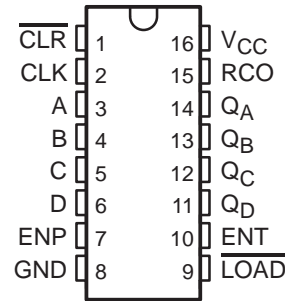


# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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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 ( $\overline{\text{CLR}}$ ) input sets all four of the flip-flop outputs low, regardless of the levels of the CLK, load (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<sub>A</sub> 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  $\overline{\text{LOAD}}$ ) 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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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**

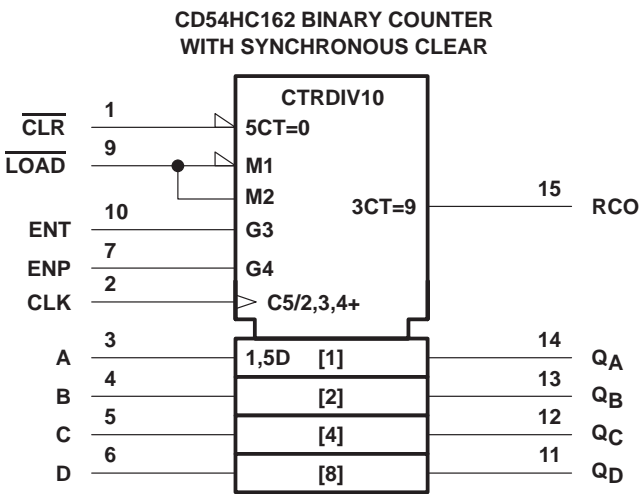
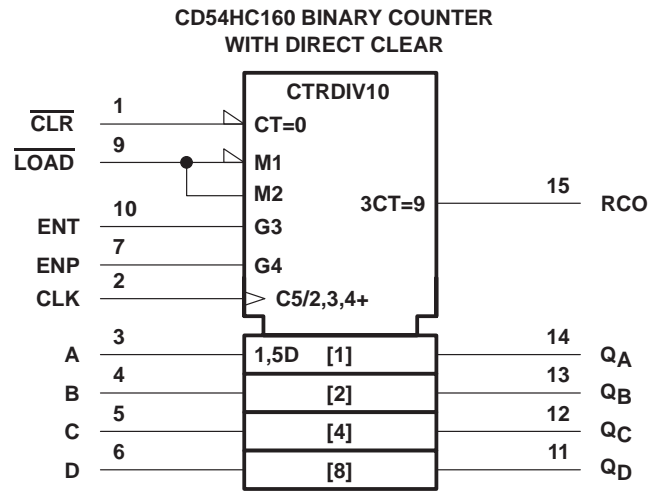
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

