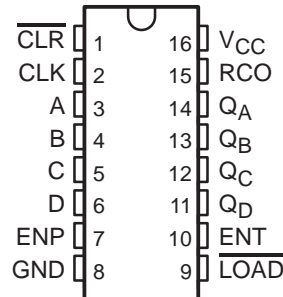


# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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- Synchronous Counting and Loading
- Two Count-Enable Inputs for n-Bit Cascading
- Asynchronous Reset (CD54HC160)
- Synchronous Reset (CD54HC162)
- Look-Ahead Carry for High-Speed Counting
- Operating Range 2-V to 6-V  $V_{CC}$
- EPIC™ (Enhanced-Performance Implanted CMOS) Process
- Packaged in Ceramic (F) DIPs

CD54HC160, CD54HC162 . . . F PACKAGE  
(TOP VIEW)



## description

These synchronous, presettable counters feature an internal carry look-ahead for application in high-speed counting designs. The CD54HC160 and CD54HC162 are BCD decade counters. 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 synchronous (ripple-clock) counters. A buffered clock (CLK) input triggers the four flip-flops on the rising (positive-going) edge of the clock waveform.

These counters are fully programmable; that is, they can be preset to any number between 0 and 9. As presetting is synchronous, setting up a low level at the 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 the enable inputs.

The clear function for the CD54HC160 is asynchronous. A low level at the clear ( $\overline{CLR}$ ) input sets all four of the flip-flop outputs low, regardless of the levels of the CLK, load ( $\overline{LOAD}$ ), or enable inputs.

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications without additional gating. Instrumental in accomplishing this function are ENP, ENT, and a ripple-carry output (RCO). Both ENP and ENT must be high to count, and ENT is fed forward to enable RCO. Enabling RCO produces a high-level pulse while the count is maximum (9 with  $Q_A$  high). This high-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.

These counters feature a fully independent clock circuit. Changes at control inputs (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 stable setup and hold times.

The CD54HC160 and CD54HC162 are supplied in 16-lead hermetic dual-in-line ceramic packages (F suffix), and are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .



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 **TEXAS  
INSTRUMENTS**

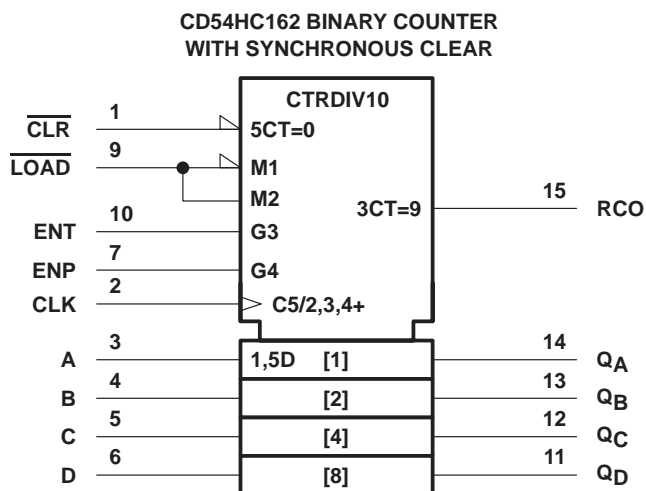
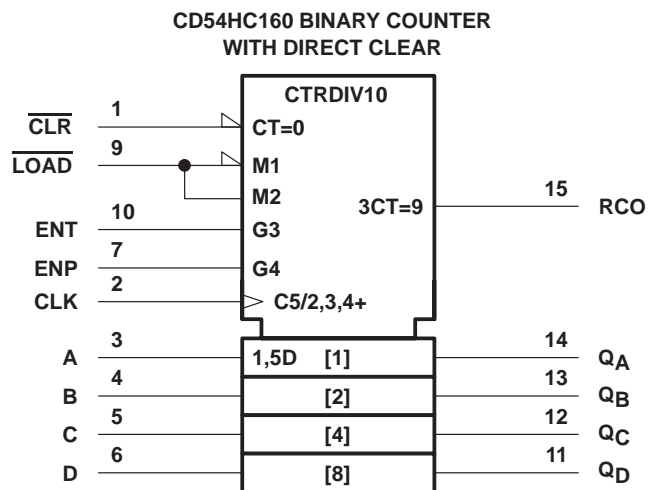
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

