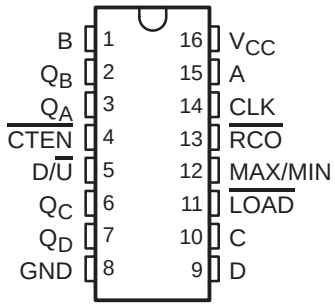
- **2-V to 6-V V_{CC} Operation ('HC190, 191)**
- **4.5-V to 5.5-V V_{CC} Operation ('HCT191)**
- **Wide Operating Temperature Range of −55°C to 125°C**
- **Synchronous Counting and Asynchronous Loading**
- **Two Outputs for n-Bit Cascading**
- **Look-Ahead Carry for High-Speed Counting**
- **Balanced Propagation Delays and Transition Times**
- **Standard Outputs Drive Up To 15 LS-TTL Loads**
- **Significant Power Reduction Compared to LS-TTL Logic ICs**

CD54HC190, 191; CD54HCT191 . . . F PACKAGE
CD74HC190 . . . E, NS, OR PW PACKAGE
CD74HC191, CD74HCT191 . . . E OR M PACKAGE
(TOP VIEW)



description/ordering information

The CD54/74HC190 are asynchronously presettable BCD decade counters, whereas the CD54/74HC191 and CD54/74HCT191 are asynchronously presettable binary counters.

Presetting the counter to the number on preset data inputs (A−D) is accomplished by a low asynchronous parallel load ($\overline{LOAD}$) input. Counting occurs when $\overline{LOAD}$ is high, count enable ($\overline{CTEN}$) is low, and the down/up (D/$\overline{U}$) input is either high for down counting or low for up counting. The counter is decremented or incremented synchronously with the low-to-high transition of the clock.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−55°C to 125°C	PDIP − E	Tube of 25	CD74HC190E	CD74HC190E
			CD74HC191E	CD74HC191E
			CD74HCT191E	CD74HCT191E
	SOIC − M	Tube of 40	CD74HC191M	HC191M
		Reel of 2500	CD74HC191M96	
		Reel of 250	CD74HC191MT	
		Tube of 40	CD74HCT191M	HCT191M
	SOP − NS	Reel of 2000	CD74HC190NSR	HC190M
	TSSOP − PW	Tube of 90	CD74HC190PW	HJ190
		Reel of 2000	CD74HC190PWR	
		Reel of 250	CD74HC190PWT	
	CDIP − F	Tube of 25	CD54HC190F3A	CD54HC190F3A
			CD54HC191F3A	CD54HC191F3A
			CD54HCT191F3A	CD54HCT191F3A

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

description/ordering information (continued)

When an overflow or underflow of the counter occurs, the MAX/MIN output, which is low during counting, goes high and remains high for one clock cycle. This output can be used for look-ahead carry in high-speed cascading (see Figure 1). The MAX/MIN output also initiates the ripple clock ($\overline{RCO}$) output, which normally is high, goes low, and remains low for the low-level portion of the clock pulse. These counters can be cascaded using $\overline{RCO}$ (see Figure 2).

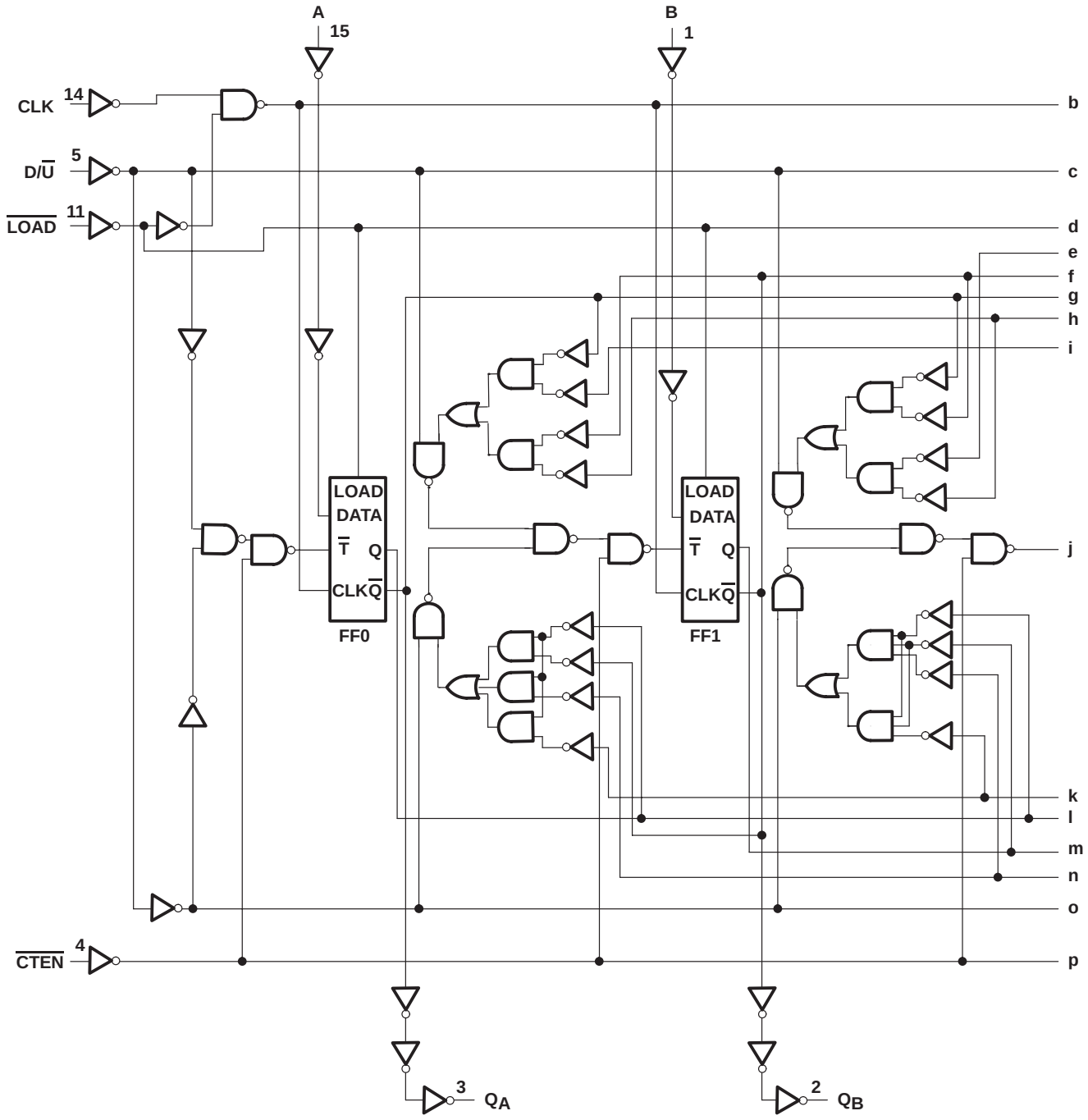
If a decade counter is preset to an illegal state or assumes an illegal state when power is applied, it returns to the normal sequence in one or two counts, as shown in the state diagrams (see Figure 3).

