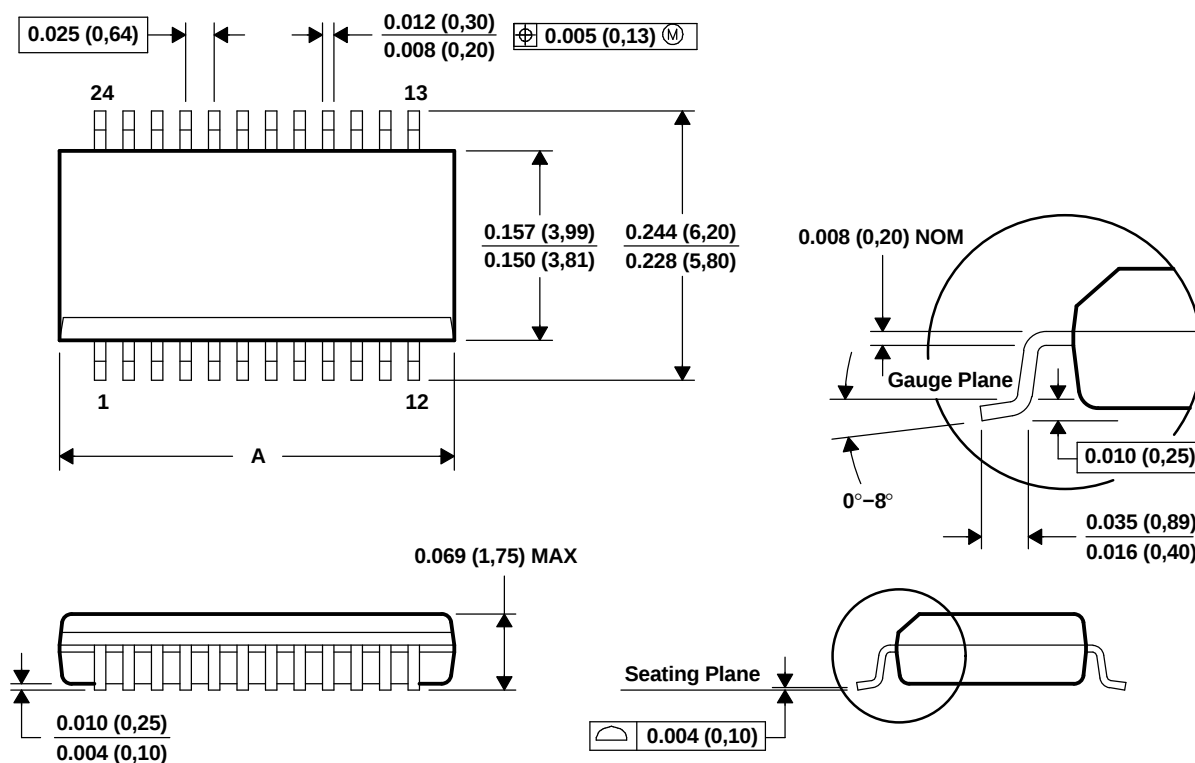
Figure 9. Adjacent Channel Crosstalk (X_{TALK})

TS5N412
4-BIT 1-OF-2 FET MULTIPLEXER/DEMULTIPLEXER
HIGH-BANDWIDTH BUS SWITCH

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MECHANICAL DATA

DBQ (R-PDSO-G**)



PINS **	16	20	24	28
DIM				
A MAX	0.197 (5,00)	0.344 (8,74)	0.344 (8,74)	0.394 (10,01)
A MIN	0.189 (4,80)	0.337 (8,56)	0.337 (8,56)	0.386 (9,80)
M0-137 VARIATION	AB	AD	AE	AF



