

SN54HC191, SN74HC191 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

SCLS121D – DECEMBER 1982 – REVISED OCTOBER 2003

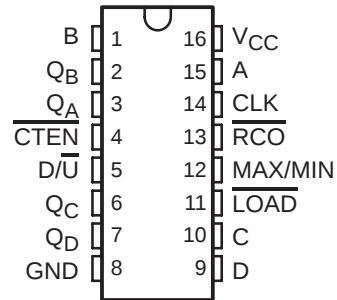
- Wide Operating Voltage Range of 2 V to 6 V
- Outputs Can Drive Up To 10 LSTTL Loads
- Low Power Consumption, 80- μ A Max I_{CC}
- Typical $t_{pd} = 13$ ns
- ± 4 -mA Output Drive at 5 V
- Low Input Current of 1 μ A Max
- Single Down/Up Count-Control Line
- Look-Ahead Circuitry Enhances Speed of Cascaded Counters
- Fully Synchronous in Count Modes
- Asynchronously Presetable With Load Control

description/ordering information

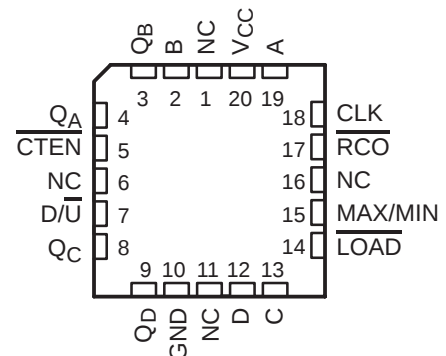
The 'HC191 devices are 4-bit synchronous, reversible, up/down binary counters. Synchronous counting operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when instructed by the steering logic. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple-clock) counters.

The outputs of the four flip-flops are triggered on a low- to high-level transition of the clock (CLK) input if the count-enable ($\overline{CTEN}$) input is low. A high at $\overline{CTEN}$ inhibits counting. The direction of the count is determined by the level of the down/up (D/U) input. When D/U is low, the counter counts up, and when D/U is high, it counts down.

SN54HC191 . . . J OR W PACKAGE
SN74HC191 . . . D, N, OR NS PACKAGE
(TOP VIEW)



SN54HC191 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

ORDERING INFORMATION

T_A	PACKAGE [†]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	PDIP – N	Tube of 25	SN74HC191N	SN74HC191N
	SOIC – D	Tube of 40	SN74HC191D	HC191
		Reel of 2500	SN74HC191DR	
		Reel of 250	SN74HC191DT	
–55°C to 125°C	SOP – NS	Reel of 2000	SN74HC191NSR	HC191
	CDIP – J	Tube of 25	SNJ54HC191J	SNJ54HC191J
	CFP – W	Tube of 150	SNJ54HC191W	SNJ54HC191W
	LCCC – FK	Tube of 55	SNJ54HC191FK	SNJ54HC191FK

[†] Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at 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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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

SN54HC191, SN74HC191

4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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description/ordering information (continued)

These counters feature a fully independent clock circuit. Change at the control ($\overline{CTEN}$ and $D/\overline{U}$) inputs that modifies the operating mode have no effect on the contents of the counter until clocking occurs. The function of the counter is dictated solely by the condition meeting the stable setup and hold times.

These counters are fully programmable; that is, each of the outputs can be preset to either level by placing a low on the load ($\overline{LOAD}$) input and entering the desired data at the data inputs. The output changes to agree with the data inputs independently of the level of CLK. This feature allows the counters to be used as modulo-N dividers simply by modifying the count length with the preset inputs.

Two outputs are available to perform the cascading function: ripple clock ($\overline{RCO}$) and maximum/minimum (MAX/MIN) count. MAX/MIN produces a high-level output pulse with a duration approximately equal to one complete cycle of the clock while the count is zero (all outputs low) counting down, or maximum (9 or 15) counting up. $\overline{RCO}$ produces a low-level output pulse under those same conditions, but only while CLK is low. The counters can be cascaded easily by feeding $\overline{RCO}$ to $\overline{CTEN}$ of the succeeding counter if parallel clocking is used, or to CLK if parallel enabling is used. MAX/MIN can be used to accomplish look ahead for high-speed operation.

