

# MM54HC192/MM74HC192 Synchronous Decade Up/Down Counters MM54HC193/MM74HC193 Synchronous Binary Up/Down Counters

## General Description

These high speed synchronous counters utilize advanced silicon-gate CMOS technology to achieve the high noise immunity and low power consumption of CMOS technology, along with the speeds of low power Schottky TTL. The MM54HC192/MM74HC192 is a decade counter, and the MM54HC193/MM74HC193 is a binary counter. Both counters have two separate clock inputs, an UP COUNT input and a DOWN COUNT input. All outputs of the flip-flops are simultaneously triggered on the low to high transition of either clock while the other input is held high. The direction of counting is determined by which input is clocked.

These counters may be preset by entering the desired data on the DATA A, DATA B, DATA C, and DATA D inputs. When the LOAD input is taken low the data is loaded independently of either clock input. This feature allows the counters to be used as divide-by-n counters by modifying the count length with the preset inputs.

In addition both counters can also be cleared. This is accomplished by inputting a high on the CLEAR input. All 4 internal stages are set to a low level independently of either COUNT input.

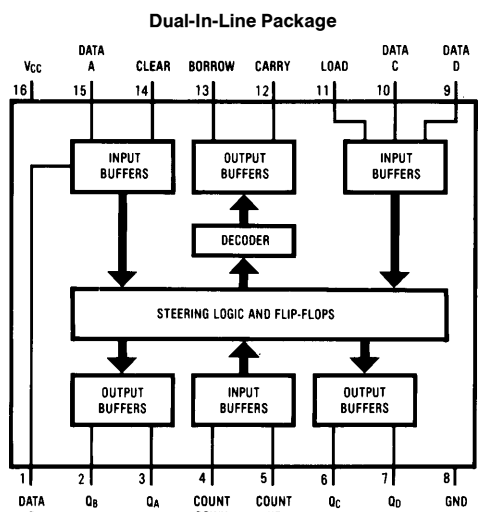
Both a BORROW and CARRY output are provided to enable cascading of both up and down counting functions. The BORROW output produces a negative going pulse when the counter underflows and the CARRY outputs a pulse when the counter overflows. The counters can be cascaded by connecting the CARRY and BORROW outputs of one device to the COUNT UP and COUNT DOWN inputs, respectively, of the next device.

All inputs are protected from damage due to static discharge by diodes to  $V_{CC}$  and ground.

## Features

- Typical propagation delay, Count up to Q: 28 ns
- Typical operating frequency: 27 MHz
- Wide power supply range: 2–6V
- Low quiescent supply current: 80  $\mu$ A maximum (74HC Series)
- Low input current: 1  $\mu$ A maximum
- 4 mA output drive

## Connection Diagram



TL/F/5011-1

Order Number MM54HC192/193 or MM74HC192/193

## Truth Table

| Count |      | Clear | Load | Function   |
|-------|------|-------|------|------------|
| Up    | Down |       |      |            |
| ↑     | H    | L     | H    | Count Up   |
| H     | ↑    | L     | H    | Count Down |
| X     | X    | H     | X    | Clear      |
| X     | X    | L     | L    | Load       |

H = high level

L = low level

↑ = transition from low-to-high

X = don't care

MM54HC192/MM74HC192 Synchronous Decade Up/Down Counters  
MM54HC193/MM74HC193 Synchronous Binary Up/Down Counters

**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 ( $t_r, t_f$ )          |     |          |       |
| $V_{CC} = 2V$                                    |     | 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                         | 54HC                          | Units |
|-----------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|-------------------|------------------------------|-------------------------------|-------|
|                 |                                   |                                                                                                                      |                 |                       |                   | T <sub>A</sub> = −40 to 85°C | T <sub>A</sub> = −55 to 125°C |       |
|                 |                                   |                                                                                                                      |                 | 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  $5V \pm 10\%$  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  $V_{CC} = 5.5V$  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 $T_A = 25^\circ\text{C}$ , $V_{CC} = 5.0\text{V}$ , $t_r = t_f = 6\text{ ns}$ , $C_L = 15\text{ pF}$ (unless otherwise specified)

