

# **MM74HC160 Synchronous Decade Counter with Asynchronous Clear** **MM54HC161/MM74HC161 Synchronous Binary Counter with Asynchronous Clear** **MM54HC162/MM74HC162 Synchronous Decade Counter with Synchronous Clear** **MM54HC163/MM74HC163 Synchronous Binary Counter with Synchronous Clear** **General Description**

The MM54HC160/MM74HC160, MM54HC161/MM74HC161, MM54HC162/MM74HC162, and MM54HC163/MM74HC163 synchronous presettable counters utilize advanced silicon-gate CMOS technology and internal look-ahead carry logic for use in high speed counting applications. They offer the high noise immunity and low power consumption inherent to CMOS with speeds similar to low power Schottky TTL. The 'HC160 and the 'HC162 are 4 bit decade counters, and the 'HC161 and the 'HC163 are 4 bit binary counters. All flip-flops are clocked simultaneously on the low to high transition (positive edge) of the CLOCK input waveform.

These counters may be preset using the LOAD input. Pre-setting of all four flip-flops is synchronous to the rising edge of CLOCK. When LOAD is held low counting is disabled and the data on the A, B, C, and D inputs is loaded into the counter on the rising edge of CLOCK. If the load input is taken high before the positive edge of CLOCK the count operation will be unaffected.

All of these counters may be cleared by utilizing the CLEAR input. The clear function on the MM54HC162/MM74HC162 and MM54HC163/MM74HC163 counters are synchronous to the clock. That is, the counters are cleared on the positive edge of CLOCK while the clear input is held low.

The MM54HC160/MM74HC160 and MM54HC161/MM74HC161 counters are cleared asynchronously. When the CLEAR is taken low the counter is cleared immediately regardless of the CLOCK.

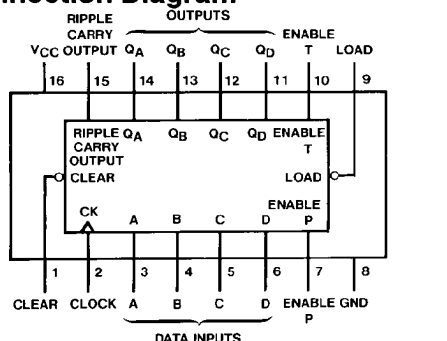
Two active high enable inputs (ENP and ENT) and a RIPLE CARRY (RC) output are provided to enable easy cascading of counters. Both ENABLE inputs must be high to count. The ENT input also enables the RC output. When enabled, the RC outputs a positive pulse when the counter overflows. This pulse is approximately equal in duration to the high level portion of the Q<sub>A</sub> output. The RC output is fed to successive cascaded stages to facilitate easy implementation of N-bit counters.

All inputs are protected from damage due to static discharge by diodes to V<sub>CC</sub> and ground.

## **Features**

- Typical operating frequency: 40 MHz
- Typical propagation delay; clock to Q: 18 ns
- Low quiescent current: 80  $\mu$ A maximum (74HC Series)
- Low input current: 1  $\mu$ A maximum
- Wide power supply range: 2–6V

## **Connection Diagram**



Order Number MM54HC161/162/163  
or MM74HC160/161/162/163

TL/F/5008-1

## **Truth Tables**

'HC160/HC161

| CLK | CLR | ENP | ENT | Load | Function            |
|-----|-----|-----|-----|------|---------------------|
| X   | L   | X   | X   | X    | Clear               |
| X   | H   | H   | L   | H    | Count & RC disabled |
| X   | H   | L   | H   | H    | Count disabled      |
| X   | H   | L   | L   | H    | Count & RC disabled |
| ↑   | H   | X   | X   | L    | Load                |
| ↑   | H   | H   | H   | H    | Increment Counter   |

H = high level, L = low level

X = don't care, ↑ = low to high transition

'HC162/HC163

| CLK | CLR | ENP | ENT | Load | Function            |
|-----|-----|-----|-----|------|---------------------|
| ↑   | L   | X   | X   | X    | Clear               |
| X   | H   | H   | L   | H    | Count & RC disabled |
| X   | H   | L   | H   | H    | Count disabled      |
| X   | H   | L   | L   | H    | Count & RC disabled |
| ↑   | H   | X   | X   | L    | Load                |
| ↑   | H   | H   | H   | H    | Increment Counter   |