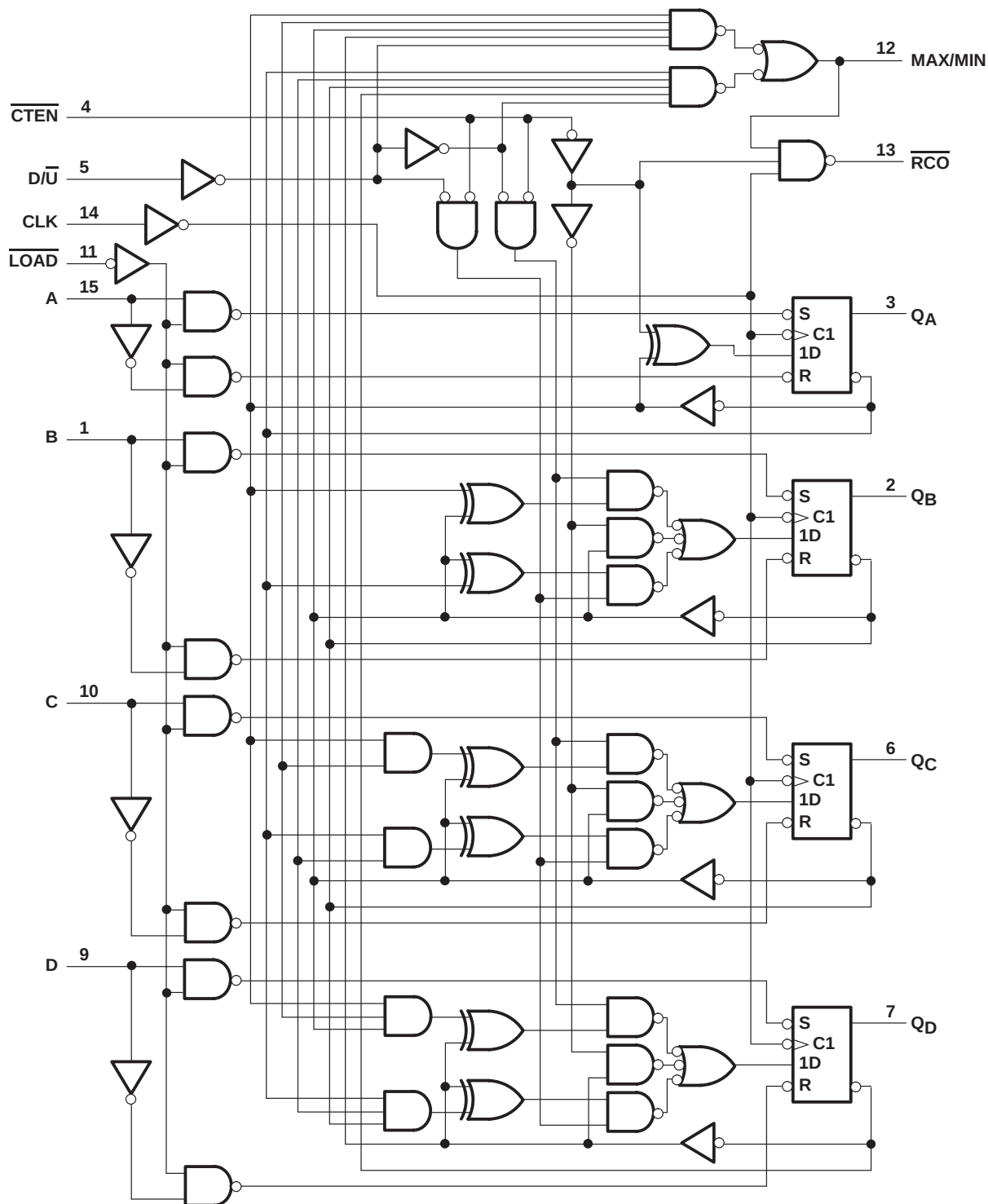


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SN54HC191, SN74HC191 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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logic diagram (positive logic)



Pin numbers shown are for the D, J, N, NS, and W packages.

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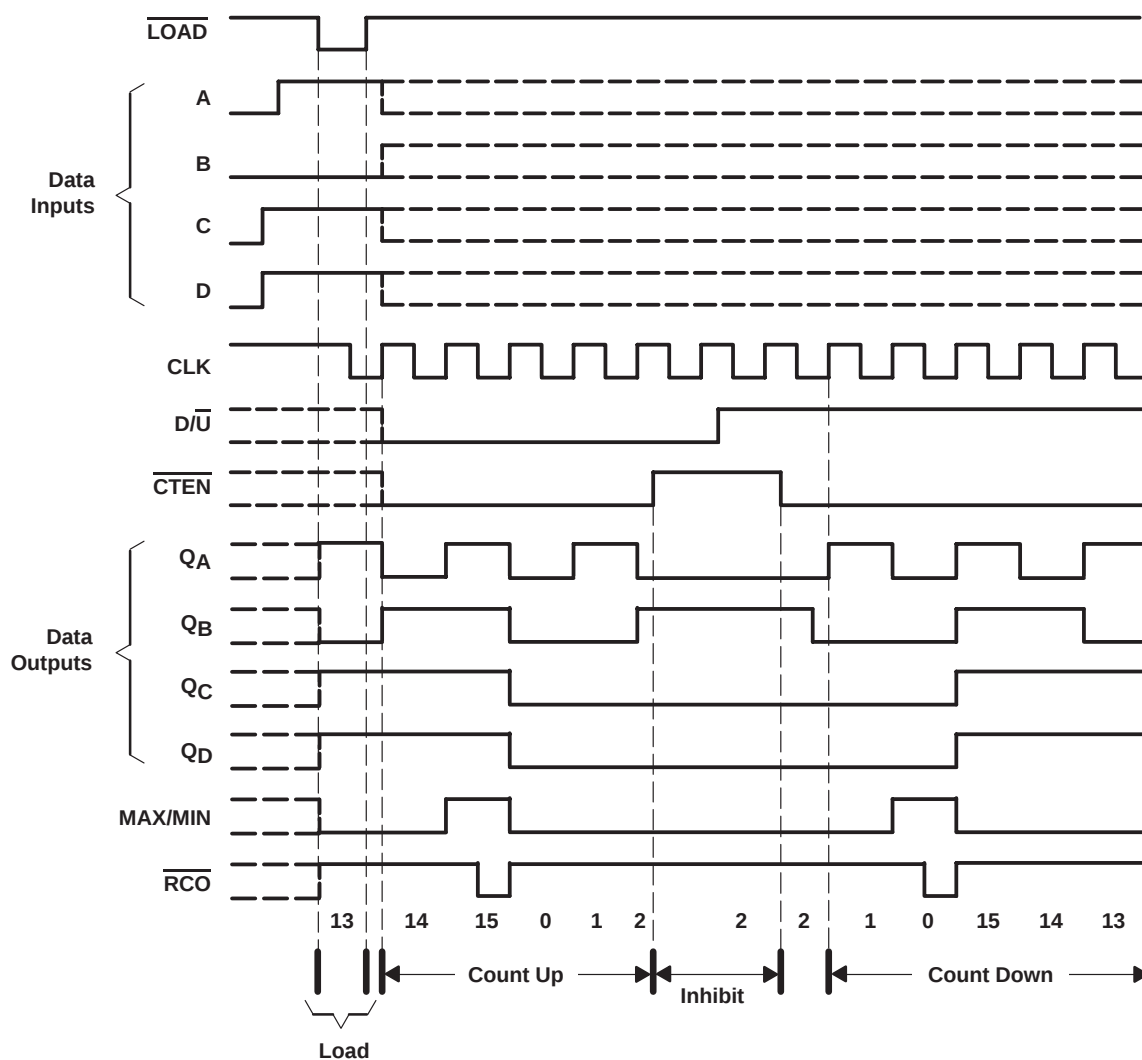
4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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typical load, count, and inhibit sequence