| Symbol           | Parameter                             | Conditions              |        | Typ | Guaranteed Limit | Units |
|------------------|---------------------------------------|-------------------------|--------|-----|------------------|-------|
| $f_{\text{MAX}}$ | Maximum Clock Frequency               | Count Up                |        | 27  | 20               | MHz   |
|                  |                                       | Count Down              |        | 31  | 24               | MHz   |
| $t_{\text{PLH}}$ | Maximum Propagation Delay Low to High | Count Up to Carry       |        | 17  | 26               | ns    |
| $t_{\text{PHL}}$ | Maximum Propagation Delay High to Low |                         |        | 18  | 24               | ns    |
| $t_{\text{PLH}}$ | Maximum Propagation Delay Low to High | Count Down to Borrow    |        | 16  | 24               | ns    |
| $t_{\text{PHL}}$ | Maximum Propagation Delay High to Low |                         |        | 15  | 24               | ns    |
| $t_{\text{PLH}}$ | Maximum Propagation Delay Low to High | Count Up Or Down to Q   |        | 28  | 40               | ns    |
| $t_{\text{PHL}}$ | Maximum Propagation Delay High to Low |                         |        | 36  | 52               | ns    |
| $t_{\text{PLH}}$ | Maximum Propagation Delay Low to High | Data or Load to Q       |        | 30  | 42               | ns    |
| $t_{\text{PHL}}$ | Maximum Propagation Delay High to Low |                         |        | 40  | 55               | ns    |
| $t_{\text{PHL}}$ | Maximum Propagation Delay High to Low | Clear to Q              |        | 35  | 47               | ns    |
| $t_w$            | Minimum Pulse Width                   | Clear                   | 'HC192 | 40  | 52               | ns    |
|                  |                                       |                         | 'HC193 | 20  | 26               | ns    |
|                  |                                       | Load                    | 'HC192 | 40  | 52               | ns    |
|                  |                                       |                         | 'HC193 | 10  | 20               | ns    |
|                  |                                       | Count Up/Down           |        | 15  | 22               | ns    |
| $t_{\text{SD}}$  | Minimum Setup time                    | Data to Load            |        | 10  | 20               | ns    |
| $t_{\text{HD}}$  | Minimum Hold Time                     |                         |        | -3  | 0                | ns    |
| $t_{\text{REM}}$ | Minimum Removal Time                  | Clear Inactive to Clock |        |     | 10               | ns    |

# AC Electrical Characteristics $V_{CC} = 2.0\text{V to }6.0\text{V}$ , $C_L = 50\text{ pF}$ , $t_r = t_f = 6\text{ ns}$

| Symbol           | Parameter                                | Conditions | V <sub>CC</sub> | T <sub>A</sub> = 25°C |                   | 74HC | 54HC | Units |
|------------------|------------------------------------------|------------|-----------------|-----------------------|-------------------|------|------|-------|
|                  |                                          |            |                 | Typ                   | Guaranteed Limits |      |      |       |
| f <sub>MAX</sub> | Maximum Clock Frequency                  | Count Up   | 2.0V            | 5                     | 3                 | 2.5  | 2    | MHz   |
|                  |                                          |            | 4.5V            | 25                    | 18                | 14   | 12   | MHz   |
|                  |                                          |            | 6.0V            | 29                    | 20                | 16   | 13   | MHz   |
|                  |                                          | Count Down | 2.0V            | 5                     | 4                 | 3    | 2    | MHz   |
|                  |                                          |            | 4.5V            | 27                    | 20                | 16   | 11   | MHz   |
|                  |                                          |            | 6.0V            | 31                    | 23                | 18   | 12   | MHz   |
| t <sub>PLH</sub> | Maximum Propagation Delay<br>Low to High | Count Up   | 2.0V            | 30                    | 140               | 175  | 210  | ns    |
|                  |                                          |            | 4.5V            | 13                    | 28                | 35   | 42   | ns    |
|                  |                                          |            | 6.0V            | 11                    | 24                | 30   | 36   | ns    |
| t <sub>PHL</sub> | Maximum Propagation Delay<br>High to Low | to Carry   | 2.0V            | 39                    | 130               | 163  | 195  | ns    |
|                  |                                          |            | 4.5V            | 16                    | 26                | 33   | 39   | ns    |
|                  |                                          |            | 6.0V            | 14                    | 22                | 28   | 33   | ns    |

