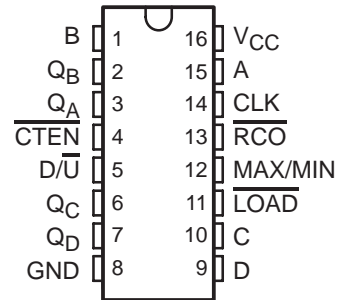


# SN54HC191, SN74HC191 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

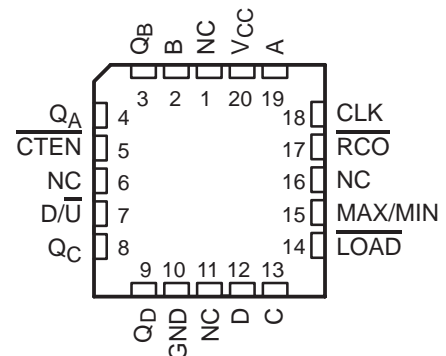
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- Wide Operating Voltage Range of 2 V to 6 V
- Outputs Can Drive Up To 10 LSTTL Loads
- Low Power Consumption, 80- $\mu$ A Max  $I_{CC}$
- Typical  $t_{pd} = 13$  ns
- $\pm 4$ -mA Output Drive at 5 V
- Low Input Current of 1  $\mu$ A Max
- Single Down/Up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

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



SN54HC191 . . . FK PACKAGE  
(TOP VIEW)



NC – No internal connection

## 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.

## ORDERING INFORMATION

TA	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	
	SOP – NS	Reel of 2000	SN74HC191NSR	HC191
-55°C to 125°C	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](http://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.

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

SCLS121D – DECEMBER 1982 – REVISED OCTOBER 2003

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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.