The following sequence is illustrated below:

1. Load (preset) to binary 13
2. Count up to 14, 15 (maximum), 0, 1, and 2
3. Inhibit
4. Count down to 1, 0 (minimum), 15, 14, and 13



SN54HC191, SN74HC191

4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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

Supply voltage range, V_{CC}	–0.5 V to 7 V
Input clamp current, I_{IK} ($V_I < 0$ or $V_I > V_{CC}$) (see Note 1)	±20 mA
Output clamp current, I_{OK} ($V_O < 0$ or $V_O > V_{CC}$) (see Note 1)	±20 mA
Continuous output current, I_O ($V_O = 0$ to V_{CC})	±25 mA
Continuous current through V_{CC} or GND	±50 mA
Package thermal impedance, θ_{JA} (see Note 2): D package	73°C/W
N package	67°C/W
NS package	64°C/W
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. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 3)

			SN54HC191			SN74HC191			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V _{CC}	Supply voltage		2	5	6	2	5	6	V
V _{IH}	High-level input voltage	V _{CC} = 2 V	1.5			1.5			V
		V _{CC} = 4.5 V	3.15			3.15			
		V _{CC} = 6 V	4.2			4.2			
V _{IL}	Low-level input voltage	V _{CC} = 2 V	0.5			0.5			V
		V _{CC} = 4.5 V	1.35			1.35			
		V _{CC} = 6 V	1.8			1.8			
V _I	Input voltage		0	V _{CC}		0	V _{CC}		V
V _O	Output voltage		0	V _{CC}		0	V _{CC}		V
Δt/Δv [‡]	Input transition rise/fall time	V _{CC} = 2 V	1000			1000			ns
		V _{CC} = 4.5 V	500			500			
		V _{CC} = 6 V	400			400			
T _A	Operating free-air temperature		−55	125		−40	85		°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.

[‡] If this device is used in the threshold region (from $V_{ILmax} = 0.5$ V to $V_{IHmin} = 1.5$ V), there is a potential to go into the wrong state from induced grounding, causing double clocking. Operating with the inputs at $t_f = 1000$ ns and $V_{CC} = 2$ V does not damage the device; however, functionally, the CLK inputs are not ensured while in the shift, count, or toggle operating modes.

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4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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

PARAMETER	TEST CONDITIONS		V _{CC}	T _A = 25°C			SN54HC191		SN74HC191		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V _{OH}	V _I = V _{IH} or V _{IL}	I _{OH} = -20 µA	2 V	1.9	1.998		1.9		1.9		V
			4.5 V	4.4	4.499		4.4		4.4		
			6 V	5.9	5.999		5.9		5.9		
		I _{OH} = -4 mA	4.5 V	3.98	4.3		3.7		3.84		
		I _{OH} = -5.2 mA	6 V	5.48	5.8		5.2		5.34		
V _{OL}	V _I = V _{IH} or V _{IL}	I _{OL} = 20 µA	2 V		0.002	0.1		0.1		0.1	V
			4.5 V		0.001	0.1		0.1		0.1	
			6 V		0.001	0.1		0.1		0.1	
		I _{OL} = 4 mA	4.5 V		0.17	0.26		0.4		0.33	
		I _{OL} = 5.2 mA	6 V		0.15	0.26		0.4		0.33	
I _I	V _I = V _{CC} or 0		6 V		±0.1	±100		±1000		±1000	nA
I _{CC}	V _I = V _{CC} or 0, I _O = 0		6 V			8		160		80	µA
C _i			2 V to 6 V		3	10		10		10	pF



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SN54HC191, SN74HC191

4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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

		V _{CC}	T _A = 25°C		SN54HC191		SN74HC191		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f _{clock}	Clock frequency	2 V	4.2		2.8		3.3		MHz
		4.5 V	21		14		17		
		6 V	24		16		19		
t _w	$\overline{\text{LOAD}}$ low	2 V	120		180		150		ns
		4.5 V	24		36		30		
		6 V	21		31		26		
	CLK high or low	2 V	120		180		150		
		4.5 V	24		36		30		
		6 V	21		31		26		
t _{su}	Data before $\overline{\text{LOAD}}\uparrow$	2 V	150		230		188		ns
		4.5 V	30		46		38		
		6 V	25		38		32		
	$\overline{\text{CTEN}}$ before CLK $\uparrow$	2 V	205		306		255		
		4.5 V	41		61		51		
		6 V	35		53		44		
	D/ $\overline{\text{U}}$ before CLK $\uparrow$	2 V	205		306		255		
		4.5 V	41		61		51		
		6 V	35		53		44		
	$\overline{\text{LOAD}}$ inactive before CLK $\uparrow$	2 V	150		225		190		
		4.5 V	30		45		38		
		6 V	25		38		32		
t _h	Data after $\overline{\text{LOAD}}\uparrow$	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		
	$\overline{\text{CTEN}}$ after CLK $\uparrow$	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		
	D/ $\overline{\text{U}}$ after CLK $\uparrow$	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		