CD54HC160, CD54HC162  
BCD SYNCHRONOUS DECADE COUNTERS

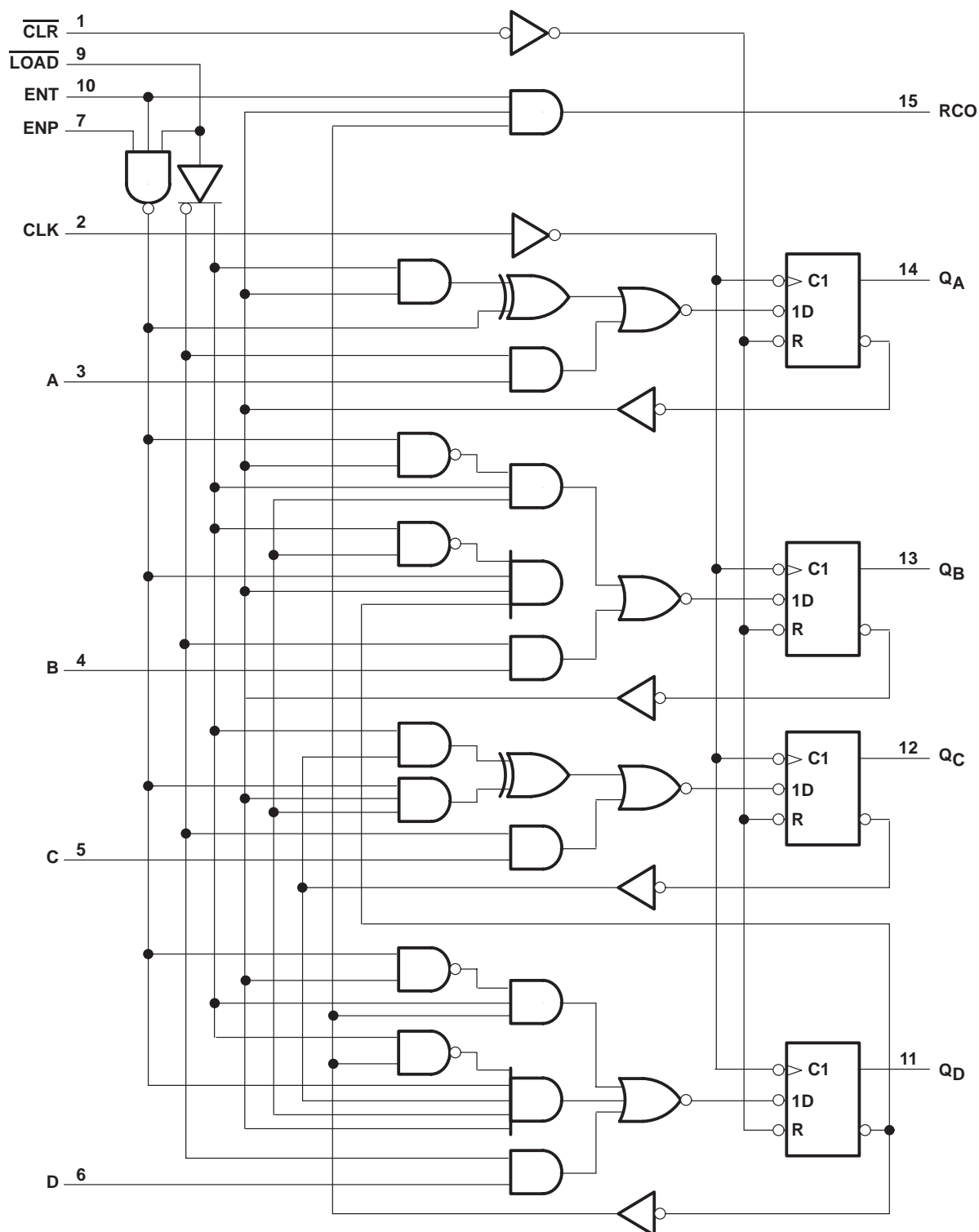
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logic symbol†