**Absolute Maximum Ratings** (Notes 1 & 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|                                                  |                         |
|--------------------------------------------------|-------------------------|
| Supply Voltage ( $V_{CC}$ )                      | −0.5 to +7.0V           |
| DC Input Voltage ( $V_{IN}$ )                    | −1.5 to $V_{CC}$ + 1.5V |
| DC Output Voltage ( $V_{OUT}$ )                  | −0.5 to $V_{CC}$ + 0.5V |
| Clamp Diode Current ( $I_{IK}, I_{OK}$ )         | ±20 mA                  |
| DC Output Current, per pin ( $I_{OUT}$ )         | ±25 mA                  |
| DC $V_{CC}$ or GND Current, per pin ( $I_{CC}$ ) | ±50 mA                  |
| Storage Temperature Range ( $T_{STG}$ )          | −65°C to +150°C         |
| Power Dissipation ( $P_D$ )                      |                         |
| (Note 3)                                         | 600 mW                  |
| S.O. Package only                                | 500 mW                  |
| Lead Temp. ( $T_L$ ) (Soldering 10 seconds)      | 260°C                   |

**Operating Conditions**

|                                                  | Min | Max      | Units |
|--------------------------------------------------|-----|----------|-------|
| Supply Voltage ( $V_{CC}$ )                      | 2   | 6        | V     |
| DC Input or Output Voltage ( $V_{IN}, V_{OUT}$ ) | 0   | $V_{CC}$ | V     |
| Operating Temp. Range ( $T_A$ )                  |     |          |       |
| MM74HC                                           | −40 | +85      | °C    |
| MM54HC                                           | −55 | +125     | °C    |
| Input Rise or Fall Times ( $t_r, t_f$ )          |     |          |       |
| $V_{CC}$ = 2.0V                                  |     | 1000     | ns    |
| $V_{CC}$ = 4.5V                                  |     | 500      | ns    |
| $V_{CC}$ = 6.0V                                  |     | 400      | ns    |

**DC Electrical Characteristics** (Note 4)

| Symbol          | Parameter                         | Conditions                                                                                                           | V <sub>CC</sub> | T <sub>A</sub> = 25°C |                   | 74HC<br>T <sub>A</sub> = −40 to 85°C |      | 54HC<br>T <sub>A</sub> = −55 to 125°C |  | Units |  |
|-----------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|-------------------|--------------------------------------|------|---------------------------------------|--|-------|--|
|                 |                                   |                                                                                                                      |                 | Typ                   | Guaranteed Limits |                                      |      |                                       |  |       |  |
|                 |                                   |                                                                                                                      |                 |                       |                   |                                      |      |                                       |  |       |  |
| V <sub>IH</sub> | Minimum High Level Input Voltage  |                                                                                                                      | 2.0V            |                       | 1.5               | 1.5                                  | 1.5  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 4.5V            |                       | 3.15              | 3.15                                 | 3.15 | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            |                       | 4.2               | 4.2                                  | 4.2  | V                                     |  |       |  |
| V <sub>IL</sub> | Maximum Low Level Input Voltage** |                                                                                                                      | 2.0V            |                       | 0.5               | 0.5                                  | 0.5  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 4.5V            |                       | 1.35              | 1.35                                 | 1.35 | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            |                       | 1.8               | 1.8                                  | 1.8  | V                                     |  |       |  |
| V <sub>OH</sub> | Minimum High Level Output Voltage | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br> I <sub>OUT</sub>   ≤ 20 μA                                  | 2.0V            | 2.0                   | 1.9               | 1.9                                  | 1.9  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 4.5V            | 4.5                   | 4.4               | 4.4                                  | 4.4  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            | 6.0                   | 5.9               | 5.9                                  | 5.9  | V                                     |  |       |  |
|                 |                                   | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br> I <sub>OUT</sub>   ≤ 4.0 mA<br> I <sub>OUT</sub>   ≤ 5.2 mA | 4.5V            | 4.2                   | 3.98              | 3.84                                 | 3.7  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            | 5.7                   | 5.48              | 5.34                                 | 5.2  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      |                 |                       |                   |                                      |      |                                       |  |       |  |
| V <sub>OL</sub> | Maximum Low Level Output Voltage  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br> I <sub>OUT</sub>   ≤ 20 μA                                  | 2.0V            | 0                     | 0.1               | 0.1                                  | 0.1  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 4.5V            | 0                     | 0.1               | 0.1                                  | 0.1  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            | 0                     | 0.1               | 0.1                                  | 0.1  | V                                     |  |       |  |
|                 |                                   | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br> I <sub>OUT</sub>   ≤ 4.0 mA<br> I <sub>OUT</sub>   ≤ 5.2 mA | 4.5V            | 0.2                   | 0.26              | 0.33                                 | 0.4  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      | 6.0V            | 0.2                   | 0.26              | 0.33                                 | 0.4  | V                                     |  |       |  |
|                 |                                   |                                                                                                                      |                 |                       |                   |                                      |      |                                       |  |       |  |
| I <sub>IN</sub> | Maximum Input Current             | V <sub>IN</sub> = V <sub>CC</sub> or GND                                                                             | 6.0V            |                       | ±0.1              | ±1.0                                 | ±1.0 | μA                                    |  |       |  |
| I <sub>CC</sub> | Maximum Quiescent Supply Current  | V <sub>IN</sub> = V <sub>CC</sub> or GND<br>I <sub>OUT</sub> = 0 μA                                                  | 6.0V            |                       | 8.0               | 80                                   | 160  | μA                                    |  |       |  |