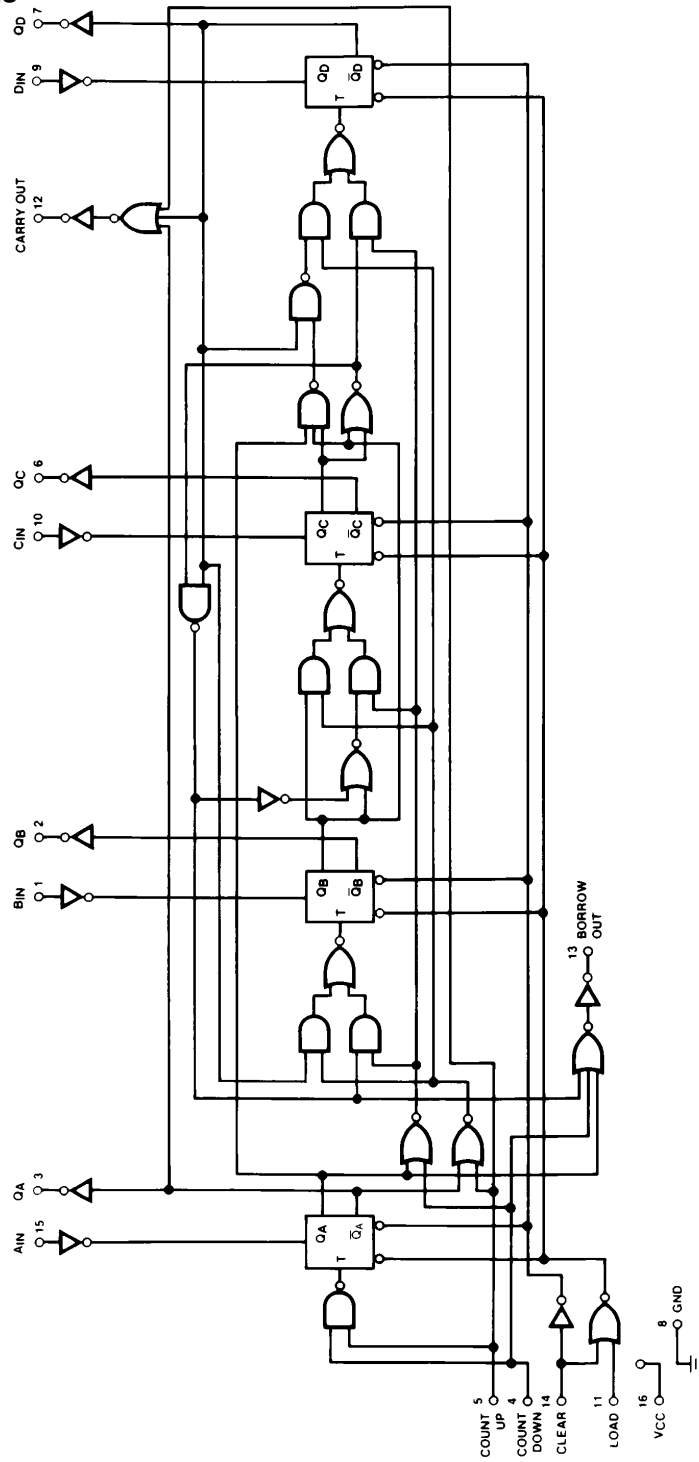
# AC Electrical Characteristics (Continued) $V_{CC} = 2.0V$ to $6.0V$ , $C_L = 50$ pF, $t_r = t_f = 6$ ns