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

CD54HC160 logic diagram (positive logic)<sup>†</sup>

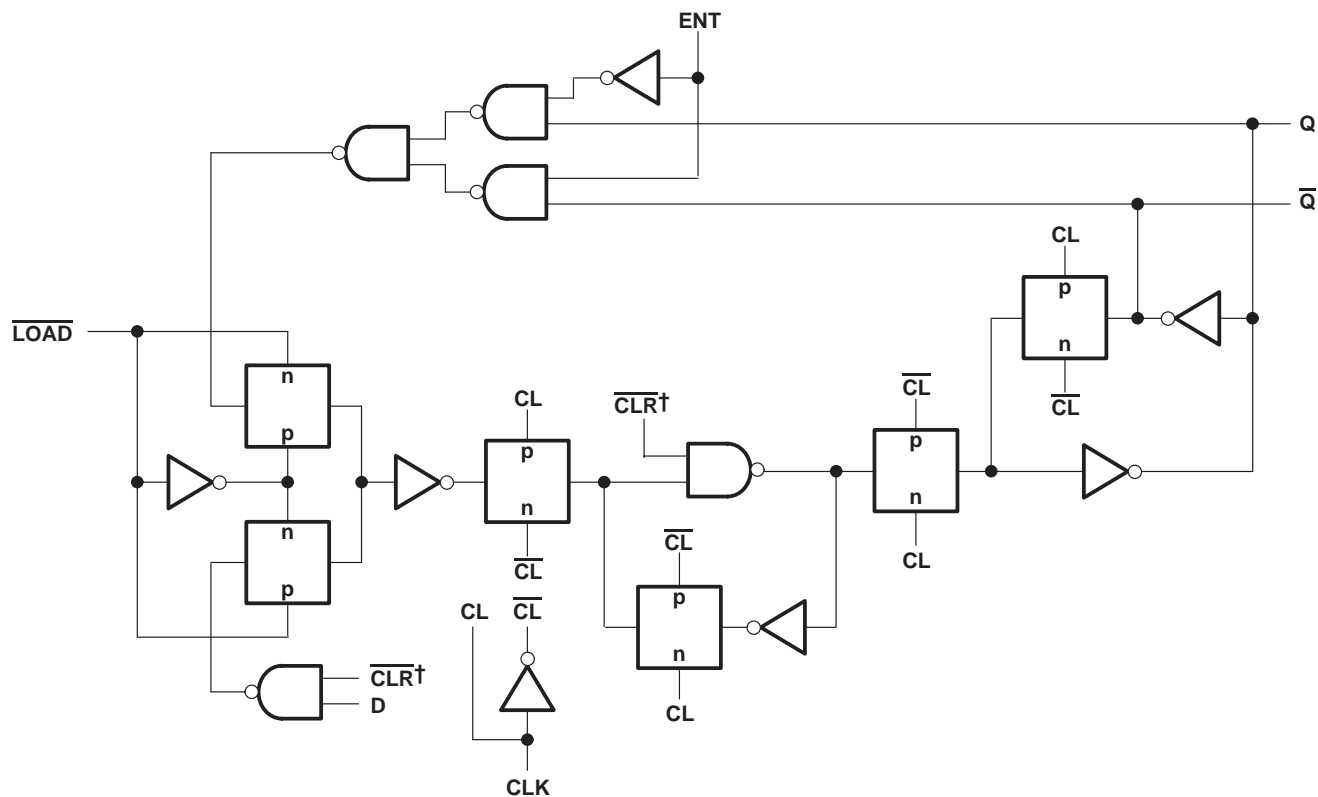


<sup>†</sup> CD54HC162 decade counter is similar; however, the clear is synchronous.

