- **ESD Protection for RS-232 Bus Pins**
  – ±15-kV Human-Body Model

- **Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards**

- **Operates at 5-V V_{CC} Supply**

- **Operates Up To 200 kbit/s**

- **Low Supply Current in Shutdown Mode . . . 2 μA Typical**

- **External Capacitors . . . 4 × 0.1 μF**

- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**

- **Applications**
  – **Battery-Powered Systems, PDAs, Notebooks, Laptops, Palmtop PCs, and Hand-Held Equipment**

DW OR N PACKAGE
(TOP VIEW)

NC	1	18	SHDN
C1+	2	17	V_{CC}
V+	3	16	GND
C1−	4	15	DOUT1
C2+	5	14	RIN1
C2−	6	13	ROUT1
V−	7	12	DIN1
DOUT2	8	11	DIN2
RIN2	9	10	ROUT2
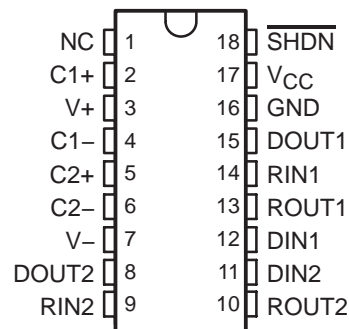
description/ordering information

The MAX222 consists of two line drivers, two line receivers, and a dual charge-pump circuit with ±15-kV ESD protection pin to pin (serial-port connection pins, including GND). This 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 5-V supply. This device operates at data signaling rates up to 200 kbit/s and a maximum of 30-V/μs driver output slew rate. By using SHDN, all receivers can be disabled.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP (N)	Tube of 20	MAX222CN	MAX222CN
	SOIC (DW)	Tube of 20	MAX222CDW	MAX222C
		Reel of 1000	MAX222CDWR	
−40°C to 85°C	PDIP (N)	Tube of 20	MAX222IN	MAX222IN
	SOIC (DW)	Tube of 20	MAX222IDW	MAX222I
		Reel of 1000	MAX222IDWR	

† 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.

TEXAS INSTRUMENTS

Function Tables

EACH DRIVER

INPUT D_{IN}	OUTPUT D_{OUT}
L	H
H	L

H = high level, L = low level

EACH RECEIVER

INPUT R_{IN}	OUTPUT R_{OUT}
L	H
H	L
Open	H

H = high level, L = low level, Open = input disconnected or connected driver off

logic diagram (positive logic)
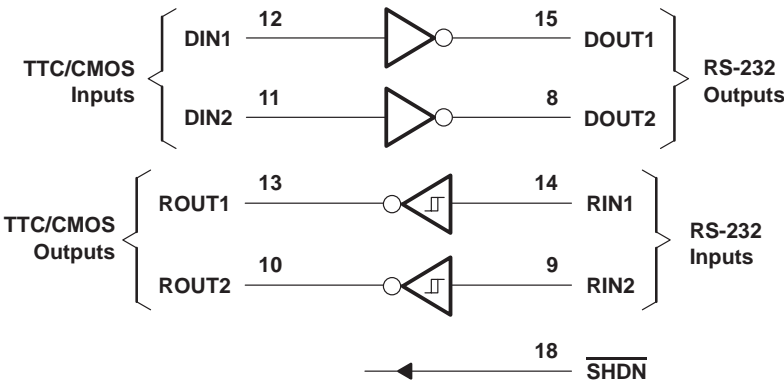
TTC/CMOS Inputs	DIN1 12 ──▷○── 15 DOUT1	RS-232 Outputs
	DIN2 11 ──▷○── 8 DOUT2	
TTC/CMOS Outputs	ROUT1 13 ──○◁⎓── 14 RIN1	RS-232 Inputs
	ROUT2 10 ──○◁⎓── 9 RIN2	
	◀──── 18 $\overline{SHDN}$	

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} (see Note 1) .... −0.3 V to 6 V
Input voltage range, V_I: Drivers .... −0.3 V to V_{CC} − 0.3 V
                      Receivers .... ±30 V
Output voltage range, V_O: Drivers .... ±15 V
                      Receivers .... −0.3 V to V_{CC} + 0.3 V
Short-circuit duration, D_{OUT} .... Continuous
Package thermal impedance, θ_{JA} (see Notes 2 and 3): DW package .... TBD°C/W
                                        N package .... TBD°C/W
Operating virtual junction temperature, T_J .... 150°C
Storage temperature range, T_{stg} .... −65°C to 150°C

† 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.