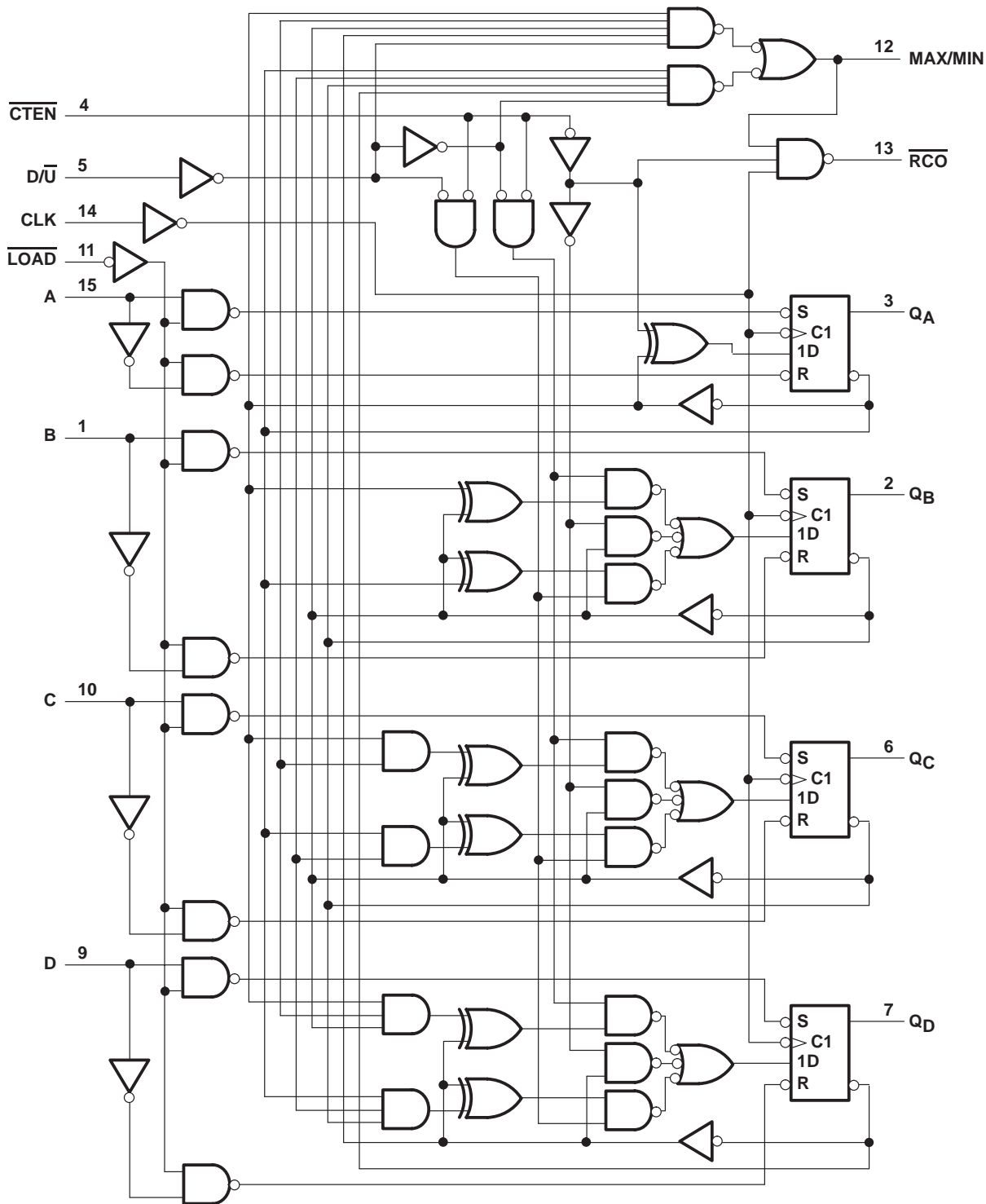


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# SN54HC191, SN74HC191 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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logic diagram (positive logic)



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

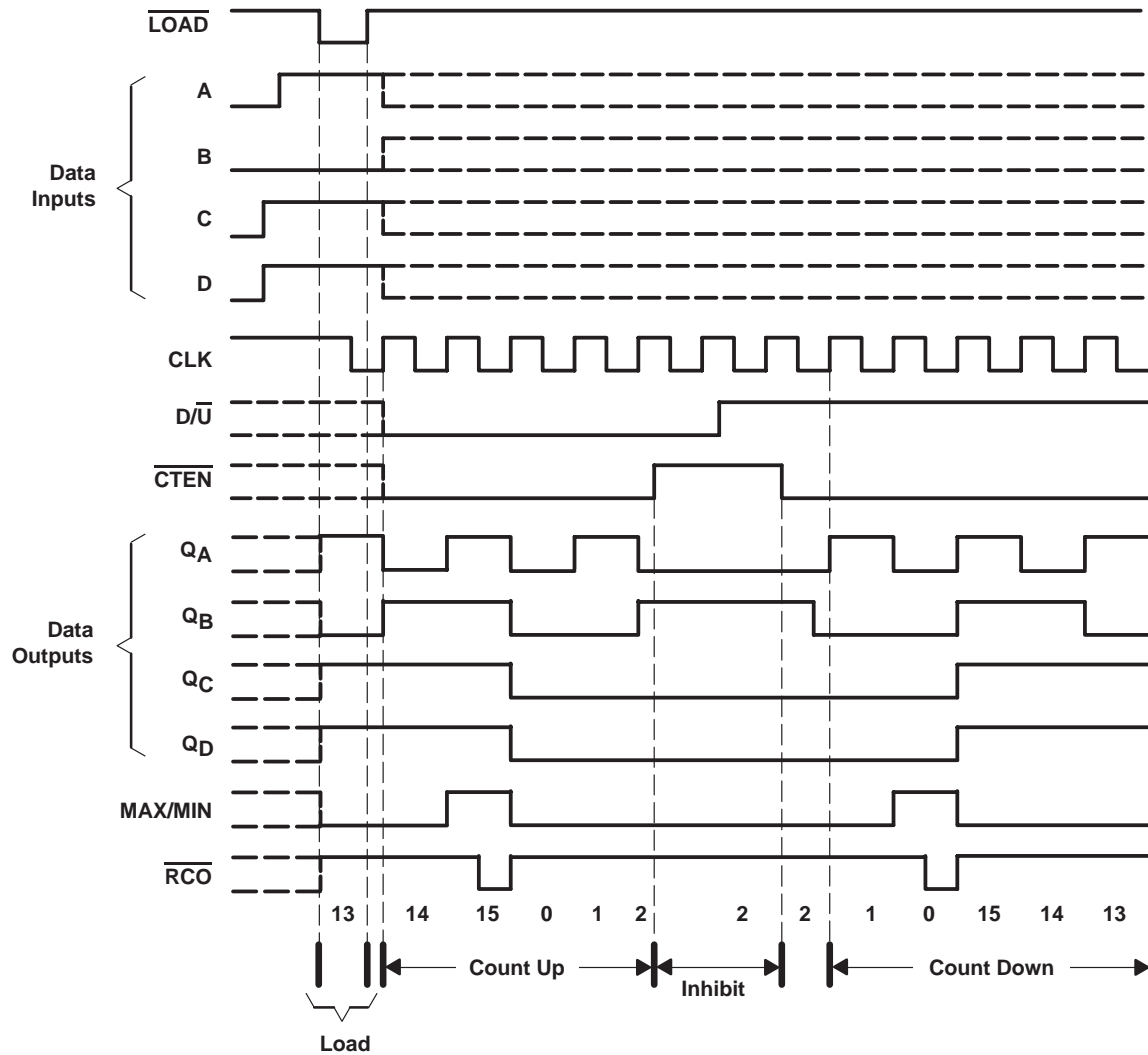
# SN54HC191, SN74HC191 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