FUNCTION TABLE

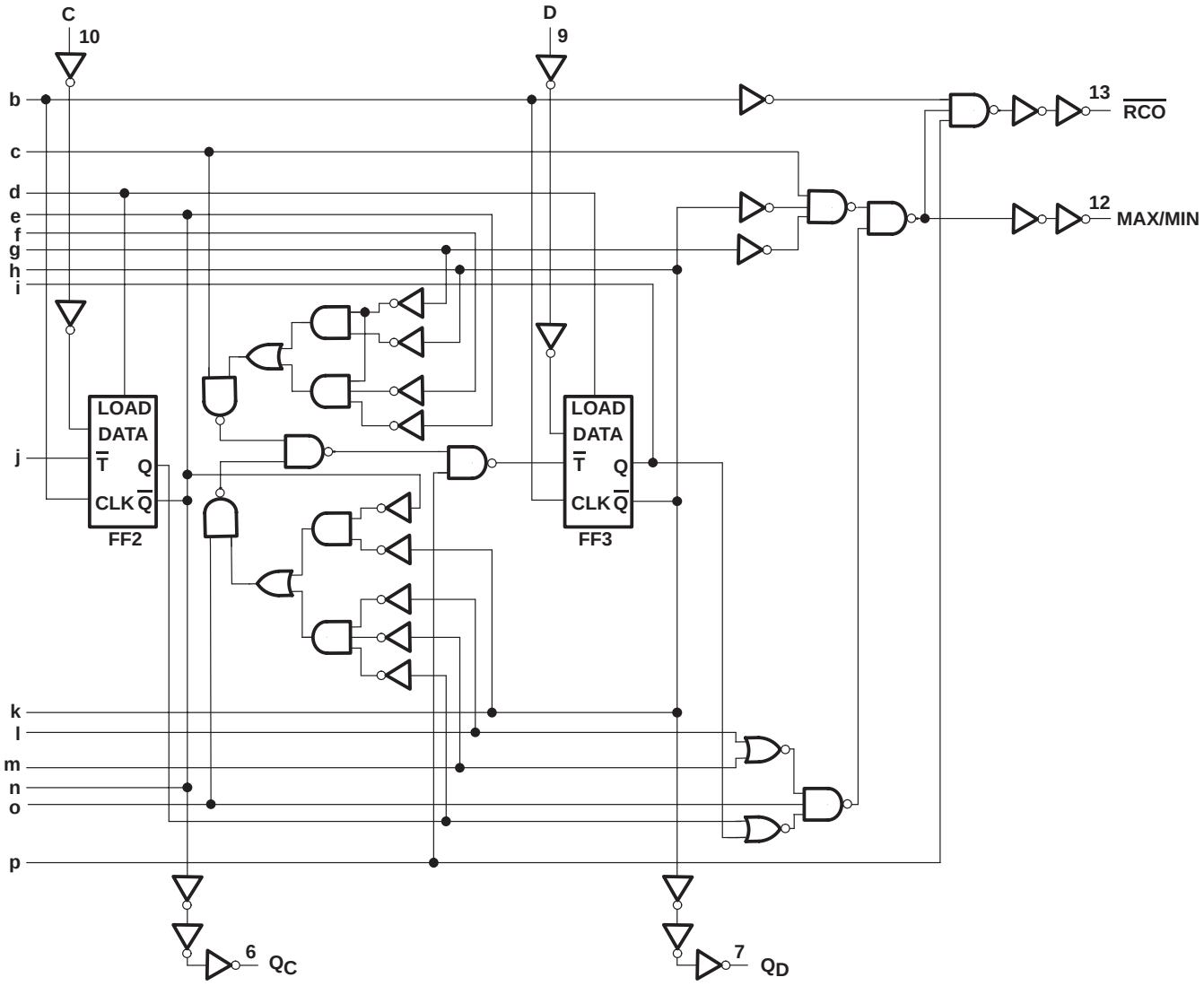
INPUTS				FUNCTION
$\overline{LOAD}$	$\overline{CTEN}$	D/$\overline{U}$	CLK	
H	L	L	⌐	Count up
H	L	H	⌐	Count down
L	X	X	X	Asynchronous preset
H	H	X	X	No change

D/$\overline{U}$ or $\overline{CTEN}$ should be changed only when clock is high.
X = Don't care
⌐ Low-to-high clock transition