NOTES: 1. All voltages are with respect to network GND.
         2. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) − T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
         3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4 and Figure 4)

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4.5	5	5.5	V
V_{IH}	Driver high-level input voltage	D_{IN}	2			V
	Shutdown high-level input voltage	$\overline{SHDN}$	2			V
V_{IL}	Driver low-level input voltage	D_{IN}			0.8	V
	Shutdown low-level input voltage	$\overline{SHDN}$			0.8	V
V_I	Driver input voltage	D_{IN}	0		5.5	V
	Receiver input voltage		−30		30	
T_A	Operating free-air temperature	MAX222C	0		70	°C
		MAX222I	−40		85	

NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 5 V ± 0.5 V.

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
I_{CC}	Supply current	V_{CC} = 5 V	$\overline{SHDN}$ = V_{CC}	No load		4	10	mA
				3 kΩ on both inputs		15		
	Shutdown supply current					2	50	µA
$\overline{SHDN}$	Shutdown input leakage current						±1	µA

NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 5 V ± 0.5 V.

DRIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	DOUT at R_L = 3 kΩ to GND,	D_{IN} = GND	5	8		V
V_{OL}	Low-level output voltage	DOUT at R_L = 3 kΩ to GND,	D_{IN} = V_{CC}	−5	−8		V
I_{IH}	Driver high-level input current	DIN = V_{CC}			5	40	μA
	Control high-level input current	$\overline{SHDN}$ = V_{CC}			0.01	1	
I_{IL}	Driver low-level input current	DIN = 0 V			−5	−40	μA
	Control low-level input current	$\overline{SHDN}$ = 0 V			−0.01	−1	
I_{OS}‡	Short-circuit output current	V_{CC} = 5.5 V,	V_O = 0 V	±7	±22		mA
I_{off}	Output leakage current	V_{CC} = 5.5 V, $\overline{SHDN}$ = GND,	V_O = ±10 V		±0.01	±10	μA
r_O	Output resistance	V_{CC}, V+, and V− = 0 V,	V_O = ±2 V	300	10 M		Ω

† All typical values are at V_{CC} = 5 V, and T_A = 25°C.
‡ 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.
NOTE 4: Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
	Data rate	C_L = 1000 pF, One D_{OUT} switching,	R_L = 3 kΩ, See Figure 1	200			kbit/s
$t_{PLH (D)}$	Propagation delay time, low- to high-level output	See Figure 1			1.5	3.5	μs
$t_{PHL (D)}$	Propagation delay time, high- to low-level output	See Figure 1			1.3	3.5	μs
$t_{PHL (D)} − t_{PLH (D)}$	Driver (+ to −) propagation delay difference				300		ns
$t_{sk(p)}$	Pulse skew§	C_L = 150 pF to 2500 pF	R_L = 3 kΩ to 7 kΩ, See Figure 2		300		ns
SR(tr)	Slew rate, transition region (see Figure 1)	R_L = 3 kΩ to 7 kΩ, V_{CC} = 5 V	C_L = 50 pF to 2500 pF	6	12	30	V/μs
t_{ET}	Driver output enable time (after $\overline{SHDN}$ goes high)				250		μs
t_{DT}	Driver output disable time (after $\overline{SHDN}$ goes low)				300		ns

† All typical values are at V_{CC} = 5 V and T_A = 25°C.
§ Pulse skew is defined as $|t_{PLH} − t_{PHL}|$ of each channel of the same device.
NOTE 4: Test conditions are C1–C4 = 0.1 μF at V_{CC} = 5 V ± 0.5 V.

RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

	PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	$I_{OH} = -1$ mA	3.5	$V_{CC} - 0.2$ V		V
V_{OL}	Low-level output voltage	$I_{OL} = 3.2$ mA			0.4	V
V_{IT+}	Positive-going input threshold voltage	$V_{CC} = 5$ V		1.7	2.4	V
V_{IT-}	Negative-going input threshold voltage	$V_{CC} = 5$ V	0.8	1.3		V
V_{hys}	Input hysteresis ($V_{IT+} - V_{IT-}$)		0.2	0.5	1	V
r_i	Input resistance	$V_I = \pm 3$ V to ± 25 V	3	5	7	kΩ

† All typical values are at $V_{CC} = 5$ V, and $T_A = 25°C$.
NOTE 4: Test conditions are C1–C4 = 0.1 µF at $V_{CC} = 5$ V $\pm$ 0.5 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 3)

	PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t_{PLH} (R)	Propagation delay time, low- to high-level output	$C_L = 150$ pF		0.6	1	µs
t_{PHL} (R)	Propagation delay time, high- to low-level output	$C_L = 150$ pF		0.5	1	µs
t_{PHL} (R) − t_{PLH} (R)	Receiver (+ to −) propagation delay difference			100		ns
$t_{sk(p)}$	Pulse skew‡			100		ns

† All typical values are at $V_{CC} = 5$ V and $T_A = 25°C$.
‡ Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.
NOTE 4: Test conditions are C1–C4 = 0.1 µF, at $V_{CC} = 5$ V $\pm$ 0.5 V.

ESD protection

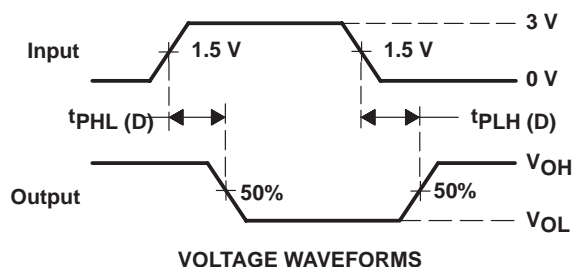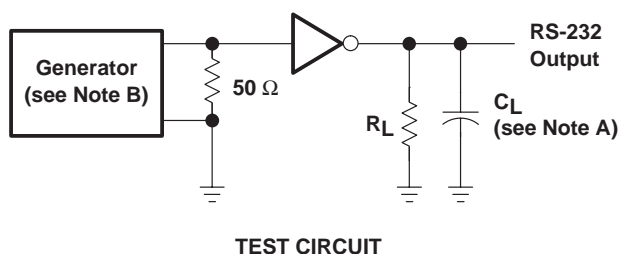| PIN	TEST CONDITIONS	TYP	UNIT
D_{OUT}, R_{IN}	Human-Body Model	±15	kV

PARAMETER MEASUREMENT INFORMATION

$$SR(tr) = \frac{6\ V}{t_{PHL\ (D)}\ or\ t_{PLH\ (D)}}$$

NOTES: A. C_L includes probe and jig capacitance.
          B. The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.
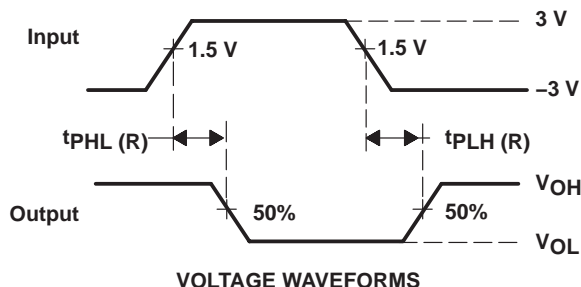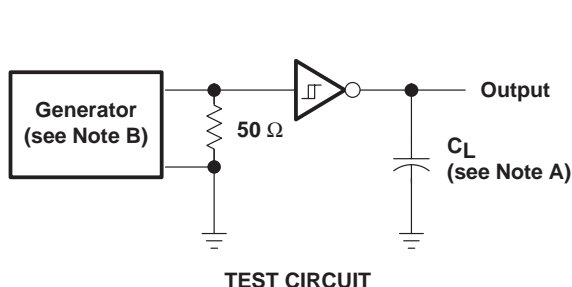
Figure 1. Driver Slew Rate