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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

SCLS121D – DECEMBER 1982 – REVISED OCTOBER 2003

### 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, $\theta_{JA}$ (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	$V_{CC} = 2$ V		1.5	V
		$V_{CC} = 4.5$ V		3.15	$V_{CC} = 4.5$ V		3.15	
		$V_{CC} = 6$ V		4.2	$V_{CC} = 6$ V		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
$\Delta t/\Delta v$ ‡	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.



# SN54HC191, SN74HC191

## 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 <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC191		SN74HC191		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -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 <sub>OH</sub> = -4 mA	4.5 V	3.98	4.3		3.7		3.84		
		I <sub>OH</sub> = -5.2 mA	6 V	5.48	5.8		5.2		5.34		
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 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 <sub>OL</sub> = 4 mA	4.5 V		0.17	0.26		0.4		0.33	
		I <sub>OL</sub> = 5.2 mA	6 V		0.15	0.26		0.4		0.33	
I <sub>I</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0		6 V		±0.1	±100		±1000		±1000	nA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0		6 V			8		160		80	μA
C <sub>i</sub>			2 V to 6 V		3	10		10		10	pF



# SN54HC191, SN74HC191

## 4-BIT SYNCHRONOUS UP/DOWN BINARY COUNTERS

SCLS121D – DECEMBER 1982 – REVISED OCTOBER 2003

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

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC191		SN74HC191		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	4.2		2.8		3.3		MHz
		4.5 V	21		14		17		
		6 V	24		16		19		
t <sub>w</sub>	$\overline{\text{LOAD}}$ 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 <sub>su</sub>	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 <sub>h</sub>	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

SCLS121D – DECEMBER 1982 – REVISED OCTOBER 2003

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		
			$\overline{\text{RCO}}$	2 V		58	120		180			150
				4.5 V		17	24		36			30
				6 V		14	21		31			26
	CLK	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		

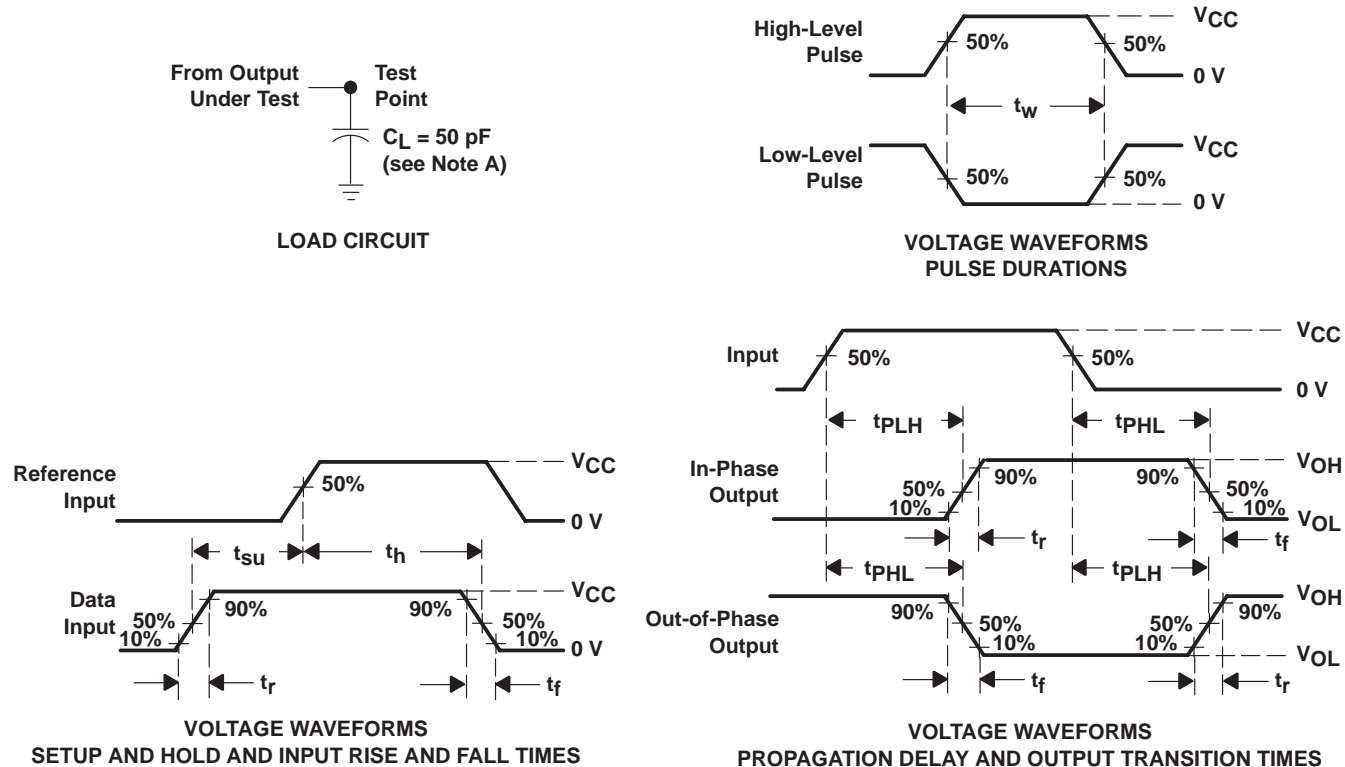
## operating characteristics, $T_A = 25^\circ\text{C}$