SN54HC191, SN74HC191

4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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switching characteristics over recommended operating free-air temperature range, $C_L = 50$ pF (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC}	$T_A = 25^\circ\text{C}$			SN54HC191		SN74HC191		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	4.2	8		2.8		3.3		MHz
			4.5 V	21	42		14		17		
			6 V	24	48		16		19		
t_{pd}	$\overline{\text{LOAD}}$	Any Q	2 V		130	264		396		330	ns
			4.5 V		40	53		79		66	
			6 V		33	45		67		56	
	A, B, C, or D	$Q_A, Q_B, Q_C,$ or Q_D	2 V		135	240		360		300	
			4.5 V		36	48		72		60	
			6 V		30	41		61		51	
	CLK	$\overline{\text{RCO}}$	2 V		58	120		180		150	
			4.5 V		17	24		36		30	
			6 V		14	21		31		26	
		Any Q	2 V		107	192		288		240	
			4.5 V		31	38		58		48	
			6 V		26	32		49		41	
		MAX/MIN	2 V		123	252		378		315	
			4.5 V		39	50		76		63	
			6 V		32	43		65		54	
	D/ $\overline{U}$	$\overline{\text{RCO}}$	2 V		102	228		342		285	
			4.5 V		29	46		68		57	
			6 V		24	38		59		49	
		MAX/MIN	2 V		86	192		288		240	
			4.5 V		24	38		58		48	
			6 V		20	32		49		41	
	$\overline{\text{CTEN}}$	$\overline{\text{RCO}}$	2 V		50	132		198		165	
			4.5 V		15	26		40		33	
			6 V		13	23		34		28	
t_t		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

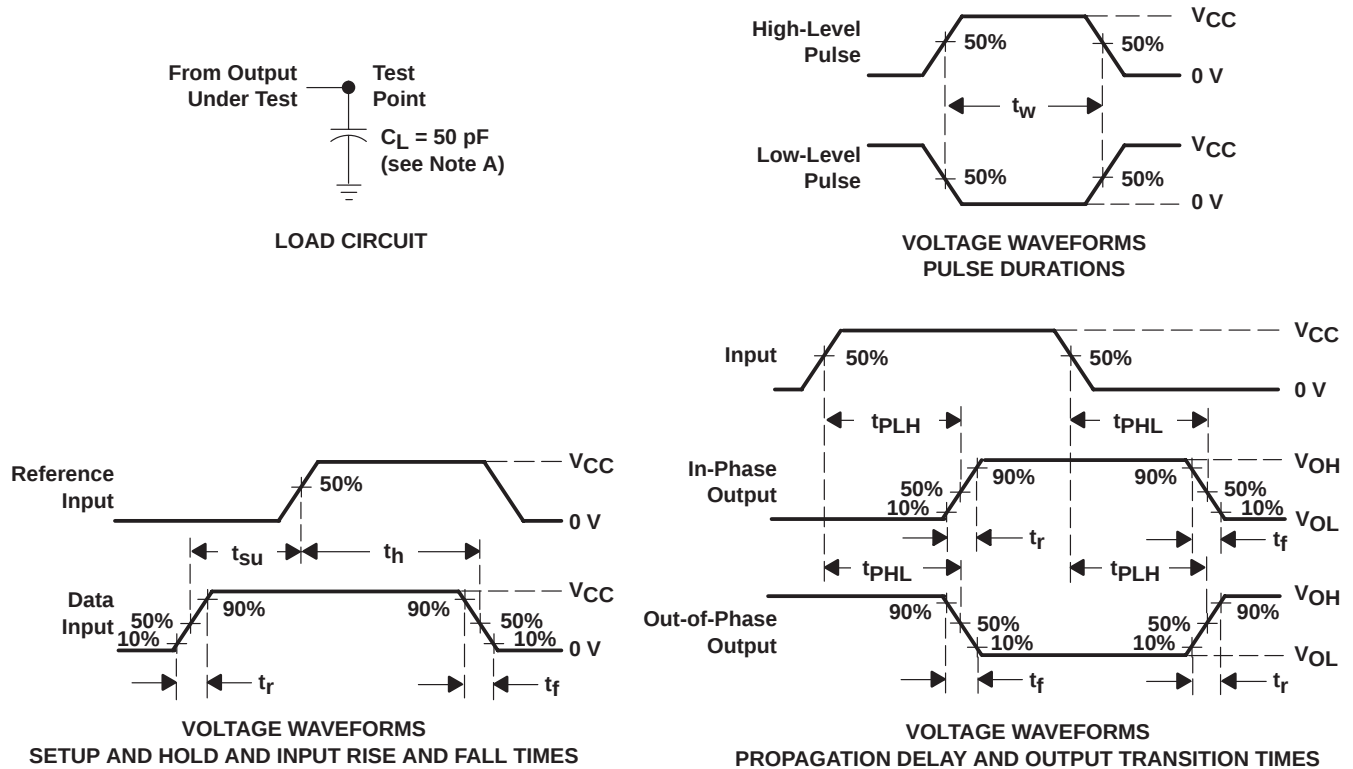
operating characteristics, $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	TYP	UNIT
C_{pd}	Power dissipation capacitance	No load	50	pF



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PARAMETER MEASUREMENT INFORMATION



- NOTES:
- A. C_L includes probe and test-fixture capacitance.
 - B. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics: $PRR \leq 1 \text{ MHz}$, $Z_O = 50 \Omega$, $t_r = 6 \text{ ns}$, $t_f = 6 \text{ ns}$.
 - C. For clock inputs, f_{max} is measured when the input duty cycle is 50%.
 - D. The outputs are measured one at a time with one input transition per measurement.
 - E. t_{PLH} and t_{PHL} are the same as t_{pd} .