**Note 1:** Absolute Maximum Ratings are those values beyond which damage to the device may occur.

**Note 2:** Unless otherwise specified all voltages are referenced to ground.

**Note 3:** Power Dissipation temperature derating — plastic "N" package: −12 mW/°C from 65°C to 85°C; ceramic "J" package: −12 mW/°C from 100°C to 125°C.

**Note 4:** For a power supply of 5V ±10% the worst case output voltages ( $V_{OH}$  and  $V_{OL}$ ) occur for HC at 4.5V. Thus the 4.5V values should be used when designing with this supply. Worst case  $V_{IH}$  and  $V_{IL}$  occur at  $V_{CC} = 5.5\text{V}$  and 4.5V respectively. (The  $V_{IH}$  value at 5.5V is 3.85V.) The worst case leakage current ( $I_{IN}$ ,  $I_{CC}$ , and  $I_{OZ}$ ) occur for CMOS at the higher voltage and so the 6.0V values should be used.

\*\* $V_{IL}$  limits are currently tested at 20% of  $V_{CC}$ . The above  $V_{IL}$  specification (30% of  $V_{CC}$ ) will be implemented no later than Q1, CY'89.

### AC Electrical Characteristics $V_{CC}=5V$ , $T_A=25^{\circ}C$ , $C_L=15\text{ pF}$ , $t_r=t_f=6\text{ ns}$

| Symbol                | Parameter                                                | Conditions | Typ | Guaranteed Limit | Units |
|-----------------------|----------------------------------------------------------|------------|-----|------------------|-------|
| $f_{MAX}$             | Maximum Operating Frequency                              |            | 43  | 30               | MHz   |
| $t_{PHL}$ , $t_{PLH}$ | Maximum Propagation Delay, Clock to RC                   |            | 30  | 35               | ns    |
| $t_{PHL}$ , $t_{PLH}$ | Maximum Propagation Delay, Clock to Q                    |            | 29  | 34               | ns    |
| $t_{PHL}$ , $t_{PLH}$ | Maximum Propagation Delay, ENT to RC                     |            | 18  | 32               | ns    |
| $t_{PHL}$             | Maximum Propagation Delay, Clear to Q or RC              |            | 27  | 38               | ns    |
| $t_{REM}$             | Minimum Removal Time, Clear to Clock                     |            | 10  | 20               | ns    |
| $t_S$                 | Minimum Set Up Time Clear, Load, Enable or Data to Clock |            |     | 30               | ns    |
| $t_H$                 | Minimum Hold Time, Data from Clock                       |            |     | 5                | ns    |
| $t_W$                 | Minimum Pulse Width Clock, Clear, or Load                |            |     | 16               | ns    |