NOTES: A. C_L includes probe and jig capacitance.
          B. The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.
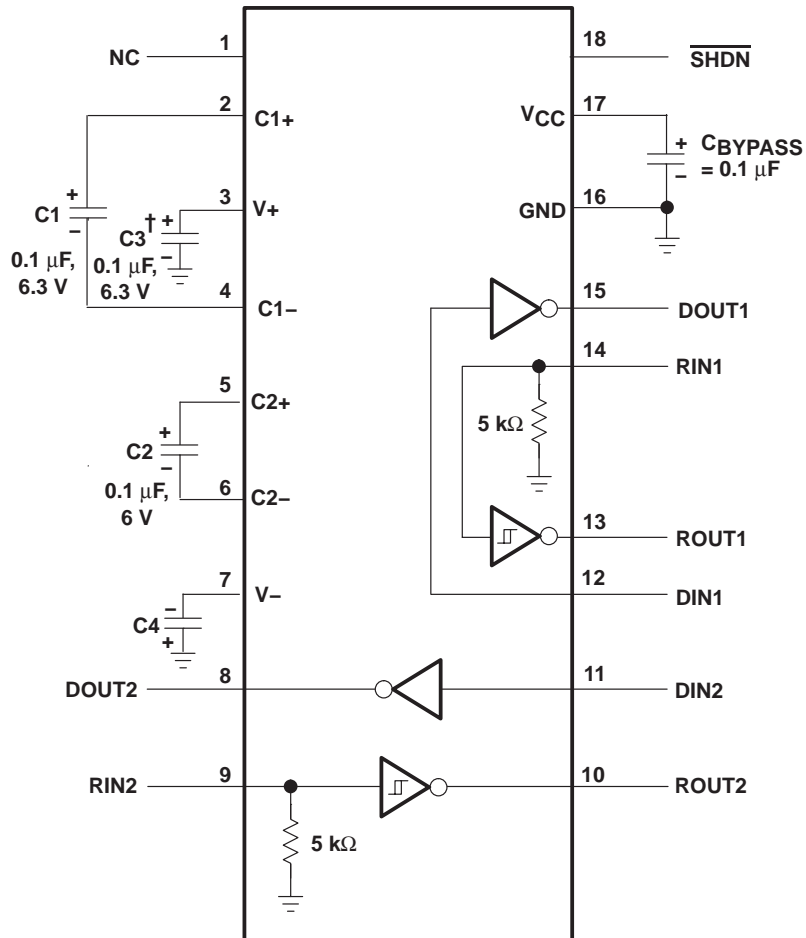
Figure 2. Driver Pulse Skew

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

Figure 3. Receiver Propagation Delay Times

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.

Figure 4. Typical Operating Circuit and Capacitor Values

APPLICATION INFORMATION

capacitor selection

The capacitor type used for C1–C4 is not critical for proper operation. The MAX222 requires 0.1-μF capacitors, although capacitors up to 10 μF can be used without harm. Ceramic dielectrics are suggested for the 0.1-μF capacitors. When using the minimum recommended capacitor values, ensure that the capacitance value does not degrade excessively as the operating temperature varies. If in doubt, use capacitors with a larger (e.g., 2×) nominal value. The capacitors' effective series resistance (ESR), which usually rises at low temperatures, influences the amount of ripple on V_+ and V_-.

Use larger capacitors (up to 10 μF) to reduce the output impedance at V_+ and V_-.

Bypass V_{CC} to ground with at least 0.1 μF. In applications sensitive to power-supply noise generated by the charge pumps, decouple V_{CC} to ground with a capacitor the same size as (or larger than) the charge-pump capacitors (C1–C4).

ESD protection

TI MAX222 devices have standard ESD protection structures incorporated on the pins to protect against electrostatic discharges encountered during assembly and handling. In addition, the RS232 bus pins (driver outputs and receiver inputs) of these devices have an extra level of ESD protection. Advanced ESD structures were designed to successfully protect these bus pins against ESD discharge of ±15-kV when powered down.

ESD test conditions

ESD testing stringently is performed by TI, based on various conditions and procedures. Contact TI for a reliability report that documents test setup, methodology, and results.

