

# SN74F161A SYNCHRONOUS 4-BIT BINARY COUNTER

SDFS056B – MARCH 1987 – REVISED AUGUST 2001

- Internal Look-Ahead Circuitry for Fast Counting
- Carry Output for N-Bit Cascading
- Fully Synchronous Operation for Counting

## description

This synchronous, presettable, 4-bit binary counter has internal carry look-ahead circuitry for use in high-speed counting designs. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the count-enable (ENP, ENT) inputs and internal gating. This mode of operation eliminates the output counting spikes that are normally associated with asynchronous (ripple-clock) counters. However, counting spikes can occur on the ripple-carry (RCO) output. A buffered clock (CLK) input triggers the four flip-flops on the rising (positive-going) edge of CLK.

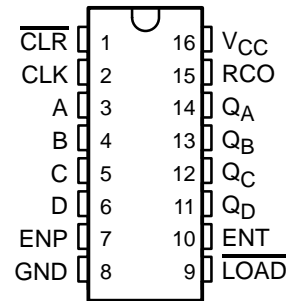
This counter is fully programmable. That is, it can be preset to any number between 0 and 15. Because presetting is synchronous, a low logic level at the load ( $\overline{LOAD}$ ) input disables the counter and causes the outputs to agree with the setup data after the next clock pulse, regardless of the levels of ENP and ENT.

The clear function is asynchronous, and a low logic level at the clear ( $\overline{CLR}$ ) input sets all four of the flip-flop outputs to low, regardless of the levels of CLK,  $\overline{LOAD}$ , ENP, and ENT.

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications, without additional gating. This function is implemented by the ENP and ENT inputs and an RCO output. Both ENP and ENT must be high to count, and ENT is fed forward to enable RCO. RCO, thus enabled, produces a high-logic-level pulse while the count is 15 (HHHH). The high-logic-level overflow ripple-carry pulse can be used to enable successive cascaded stages. Transitions at ENP or ENT are allowed, regardless of the level of CLK.

The SN74F161A features a fully independent clock circuit. Changes at ENP, ENT, or  $\overline{LOAD}$  that modify the operating mode have no effect on the contents of the counter until clocking occurs. The function of the counter (whether enabled, disabled, loading, or counting) is dictated solely by the conditions meeting the setup and hold times.

D, DB, OR N PACKAGE  
(TOP VIEW)



## ORDERING INFORMATION

T <sub>A</sub>	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP – N	Tube	SN74F161AN	SN74F161AN
	SOIC – D	Tube	SN74F161AD	F161A
		Tape and reel	SN74F161ADR	
	SSOP – DB	Tape and reel	SN74F161ADBR	F161A

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



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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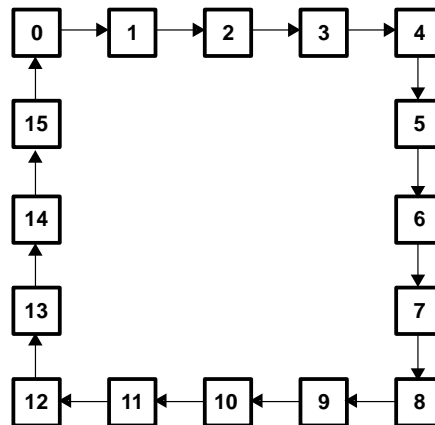
# SN74F161A

## SYNCHRONOUS 4-BIT BINARY COUNTER

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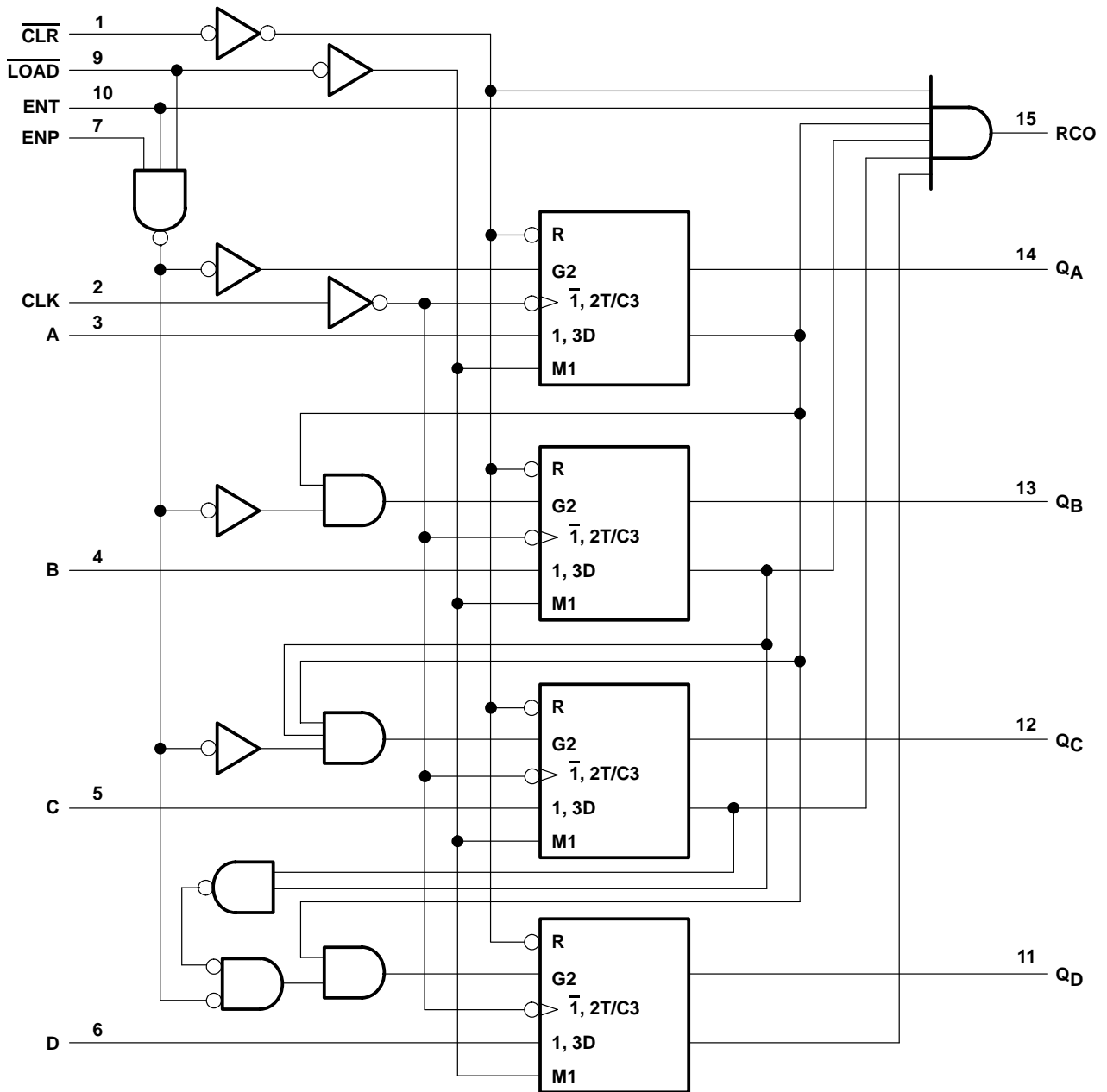
### state diagram



