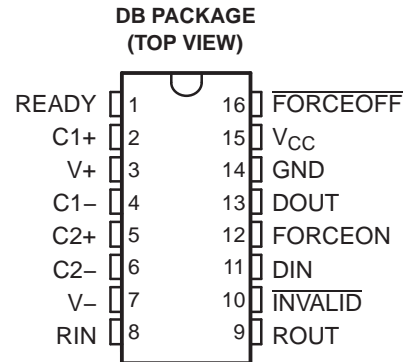


FEATURES

- Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards
- Operates With 3-V to 5.5-V V_{CC} Supply
- Operates at Least 1 Mbit/s
- Low Standby Current . . . 1 μ A Typ
- External Capacitors . . . $4 \times 0.1 \mu$ F
- Accepts 5-V Logic Input With 3.3-V Supply
- Designed to Be Interchangeable With Maxim™ MAX3227E
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Protection for RS-232 I/O Pins
 - ± 15 kV – Human-Body Model
 - ± 8 kV – IEC61000-4-2, Contact Discharge
 - ± 15 kV – IEC61000-4-2, Air-Gap Discharge
- Auto-Powerdown Plus Feature Automatically Disables Drivers for Power Savings
- Packaged in Plastic Shrink Small-Outline Package

APPLICATIONS

- Battery-Powered, Hand-Held, and Portable Equipment
- PDAs and Palmtop PCs
- Notebooks, Sub-Notebooks, and Laptops
- Digital Cameras
- Mobile Phones and Wireless Devices



DESCRIPTION/ORDERING INFORMATION

The MAX3227E consists of one line driver, one line receiver, and a dual charge-pump circuit with ± 15 -kV IEC ESD protection pin to pin (serial-port connection pins, including GND). The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. This device operates at data-signaling rates of 1 Mbit/s in normal operating mode and a maximum of 30-V/ μ s driver output slew rate. This device also features a logic-level output (READY) that asserts when the charge pump is regulating and the device is ready to begin transmitting.

The MAX3227E achieves a 1- μ A supply current using the auto-powerdown plus feature. This device automatically enters a low-power powerdown mode when the RS-232 cable is disconnected or the drivers of the connected peripherals are inactive for more than 30 s. They turn on again when they sense a valid transition at any driver or receiver input. Auto-powerdown saves power without changes to the existing BIOS or operating system.

The MAX3227EC is characterized for operation from 0°C to 70°C. The MAX3227EI is characterized for operation from -40°C to 85°C.

ORDERING INFORMATION

T _A	PACKAGE ⁽¹⁾⁽²⁾	ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	SSOP – DB	Tube of 80	MAX3227ECDB
		Reel of 2000	MAX3227ECDBR
-40°C to 85°C	SSOP – DB	Tube of 80	MAX3227EIDB
		Reel of 2000	MAX3227EIDBR

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

(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.



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MAX3227E
3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER
WITH ± 15 -kV IEC ESD PROTECTION

SLLS715A—FEBRUARY 2006—REVISED JUNE 2007

FUNCTION TABLE⁽¹⁾

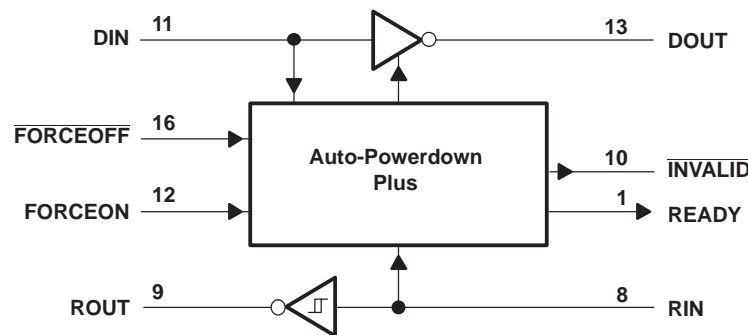
INPUT CONDITIONS				OUTPUT STATES				OPERATING MODE
FORCEON	$\overline{\text{FORCEOFF}}$	RECEIVER OR DRIVER EDGE WITHIN 30 s	VALID RS-232 LEVEL PRESENT AT RECEIVER	DRIVER	RECEIVER	$\overline{\text{INVALID}}$	READY	
Auto-Powerdown Plus Conditions								
H	H	NO	NO	Active	Active	L	H	Normal operation, auto-powerdown plus disabled
H	H	NO	YES	Active	Active	H	H	Normal operation, auto-powerdown plus disabled
L	H	YES	NO	Active	Active	L	H	Normal operation, auto-powerdown plus enabled
L	H	YES	YES	Active	Active	H	H	Normal operation, auto-powerdown plus enabled
L	H	NO	NO	Z	Active	L	L	Powerdown, auto-powerdown plus enabled
L	H	NO	YES	Z	Active	H	L	Powerdown, auto-powerdown plus enabled
X	L	X	NO	Z	Active	L	L	Manual powerdown
X	L	X	YES	Z	Active	H	L	Manual powerdown
Auto-Powerdown Conditions								
$\overline{\text{INVALID}}$	$\overline{\text{INVALID}}$	X	NO	Z	Active	L	L	Powerdown, auto-powerdown enabled
$\overline{\text{INVALID}}$	$\overline{\text{INVALID}}$	X	YES	Active	Active	H	H	Normal operation, auto-powerdown enabled