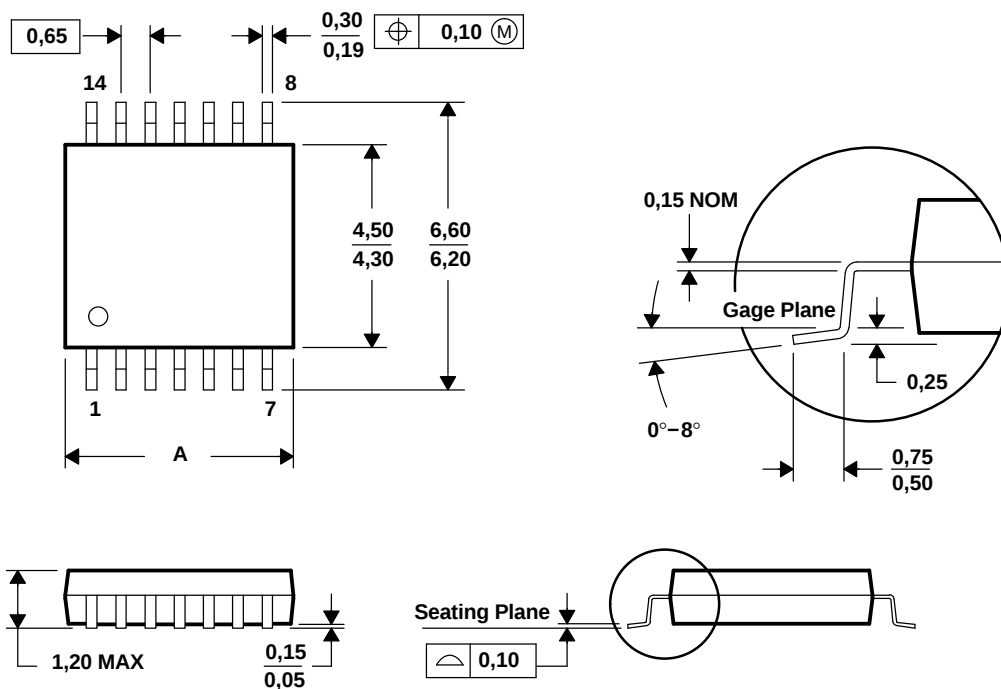
4073301/F 02/2002

- NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MO-137.

MECHANICAL DATA

PW (R-PDSO-G**)

14 PINS SHOWN



PINS ** DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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)
TS5N412DBQR	Active	Production	SSOP (DBQ) 16	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YB412
TS5N412DBQR.A	Active	Production	SSOP (DBQ) 16	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	YB412
TS5N412PW	Active	Production	TSSOP (PW) 16	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YB412
TS5N412PW.A	Active	Production	TSSOP (PW) 16	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	YB412

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

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

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

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

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

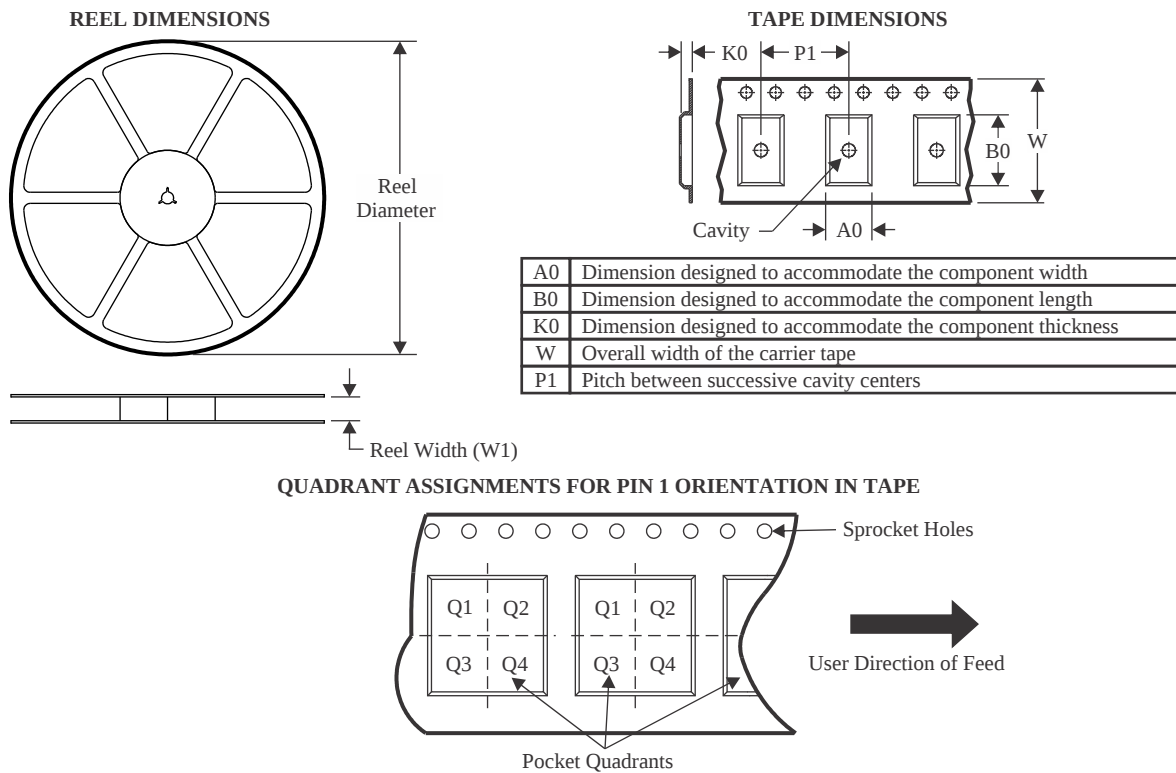
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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