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⁾
5962-86891012A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-8689101EA	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
SN54HC191J	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type
SN74HC191D	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DT	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DTE4	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191DTG4	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191N	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
SN74HC191N3	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI
SN74HC191NE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
SN74HC191NSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191NSRE4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74HC191NSRG4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SNJ54HC191FK	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
SNJ54HC191J	ACTIVE	CDIP	J	16	1	TBD	A42	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.

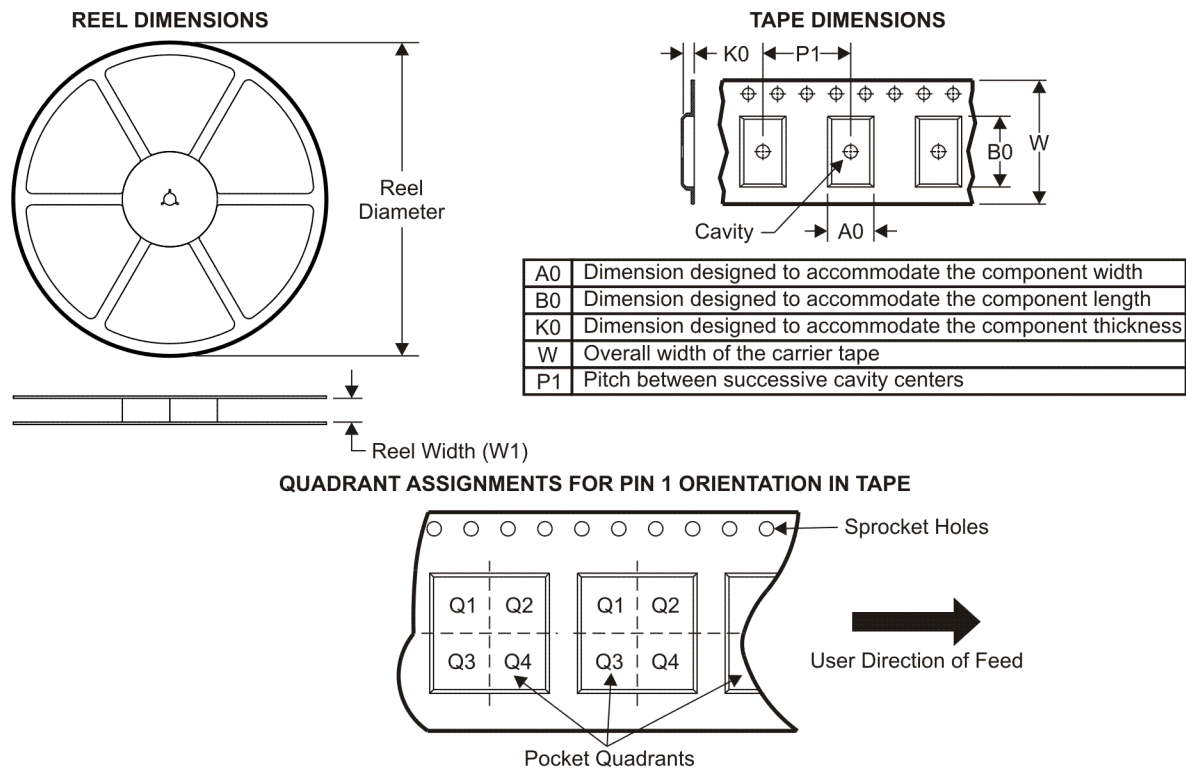
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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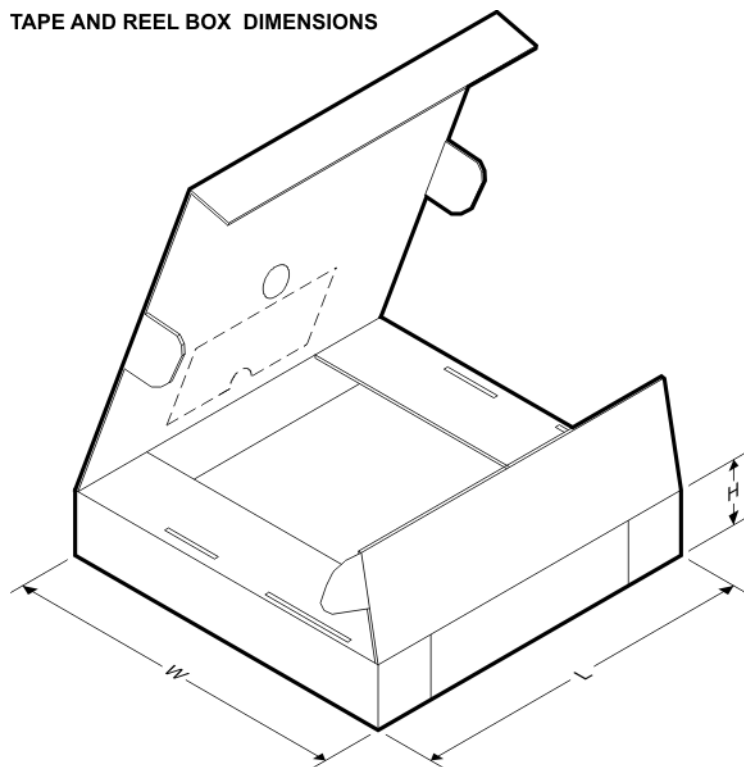
TAPE AND REEL INFORMATION



*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
SN74HC191DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74HC191NSR	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)
SN74HC191DR	SOIC	D	16	2500	333.2	345.9	28.6
SN74HC191NSR	SO	NS	16	2000	346.0	346.0	33.0