(1) H = high level, L = low level, X = irrelevant, Z = high impedance

TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
NAME	NO.	
C1+	2	Positive terminal of voltage-doubler charge-pump capacitor
C1-	4	Negative terminal of voltage-doubler charge-pump capacitor
C2+	5	Positive terminal of inverting charge-pump capacitor
C2-	6	Negative terminal of inverting charge-pump capacitor
DIN	11	CMOS driver input
DOUT	13	RS-232 driver output
$\overline{\text{FORCEOFF}}$	16	Force-off input, active low. Drive low to shut down drivers, receivers, and charge pump. This overrides auto-shutdown and FORCEON (see Function Table).
FORCEON	12	Force-on input, active high. Drive high to override powerdown, keeping drivers and receivers on ($\overline{\text{FORCEOFF}}$ must be high) (see Function Table).
GND	14	Ground
$\overline{\text{INVALID}}$	10	Valid signal detector output, active low. A logic high indicates that a valid RS-232 level is present on a receiver input.
READY	1	Ready to transmit output, active high. READY is enabled high when V- goes below -3.5 V and the device is ready to transmit.
RIN	8	RS-232 receiver input
ROUT	9	CMOS receiver output
V+	3	$+2 \times V_{\text{CC}}$ generated by the charge pump
V-	7	$-2 \times V_{\text{CC}}$ generated by the charge pump
V _{CC}	15	3-V to 5.5-V single-supply voltage

LOGIC DIAGRAM (POSITIVE LOGIC)



MAX3227E

3-V TO 5.5-V SINGLE-CHANNEL RS-232 LINE DRIVER/RECEIVER

WITH ± 15 -kV IEC ESD PROTECTION

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Absolute Maximum Ratings⁽¹⁾

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

		MIN	MAX	UNIT
V _{CC}	Supply voltage range ⁽²⁾	-0.3	6	V
V+	Positive output supply voltage range ⁽²⁾	-0.3	7	V
V-	Negative output supply voltage range ⁽²⁾	0.3	-7	V
V+ - V-	Supply voltage difference ⁽²⁾		13	V
V _I	Input voltage range	Driver ($\overline{\text{FORCEOFF}}$, FORCEON)		V
		Receiver		
V _O	Output voltage range	Driver		V
		Receiver ($\overline{\text{INVALID}}$, READY)		
	Short-circuit duration	DOUT to GND		Unlimited
θ_{JA}	Package thermal impedance ⁽³⁾			82
		Lead temperature 1,6 mm (1/16 in) from case for 10 s		260
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 network GND.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions⁽¹⁾

See [Figure 5](#)

		MIN	NOM	MAX	UNIT
Supply voltage		V _{CC} = 3.3 V			V
		3	3.3	3.6	
V _{IH}	Driver and control high-level input voltage	V _{CC} = 5 V			V
		4.5	5	5.5	
V _{IL}	Driver and control low-level input voltage	V _{CC} = 3.3 V			V
		2		5.5	
V _I	Receiver input voltage	V _{CC} = 5 V			V
		2.4		5.5	
T _A	Operating free-air temperature	MAX3227EC			°C
		0		70	
T _A	Operating free-air temperature	MAX3227EI			°C
		-40		85	

- (1) Test conditions are C1–C4 = 0.1 μ F at V_{CC} = 3.3 V \pm 0.3 V; C1 = 0.047 μ F, C2–C4 = 0.33 μ F at V_{CC} = 5 V \pm 0.5 V.