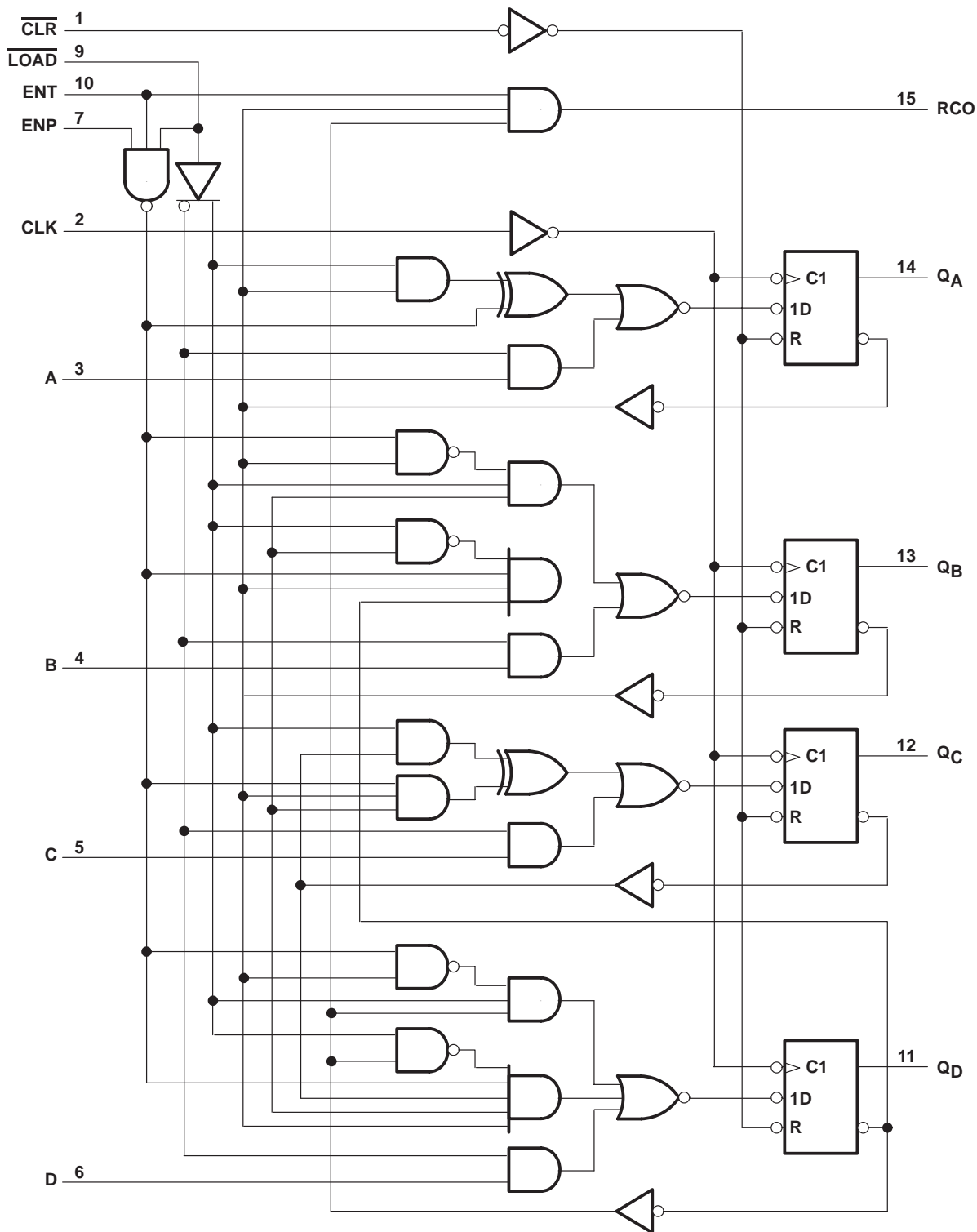
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## logic symbol†