MECHANICAL DATA

NS (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN

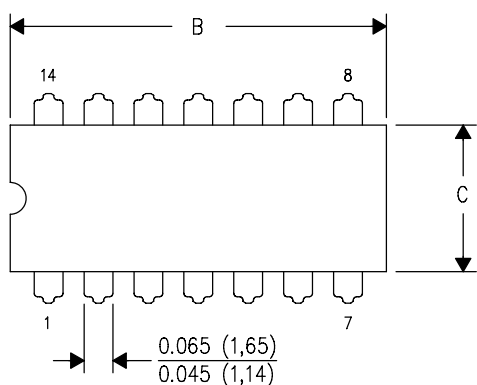


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

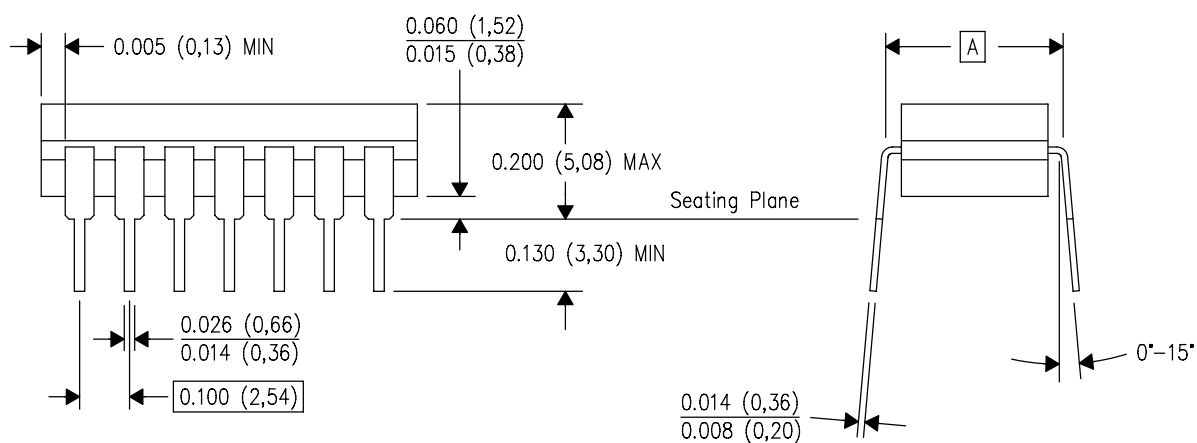
J (R-GDIP-T**)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



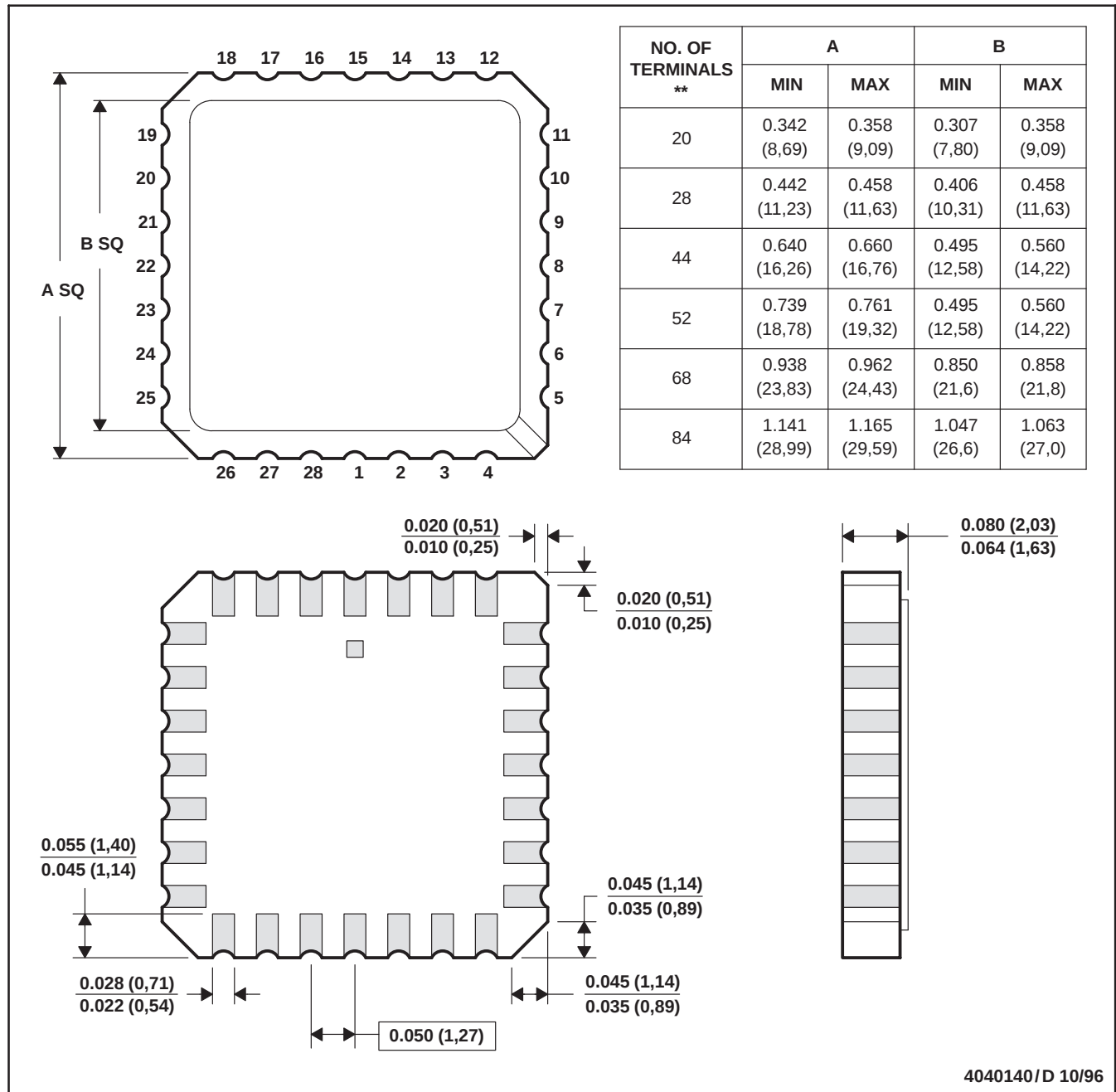
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- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package is hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
 - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