Human-Body Model

The Human-Body Model (HBM) of ESD testing is shown in Figure 5, while Figure 6 shows the current waveform that is generated during a discharge into a low impedance. The model consists of a 100-pF capacitor, charged to the ESD voltage of concern, and subsequently discharged into the DUT through a 1.5-kΩ resistor.
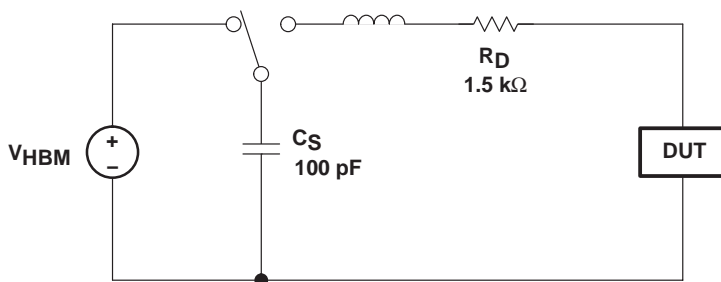

Figure 5. HBM ESD Test Circuit

APPLICATION INFORMATION
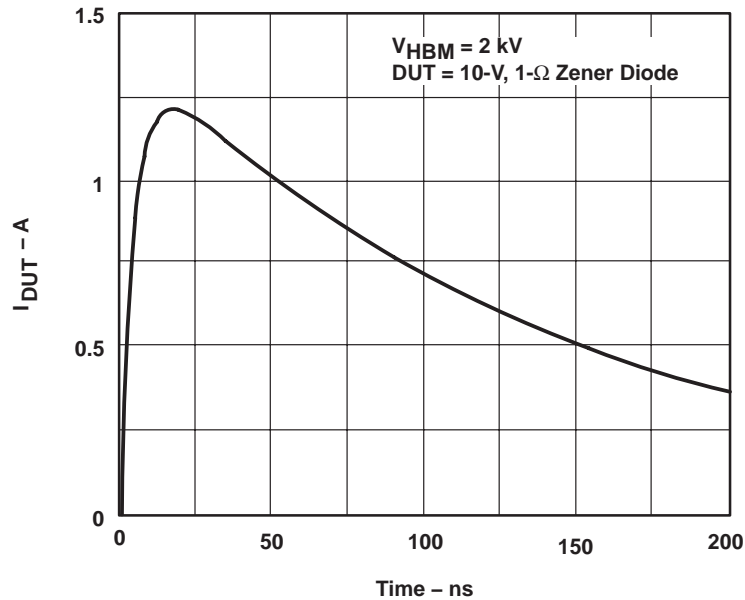
Figure 6. Typical HBM Current Waveform

Machine Model

The Machine Model (MM) ESD test applies to all pins using a 200-pF capacitor with no discharge resistance. The purpose of the MM test is to simulate possible ESD conditions that can occur during the handling and assembly processes of manufacturing. In this case, ESD protection is required for all pins, not just RS-232 pins. However, after PC board assembly, the MM test no longer is as pertinent to the RS-232 pins.