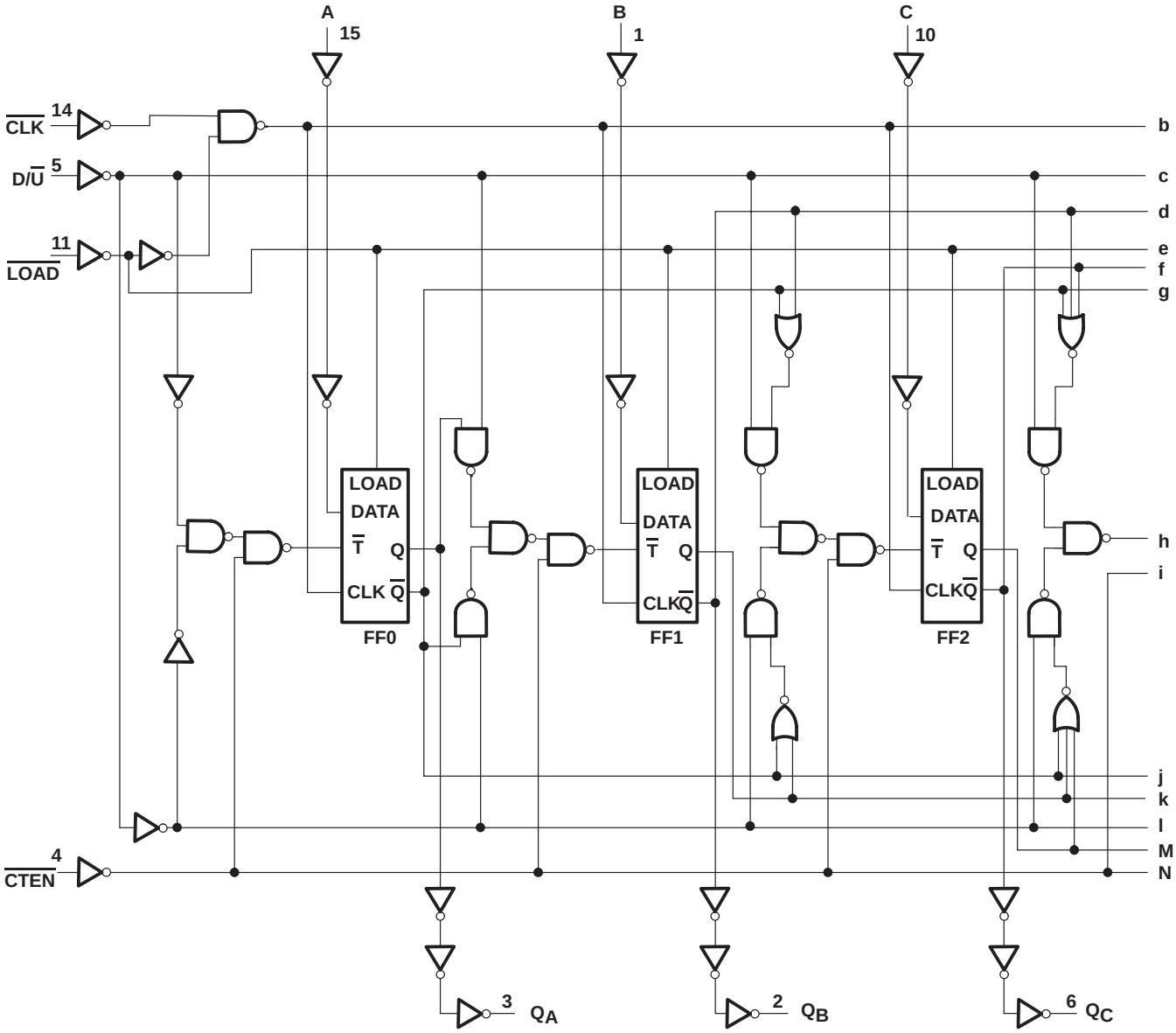
'HC190 logic diagram



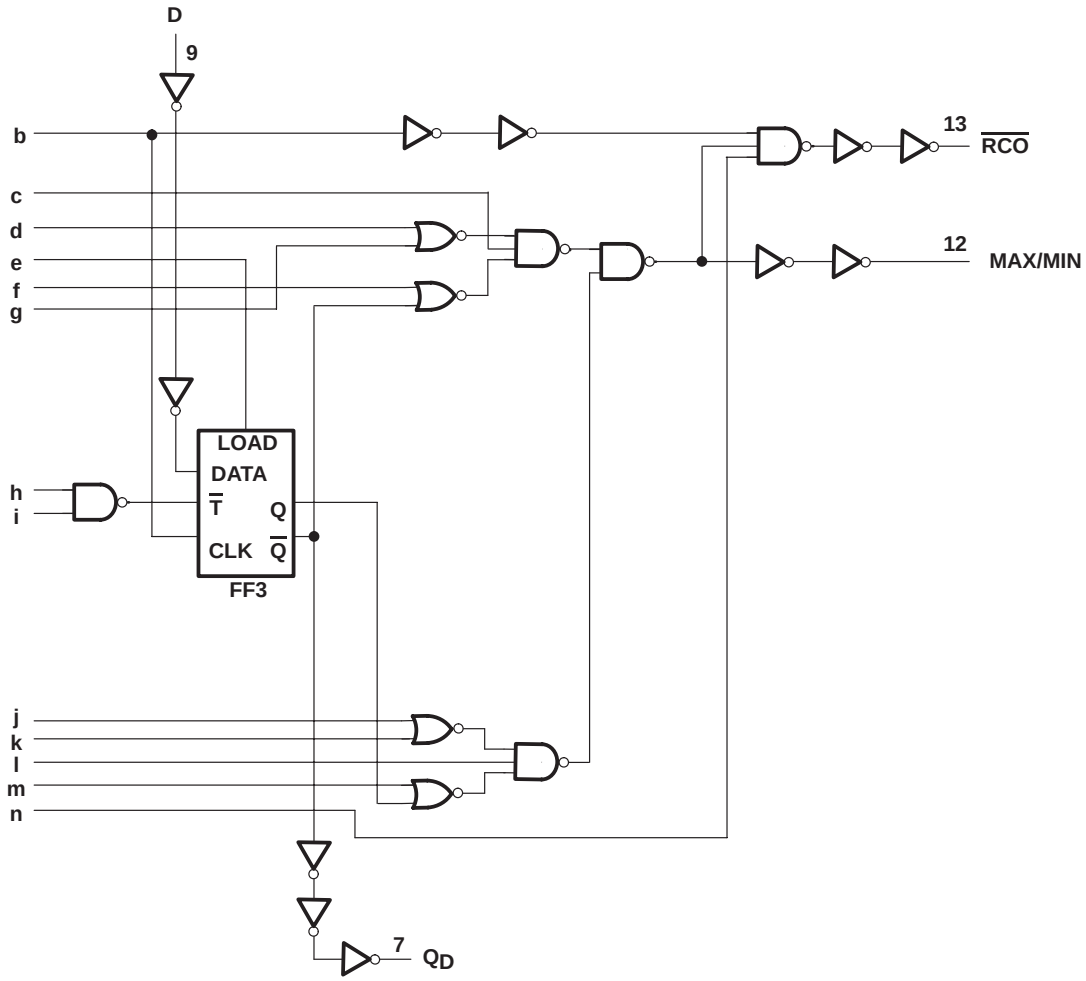
'HC190 logic diagram (continued)