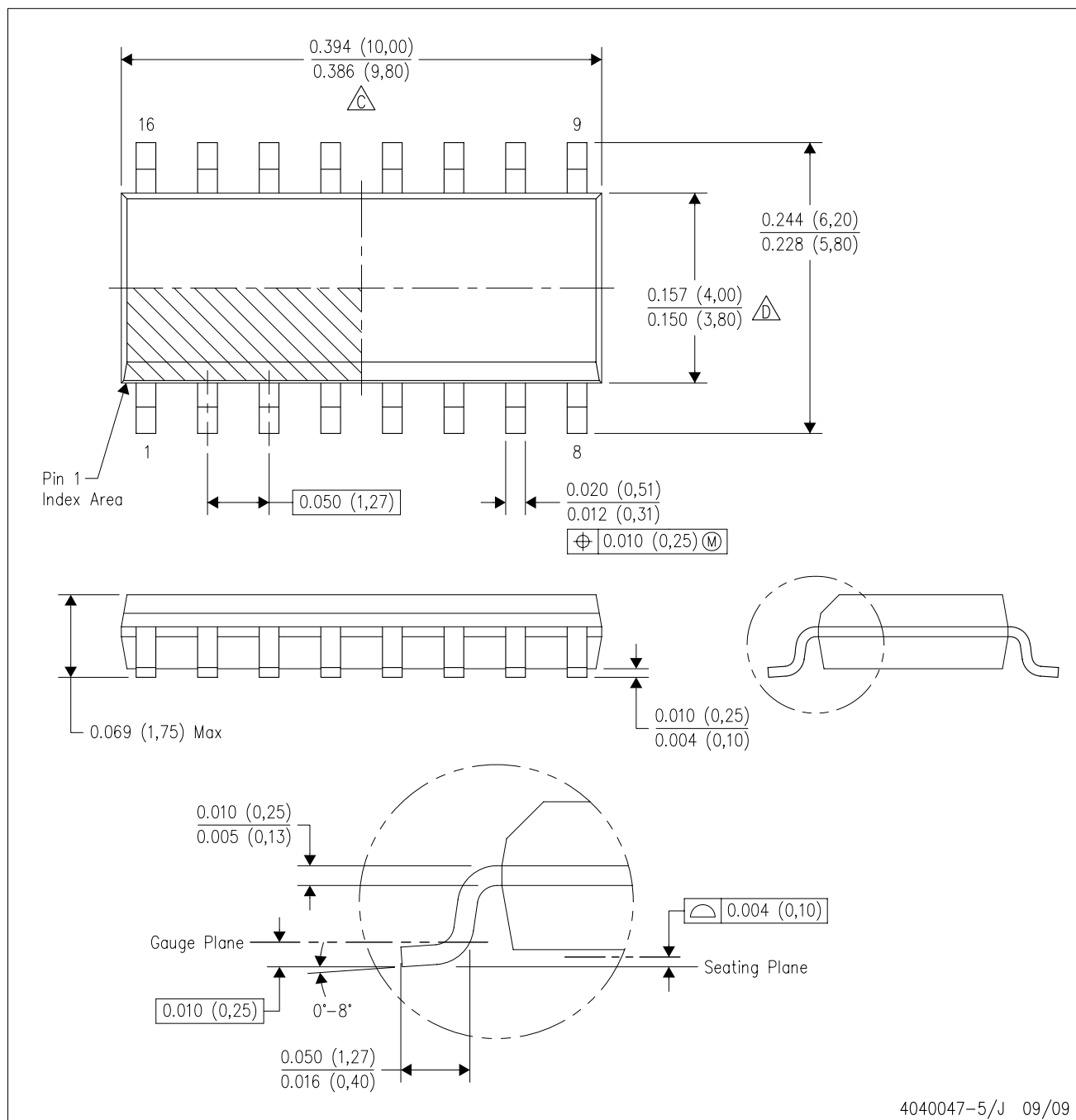
28 TERMINAL SHOWN



- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - This package can be hermetically sealed with a metal lid.
 - The terminals are gold plated.
 - Falls within JEDEC MS-004