Electrical Characteristics⁽¹⁾

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 5](#))

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
I _I	Input leakage current	$\overline{\text{FORCEOFF}}$, FORCEON		± 0.01	± 1	μ A
I _{CC}	Supply current (T _A = 25°C)	Auto-powerdown plus disabled	No load, $\overline{\text{FORCEOFF}}$ and FORCEON at V _{CC}	0.3	2	mA
		Powered off	No load, $\overline{\text{FORCEOFF}}$ at GND	1	10	
		Auto-powerdown plus enabled	No load, $\overline{\text{FORCEOFF}}$ at V _{CC} , FORCEON at GND, All RIN are open or grounded	1	10	μ A

- (1) Test conditions are C1–C4 = 0.1 μ F at V_{CC} = 3.3 V \pm 0.3 V; C1 = 0.047 μ F, C2–C4 = 0.33 μ F at V_{CC} = 5 V \pm 0.5 V.
- (2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

DRIVER SECTION

Electrical Characteristics⁽¹⁾

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)
(see Figure 1 and Figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
V _{OH}	High-level output voltage DOUT at R _L = 3 k Ω to GND, DIN = GND	5	5.4		V
V _{OL}	Low-level output voltage DOUT at R _L = 3 k Ω to GND, DIN = V _{CC}	-5	-5.4		V
I _{IH}	High-level input current V _I = V _{CC}		± 0.01	± 1	μ A
I _{IL}	Low-level input current V _I at GND		± 0.01	± 1	μ A
I _{OS}	Short-circuit output current ⁽³⁾ V _{CC} = 3.6 V, V _O = 0 V V _{CC} = 5.5 V, V _O = 0 V		± 35	± 60	mA
			± 35	± 60	
r _o	Output resistance V _{CC} , V+, and V- = 0 V, V _O = ± 2 V	300	10M		Ω
I _{off}	Output leakage current FORCEOFF = GND, V _O = ± 12 V, V _{CC} = 0 to 5.5 V			± 25	μ A

(1) Test conditions are C1–C4 = 0.1 μ F at V_{CC} = 3.3 V \pm 0.3 V; C1 = 0.047 μ F, C2–C4 = 0.33 μ F at V_{CC} = 5 V \pm 0.5 V.

(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

(3) Short-circuit durations should be controlled to prevent exceeding the device absolute power dissipation ratings, and not more than one output should be shorted at a time.

Switching Characteristics⁽¹⁾

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)
(see Figure 1 and Figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
Maximum data rate	C _L = 1000 pF, One DIN switching, R _L = 3 k Ω , See Figure 1	250			kbit/s
	C _L = 1000 pF, V _{CC} = 4.5 V, R _L = 3 k Ω , See Figure 1	1000			
	C _L = 250 pF, V _{CC} = 3 V, R _L = 3 k Ω , See Figure 1	1000			
t _{sk(p)}	Pulse skew ⁽³⁾ C _L = 150 pF to 2500 pF, R _L = 3 k Ω to 7 k Ω , See Figure 2		25		ns
SR(tr)	Slew rate, transition region V _{CC} = 3.3 V, C _L = 150 pF to 1000 pF, R _L = 3 k Ω to 7 k Ω , See Figure 1	24		150	V/ μ s

(1) Test conditions are C1–C4 = 0.1 μ F at V_{CC} = 3.3 V \pm 0.3 V; C1 = 0.047 μ F, C2–C4 = 0.33 μ F at V_{CC} = 5 V \pm 0.5 V.

(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

(3) Pulse skew is defined as |t_{pLH} - t_{pHL}| of each channel of the same device.

ESD Protection

TERMINAL	TEST CONDITIONS	TYP	UNIT	
NAME	NO.			
DOUT	13	Human-Body Model	± 15	kV
		Contact Discharge (IEC61000-4-2)	± 8	
		Air-Gap Discharge (IEC61000-4-2)	± 15	

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RECEIVER SECTION

Electrical Characteristics⁽¹⁾

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 3](#))

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
V _{OH}	High-level output voltage	I _{OH} = -1 mA	V _{CC} - 0.6	V _{CC} - 0.1		V
V _{OL}	Low-level output voltage	I _{OL} = 1.6 mA			0.4	V
V _{IT+}	Positive-going input threshold voltage	V _{CC} = 3.3 V		1.5	2.4	V
		V _{CC} = 5 V		1.8	2.4	
V _{IT-}	Negative-going input threshold voltage	V _{CC} = 3.3 V	0.6	1.2		V
		V _{CC} = 5 V	0.8	1.5		
V _{hys}	Input hysteresis (V _{IT+} - V _{IT-})			0.5		V
I _{off}	Output leakage current			±0.05	±10	µA
r _i	Input resistance	V _I = ±3 V to ±25 V	3	5	7	kΩ

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

Switching Characteristics⁽¹⁾

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TYP ⁽²⁾	UNIT
t _{PLH}	Propagation delay time, low- to high-level output	C _L = 150 pF, See Figure 3	150	ns
t _{PHL}	Propagation delay time, high- to low-level output	C _L = 150 pF, See Figure 3	150	ns
t _{sk(p)}	Pulse skew ⁽³⁾	See Figure 3	50	ns

(1) Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

(2) All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

(3) Pulse skew is defined as |t_{PLH} - t_{PHL}| of each channel of the same device.