# CD54HC160, CD54HC162 BCD SYNCHRONOUS DECADE COUNTERS

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

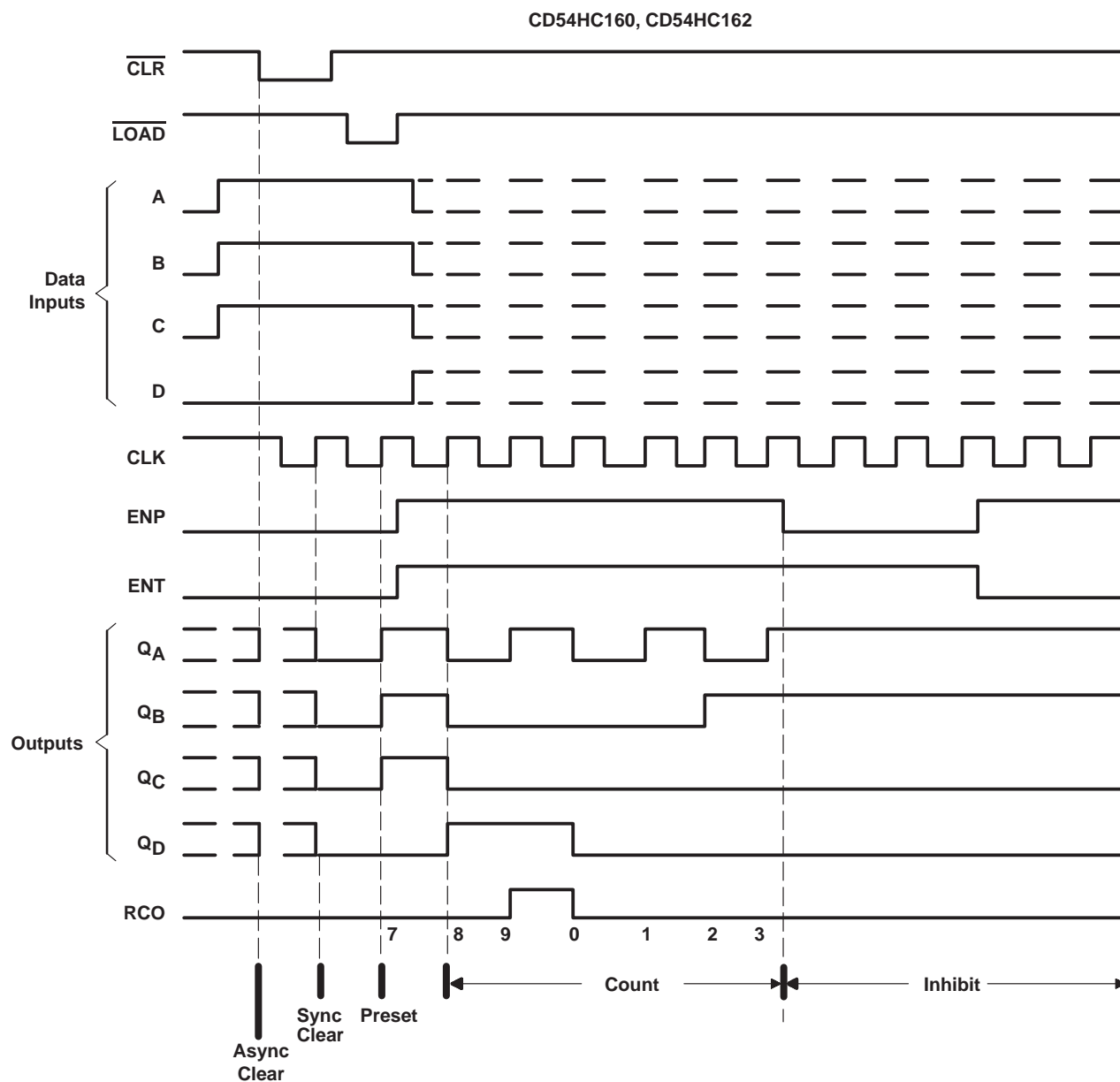


† Connect to  $V_{DD}$  for CD54HC162.

## 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)<sup>†</sup>

|  |                            |
|--|----------------------------|
| 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)  | ±20 mA                     |
| Output clamp current, $I_{OK}$ ( $V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V)   | ±20 mA                     |
| Continuous output current, $I_O$ ( $V_O = -0.5$ V to $V_{CC} + 0.5$ V)   | ±25 mA                     |
| Continuous current through $V_{CC}$ or GND   | ±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)<br>with solder contacting lead tips only | 300°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 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<br>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<br>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   |
|                  |                        | 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                     |     |      |
|                  |                        | LOAD low              | 60                    |     | 90                     |     |      |
|                  |                        | CLR ('162 only)       | 65                    |     | 100                    |     |      |
|                  |                        | 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                      |     |      |
|                  |                        | 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<br>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                     |      |
| $t_{\text{su}}$ | 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<br>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                     |      |
| $t_{\text{su}}$ | 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<br>(INPUT)         | TO<br>(OUTPUT)  | LOAD<br>CAPACITANCE  | $T_A = 25^\circ\text{C}$ |     | CD54HC160<br>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<br>(INPUT)         | TO<br>(OUTPUT)  | LOAD<br>CAPACITANCE  | $T_A = 25^\circ\text{C}$ |     | CD54HC160<br>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