† These symbols are in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

CD54HC160 logic diagram (positive logic)†

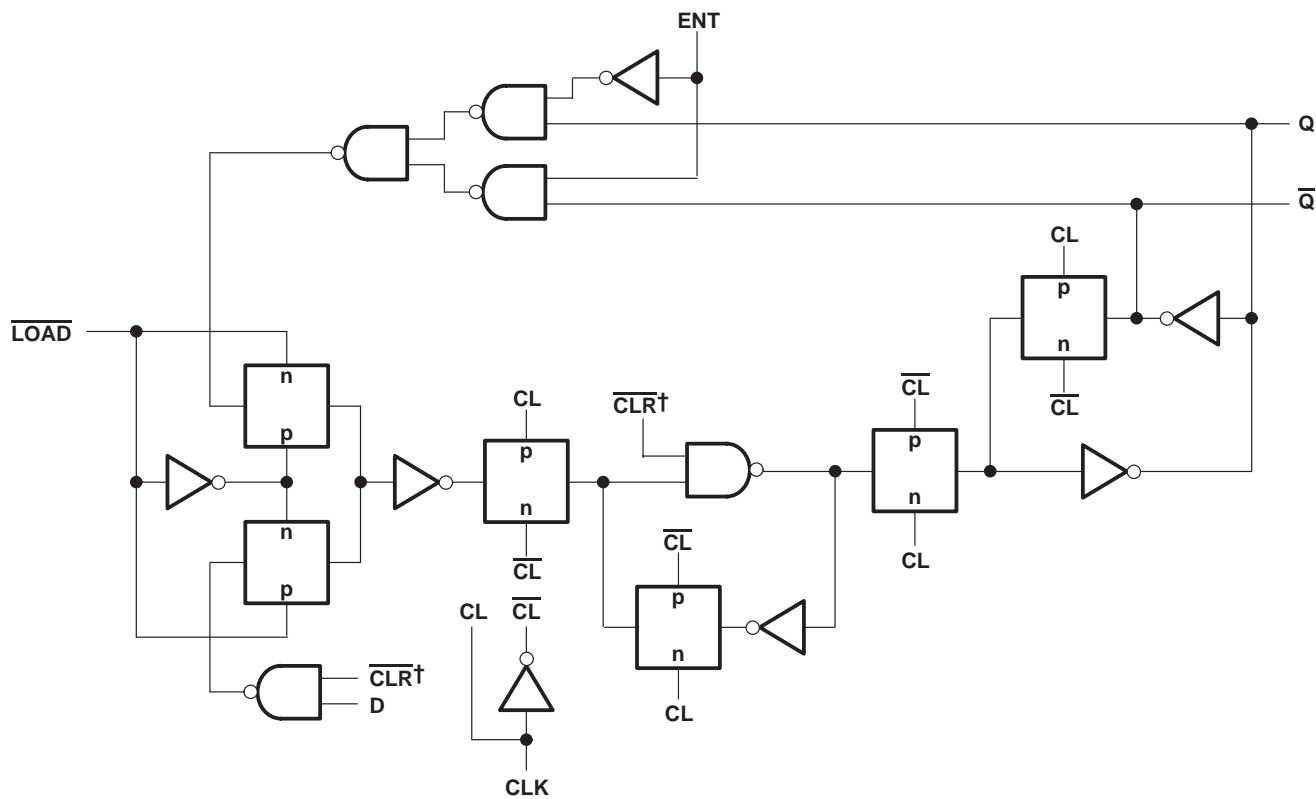


† CD54HC162 decade counter is similar; however, the clear is synchronous.

# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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logic diagram, each D/T flip-flop (positive logic)

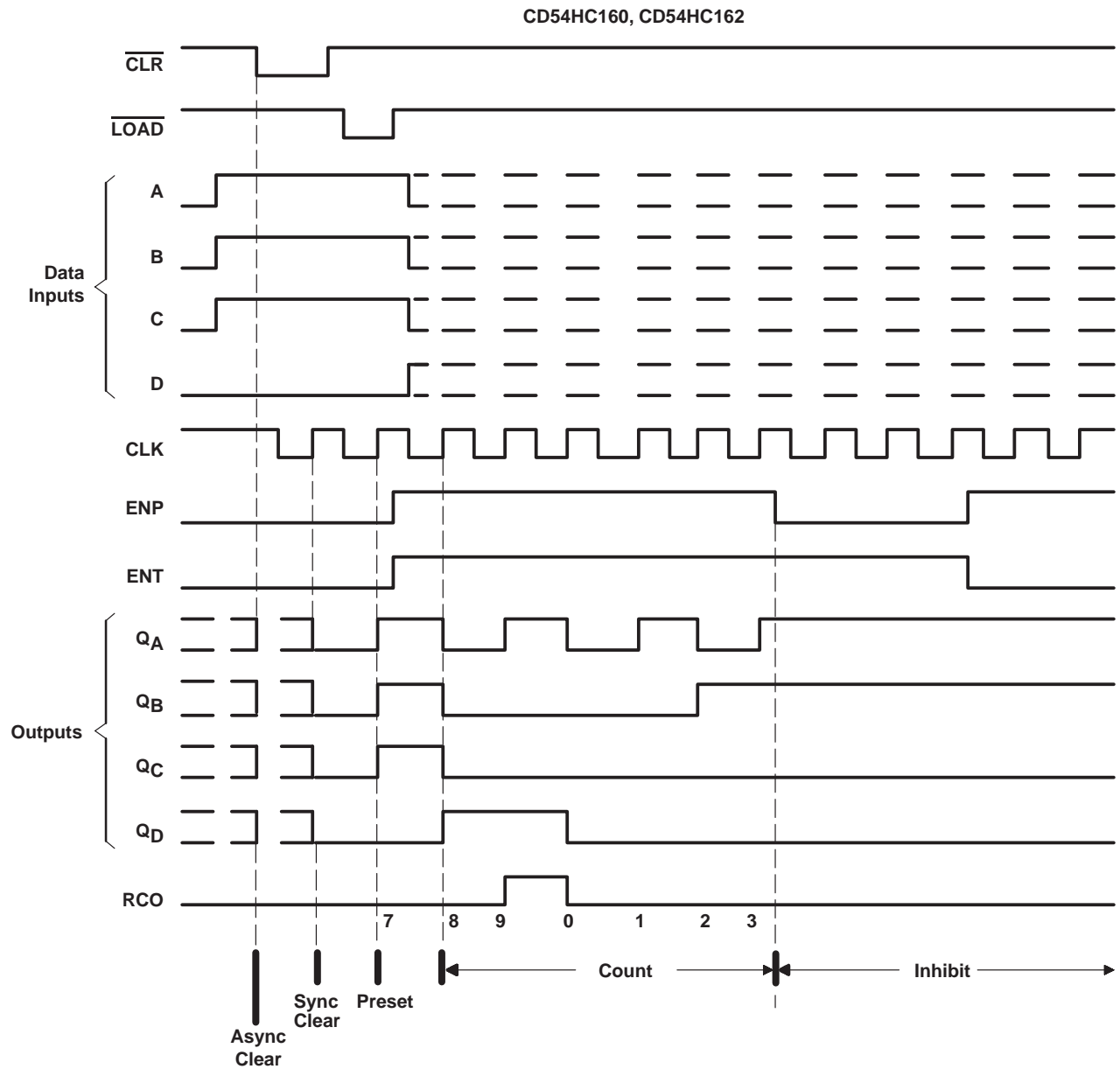


† Connect to  $V_{DD}$  for CD54HC162.