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

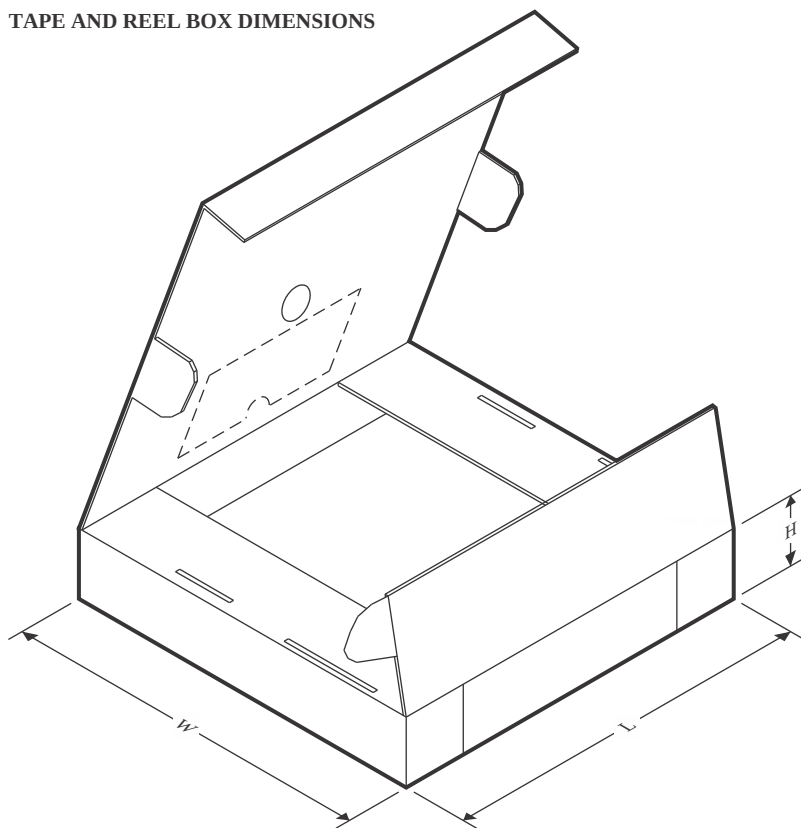
TAPE AND REEL INFORMATION



*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
TS5N412DBQR	SSOP	DBQ	16	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1

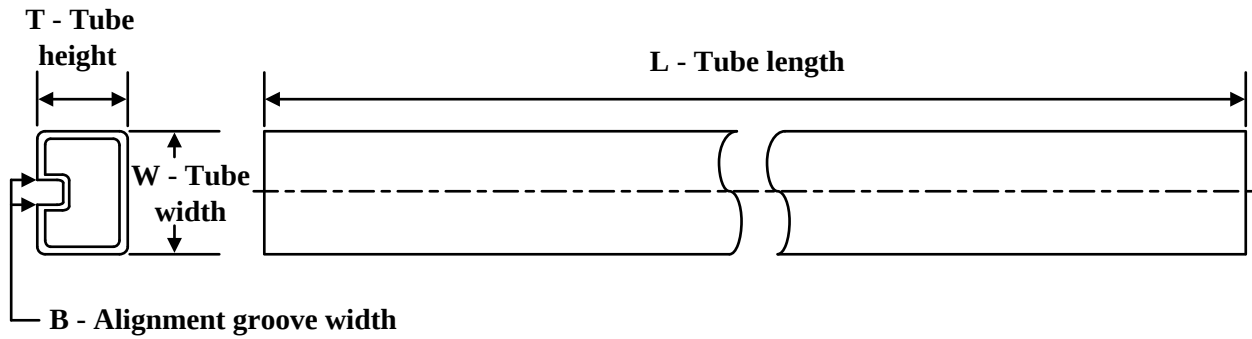
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