# SN74F161A SYNCHRONOUS 4-BIT BINARY COUNTER

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logic diagram (positive logic)

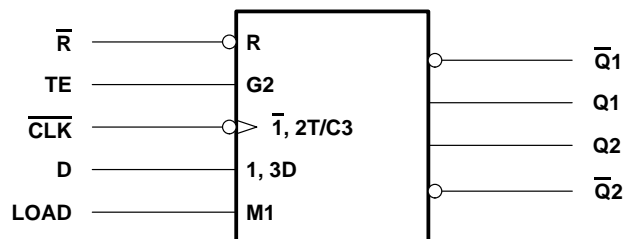


# SN74F161A

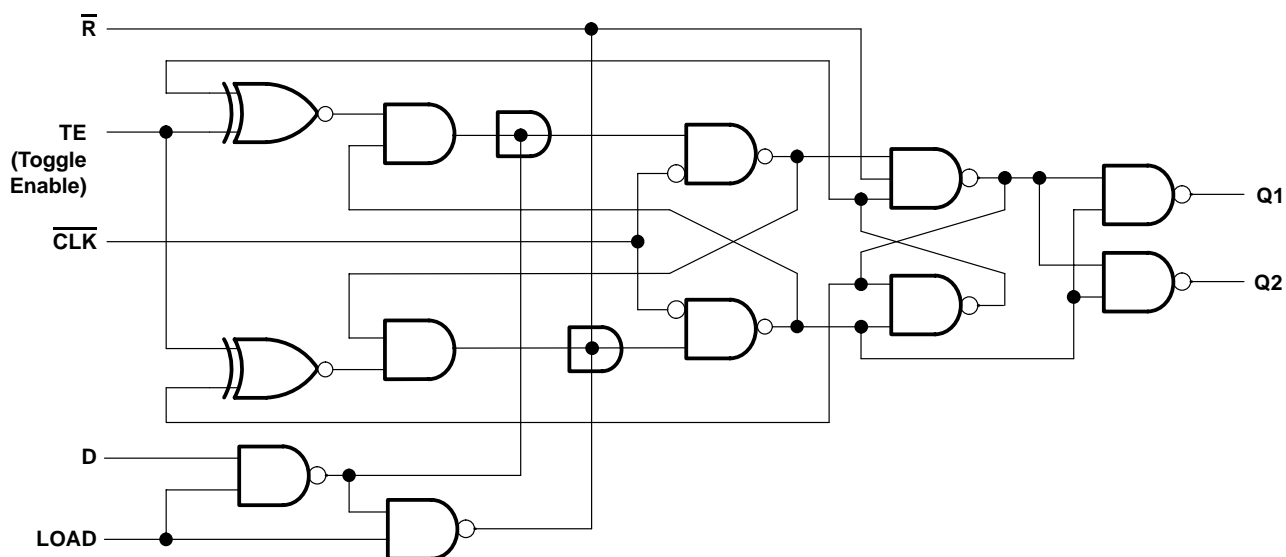
## SYNCHRONOUS 4-BIT BINARY COUNTER

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### logic symbol, each flip-flop