### AC Electrical Characteristics $C_L=50\text{ pF}$ , $t_r=t_f=6\text{ ns}$ (unless otherwise specified)

| Symbol           | Parameter                                 | Conditions | V <sub>CC</sub> | T <sub>A</sub> = 25°C |                   | 74HC                         | 54HC                          | Units |
|------------------|-------------------------------------------|------------|-----------------|-----------------------|-------------------|------------------------------|-------------------------------|-------|
|                  |                                           |            |                 |                       |                   | T <sub>A</sub> = −40 to 85°C | T <sub>A</sub> = −55 to 125°C |       |
|                  |                                           |            |                 | Typ                   | Guaranteed Limits |                              |                               |       |
| f <sub>MAX</sub> | Maximum Operating Frequency               |            | 2.0V            | 10                    | 5                 | 4                            | 4                             | MHz   |
|                  |                                           |            | 4.5V            | 40                    | 27                | 21                           | 18                            |       |
|                  |                                           |            | 6.0V            | 45                    | 32                | 25                           | 21                            |       |
| t <sub>PHL</sub> | Maximum Propagation Delay, Clock to RC    |            | 2.0V            | 100                   | 215               | 271                          | 320                           | ns    |
|                  |                                           |            | 4.5V            | 32                    | 43                | 54                           | 64                            | ns    |
|                  |                                           |            | 6.0V            | 28                    | 37                | 46                           | 54                            | ns    |
| t <sub>PLH</sub> | Maximum Propagation Delay, Clock to RC    |            | 2.0V            | 88                    | 175               | 220                          | 260                           | ns    |
|                  |                                           |            | 4.5V            | 18                    | 35                | 44                           | 52                            | ns    |
|                  |                                           |            | 6.0V            | 15                    | 30                | 37                           | 44                            | ns    |
| t <sub>PHL</sub> | Maximum Propagation Delay, Clock to Q     |            | 2.0V            | 95                    | 205               | 258                          | 305                           | ns    |
|                  |                                           |            | 4.5V            | 30                    | 41                | 52                           | 61                            | ns    |
|                  |                                           |            | 6.0V            | 26                    | 35                | 44                           | 52                            | ns    |
| t <sub>PLH</sub> | Maximum Propagation Delay, Clock to Q     |            | 2.0V            | 85                    | 170               | 214                          | 253                           | ns    |
|                  |                                           |            | 4.5V            | 17                    | 34                | 43                           | 51                            | ns    |
|                  |                                           |            | 6.0V            | 14                    | 29                | 36                           | 43                            | ns    |
| t <sub>PHL</sub> | Maximum Propagation Delay, ENT to RC      |            | 2.0V            | 90                    | 195               | 246                          | 291                           | ns    |
|                  |                                           |            | 4.5V            | 28                    | 39                | 49                           | 58                            | ns    |
|                  |                                           |            | 6.0V            | 24                    | 33                | 42                           | 49                            | ns    |
| t <sub>PLH</sub> | Maximum Propagation Delay, ENT to RC      |            | 2.0V            | 80                    | 160               | 202                          | 238                           | ns    |
|                  |                                           |            | 4.5V            | 16                    | 32                | 40                           | 48                            | ns    |
|                  |                                           |            | 6.0V            | 14                    | 27                | 34                           | 41                            | ns    |
| t <sub>PHL</sub> | Maximum Propagation Delay, Clear to RC    |            | 2.0V            | 100                   | 220               | 275                          | 325                           | ns    |
|                  |                                           |            | 4.5V            | 32                    | 44                | 55                           | 66                            | ns    |
|                  |                                           |            | 6.0V            | 28                    | 37                | 47                           | 55                            | ns    |
| t <sub>PHL</sub> | Maximum Propagation Delay, Clear to Q     |            | 2.0V            | 100                   | 210               | 260                          | 315                           | ns    |
|                  |                                           |            | 4.5V            | 32                    | 42                | 52                           | 63                            | ns    |
|                  |                                           |            | 6.0V            | 28                    | 36                | 45                           | 54                            | ns    |
| t <sub>REM</sub> | Minimum Removal Time Clear to Clock       |            | 2.0V            |                       | 125               | 158                          | 186                           | ns    |
|                  |                                           |            | 4.5V            |                       | 25                | 32                           | 37                            | ns    |
|                  |                                           |            | 6.0V            |                       | 21                | 27                           | 32                            | ns    |
| t <sub>S</sub>   | Minimum Setup Time Clear or Data to Clock |            | 2.0V            |                       | 150               | 190                          | 225                           | ns    |
|                  |                                           |            | 4.5V            |                       | 30                | 38                           | 45                            | ns    |
|                  |                                           |            | 6.0V            |                       | 26                | 32                           | 38                            | ns    |
| t <sub>S</sub>   | Minimum Setup Time Load to Clock          |            | 2.0V            |                       | 135               | 170                          | 200                           | ns    |
|                  |                                           |            | 4.5V            |                       | 27                | 34                           | 41                            | ns    |
|                  |                                           |            | 6.0V            |                       | 23                | 29                           | 35                            | ns    |
| t <sub>S</sub>   | Minimum Setup Time Enable to Clock        |            | 2.0V            |                       | 175               | 220                          | 260                           | ns    |
|                  |                                           |            | 4.5V            |                       | 35                | 44                           | 52                            | ns    |
|                  |                                           |            | 6.0V            |                       | 30                | 37                           | 44                            | ns    |
| t <sub>H</sub>   | Minimum Hold Time Data from Clock         |            | 2.0V            |                       | 50                | 63                           | 75                            | ns    |
|                  |                                           |            | 4.5V            |                       | 10                | 13                           | 15                            | ns    |
|                  |                                           |            | 6.0V            |                       | 9                 | 11                           | 13                            | ns    |