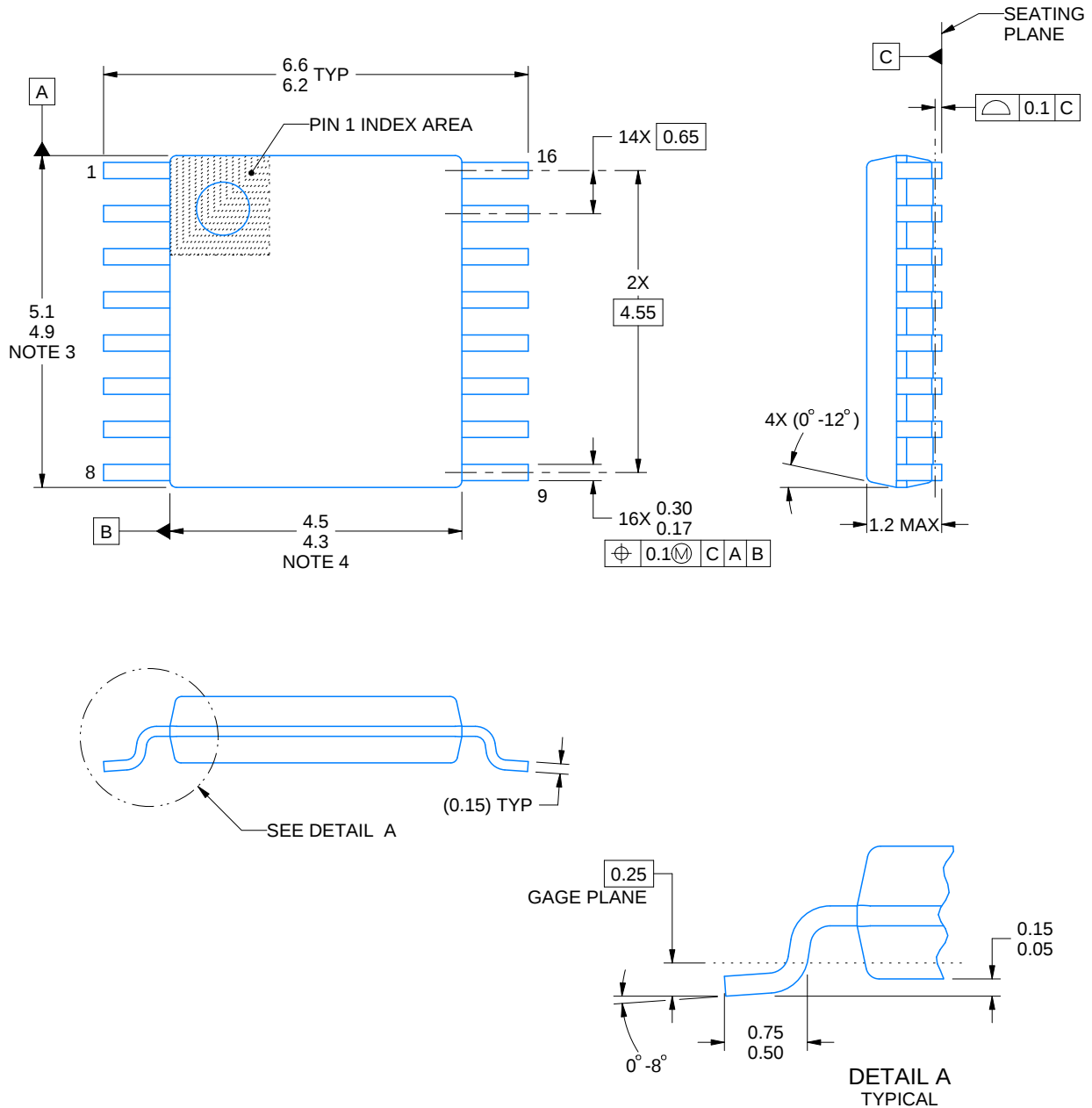
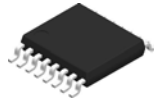
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS5N412DBQR	SSOP	DBQ	16	2500	340.5	338.1	20.6