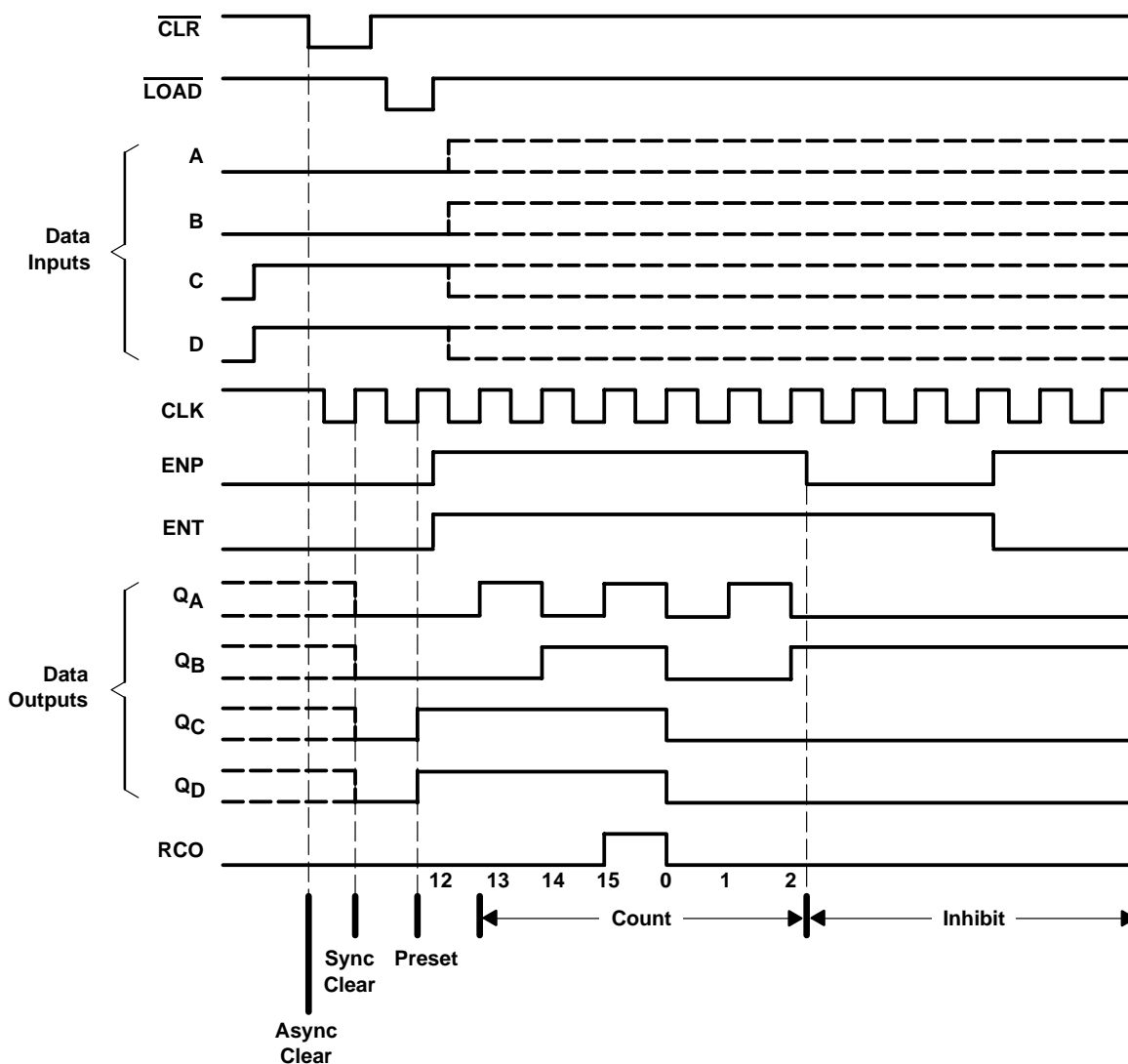
### logic diagram, each flip-flop (positive logic)



### typical clear, preset, count, and inhibit sequences

The following timing sequence is illustrated below:

1. Clear outputs to zero
2. Preset to binary 12
3. Count to 13, 14, 15, 0, 1, and 2
4. Inhibit



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## SYNCHRONOUS 4-BIT BINARY COUNTER

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### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

Supply voltage range, $V_{CC}$	–0.5 V to 7 V
Input voltage range, $V_I$ (see Note 1)	–1.2 V to 7 V
Input current range	–30 mA to 5 mA
Voltage range applied to any output in the high state	–0.5 V to $V_{CC}$
Current into any output in the low state	40 mA
Package thermal impedance, $\theta_{JA}$ (see Note 2): D package	73°C/W
DB package	82°C/W
N package	67°C/W
Storage temperature range, $T_{stg}$	–65°C to 150°C

<sup>†</sup> 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. The input voltage ratings may be exceeded provided the input current ratings are observed.  
2. The package thermal impedance is calculated in accordance with JESD 51-7.

### recommended operating conditions (see Note 3)

	MIN	NOM	MAX	UNIT
$V_{CC}$ Supply voltage	4.5	5	5.5	V
$V_{IH}$ High-level input voltage	2			V
$V_{IL}$ Low-level input voltage			0.8	V
$I_{IK}$ Input clamp current			–18	mA
$I_{OH}$ High-level output current			–1	mA
$I_{OL}$ Low-level output current			20	mA
$T_A$ Operating free-air temperature	0		70	°C

NOTE 3: 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.

### electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP <sup>‡</sup>	MAX	UNIT
$V_{IK}$	$V_{CC} = 4.5$ V, $I_I = -18$ mA			–1.2	V
$V_{OH}$	$V_{CC} = 4.5$ V, $I_{OH} = -1$ mA	2.5	3.4		V
	$V_{CC} = 4.75$ V, $I_{OH} = -1$ mA	2.7			
$V_{OL}$	$V_{CC} = 4.5$ V, $I_{OL} = 20$ mA		0.3	0.5	V
$I_I$	$V_{CC} = 5.5$ V, $V_I = 7$ V			0.1	mA
$I_{IH}$	$V_{CC} = 5.5$ V, $V_I = 2.7$ V			20	μA
$I_{IL}$	ENP, CLK, A, B, C, D			–0.6	mA
	ENT, LOAD			–1.2	
	CLR			–0.6	
$I_{OS}^{\S}$	$V_{CC} = 5.5$ V, $V_O = 0$	–60		–150	mA
$I_{CC}$	$V_{CC} = 5.5$ V		37	55	mA

<sup>‡</sup> All typical values are at  $V_{CC} = 5$  V,  $T_A = 25^\circ\text{C}$ .