MAX222
5-V DUAL RS-232 LINE DRIVER/RECEIVER
WITH ±15-kV ESD PROTECTION
SLLS590D – SEPTEMBER 2003 – REVISED AUGUST 2004

MECHANICAL DATA

DW (R−PDSO−G18)   PLASTIC SMALL−OUTLINE PACKAGE
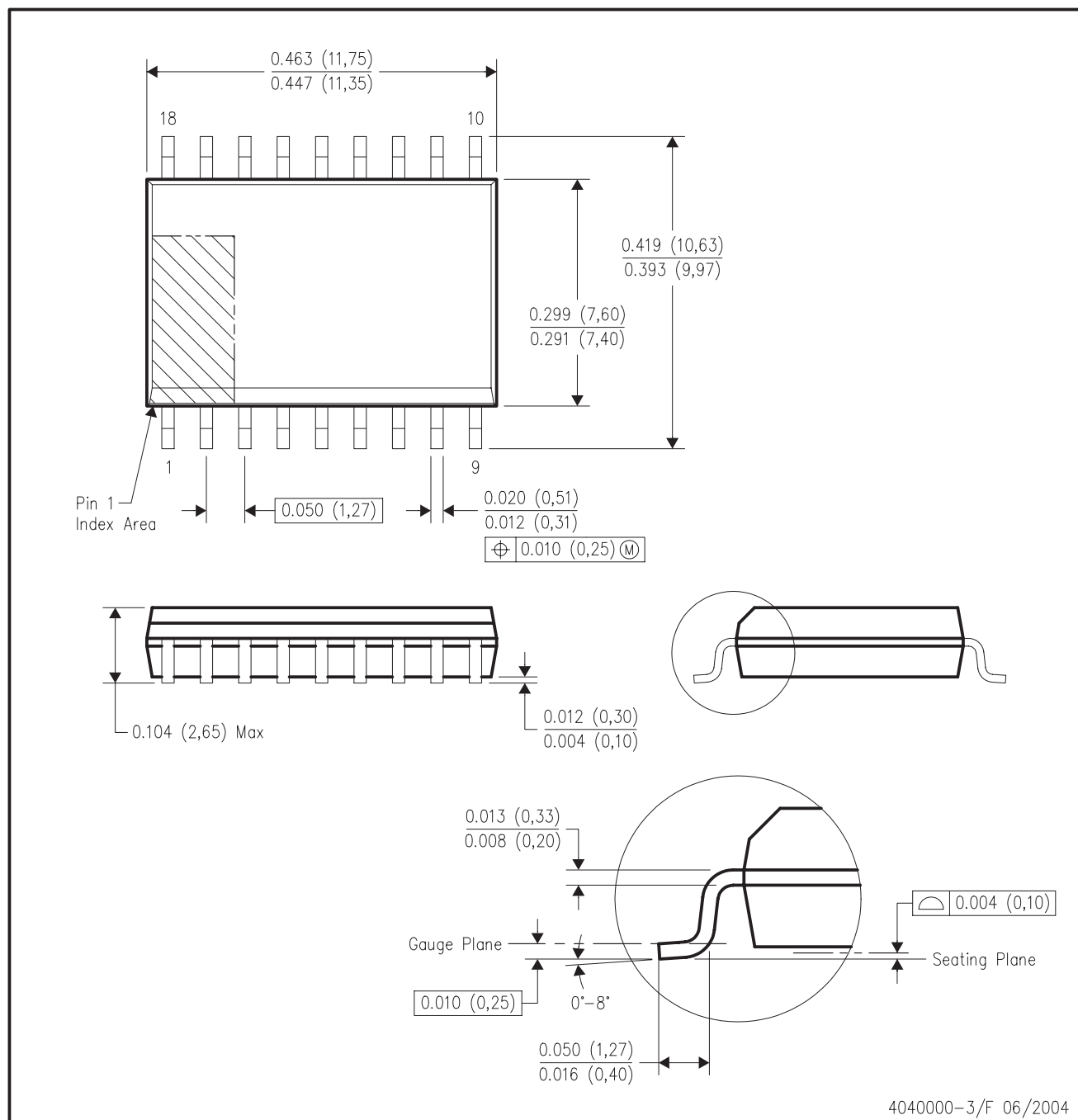
NOTES: A.   All linear dimensions are in inches (millimeters).
         B.   This drawing is subject to change without notice.
         C.   Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
         D.   Falls within JEDEC MS−013 variation AB.

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MAX222CDW	ACTIVE	SOIC	DW	18	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222CDWG4	ACTIVE	SOIC	DW	18	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222CDWR	ACTIVE	SOIC	DW	18	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222CDWRG4	ACTIVE	SOIC	DW	18	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222CN	ACTIVE	PDIP	N	18	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX222CNE4	ACTIVE	PDIP	N	18	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX222IDW	ACTIVE	SOIC	DW	18	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222IDWG4	ACTIVE	SOIC	DW	18	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222IDWR	ACTIVE	SOIC	DW	18	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222IDWRG4	ACTIVE	SOIC	DW	18	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
MAX222IN	ACTIVE	PDIP	N	18	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX222INE4	ACTIVE	PDIP	N	18	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