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
TS5N412PW	PW	TSSOP	16	90	530	10.2	3600	3.5
TS5N412PW.A	PW	TSSOP	16	90	530	10.2	3600	3.5



4220204/B 12/2023

NOTES:

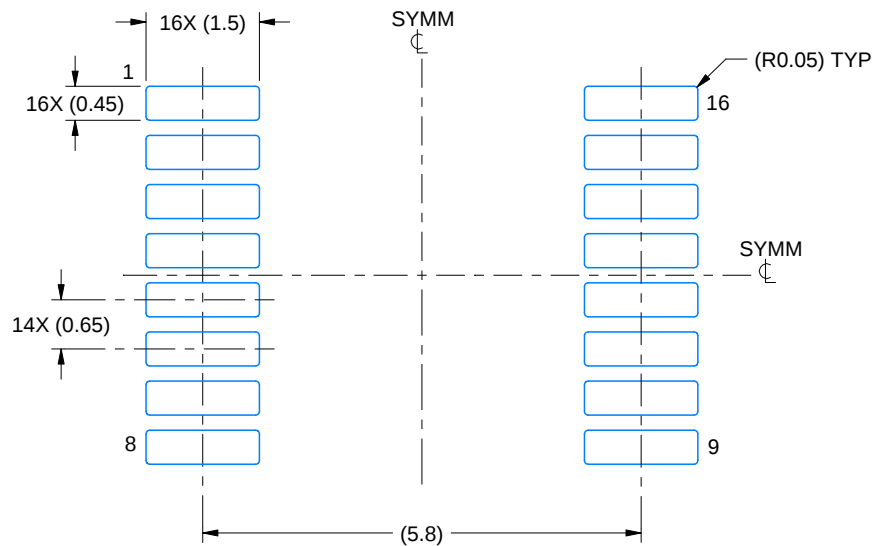
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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.

EXAMPLE BOARD LAYOUT

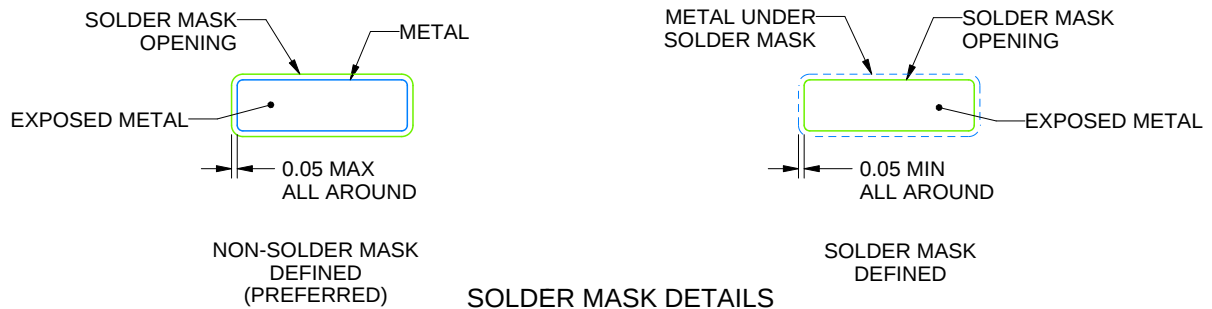
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220204/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

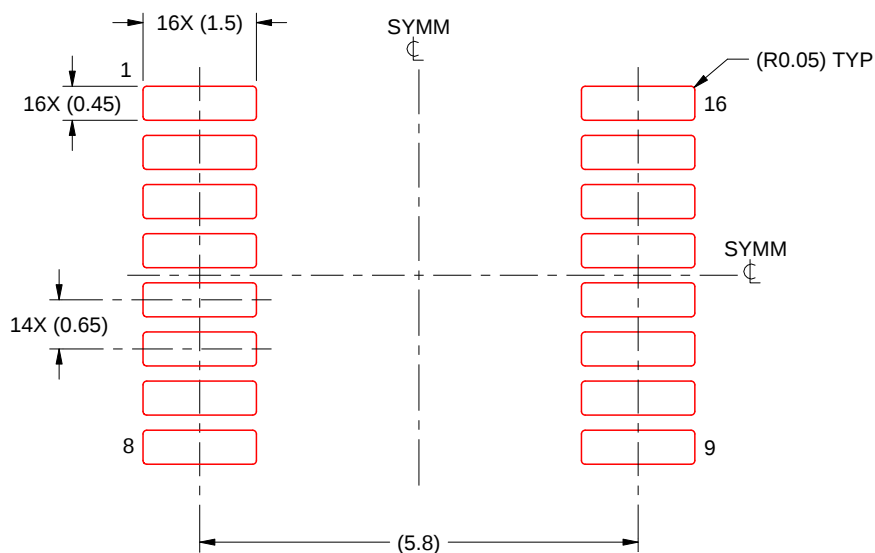
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