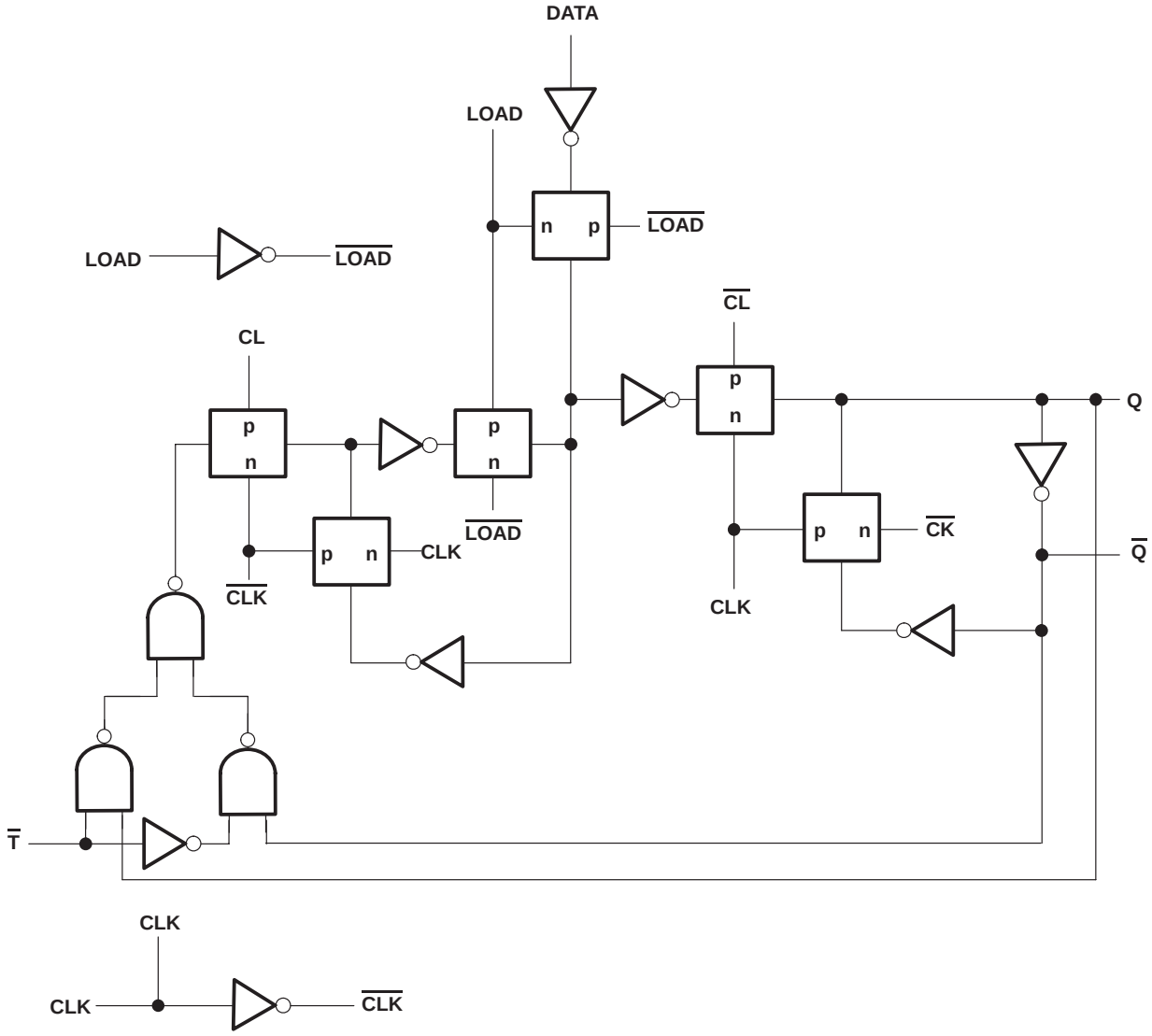
'HC191, 'HCT191 logic diagram



'HC191, 'HCT191 logic diagram (continued)



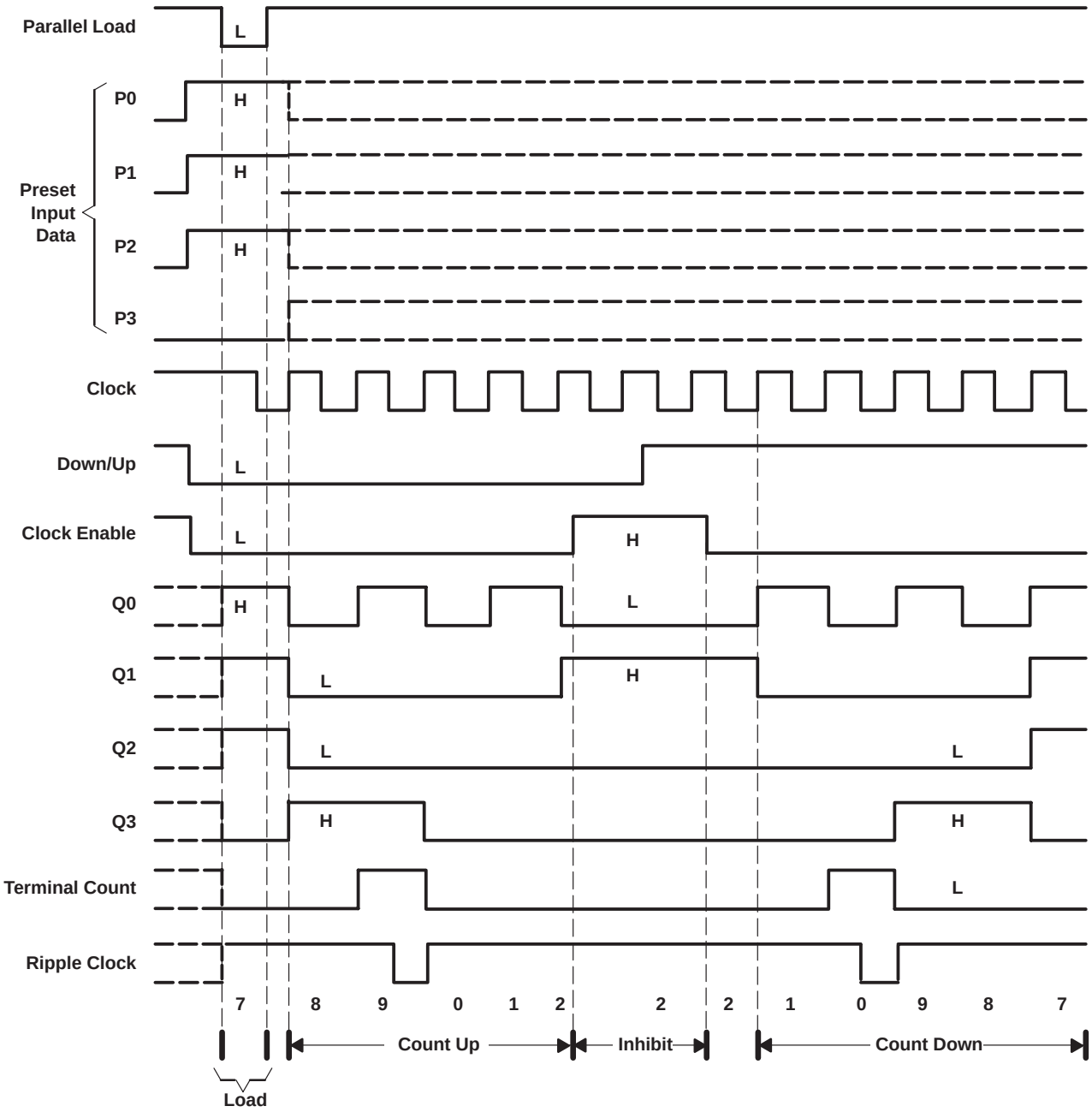
'HC190 and 'HC191/HCT191 flip-flop



typical load, count, and inhibit sequence for ’HC190

The following sequence is illustrated below:

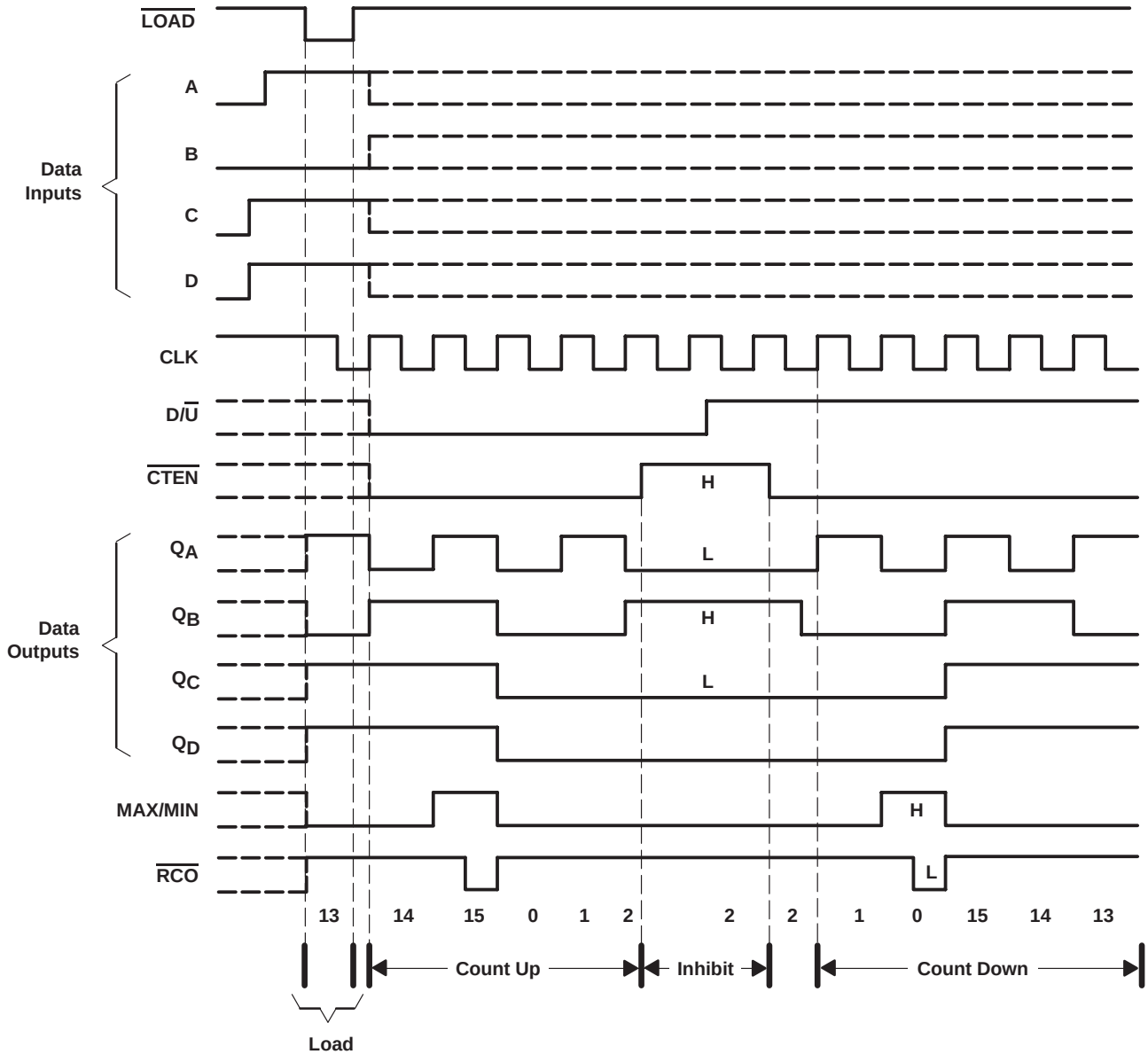
1. Load (preset) to BCD 7
2. Count up to 8, 9 (maximum), 0, 1, and 2
3. Inhibit
4. Count down to 1, 0 (minimum), 9, 8, and 7



typical load, count, and inhibit sequence for ’HC191 and ’HCT191

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



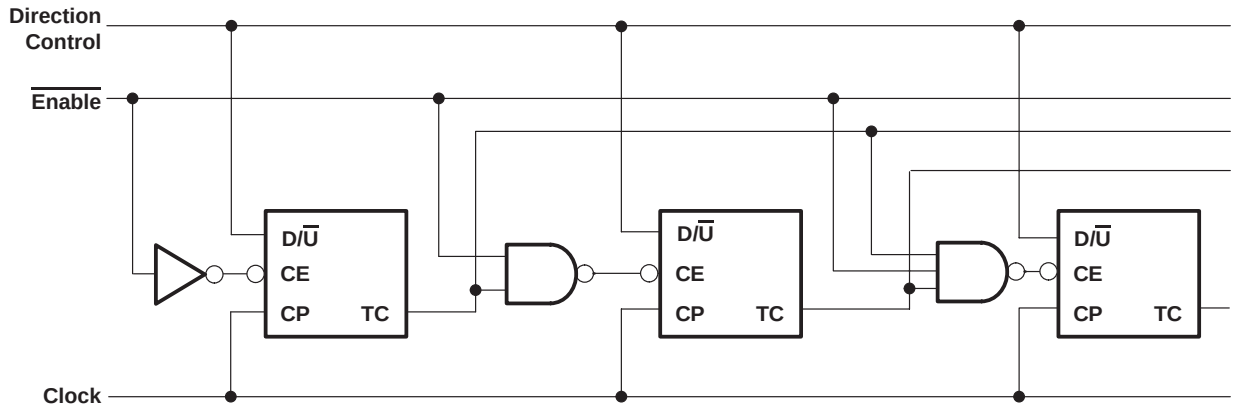


Figure 1. 'HC190 Synchronous n-Stage Counter With Parallel Gated Terminal Count

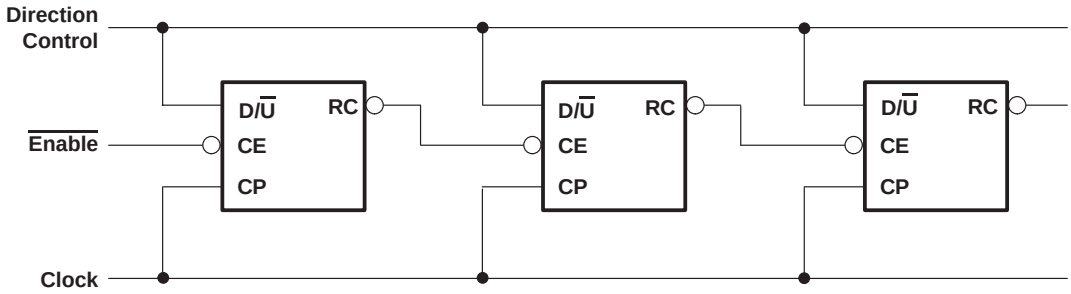
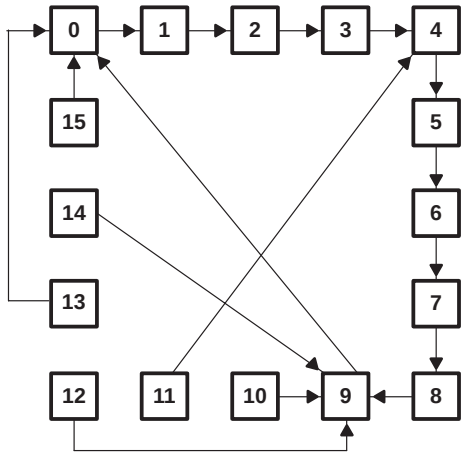
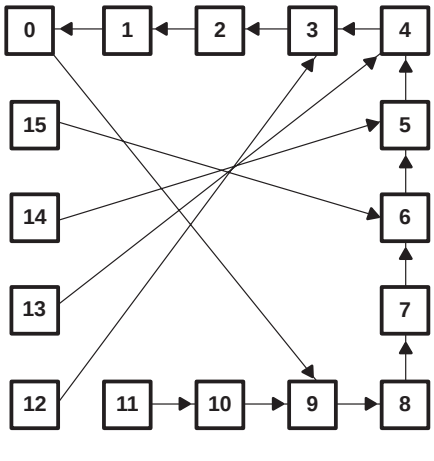