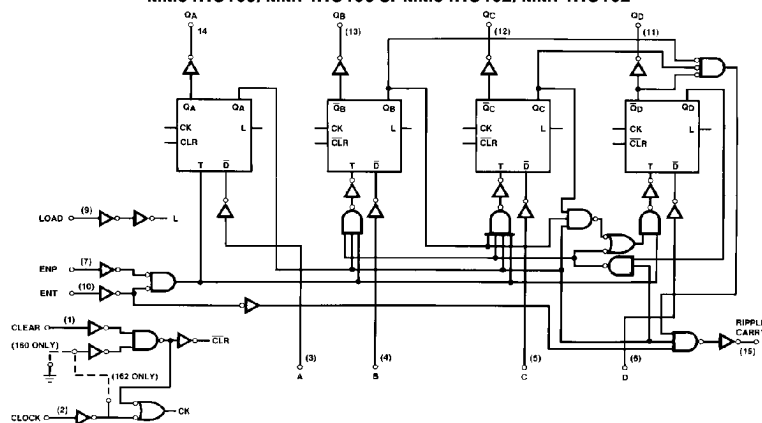
# AC Electrical Characteristics (Continued) $C_L = 50 \text{ pF}$ , $t_r = t_f = 6 \text{ ns}$ (unless otherwise specified)

| Symbol                              | Parameter                                              | Conditions    | V <sub>CC</sub> | T <sub>A</sub> = 25°C |                   | 74HC                         | 54HC                          | Units |
|-------------------------------------|--------------------------------------------------------|---------------|-----------------|-----------------------|-------------------|------------------------------|-------------------------------|-------|
|                                     |                                                        |               |                 |                       |                   | T <sub>A</sub> = −40 to 85°C | T <sub>A</sub> = −55 to 125°C |       |
|                                     |                                                        |               |                 | Typ                   | Guaranteed Limits |                              |                               |       |
| t <sub>H</sub>                      | Minimum Hold Time<br>Enable, Load or Clear<br>to Clock |               | 2.0V            |                       | 0                 | 0                            | 0                             | ns    |
|                                     |                                                        |               | 4.5V            |                       | 0                 | 0                            | 0                             | ns    |
|                                     |                                                        |               | 6.0V            |                       | 0                 | 0                            | 0                             | ns    |
| t <sub>W</sub>                      | Minimum Pulse Width<br>Clock, Clear, or<br>Load        |               | 2.0V            |                       | 80                | 100                          | 120                           | ns    |
|                                     |                                                        |               | 4.5V            |                       | 16                | 20                           | 24                            | ns    |
|                                     |                                                        |               | 6.0V            |                       | 14                | 17                           | 20                            | ns    |
| t <sub>TLH</sub> , t <sub>THL</sub> | Maximum<br>Output Rise and<br>Fall Time                |               | 2.0V            | 40                    | 75                | 95                           | 110                           | ns    |
|                                     |                                                        |               | 4.5V            | 8                     | 15                | 19                           | 22                            | ns    |
|                                     |                                                        |               | 6.0V            | 7                     | 13                | 16                           | 19                            | ns    |
| t <sub>r</sub> , t <sub>f</sub>     | Maximum Input Rise and<br>Fall Time                    |               | 2.0V            |                       | 1000              | 1000                         | 1000                          | ns    |
|                                     |                                                        |               | 4.5V            |                       | 500               | 500                          | 500                           | ns    |
|                                     |                                                        |               | 6.0V            |                       | 400               | 400                          | 400                           | ns    |
| C <sub>PD</sub>                     | Power Dissipation<br>Capacitance (Note 5)              | (per package) |                 | 90                    |                   |                              |                               | pF    |
| C <sub>IN</sub>                     | Maximum Input Capacitance                              |               |                 | 5                     | 10                | 10                           | 10                            | pF    |

**Note 5:**  $C_{PD}$  determines the no load dynamic power consumption,  $P_D = C_{PD} V_{CC}^2 f + I_{CC} V_{CC}$ , and the no load dynamic current consumption,  $I_S = C_{PD} V_{CC} f + I_{CC}$ .