ESD Protection

TERMINAL		TEST CONDITIONS	TYP	UNIT
NAME	NO.			
RIN	8	Human-Body Model	±15	kV
		Contact Discharge (IEC61000-4-2)	±8	
		Air-Gap Discharge (IEC61000-4-2)	±15	

AUTO-POWERDOWN SECTION

Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
V_{T+} (valid)	Receiver input threshold for $\overline{\text{INVALID}}$ high-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$		2.7	V
V_{T-} (valid)	Receiver input threshold for $\overline{\text{INVALID}}$ high-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	–2.7		V
V_{T} (invalid)	Receiver input threshold for $\overline{\text{INVALID}}$ low-level output voltage	FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	–0.3	0.3	V
V_{OH}	$\overline{\text{INVALID}}$, READY output voltage high	$I_{OH} = -1$ mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$	$V_{CC} - 0.6$		V
V_{OL}	$\overline{\text{INVALID}}$, READY output voltage low	$I_{OL} = 1.6$ mA, FORCEON = GND, $\overline{\text{FORCEOFF}} = V_{CC}$		0.4	V

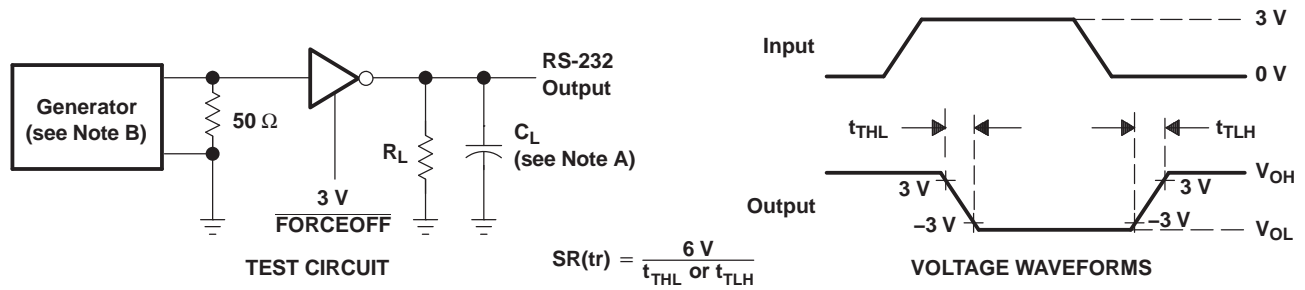
Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 4](#))

PARAMETER		MIN	TYP ⁽¹⁾	MAX	UNIT	
t_{INVH}	Propagation delay time, low- to high-level output		1		μs	
t_{INVL}	Propagation delay time, high- to low-level output		30		μs	
t_{WU}	Supply enable time		100		μs	
t_{AUTOPRDN}	Driver or receiver edge to driver's shutdown	$V_{CC} = 5$ V	15	30	60	s

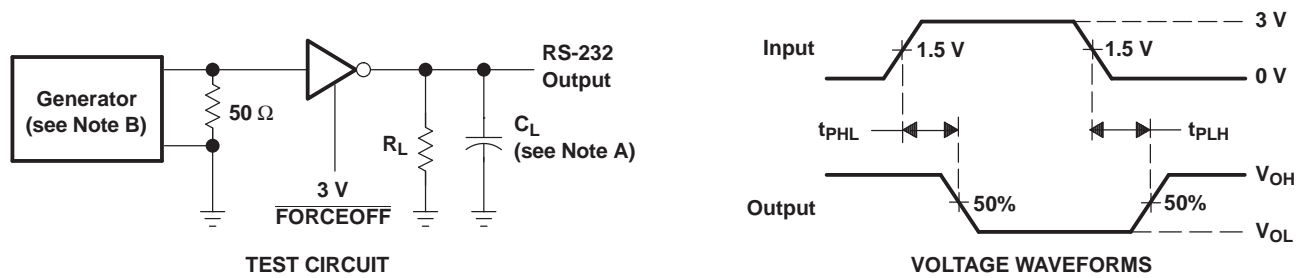
(1) All typical values are at $V_{CC} = 3.3$ V or $V_{CC} = 5$ V, and $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION



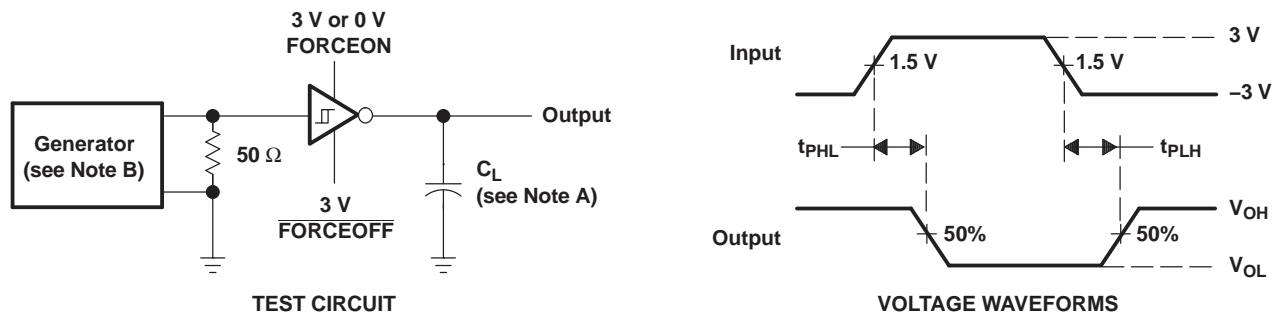
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 1. Driver Slew Rate



NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

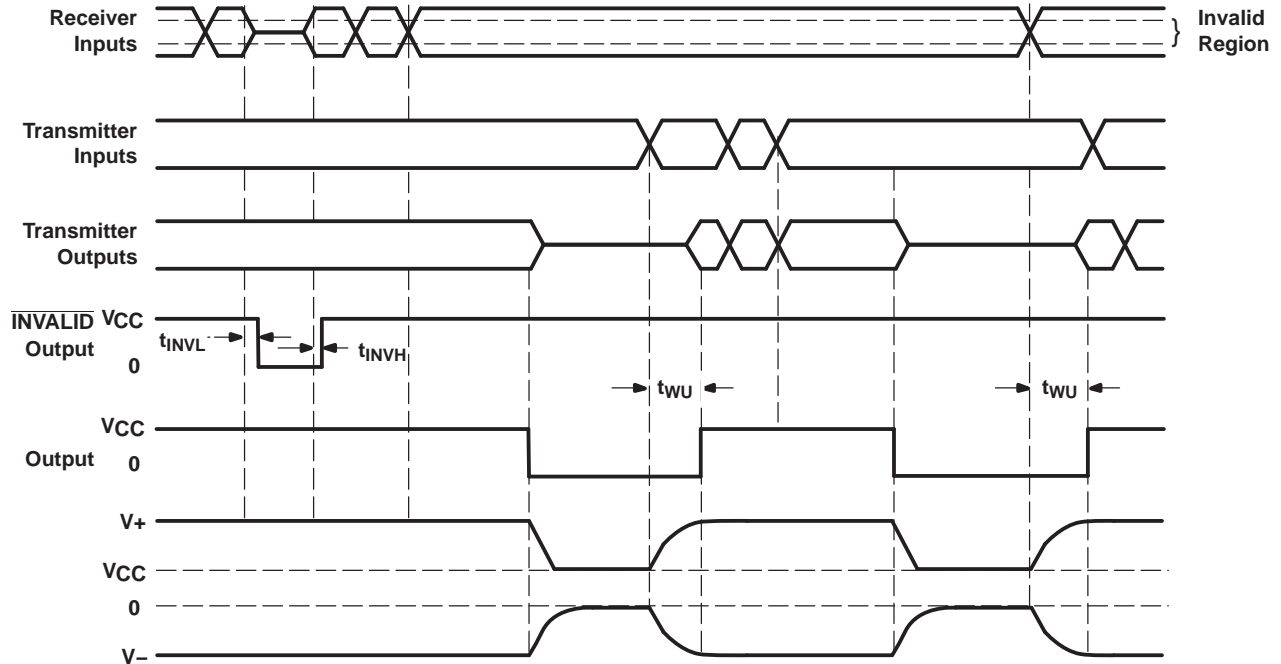
Figure 2. Driver Pulse Skew



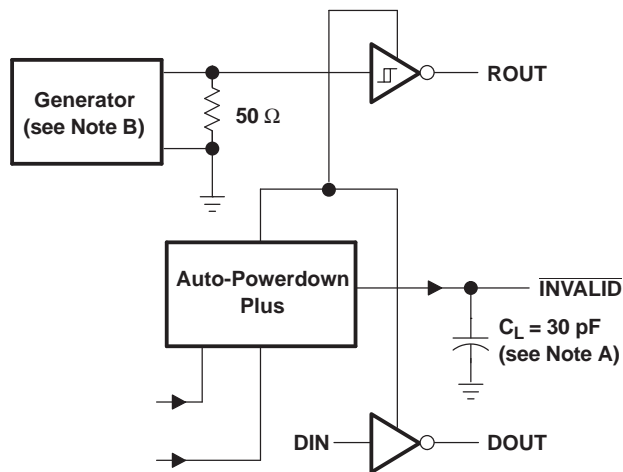
NOTES: A. C_L includes probe and jig capacitance.
 B. The pulse generator has the following characteristics: $Z_O = 50\ \Omega$, 50% duty cycle, $t_r \leq 10\text{ ns}$, $t_f \leq 10\text{ ns}$.