<sup>\S</sup> Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second.



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## SYNCHRONOUS 4-BIT BINARY COUNTER

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

				V <sub>CC</sub> = 5 V, T <sub>A</sub> = 25°C		MIN	MAX	UNIT
				MIN	MAX			
f <sub>clock</sub>	Clock frequency			0	100	0	90	MHz
t <sub>w</sub>	Pulse duration	CLK high or low (loading)		5		5		ns
		CLK (counting)	High	4		4		
			Low	6		7		
		CLR low		5		5		
t <sub>su</sub>	Setup time	Data before CLK↑	High or low	5		5		ns
		LOAD before CLK↑	High	11		11.5		
			Low	8.5		9.5		
		ENP and ENT before CLK↑	High	11		11.5		
			Low	5		5		
t <sub>h</sub>	Hold time	Data after CLK↑	High or low	2		2		ns
		LOAD after CLK↑	High	2		2		
			Low	0		0		
		ENP and ENT after CLK↑	High or low	0		0		
t <sub>su</sub>	Inactive-state setup time, CLR high before CLK↑†			6		6		ns

<sup>†</sup> Inactive-state setup time also is referred to as recovery time.

### switching characteristics (see Note 4)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 5\text{ V}$ , $C_L = 50\text{ PF}$ , $R_L = 500\ \Omega$ , $T_A = 25^\circ\text{C}$			$V_{CC} = 4.5\text{ V TO } 5.5\text{ V}$ , $C_L = 50\text{ PF}$ , $R_L = 500\ \Omega$ , $T_A = \text{MIN TO MAX}^\ddagger$		UNIT
			MIN	TYP	MAX	MIN	MAX	
$f_{\text{max}}$			100	120		90		MHz
$t_{\text{PLH}}$	CLK ( $\overline{\text{LOAD}}$ high)	Any Q	2.7	5.1	7.5	2.7	8.5	ns
$t_{\text{PHL}}$			2.7	7.1	10	2.7	11	
$t_{\text{PLH}}$	CLK ( $\overline{\text{LOAD}}$ low)	Any Q	3.2	5.6	8.5	3.2	9.5	ns
$t_{\text{PHL}}$			3.2	5.6	8.5	3.2	9.5	
$t_{\text{PLH}}$	CLK	RCO	4.2	9.6	14	4.2	15	ns
$t_{\text{PHL}}$			4.2	9.6	14	4.2	15	
$t_{\text{PLH}}$	ENT	RCO	1.7	4.1	7.5	1.7	8.5	ns
$t_{\text{PHL}}$			1.7	4.1	7.5	1.7	8.5	
$t_{\text{PHL}}$	CLR	Any Q	4.7	8.6	12	4.7	13	ns
		RCO	3.7	7.6	10.5	3.7	11.5	

<sup>‡</sup> For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

NOTE 4: Load circuits and waveforms are shown in Figure 1.

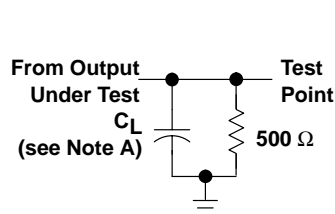


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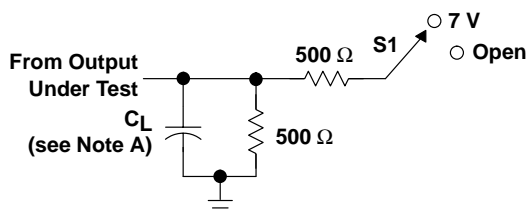
## SYNCHRONOUS 4-BIT BINARY COUNTER

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### PARAMETER MEASUREMENT INFORMATION

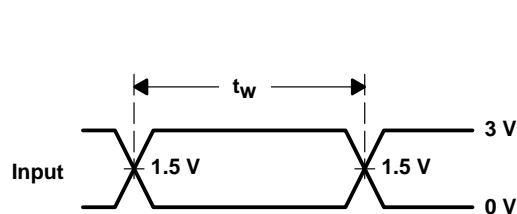


LOAD CIRCUIT FOR TOTEM-POLE OUTPUTS

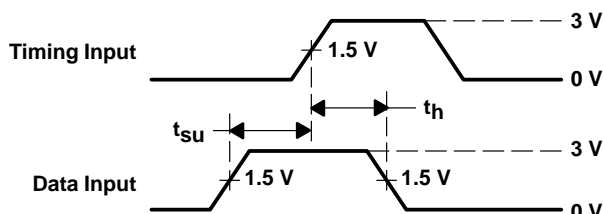


LOAD CIRCUIT FOR 3-STATE AND OPEN-DRAIN OUTPUTS

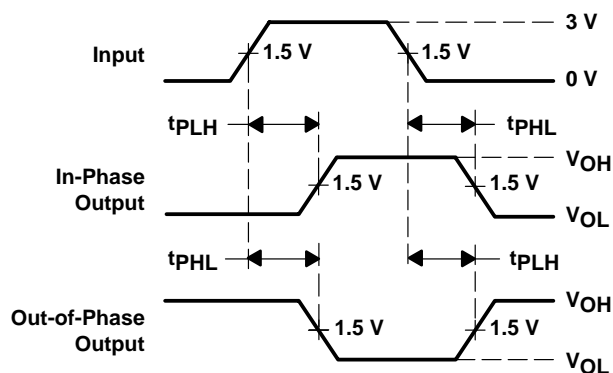
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	7 V
$t_{PHZ}/t_{PZH}$	Open
Open Collector	7 V