[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] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check
http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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.
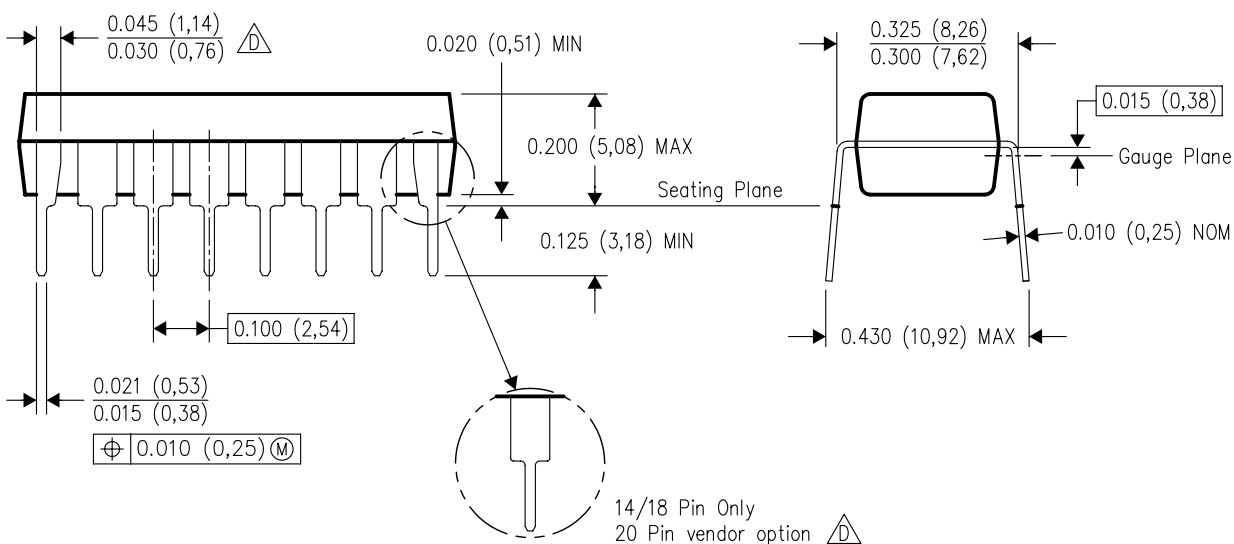
N (R−PDIP−T**)

16 PINS SHOWN

PLASTIC DUAL−IN−LINE PACKAGE
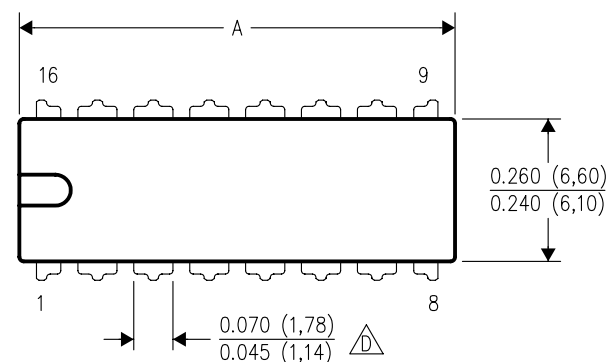
DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS−001 VARIATION	AA	BB	AC	AD

0.260 (6,60) / 0.240 (6,10)

0.070 (1,78) / 0.045 (1,14)

0.045 (1,14) / 0.030 (0,76)

0.020 (0,51) MIN

0.200 (5,08) MAX

Seating Plane

0.125 (3,18) MIN

0.100 (2,54)

0.021 (0,53) / 0.015 (0,38)

⊕ 0.010 (0,25) Ⓜ

14/18 Pin Only
20 Pin vendor option

0.325 (8,26) / 0.300 (7,62)