Figure 2. 'HC191, 'HCT191 Synchronous n-Stage Counter With Parallel Gated Terminal Count



Count Up

NOTE: Illegal states in BCD counters corrected in one count



Count Down

NOTE: Illegal states in BCD counters corrected in one or two counts

Figure 3. 'HC190 State Diagram

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 drain current per output, I_O ($V_O = 0$ to V_{CC}) . . . . . ±35 mA
Continuous output source or sink current per output, 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): E package . . . . . 67°C/W
M package . . . . . 73°C/W
NS package . . . . . 64°C/W
PW package . . . . . 108°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 for ’HC190 and ’HC191 (see Note 3)

			T_A = 25°C		T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage		2	6	2	6	2	6	V
V_{IH}	High-level input voltage	V_{CC} = 2 V	1.5		1.5		1.5		V
		V_{CC} = 4.5 V	3.15		3.15		3.15		
		V_{CC} = 6 V	4.2		4.2		4.2		
V_{IL}	Low-level input voltage	V_{CC} = 2 V		0.5		0.5		0.5	V
		V_{CC} = 4.5 V		1.35		1.35		1.35	
		V_{CC} = 6 V		1.8		1.8		1.8	
V_I	Input voltage		0	V_{CC}	0	V_{CC}	0	V_{CC}	V
V_O	Output voltage		0	V_{CC}	0	V_{CC}	0	V_{CC}	V
t_t	Input transition (rise and fall) time	V_{CC} = 2 V		1000		1000		1000	ns
		V_{CC} = 4.5 V		500		500		500	
		V_{CC} = 6 V		400		400		400	

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.

recommended operating conditions for ’HCT191 (see Note 4)

		T_A = 25°C		T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage	4.5	5.5	4.5	5.5	4.5	5.5	V
V_{IH}	High-level input voltage	2		2		2		V
V_{IL}	Low-level input voltage		0.8		0.8		0.8	V
V_I	Input voltage		V_{CC}		V_{CC}		V_{CC}	V
V_O	Output voltage		V_{CC}		V_{CC}		V_{CC}	V
t_t	Input transition (rise and fall) time		500		500		500	ns

NOTE 4: 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.

'HC190, 'HC191

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

PARAMETER	TEST CONDITIONS		V_{CC}	T_A = 25°C		T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
V_{OH}	V_I = V_{IH} or V_{IL}	I_{OH} = −20 μA	2 V	1.9		1.9		1.9		V
			4.5 V	4.4		4.4		4.4		
			6 V	5.9		5.9		5.9		
		I_{OH} = −4 mA	4.5 V	3.98		3.7		3.84		
		I_{OH} = −5.2 mA	6 V	5.48		5.2		5.34		
V_{OL}	V_I = V_{IH} or V_{IL}	I_{OL} = 20 μA	2 V		0.1		0.1		0.1	V
			4.5 V		0.1		0.1		0.1	
			6 V		0.1		0.1		0.1	
		I_{OL} = 4 mA	4.5 V		0.26		0.4		0.33	
		I_{OL} = 5.2 mA	6 V		0.26		0.4		0.33	
I_I	V_I = V_{CC} or 0		6 V		±0.1		±1		±1	μA
I_{CC}	V_I = V_{CC} or 0, I_O = 0		6 V		8		160		80	μA
C_i					10		10		10	pF

'HCT191

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

PARAMETER	TEST CONDITIONS		V_{CC}	T_A = 25°C			T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V_{OH}	V_I = V_{IH} or V_{IL}	I_{OH} = −20 μA	4.5 V	4.4			4.4		4.4		V
		I_{OH} = −4 mA		3.98			3.7		3.84		
V_{OL}	V_I = V_{IH} or V_{IL}	I_{OL} = 20 μA	4.5 V			0.1		0.1		0.1	V
		I_{OL} = 4 mA				0.26		0.4		0.33	
I_I	V_I = V_{CC} to GND		5.5 V			±0.1		±1		±1	μA
I_{CC}	V_I = V_{CC} or 0, I_O = 0		5.5 V			8		160		80	μA
ΔI_{CC}†	One input at V_{CC} − 2.1 V, Other inputs at 0 or V_{CC}		4.5 V to 5.5 V		100	360		490		450	μA
C_i						10		10		10	pF

† Additional quiescent supply current per input pin, TTL inputs high, 1 unit load

HCT INPUT LOADING TABLE

INPUTS	UNIT LOADS
A-D	0.4
CLK	1.5
$\overline{\text{LOAD}}$	1.5
D/$\overline{\text{U}}$	1.2
$\overline{\text{CTEN}}$	1.5

Unit load is ΔI_{CC} limit specified in electrical characteristics table, (e.g., 360 μA max at 25°C).

'HC190, 'HC191 timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 4)

			V_{CC}	T_A = 25°C		T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f_{clock}	Clock frequency†		2 V		6		4		5	MHz
			4.5 V		30		20		25	
			6 V		35		23		29	
t_w	Pulse duration	$\overline{LOAD}$ low	2 V	80		120		100		ns
			4.5 V	16		24		20		
			6 V	14		20		17		
		CLK high or low	2 V	100		150		125		
			4.5 V	20		30		25		
			6 V	17		26		21		
t_{su}	Setup time	Data before $\overline{LOAD}$↑	2 V	60		90		75		ns
			4.5 V	12		18		15		
			6 V	10		15		13		
		$\overline{CTEN}$ before CLK↑	2 V	60		90		75		
			4.5 V	12		18		15		
			6 V	10		15		13		
		D/$\overline{U}$ before CLK↑	2 V	90		135		115		
			4.5 V	18		27		23		
			6 V	15		23		20		
t_h	Hold time	Data before $\overline{LOAD}$↑	2 V	2		2		2		ns
			4.5 V	2		2		2		
			6 V	2		2		2		
		$\overline{CTEN}$ before CLK↑	2 V	2		2		2		
			4.5 V	2		2		2		
			6 V	2		2		2		
		D/$\overline{U}$ before CLK↑	2 V	0		0		0		
			4.5 V	0		0		0		
			6 V	0		0		0		
t_{rec}	Recovery time	$\overline{LOAD}$ inactive before CLK↑	2 V	60		90		75		ns
			4.5 V	12		18		15		
			6 V	10		15		13		