Figure 3. Receiver Propagation Delay Times

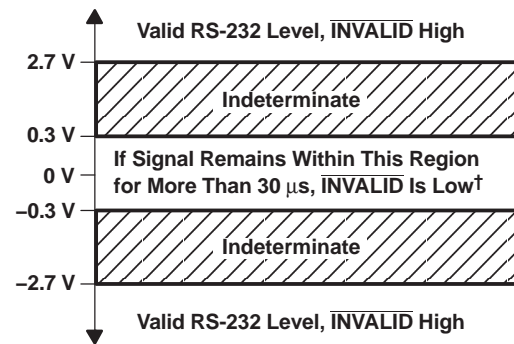
PARAMETER MEASUREMENT INFORMATION (continued)



VOLTAGE WAVEFORMS



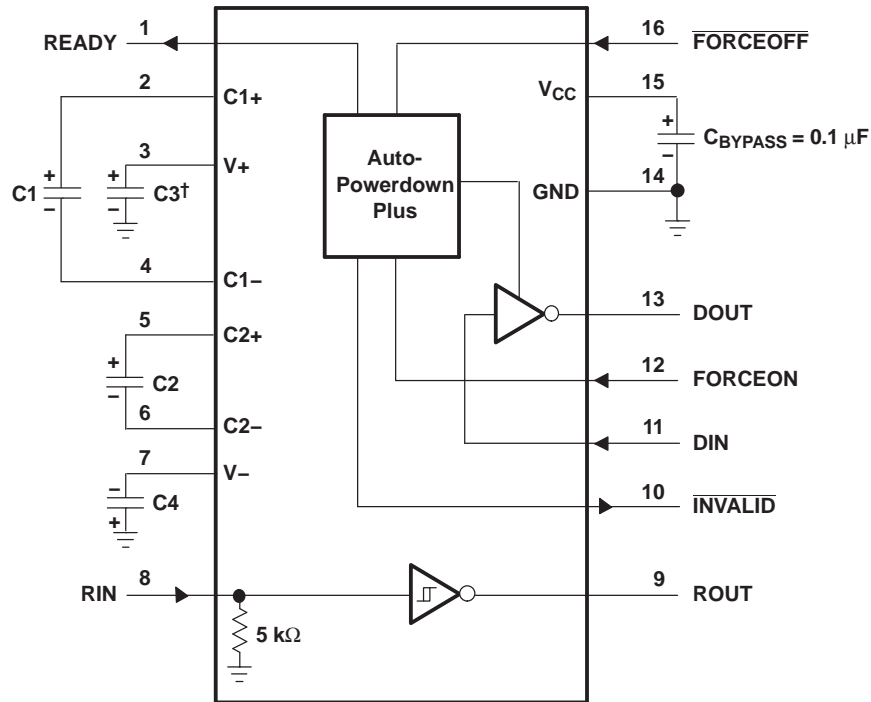
TEST CIRCUIT



† Auto-powerdown disables drivers and reduces supply current to 1 μ A.

Figure 4. $\overline{\text{INVALID}}$ Propagation Delay Times and Driver Enabling Time

APPLICATION INFORMATION



† C3 can be connected to V_{CC} or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

V_{CC} vs CAPACITOR VALUES

V_{CC}	C1	C2, C3, and C4
3.3 V \pm 0.3 V	0.1 μ F	0.1 μ F
5 V \pm 0.5 V	0.047 μ F	0.33 μ F
3 V to 5.5 V	0.1 μ F	0.47 μ F

Figure 5. Typical Operating Circuit and Capacitor Values

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
MAX3227ECDB	OBSOLETE	SSOP	DB	16		TBD	Call TI	Call TI	0 to 70	MP227EC	
MAX3227ECDBR	OBSOLETE	SSOP	DB	16		TBD	Call TI	Call TI	0 to 70	MP227EC	
MAX3227EIDB	OBSOLETE	SSOP	DB	16		TBD	Call TI	Call TI	-40 to 85	MP227EI	
MAX3227EIDBR	ACTIVE	SSOP	DB	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	MP227EI	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.