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





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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-86891012A	ACTIVE	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 86891012A SNJ54HC 191FK	<a href="#">Samples</a>
5962-8689101EA	ACTIVE	CDIP	J	16	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8689101EA SNJ54HC191J	<a href="#">Samples</a>
SN54HC191J	ACTIVE	CDIP	J	16	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	SN54HC191J	<a href="#">Samples</a>
SN74HC191D	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 85	HC191	
SN74HC191DR	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC191	<a href="#">Samples</a>
SN74HC191DT	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 85	HC191	
SN74HC191N	ACTIVE	PDIP	N	16	25	RoHS & Green	NIPDAU	N / A for Pkg Type	-40 to 85	SN74HC191N	<a href="#">Samples</a>
SN74HC191NSR	ACTIVE	SOP	NS	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC191	<a href="#">Samples</a>
SNJ54HC191FK	ACTIVE	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 86891012A SNJ54HC 191FK	<a href="#">Samples</a>
SNJ54HC191J	ACTIVE	CDIP	J	16	25	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8689101EA SNJ54HC191J	<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) **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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**OTHER QUALIFIED VERSIONS OF SN54HC191, SN74HC191 :**

● Catalog : [SN74HC191](#)

● Military : [SN54HC191](#)

NOTE: Qualified Version Definitions:

● Catalog - TI's standard catalog product

● Military - QML certified for Military and Defense Applications

**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
SN74HC191DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74HC191NSR	SOP	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	353.0	353.0	32.0
SN74HC191NSR	SOP	NS	16	2000	356.0	356.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
5962-86891012A	FK	LCCC	20	55	506.98	12.06	2030	NA
SN74HC191N	N	PDIP	16	25	506	13.97	11230	4.32
SN74HC191N	N	PDIP	16	25	506	13.97	11230	4.32
SNJ54HC191FK	FK	LCCC	20	55	506.98	12.06	2030	NA

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.

## 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.



## GENERIC PACKAGE VIEW

**FK 20**

**LCCC - 2.03 mm max height**

8.89 x 8.89, 1.27 mm pitch

LEADLESS CERAMIC CHIP CARRIER

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4229370VA\

J (R-GDIP-T\*\*)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	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)



4040083/F 03/03

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

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

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



4040049/E 12/2002

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



# PACKAGE OUTLINE

## NS0016A

### SOP - 2.00 mm max height

SOP



4220735/A 12/2021

#### NOTES:

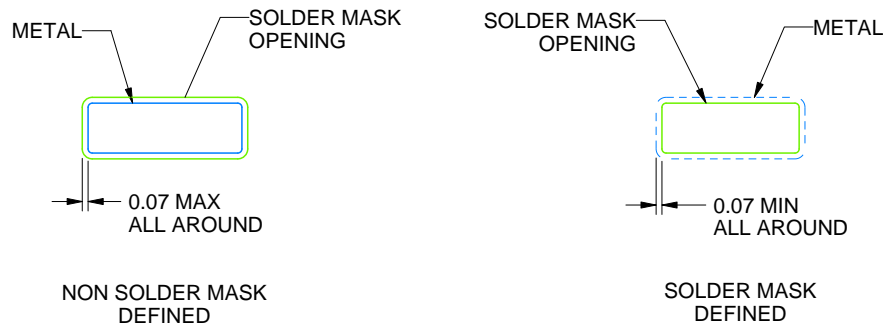
- All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
- This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.

# EXAMPLE BOARD LAYOUT

NS0016A

SOP - 2.00 mm max height

SOP



4220735/A 12/2021

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

NS0016A

SOP - 2.00 mm max height

SOP



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:7X

4220735/A 12/2021

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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