† Applies to noncascaded operation only. With cascaded counters, clock-to-terminal count propagation delays, $\overline{CTEN}$-to-clock setup times, and $\overline{CTEN}$-to-clock hold times determine maximum clock frequency. For example, with these HC devices:

$$f_{max}(CLK) = \frac{1}{\text{CLK-to-MAX/MIN propagation delay} + \overline{CTEN}\text{-to-CLK setup time} + \overline{CTEN}\text{-to-CLK hold time}} = \frac{1}{42 + 12 + 2} \approx 18 \text{ MHz}$$

'HC190, 'HC191

switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 4)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V_{CC}	T_A = 25°C			T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
					MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f_{max}				2 V	6			4		5		MHz
				4.5 V	30			20		25		
				6 V	35			23		29		
t_{pd}	$\overline{LOAD}$	Q	C_L = 50 pF	2 V			195		295		245	ns
				4.5 V			39		59		49	
				6 V			33		50		42	
			C_L = 15 pF	5 V		16						
	A, B, C, or D	Q	C_L = 50 pF	2 V			175		265		220	
				4.5 V			35		53		44	
				6 V			30		45		37	
			C_L = 15 pF	5 V		14						
	CLK	Q	C_L = 50 pF	2 V			170		255		215	
				4.5 V			34		51		43	
				6 V			29		43		37	
			C_L = 15 pF	5 V		14						
	CLK	$\overline{RCO}$	C_L = 50 pF	2 V			125		190		155	
				4.5 V			25		38		31	
				6 V			21		32		26	
			C_L = 15 pF	5 V		10						
	CLK	MAX/MIN	C_L = 50 pF	2 V			210		315		265	
				4.5 V			42		63		53	
				6 V			36		54		45	
			C_L = 15 pF	5 V		18						
	D/$\overline{U}$	$\overline{RCO}$	C_L = 50 pF	2 V			150		225		190	
				4.5 V			30		45		38	
				6 V			26		38		33	
			C_L = 15 pF	5 V		12						
	D/$\overline{U}$	MAX/MIN	C_L = 50 pF	2 V			165		250		205	
				4.5 V			33		50		41	
				6 V			28		43		35	
			C_L = 15 pF	5 V		13						
	$\overline{CTEN}$	$\overline{RCO}$	C_L = 50 pF	2 V			125		190		155	
				4.5 V			25		38		31	
				6 V			21		32		26	
			C_L = 15 pF	5 V		10						
t_t		Any	C_L = 50 pF	2 V			75		110		95	ns
				4.5 V			15		22		19	
				6 V			13		19		16	

'HCT191

timing requirements over recommended operating free-air temperature range V_{CC} = 4.5 V (unless otherwise noted) (see Figure 5)

			T_A = 25°C		T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f_{clock}	Clock frequency			30		20		25	MHz
t_w	Pulse duration	$\overline{LOAD}$ low	16		24		20		ns
		CLK high or low	20		30		25		
t_{su}	Setup time	Data before $\overline{LOAD}\uparrow$	12		18		15		ns
		$\overline{CTEN}$ before CLK$\uparrow$	12		18		15		
		D/$\overline{U}$ before CLK$\uparrow$	18		27		23		
t_h	Hold time	Data before $\overline{LOAD}\uparrow$	2		2		2		ns
		$\overline{CTEN}$ before CLK$\uparrow$	2		2		2		
		D/$\overline{U}$ before CLK$\uparrow$	0		0		0		
t_{rec}	Recovery time	$\overline{LOAD}$ inactive before CLK$\uparrow$	12		18		15		ns

'HCT191

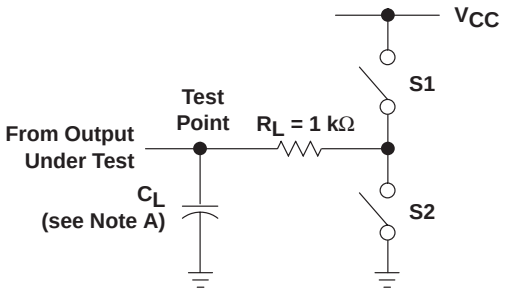
switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 5)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V_{CC}	T_A = 25°C			T_A = −55°C TO 125°C		T_A = −40°C TO 85°C		UNIT
					MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f_{max}				4.5 V	30			20		25		MHz
t_{pd}	$\overline{LOAD}$	Q	C_L = 50 pF	4.5 V			40		60		50	ns
			C_L = 15 pF	5 V		17						
	A, B, C, or D	Q	C_L = 50 pF	4.5 V			38		57		48	
			C_L = 15 pF	5 V		16						
	CLK	$\overline{RCO}$	C_L = 50 pF	4.5 V			35		53		44	
			C_L = 15 pF	5 V		14						
	CLK	Q	C_L = 50 pF	4.5 V			27		41		34	
			C_L = 15 pF	5 V		11						
	CLK	MAX/MIN	C_L = 50 pF	4.5 V			42		63		53	
			C_L = 15 pF	5 V		18						
	D/$\overline{U}$	$\overline{RCO}$	C_L = 50 pF	4.5 V			30		45		38	
			C_L = 15 pF	5 V		12						
	D/$\overline{U}$	MAX/MIN	C_L = 50 pF	4.5 V			38		57		48	
			C_L = 15 pF	5 V		16						
	$\overline{CTEN}$	$\overline{RCO}$	C_L = 50 pF	4.5 V			27		41		34	
			C_L = 15 pF	5 V		11						
t_t		Any	C_L = 50 pF	4.5 V			15		22		19	ns

operating characteristics, V_{CC} = 5 V, T_A = 25°C

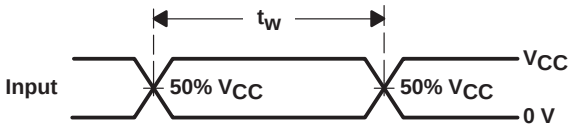
PARAMETER			TYP	UNIT
C_{pd}	Power dissipation capacitance	'HC190	59	pF
		'HC191	55	
		'HCT191	68	

PARAMETER MEASUREMENT INFORMATION − ’HC190, ’HC191

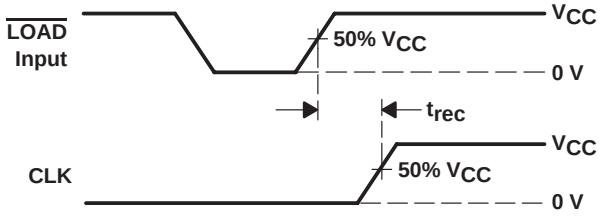


LOAD CIRCUIT

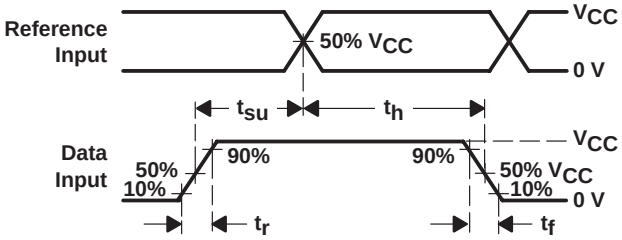
PARAMETER		S1	S2
t_{en}	t_{PZH}	Open	Closed
	t_{PZL}	Closed	Open
t_{dis}	t_{PHZ}	Open	Closed
	t_{PLZ}	Closed	Open
t_{pd} or t_t		Open	Open