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TAPE AND REEL INFORMATION

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
MAX3227EIDBR	SSOP	DB	16	2000	330.0	16.4	8.35	6.6	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MAX3227EIDBR	SSOP	DB	16	2000	356.0	356.0	35.0

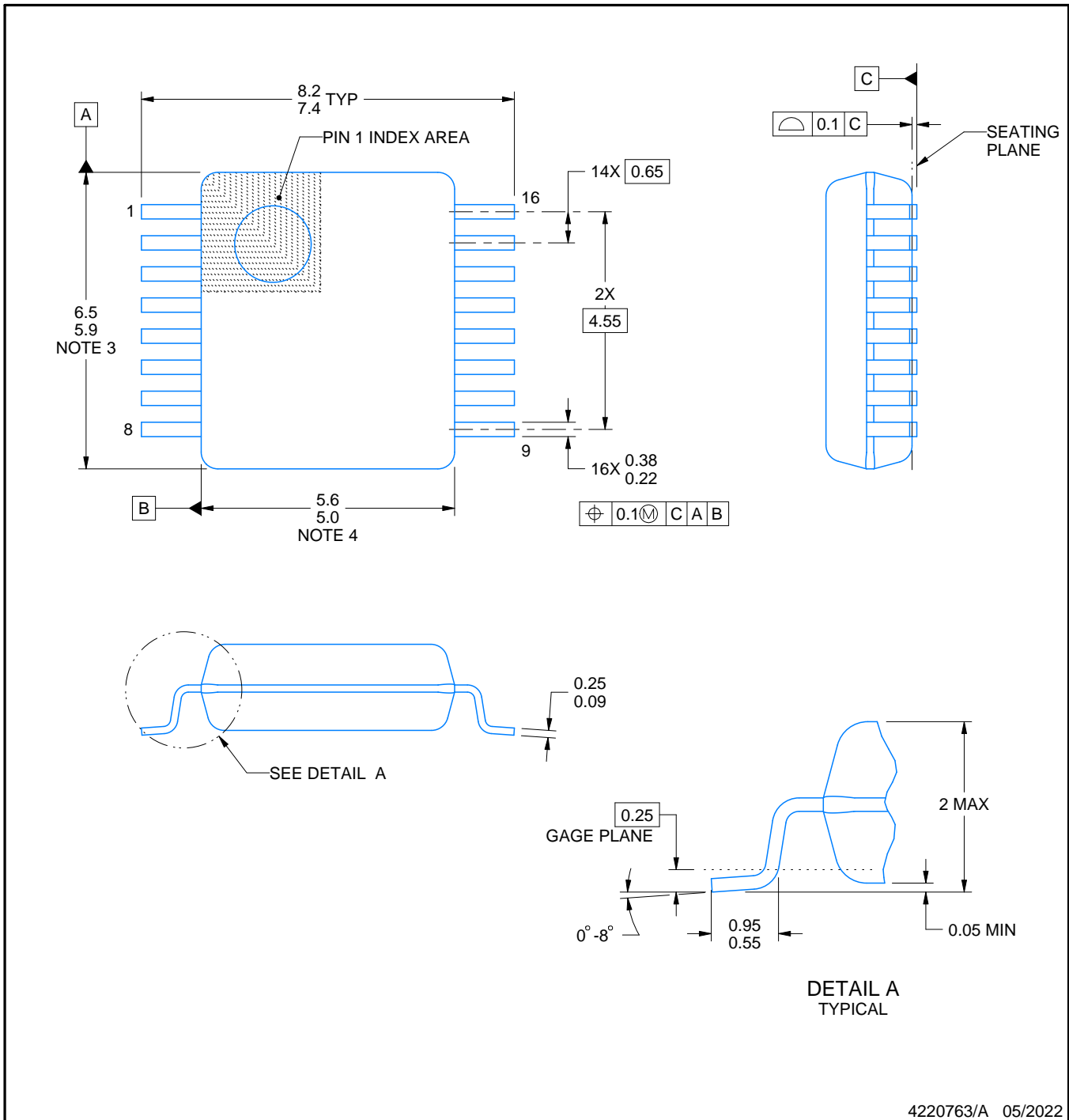
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PACKAGE OUTLINE

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



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NOTES:

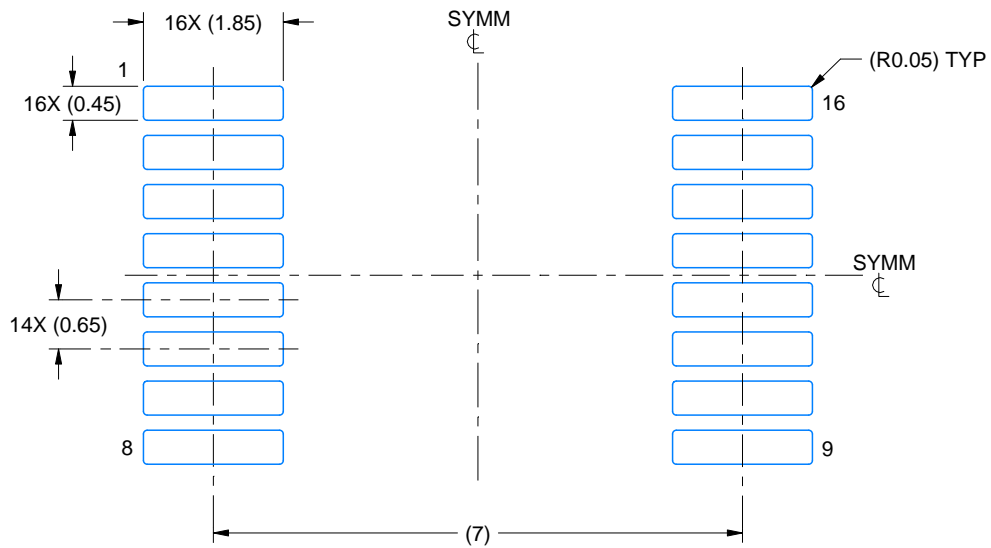
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-150.

EXAMPLE BOARD LAYOUT

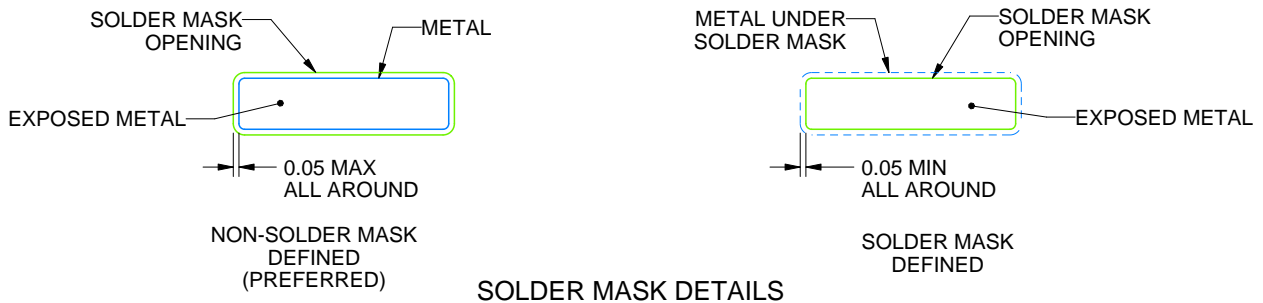
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SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



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NOTES: (continued)

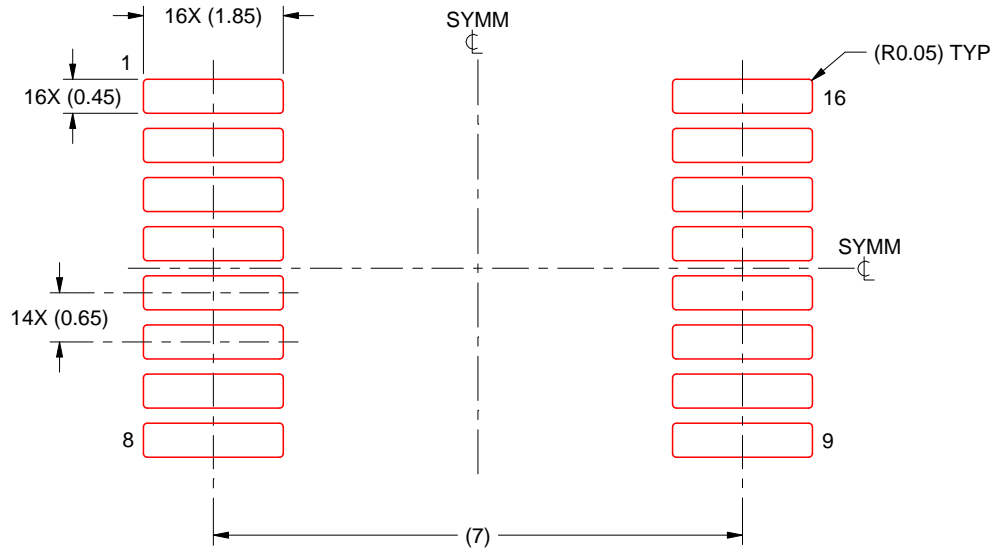
- 5. Publication IPC-7351 may have alternate designs.
- 6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DB0016A

SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



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

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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.

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