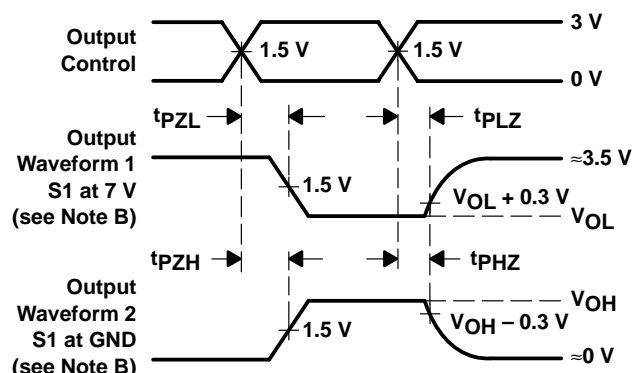
VOLTAGE WAVEFORMS PULSE DURATION



VOLTAGE WAVEFORMS SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS PROPAGATION DELAY TIMES INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS ENABLE AND DISABLE TIMES LOW- AND HIGH-LEVEL ENABLING

- 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:  $PRR \leq 1 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ , duty cycle = 50%.
  - The outputs are measured one at a time with one input transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
SN74F161AD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161ADE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161ADG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161ADR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161ADRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161ADRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F161A	<a href="#">Samples</a>
SN74F161AN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	SN74F161AN	<a href="#">Samples</a>
SN74F161AN3	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI	0 to 70		
SN74F161ANE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	SN74F161AN	<a href="#">Samples</a>
SN74F161ANSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	74F161A	<a href="#">Samples</a>
SN74F161ANSRE4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	74F161A	<a href="#">Samples</a>
SN74F161ANSRG4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	74F161A	<a href="#">Samples</a>

(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.

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**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.

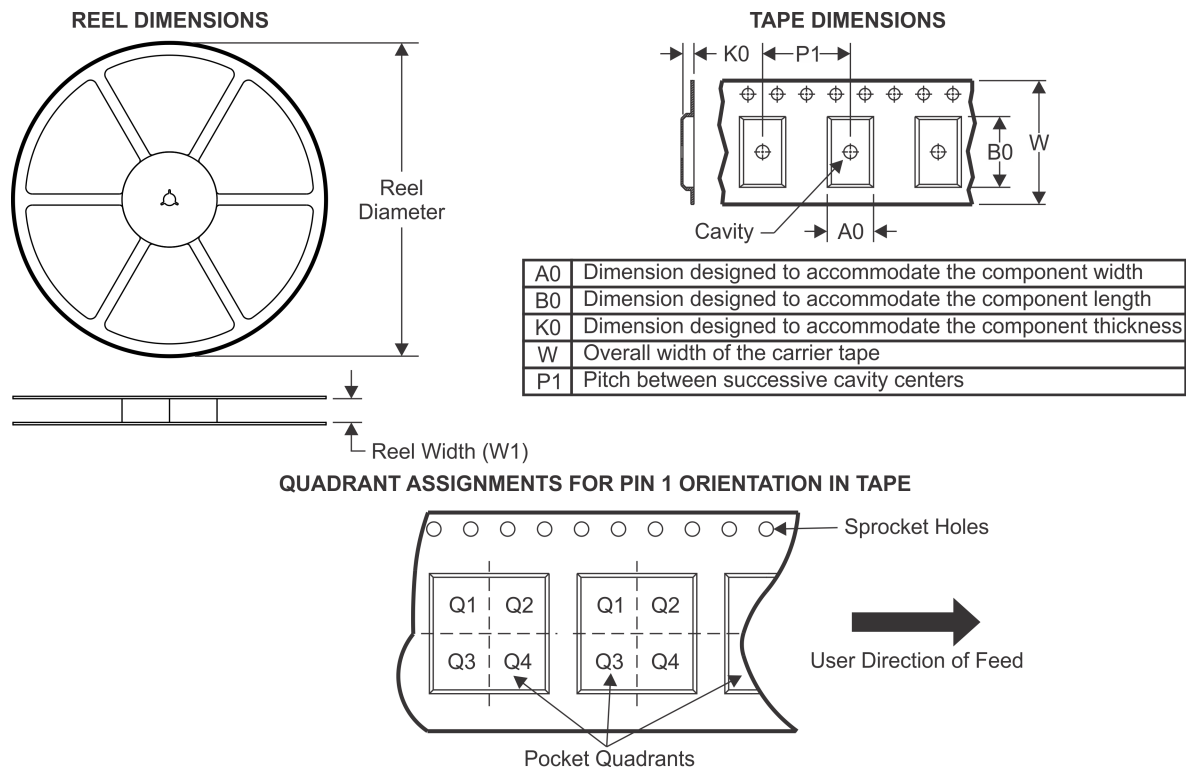
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> Only one of markings shown within the brackets will appear on the physical device.