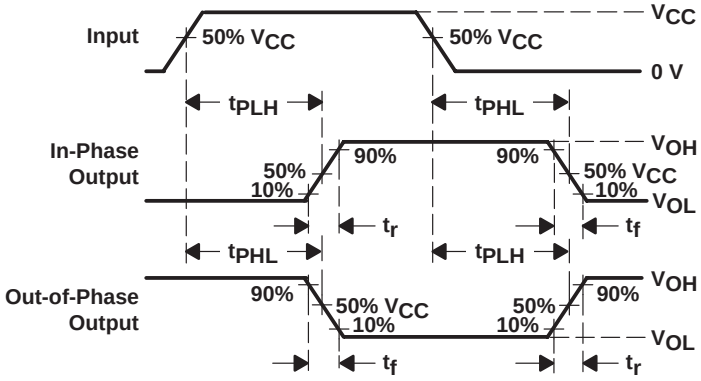
VOLTAGE WAVEFORMS
PULSE DURATION



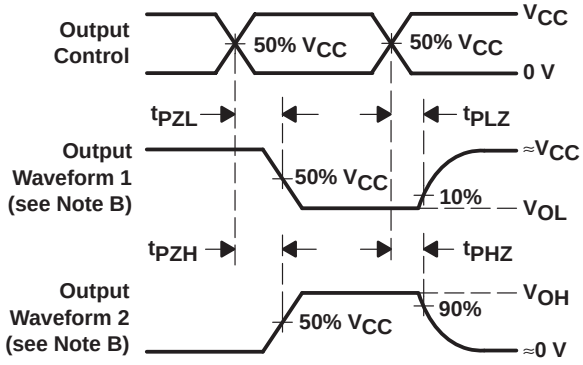
VOLTAGE WAVEFORMS
RECOVERY TIME



VOLTAGE WAVEFORMS
SETUP AND HOLD AND INPUT RISE AND FALL TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY AND OUTPUT TRANSITION TIMES

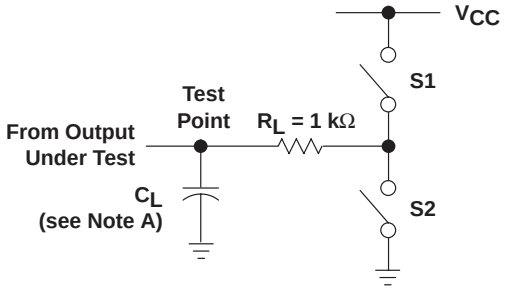


VOLTAGE WAVEFORMS
OUTPUT ENABLE AND DISABLE TIMES

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

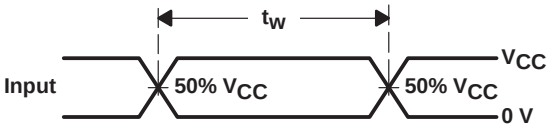
Figure 4. Load Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION − ’HCT191

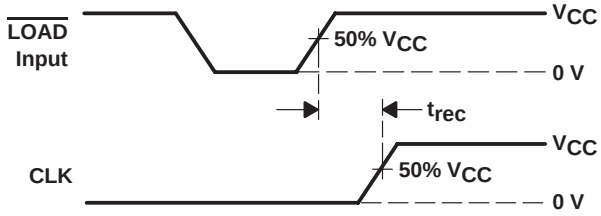


LOAD CIRCUIT

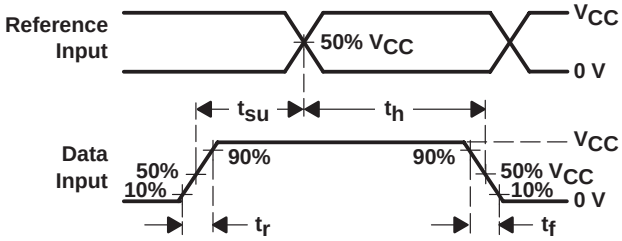
PARAMETER		S1	S2
t_{en}	t_{PZH}	Open	Closed
	t_{PZL}	Closed	Open
t_{dis}	t_{PHZ}	Open	Closed
	t_{PLZ}	Closed	Open
t_{pd} or t_t		Open	Open



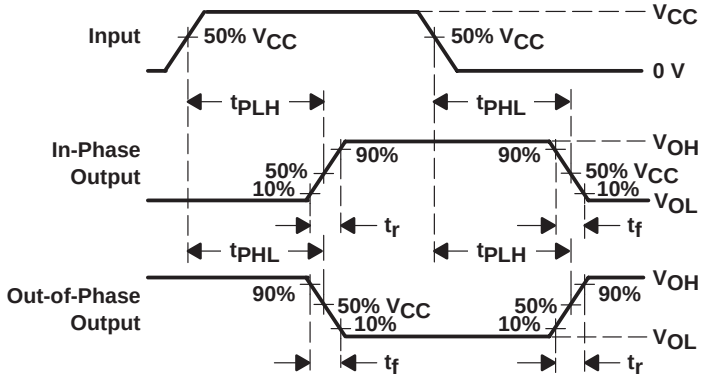
VOLTAGE WAVEFORMS
PULSE DURATION



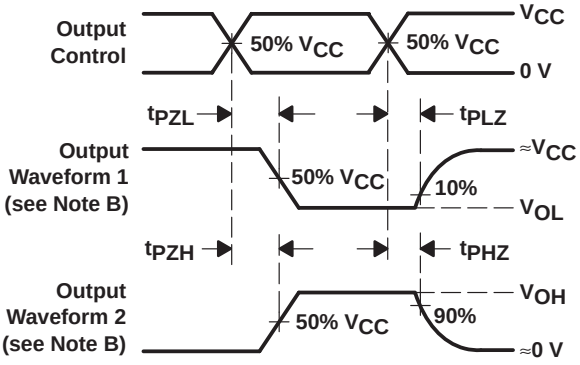
VOLTAGE WAVEFORMS
RECOVERY TIME



VOLTAGE WAVEFORMS
SETUP AND HOLD AND INPUT RISE AND FALL TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY AND OUTPUT TRANSITION TIMES



VOLTAGE WAVEFORMS
OUTPUT ENABLE AND DISABLE TIMES

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

Figure 5. Load Circuit and Voltage Waveforms