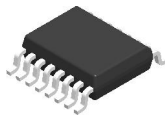


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

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.

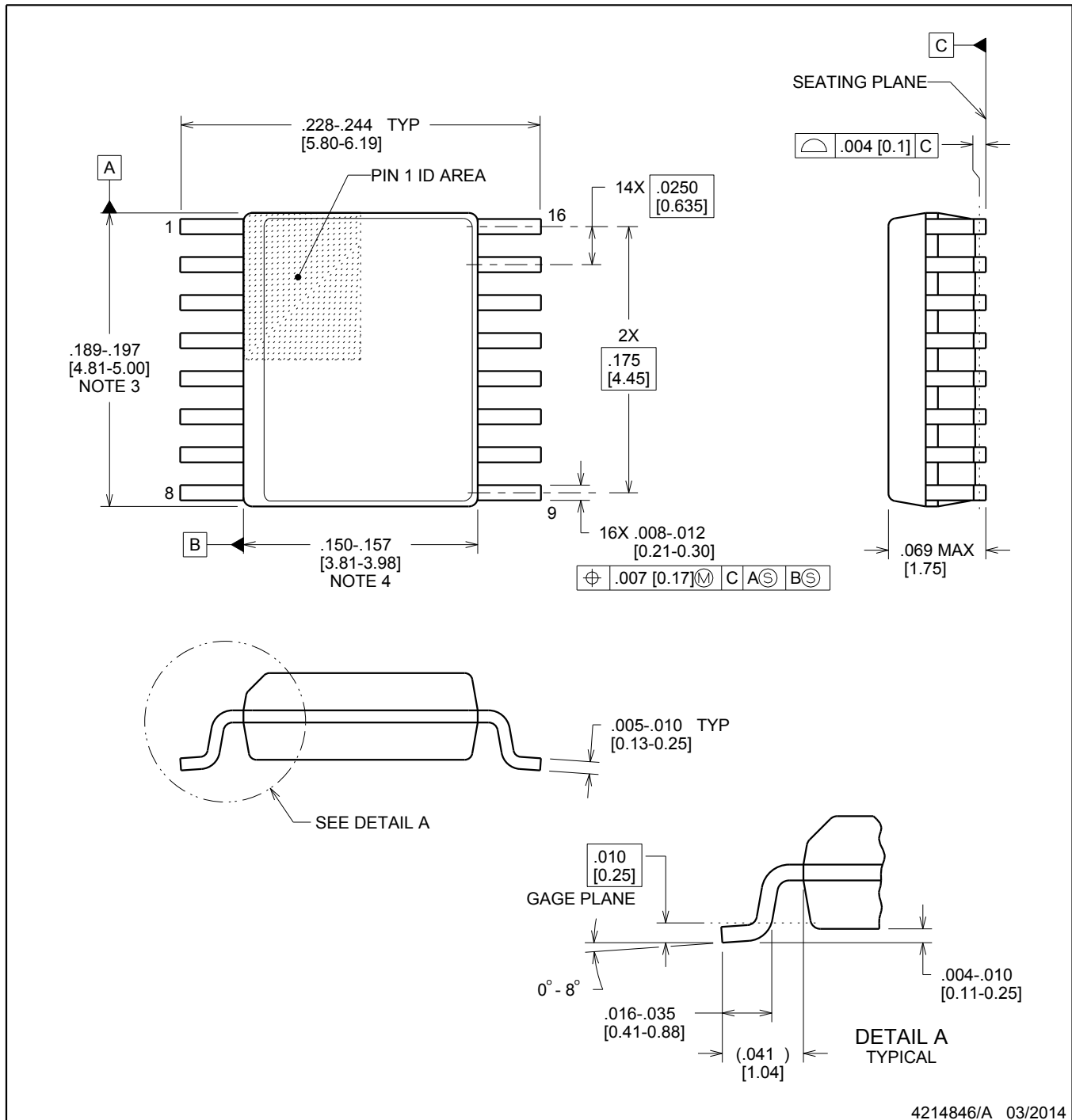


DBQ0016A

PACKAGE OUTLINE

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



4214846/A 03/2014

NOTES:

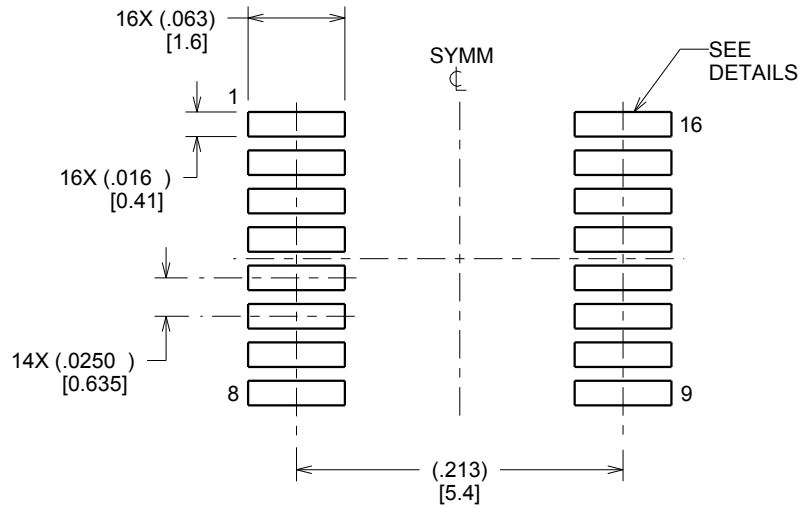
- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 inch, per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MO-137, variation AB.

EXAMPLE BOARD LAYOUT

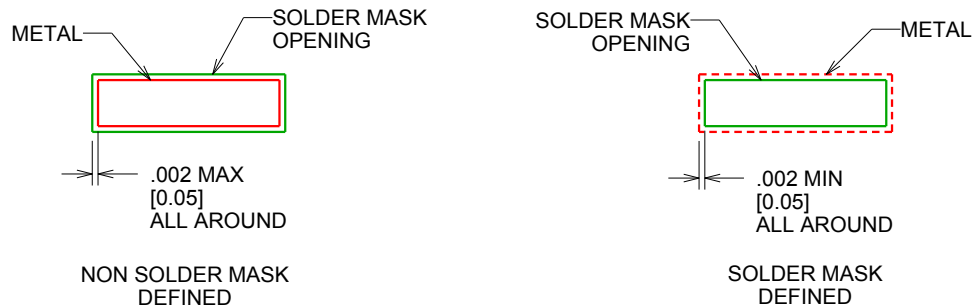
DBQ0016A

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4214846/A 03/2014

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

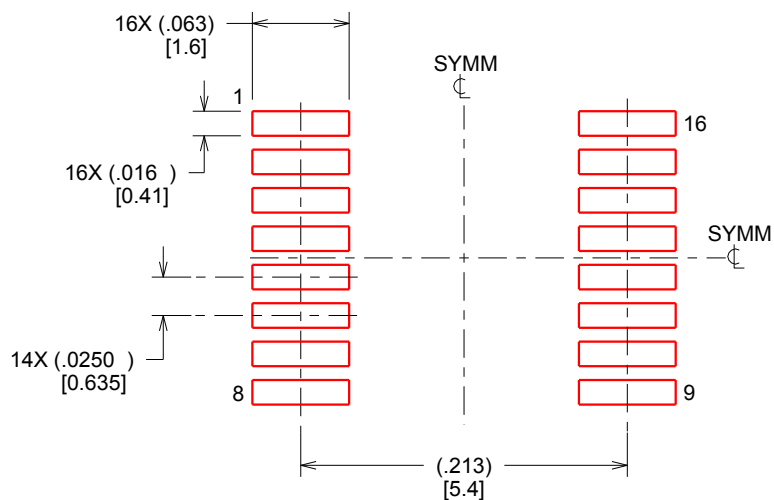
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBQ0016A

SSOP - 1.75 mm max height

SHRINK SMALL-OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.127 MM] THICK STENCIL
SCALE:8X

4214846/A 03/2014

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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