| Symbol                              | Parameter                                       | Conditions              |        | V <sub>CC</sub> | T <sub>A</sub> = 25°C |                   | 74HC | 54HC | Units |
|-------------------------------------|-------------------------------------------------|-------------------------|--------|-----------------|-----------------------|-------------------|------|------|-------|
|                                     |                                                 |                         |        |                 | Typ                   | Guaranteed Limits |      |      |       |
| t <sub>PLH</sub> , t <sub>PHL</sub> | Maximum Propagation Delay                       | Count Down to Borrow    | 2.0V   | 39              | 130                   | 163               | 195  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 16              | 26                    | 33                | 39   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 14              | 22                    | 28                | 33   | ns   |       |
| t <sub>TLH</sub> , t <sub>THL</sub> | Maximum Output Rise and Fall Time               |                         | 2.0V   | 30              | 75                    | 95                | 110  | ns   |       |
|                                     |                                                 | 4.5V                    | 8      | 15              | 19                    | 22                | ns   |      |       |
|                                     |                                                 | 6.0V                    | 7      | 13              | 16                    | 19                | ns   |      |       |
| t <sub>PLH</sub>                    | Maximum Propagation Delay Low to High           | Count Up Or Down to Q   | 2.0V   | 77              | 215                   | 269               | 323  | ns   |       |
|                                     | 4.5V                                            |                         | 35     | 43              | 54                    | 65                | ns   |      |       |
|                                     | 6.0V                                            |                         | 30     | 37              | 46                    | 55                | ns   |      |       |
| t <sub>PHL</sub>                    | Maximum Propagation Delay High to Low           |                         | 2.0V   | 95              | 275                   | 344               | 413  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 45              | 55                    | 69                | 83   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 38              | 47                    | 59                | 71   | ns   |       |
| t <sub>PLH</sub>                    | Maximum Propagation Delay Low to High           | Data or Load to Q       | 2.0V   | 85              | 230                   | 288               | 345  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 37              | 46                    | 58                | 69   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 30              | 39                    | 49                | 59   | ns   |       |
| t <sub>PHL</sub>                    | Maximum Propagation Delay High to Low           |                         | 2.0V   | 102             | 290                   | 363               | 435  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 47              | 58                    | 73                | 87   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 39              | 49                    | 61                | 74   | ns   |       |
| t <sub>PHL</sub>                    | Maximum Propagation Delay High to Low           | Clear to Q              | 2.0V   | 85              | 265                   | 331               | 398  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 42              | 53                    | 66                | 80   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 38              | 45                    | 56                | 68   | ns   |       |
| t <sub>w</sub>                      | Minimum Pulse Width                             | Clear or Load           | 'HC192 | 2.0V            | 119                   | 260               | 325  | 390  | ns    |
|                                     |                                                 |                         |        | 4.5V            | 42                    | 52                | 65   | 78   | ns    |
|                                     |                                                 |                         |        | 6.0V            | 38                    | 45                | 56   | 68   | ns    |
|                                     |                                                 | Load                    | 'HC193 | 2.0V            | 31                    | 100               | 125  | 150  | ns    |
|                                     |                                                 |                         |        | 4.5V            | 10                    | 20                | 25   | 30   | ns    |
|                                     |                                                 |                         |        | 6.0V            | 9                     | 17                | 21   | 26   | ns    |
|                                     |                                                 | Count Up/Down           |        | 2.0V            | 43                    | 110               | 138  | 165  | ns    |
|                                     |                                                 |                         |        | 4.5V            | 17                    | 22                | 28   | 33   | ns    |
|                                     | 6.0V                                            |                         | 15     | 19              | 24                    | 29                | ns   |      |       |
|                                     | Clear                                           | 'HC193                  | 2.0V   | 70              | 130                   | 163               | 195  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 21              | 26                    | 33                | 39   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 19              | 22                    | 28                | 33   | ns   |       |
| t <sub>SD</sub>                     | Minimum Setup Time                              | Data To Load            | 2.0V   | 30              | 100                   | 125               | 150  | ns   |       |
|                                     |                                                 |                         | 4.5V   | 10              | 20                    | 25                | 30   | ns   |       |
|                                     |                                                 |                         | 6.0V   | 9               | 17                    | 22                | 25   | ns   |       |
| t <sub>HD</sub>                     | Minimum Hold Time                               |                         | 2.0V   | −30             | 0                     | 0                 | 0    | ns   |       |
|                                     |                                                 |                         | 4.5V   | −3              | 0                     | 0                 | 0    | ns   |       |
|                                     |                                                 |                         | 6.0V   | −3              | 0                     | 0                 | 0    | ns   |       |
| t <sub>REM</sub>                    | Minimum Removal Time                            | Clear Inactive to Clock | 2.0V   | −20             | 10                    | 10                | 10   | ns   |       |
|                                     |                                                 |                         | 4.5V   | −3              | 10                    | 10                | 10   | ns   |       |
|                                     |                                                 |                         | 6.0V   | −2              | 10                    | 10                | 10   | ns   |       |
| t <sub>r</sub> , t <sub>f</sub>     | Maximum Count Up or Down Input Rise & Fall Time |                         | 2.0V   |                 | 500                   | 500               | 500  | ns   |       |
|                                     |                                                 |                         | 4.5V   |                 | 300                   | 300               | 300  | ns   |       |
|                                     |                                                 |                         | 6.0V   |                 | 200                   | 200               | 200  | ns   |       |
| C <sub>IN</sub>                     | Input Capacitance                               |                         |        | 5               | 10                    | 10                | 10   | pF   |       |
| C <sub>PD</sub>                     | Power Dissipation Capacitance (Note 5)          |                         |        | 100             |                       |                   |      | 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