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

Illustrated below is the following sequence:

1. Clear outputs to zero (CD54HC160 is asynchronous; CD54HC162 is synchronous)
2. Preset BCD to seven
3. Count to eight, nine, zero, one, two, and three
4. Inhibit



# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE 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 voltage range, $V_I$ (see Note 1) .....	-0.5 V to 7 V
Output voltage range, $V_O$ (see Note 1) .....	-0.5 V to $V_{CC} + 0.5$ V
Input clamp current, $I_{IK}$ ( $V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V) .....	$\pm 20$ mA
Output clamp current, $I_{OK}$ ( $V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V) .....	$\pm 20$ mA
Continuous output current, $I_O$ ( $V_O = -0.5$ V to $V_{CC} + 0.5$ V) .....	$\pm 25$ mA
Continuous current through $V_{CC}$ or GND .....	$\pm 50$ mA
Power dissipation, $P_D$ (see Note 2) .....	500 mW
Storage temperature range, $T_{stg}$ .....	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds .....	265°C
Lead temperature, unit inserted into a PC board (minimum thickness 1,6 mm, 1/16 inch) with solder contacting lead tips only .....	300°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. Above 100°C, derate linearly at a factor of 8 mW/°C.

## recommended operating conditions (see Note 3)

		MIN	MAX	UNIT	
$V_{CC}$	Supply voltage	2	6	V	
$V_{IH}$	High-level input voltage	$V_{CC} = 2$ V	1.5	V	
		$V_{CC} = 4.5$ V	3.15		
		$V_{CC} = 6$ V	4.2		
$V_{IL}$	Low-level input voltage	$V_{CC} = 2$ V	0.5	V	
		$V_{CC} = 4.5$ V	1.35		
		$V_{CC} = 6$ V	1.8		
$V_I$	Input voltage	0	$V_{CC}$	V	
$V_O$	Output voltage	0	$V_{CC}$	V	
$t_r, t_f$	Input transition rise or fall times	$V_{CC} = 2$ V	0	1000	ns
		$V_{CC} = 4.5$ V	0	500	
		$V_{CC} = 6$ V	0	400	
$T_A$	Operating free-air temperature	-55	125	°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.



# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE 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			CD54HC160 CD54HC162		UNIT
			MIN	TYP	MAX	MIN	MAX	
V <sub>OH</sub>	I <sub>OH</sub> = -20 μA	2 V	1.9			1.9		V
		4.5 V	4.4			4.4		
		6 V	5.9			5.9		
	I <sub>OH</sub> = -4 mA	4.5 V	3.98			3.7		
	I <sub>OH</sub> = -5.2 mA	6 V	5.48			5.2		
V <sub>OL</sub>	I <sub>OL</sub> = 20 μA	2 V				0.1	0.1	V
		4.5 V				0.1	0.1	
		6 V				0.1	0.1	
	I <sub>OL</sub> = 4 mA	4.5 V				0.26	0.4	
	I <sub>OL</sub> = 5.2 mA	6 V				0.26	0.4	
I <sub>I</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND	6 V				±0.1	±1	μA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0	6 V				8	160	μA
C <sub>IN</sub>						10	10	pF

**timing requirements over recommended operating free-air temperature range, V<sub>CC</sub> = 2 V (unless otherwise noted) (see Figure 1)**

			T <sub>A</sub> = 25°C		CD54HC160 CD54HC162		UNIT
			MIN	MAX	MIN	MAX	
f <sub>max</sub>	Maximum frequency	CLK	6		4		MHz
t <sub>w</sub>	Pulse duration	CLK low	80		120		ns
		$\overline{\text{CLR}}$ low ('160 only)	100		150		
t <sub>su</sub>	Setup time before CLK↑	Data (A, B, C, and D)	60		90		ns
		ENP, ENT	50		75		
		$\overline{\text{LOAD}}$ low	60		90		
		$\overline{\text{CLR}}$ ('162 only)	65		100		
		$\overline{\text{CLR}}$ high ('160 only)	75		110		
t <sub>h</sub>	Hold time after CLK↑	Data (A, B, C, and D)	3		3		ns
		ENP, ENT	0		0		
		$\overline{\text{LOAD}}$ low	3		3		

# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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timing requirements over recommended operating free-air temperature range,  $V_{CC} = 4.5\text{ V}$  (unless otherwise noted) (see Figure 1)