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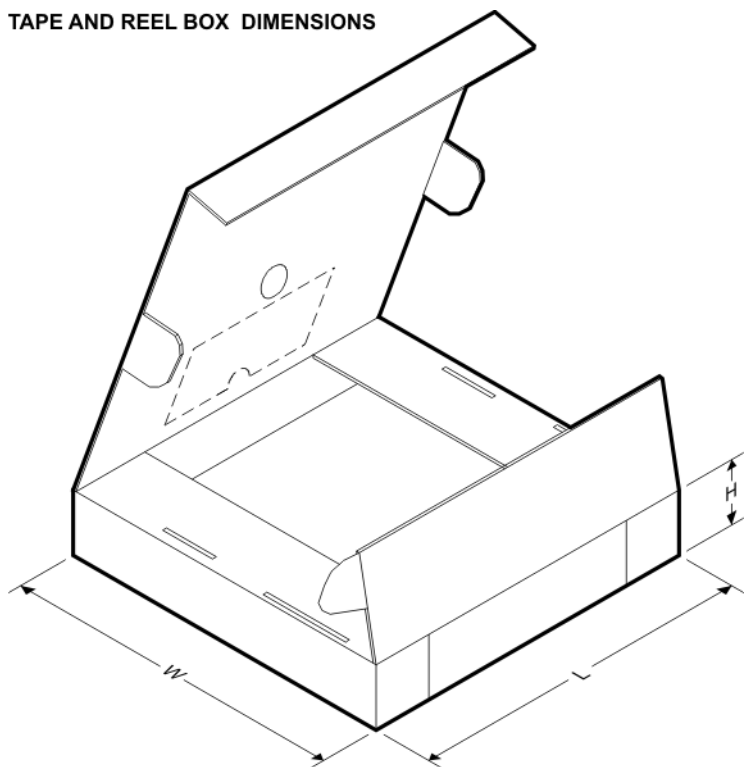
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**TAPE AND REEL INFORMATION**


\*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
SN74F161ADR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74F161ANSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



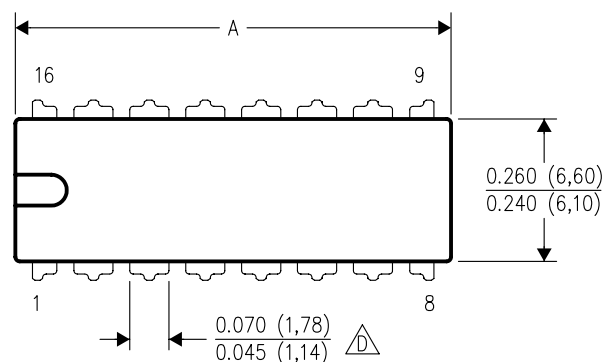
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74F161ADR	SOIC	D	16	2500	333.2	345.9	28.6
SN74F161ANSR	SO	NS	16	2000	367.0	367.0	38.0

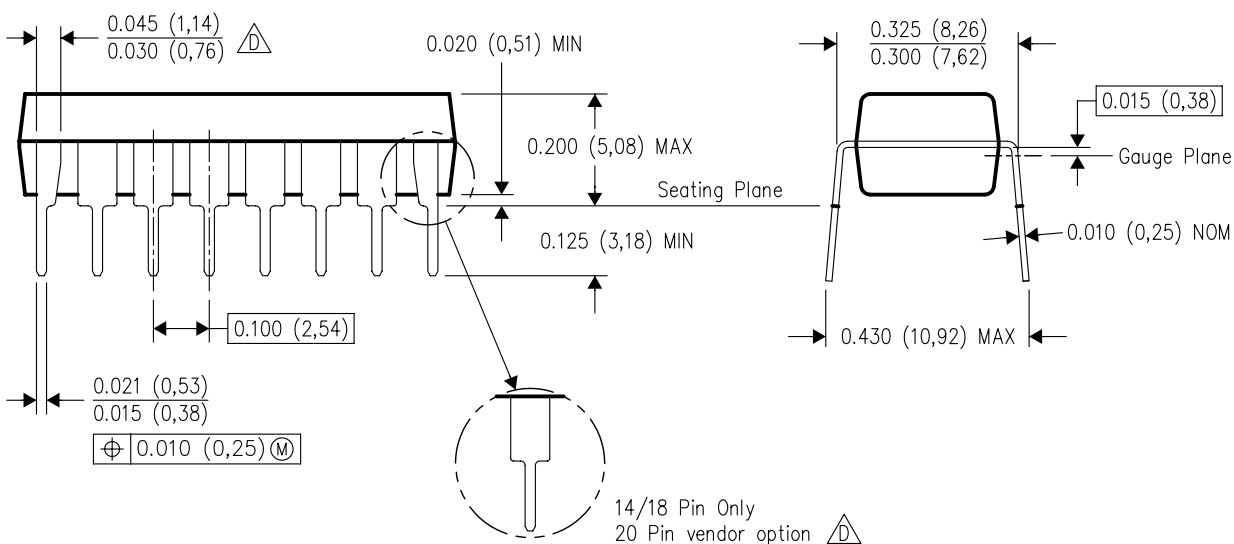
N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE





PINS ** DIM	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



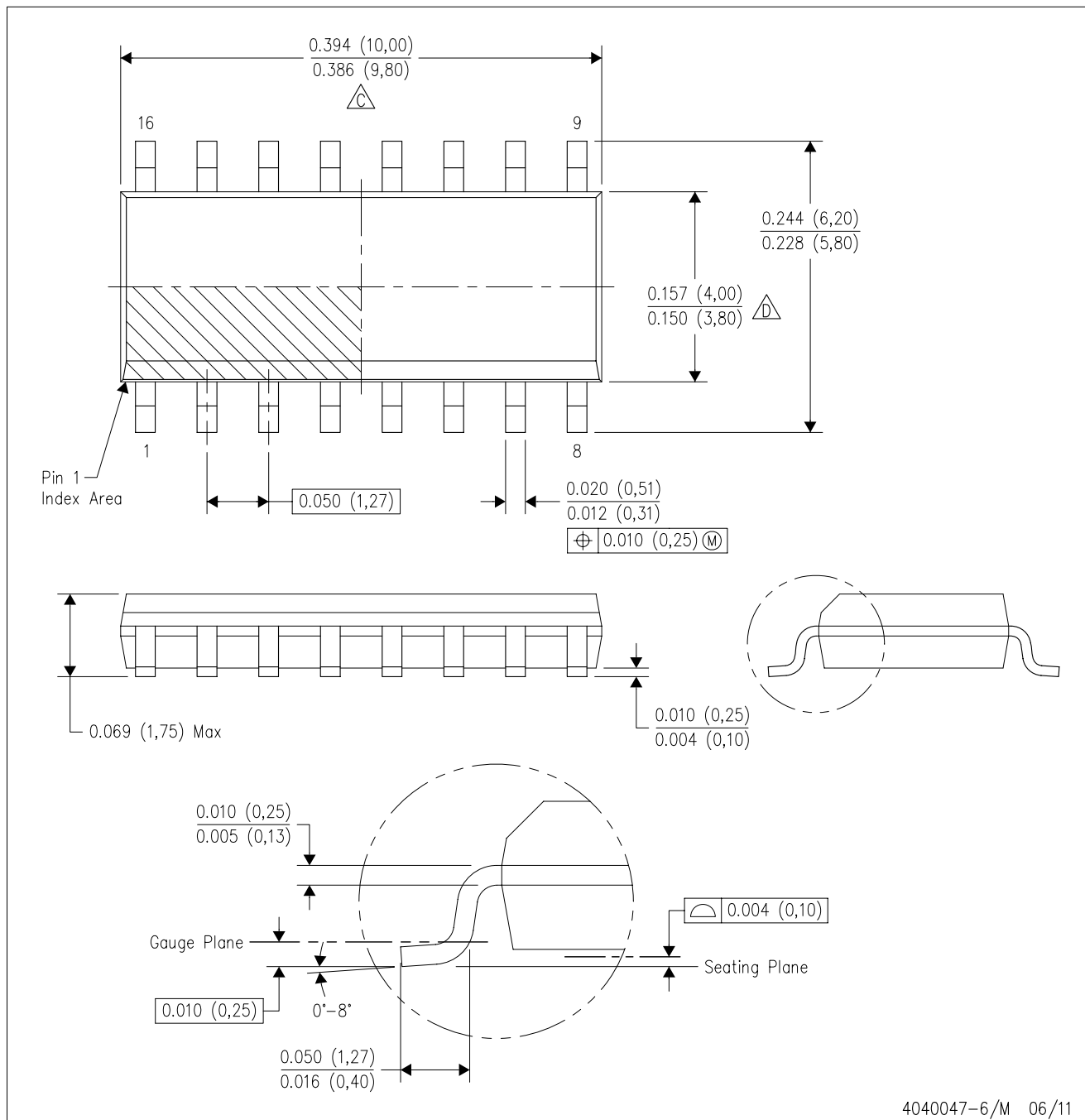
4040049/E 12/2002

NOTES:

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

D (R-PDSO-G16)

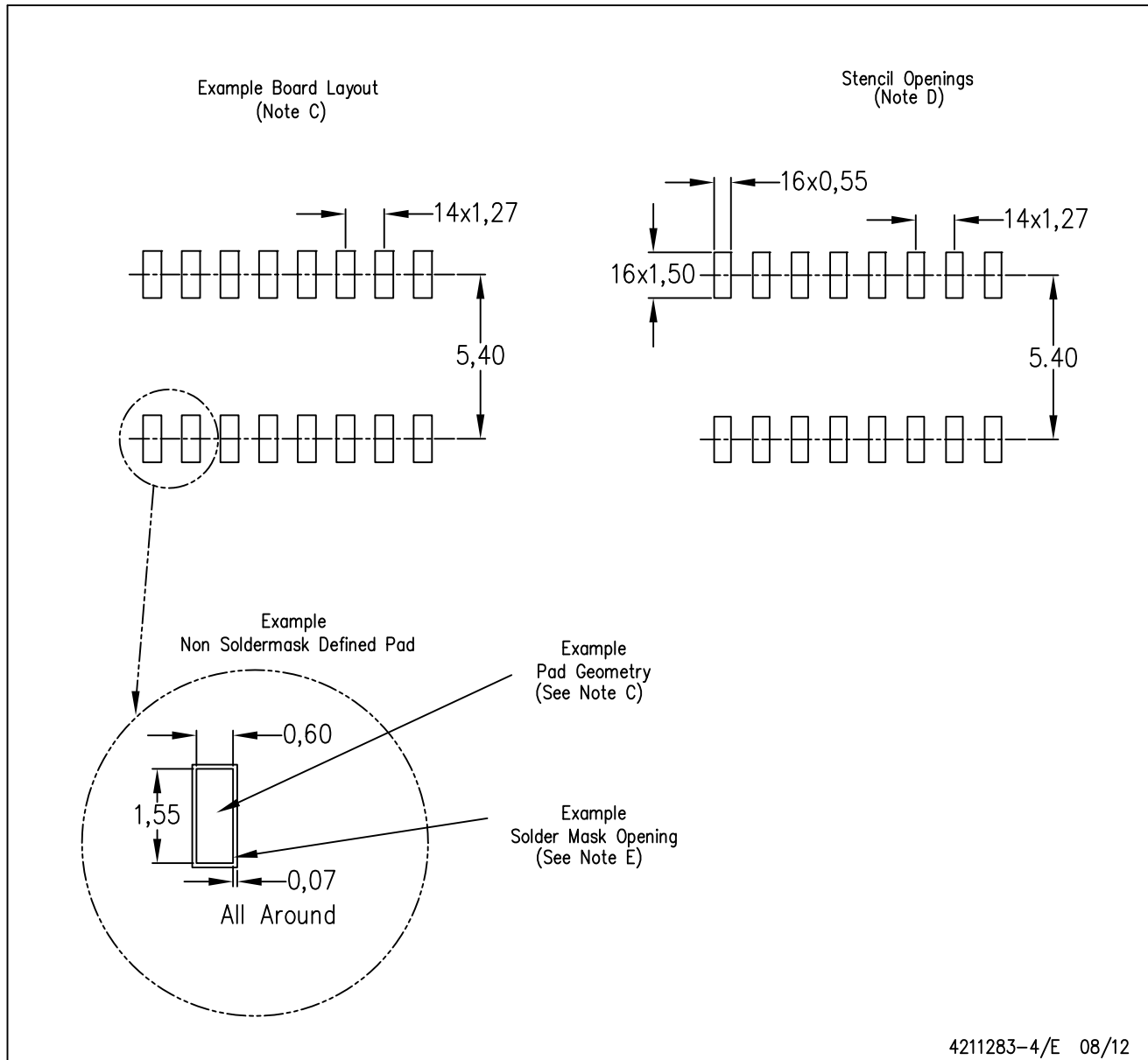
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AC.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