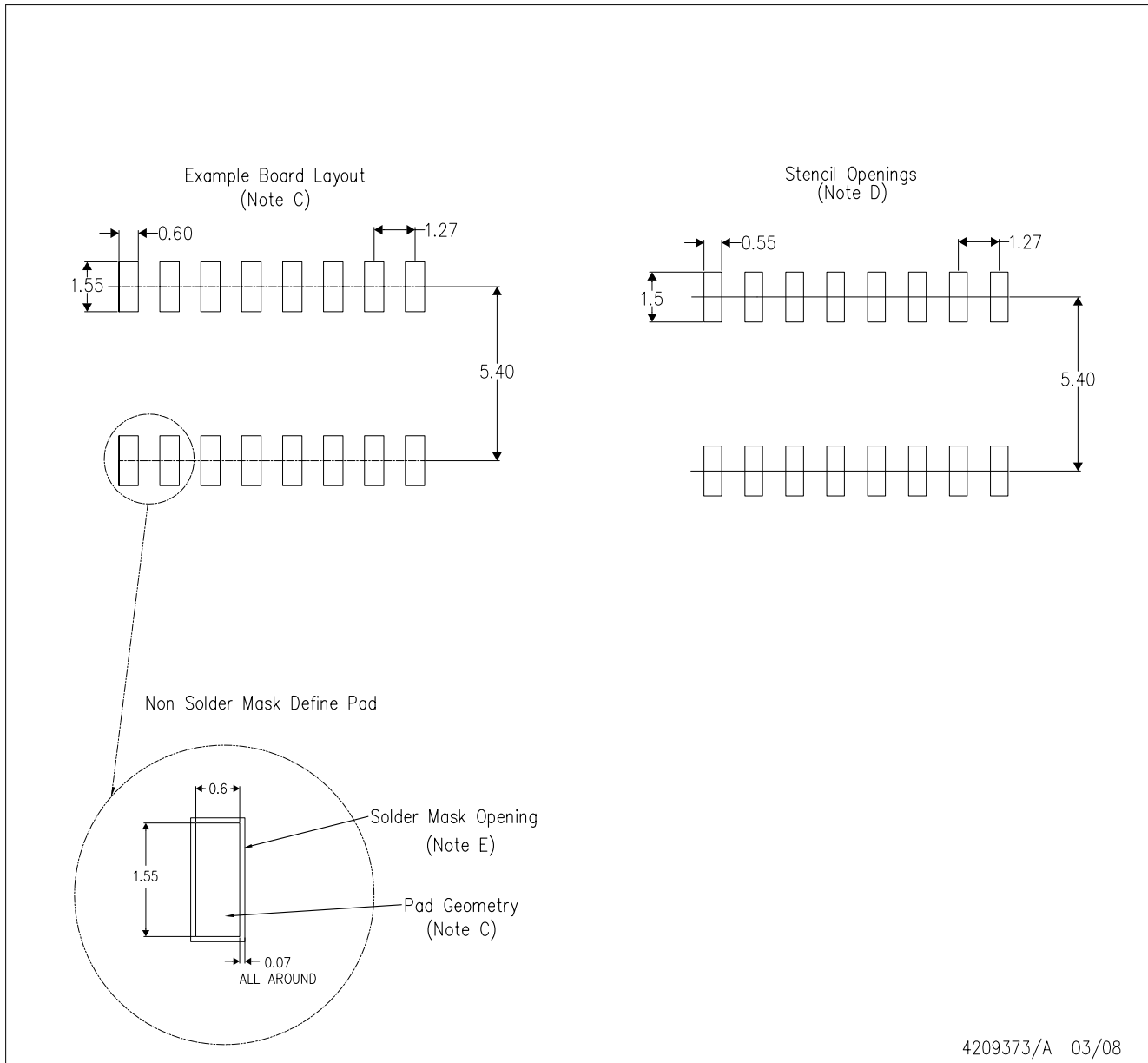
D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



- 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 .006 (0,15) per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - E. Reference JEDEC MS-012 variation AC.

D(R-PDSO-G16)



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Refer to IPC7351 for alternate board design.
 - 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
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

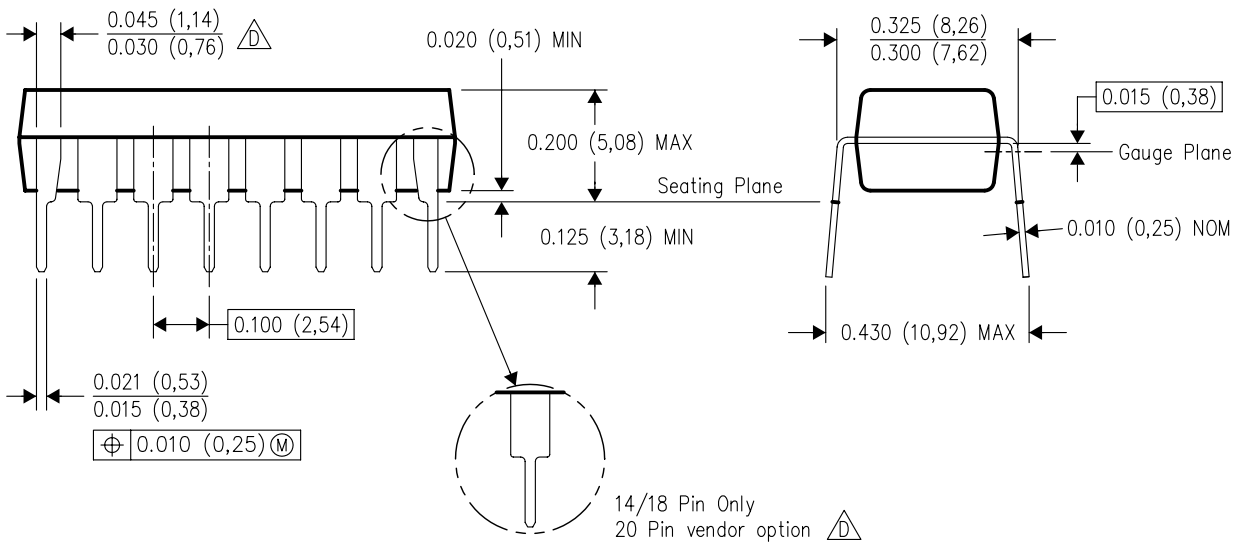
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS **	14	16	18	20
DIM				
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



14/18 Pin Only
20 Pin vendor option

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.

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