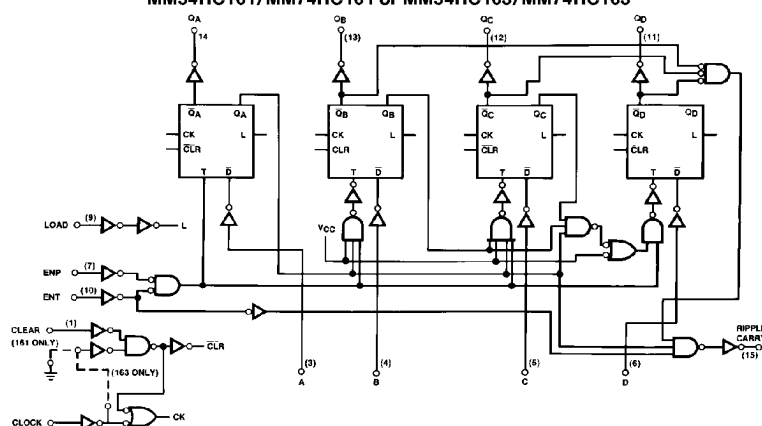
## Logic Diagrams

MM54HC160/MM74HC160 or MM54HC162/MM74HC162



TL/F/5008-2

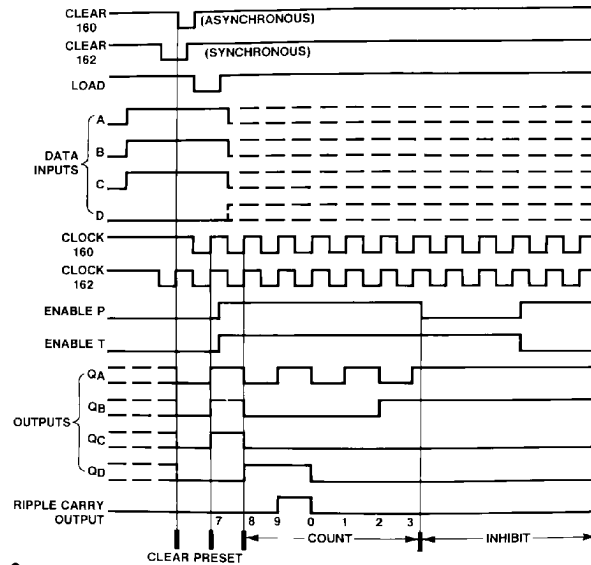
MM54HC161/MM74HC161 or MM54HC163/MM74HC163



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## Logic Waveforms

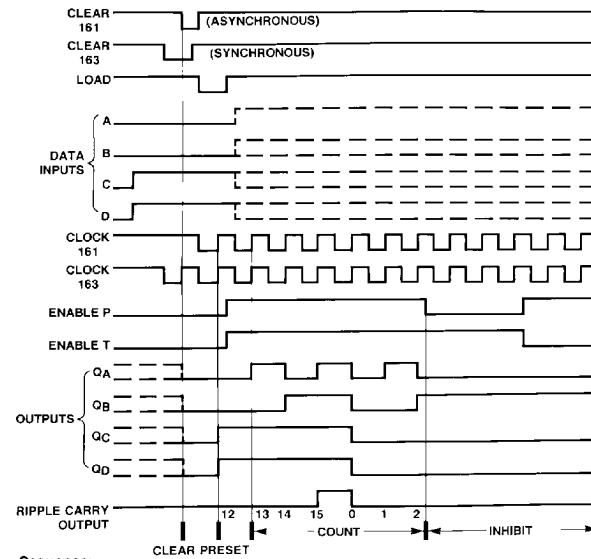
160, 162 Synchronous Decade Counters Typical Clear, Preset, Count and Inhibit Sequences



**Sequence:**  
 (1) Clear outputs to zero  
 (2) Preset to BCD seven  
 (3) Count to eight, nine, zero, one, two, and three  
 (4) Inhibit

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161, 163 Synchronous Binary Counters Typical Clear, Preset, Count and Inhibit Sequences



**Sequence:**  
 (1) Clear outputs to zero  
 (2) Preset to binary twelve  
 (3) Count to thirteen, fourteen, fifteen, zero, one and two  
 (4) Inhibit

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