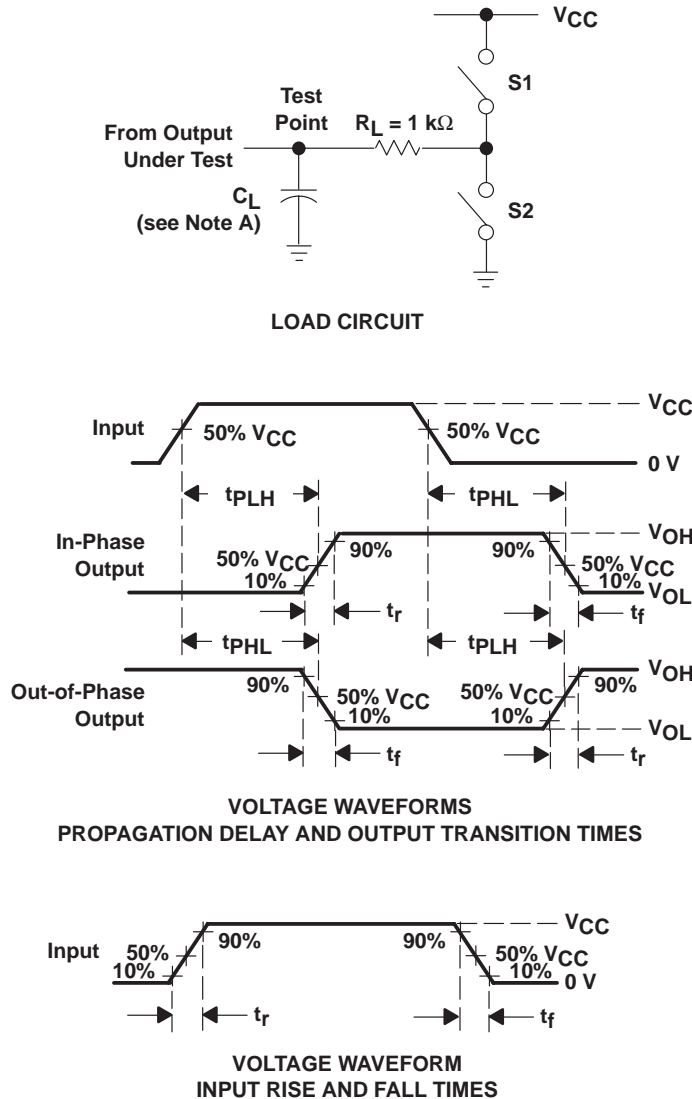
## BCD SYNCHRONOUS DECADE COUNTERS

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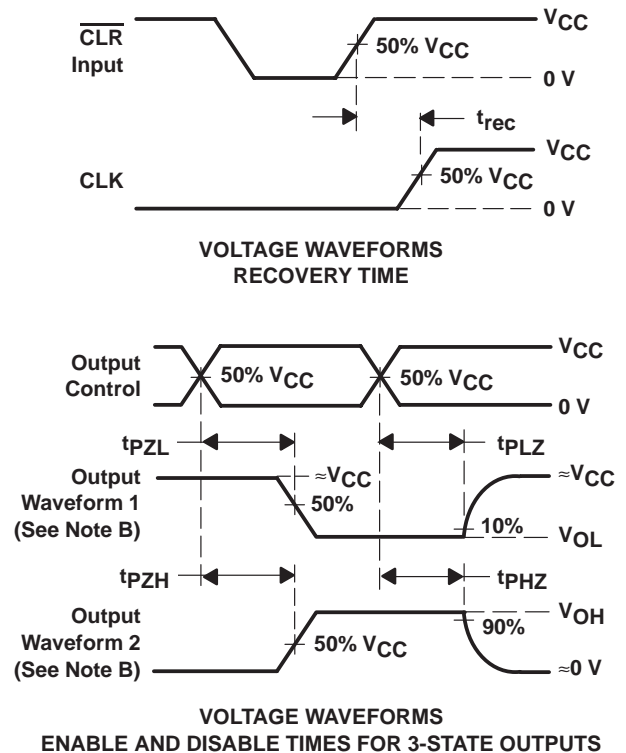
switching characteristics over recommended operating free-air temperature range,  $V_{CC} = 6\text{ V}$  (unless otherwise noted) (see Figure 1)

| PARAMETER | FROM<br>(INPUT)         | TO<br>(OUTPUT)  | LOAD<br>CAPACITANCE  | $T_A = 25^\circ\text{C}$ |     | CD54HC160<br>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



| PARAMETER         | S1     | S2     |
|-------------------|--------|--------|
| $t_{en}$          | Open   | Closed |
|                   | Closed | Open   |
| $t_{dis}$         | Open   | Closed |
|                   | Closed | Open   |
| $t_{pd}$ or $t_t$ | Open   | Open   |



- NOTES:
- $C_L$  includes probe and test-fixture 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.
  - Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1\text{ MHz}$ ,  $Z_O = 50\ \Omega$ ,  $t_r = 6\text{ ns}$ ,  $t_f = 6\text{ ns}$ .
  - The outputs are measured one at a time with one input transition per measurement.
  - $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$ .
  - $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$ .
  - $t_{PLH}$  and  $t_{PHL}$  are the same as  $t_{pd}$ .

Figure 1. Load Circuit and Voltage Waveforms

## PACKAGING INFORMATION

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| CD54HC160F3A     | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| CD54HC162F3A     | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) 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.

**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.

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

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



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



4040083/F 03/03

- 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.

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