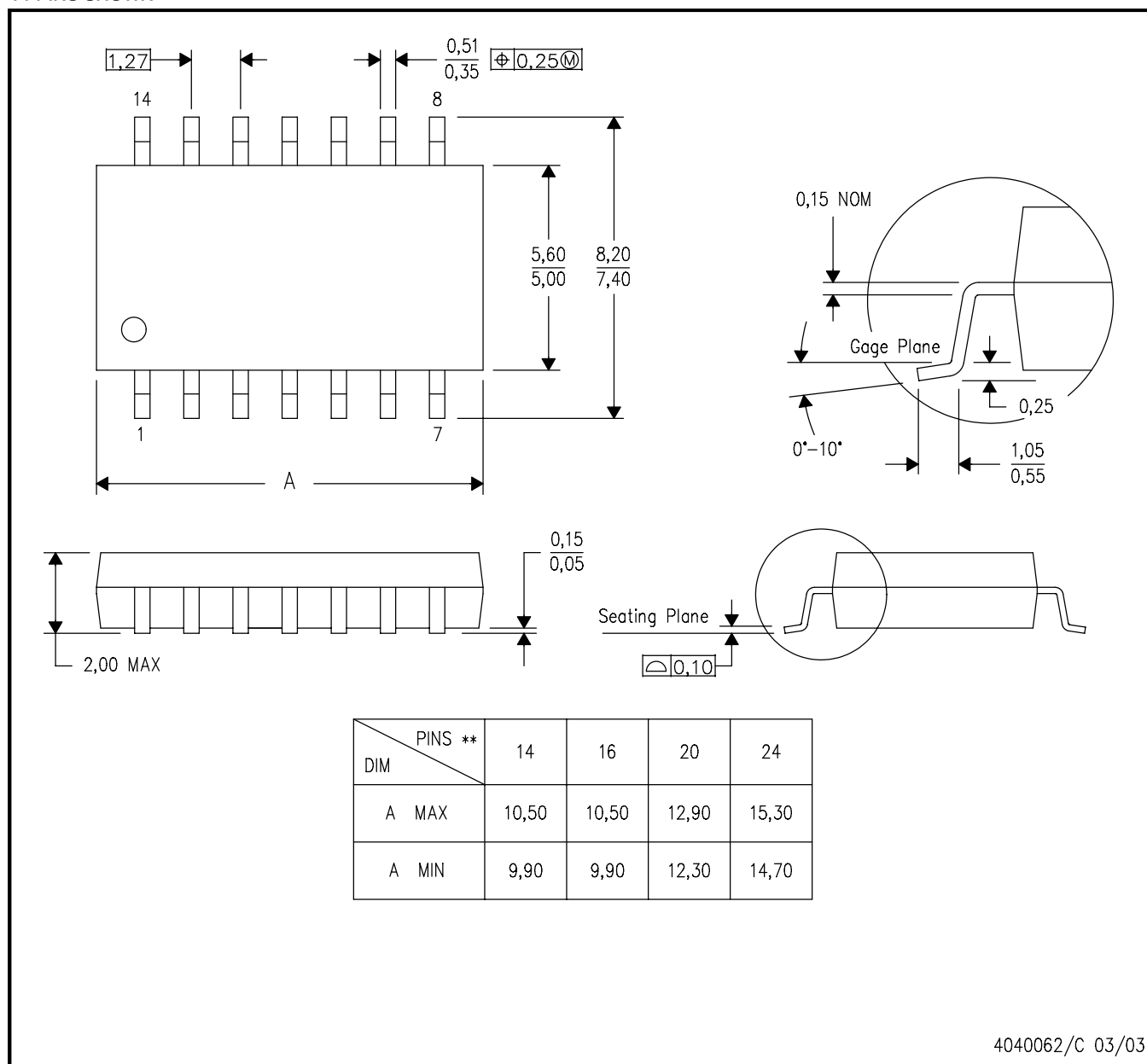
- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- 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.



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### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

moschip.ru

moschip.ru\_4

moschip.ru\_6

moschip.ru\_9