0.015 (0,38)
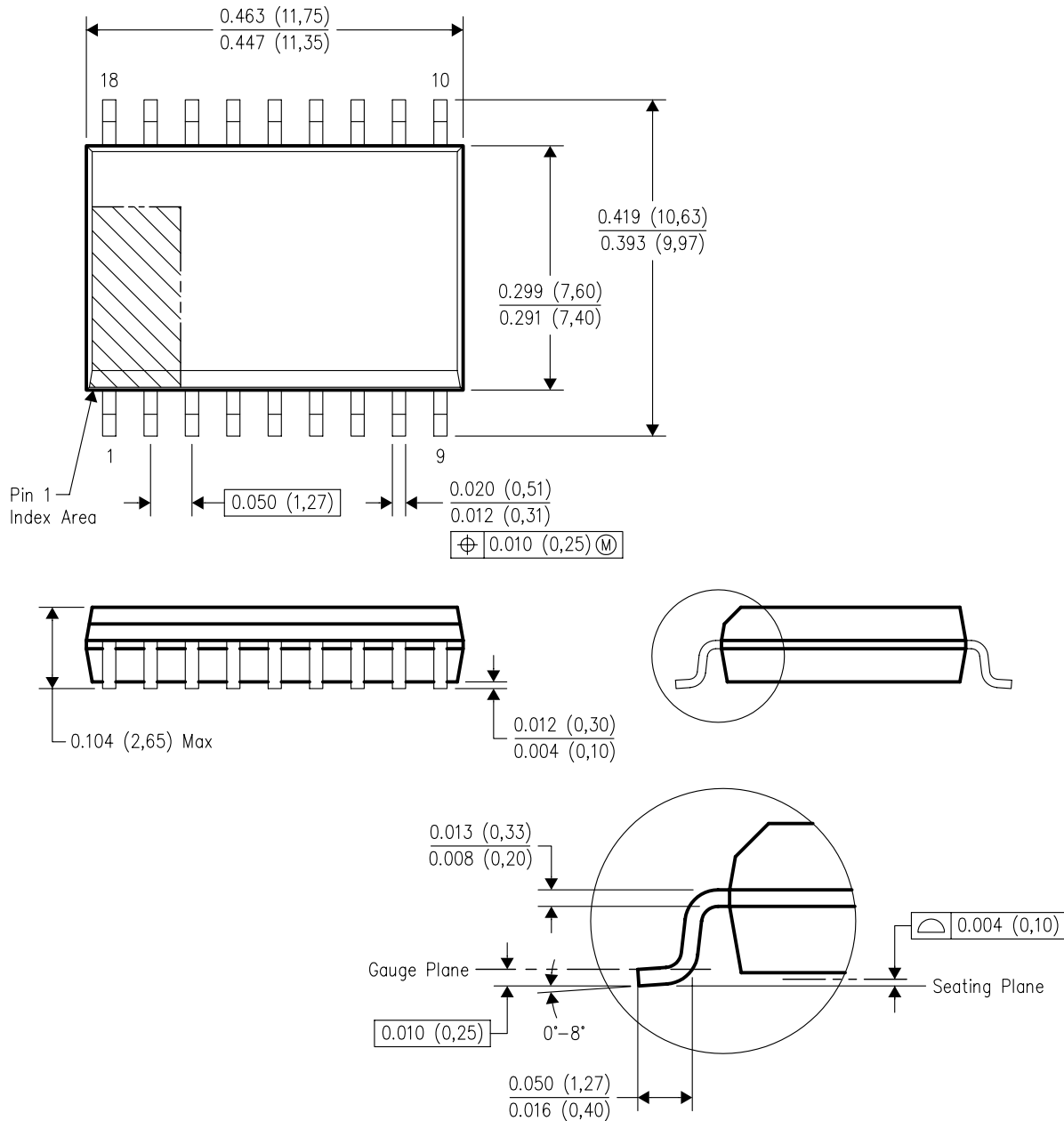
Gauge Plane

0.010 (0,25) NOM

0.430 (10,92) MAX

4040049/E 12/2002

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS−001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

DW (R−PDSO−G18)   PLASTIC SMALL−OUTLINE PACKAGE

0.463 (11,75)
0.447 (11,35)

18   10

0.419 (10,63)
0.393 (9,97)

0.299 (7,60)
0.291 (7,40)

1   9

Pin 1
Index Area

0.050 (1,27)

0.020 (0,51)
0.012 (0,31)

⊕ | 0.010 (0,25) Ⓜ

0.104 (2,65) Max

0.012 (0,30)
0.004 (0,10)

0.013 (0,33)
0.008 (0,20)

⌂ | 0.004 (0,10)

Gauge Plane

Seating Plane

0.010 (0,25)

0°−8°

0.050 (1,27)
0.016 (0,40)

4040000−3/F 06/2004

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 MS−013 variation AB.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
                              Post Office Box 655303 Dallas, Texas 75265

Copyright © 2006, Texas Instruments Incorporated