			$T_A = 25^\circ\text{C}$		CD54HC160 CD54HC162		UNIT
			MIN	MAX	MIN	MAX	
$f_{max}$	Maximum frequency	CLK	30		20		MHz
$t_w$	Pulse duration	CLK low	16		24		ns
		$\overline{\text{CLR}}$ low ('160 only)	20		30		
$t_{su}$	Setup time before CLK $\uparrow$	Data (A, B, C, and D)	12		18		ns
		ENP, ENT	10		15		
		$\overline{\text{LOAD}}$ low	12		18		
		$\overline{\text{CLR}}$ ('162 only)	13		20		
		$\overline{\text{CLR}}$ high ('160 only)	15		22		
$t_h$	Hold time after CLK $\uparrow$	Data (A, B, C, and D)	3		3		ns
		ENP, ENT	0		0		
		$\overline{\text{LOAD}}$ low	3		3		

timing requirements over recommended operating free-air temperature range,  $V_{CC} = 6\text{ V}$  (unless otherwise noted) (see Figure 1)

			$T_A = 25^\circ\text{C}$		CD54HC160 CD54HC162		UNIT
			MIN	MAX	MIN	MAX	
$f_{max}$	Maximum frequency	CLK	35		24		MHz
$t_w$	Pulse duration	CLK low	14		20		ns
		$\overline{\text{CLR}}$ low ('160 only)	17		26		
$t_{su}$	Setup time before CLK $\uparrow$	Data (A, B, C, and D)	10		15		ns
		ENP, ENT	9		13		
		$\overline{\text{LOAD}}$ low	10		15		
		$\overline{\text{CLR}}$ ('162 only)	11		17		
		$\overline{\text{CLR}}$ high ('160 only)	13		19		
$t_h$	Hold time after CLK $\uparrow$	Data (A, B, C, and D)	3		3		ns
		ENP, ENT	0		0		
		$\overline{\text{LOAD}}$ low	3		3		





# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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switching characteristics over recommended operating free-air temperature range,  $V_{CC} = 2\text{ V}$  (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	$T_A = 25^\circ\text{C}$		CD54HC160 CD54HC162		UNIT
				MIN	MAX	MIN	MAX	
$t_{PLH}$	CLK	RCO	$C_L = 50\text{ pF}$	185		280		ns
$t_{PHL}$				185		280		
$t_{PLH}$	CLK	Q	$C_L = 50\text{ pF}$	185		280		ns
$t_{PHL}$				185		280		
$t_{PLH}$	ENT	RCO	$C_L = 50\text{ pF}$	120		180		ns
$t_{PHL}$				120		180		
$t_{PHL}$	$\overline{\text{CLR}}$	Q ('160 only)	$C_L = 50\text{ pF}$	210		315		ns
		RCO ('160 only)		210		315		
$t_{TLH}$			$C_L = 50\text{ pF}$	75		110		ns
$t_{THL}$				75		110		

switching characteristics over recommended operating free-air temperature range,  $V_{CC} = 4.5\text{ V}$  (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	$T_A = 25^\circ\text{C}$		CD54HC160 CD54HC162		UNIT
				MIN	MAX	MIN	MAX	
$t_{PLH}$	CLK	RCO	$C_L = 50\text{ pF}$	37		56		ns
$t_{PHL}$				37		56		
$t_{PLH}$	CLK	Q	$C_L = 50\text{ pF}$	37		56		ns
$t_{PHL}$				37		56		
$t_{PLH}$	ENT	RCO	$C_L = 50\text{ pF}$	24		36		ns
$t_{PHL}$				24		36		
$t_{PHL}$	$\overline{\text{CLR}}$	Q ('160 only)	$C_L = 50\text{ pF}$	42		63		ns
		RCO ('160 only)		42		63		
$t_{TLH}$			$C_L = 50\text{ pF}$	15		22		ns
$t_{THL}$				15		22		

# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

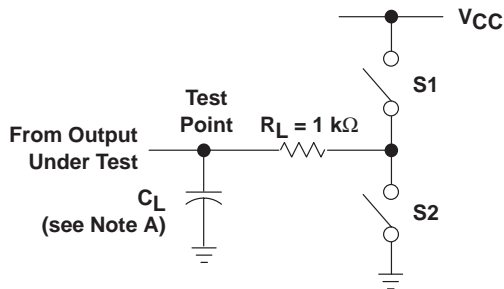
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switching characteristics over recommended operating free-air temperature range,  $V_{CC} = 6\text{ V}$  (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	$T_A = 25^\circ\text{C}$		CD54HC160 CD54HC162		UNIT
				MIN	MAX	MIN	MAX	
$t_{PLH}$	CLK	RCO	$C_L = 50\text{ pF}$	31		48		ns
$t_{PHL}$				31		48		
$t_{PLH}$	CLK	Q	$C_L = 50\text{ pF}$	31		48		ns
$t_{PHL}$				31		48		
$t_{PLH}$	ENT	RCO	$C_L = 50\text{ pF}$	20		31		ns
$t_{PHL}$				20		31		
$t_{PHL}$	$\overline{\text{CLR}}$	Q ('160 only)	$C_L = 50\text{ pF}$	36		54		ns
		RCO ('160 only)		36		54		
$t_{TLH}$			$C_L = 50\text{ pF}$	13		19		ns
$t_{THL}$				13		19		

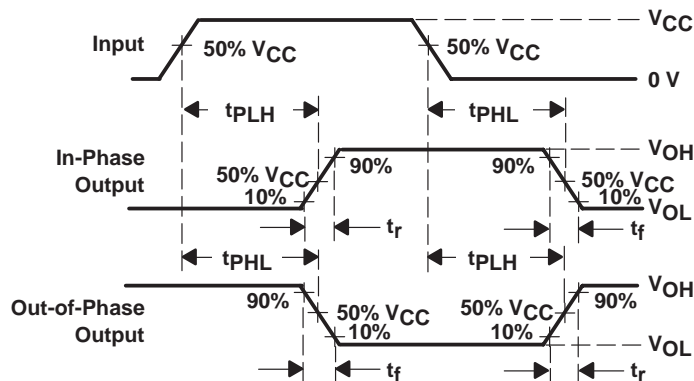


PARAMETER MEASUREMENT INFORMATION



LOAD CIRCUIT

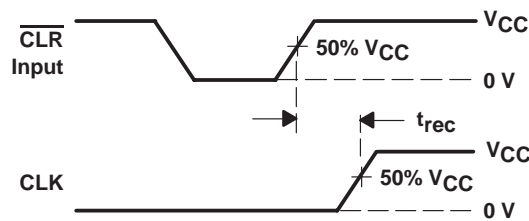
PARAMETER	S1	S2	
$t_{en}$	$t_{PZH}$	Open	Closed
	$t_{PZL}$	Closed	Open
$t_{dis}$	$t_{PHZ}$	Open	Closed
	$t_{PLZ}$	Closed	Open
$t_{pd}$ or $t_t$	Open	Open	



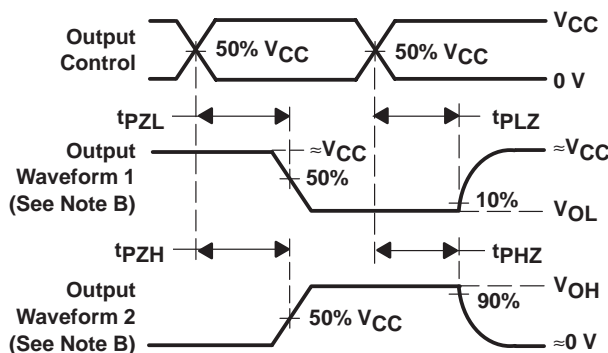
VOLTAGE WAVEFORMS  
PROPAGATION DELAY AND OUTPUT TRANSITION TIMES



VOLTAGE WAVEFORM  
INPUT RISE AND FALL TIMES



VOLTAGE WAVEFORMS  
RECOVERY TIME



VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES FOR 3-STATE OUTPUTS

- 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:  $PRR \leq 1$  MHz,  $Z_O = 50 \Omega$ ,  $t_r = 6$  ns,  $t_f = 6$  ns.
  - D. The outputs are measured one at a time with one input transition per measurement.
  - E.  $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$ .
  - F.  $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$ .
  - G.  $t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{pd}$ .

Figure 1. Load Circuit and Voltage Waveforms

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