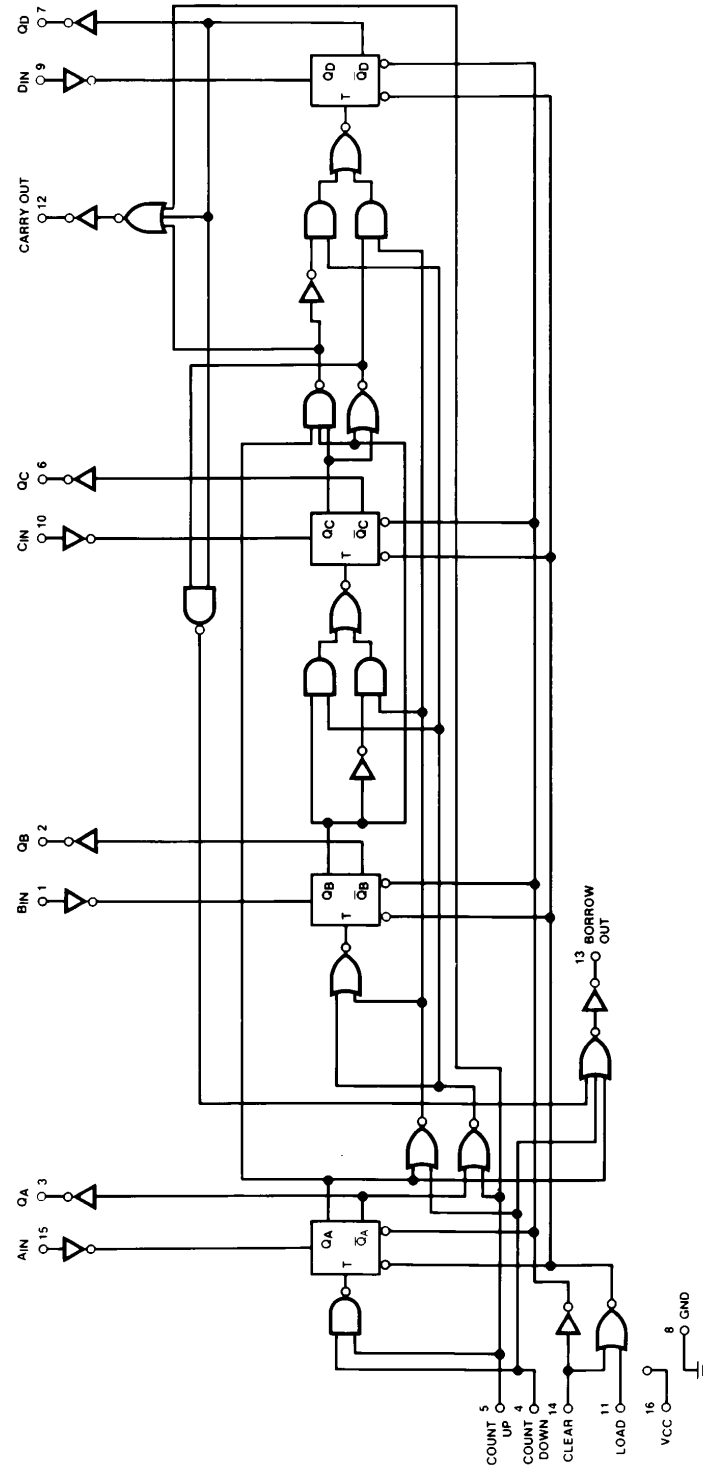
MM54HC192 Synchronous 4-Bit Up/Down Decade Counter



TL/F/5011-2

# Logic Diagrams (Continued)

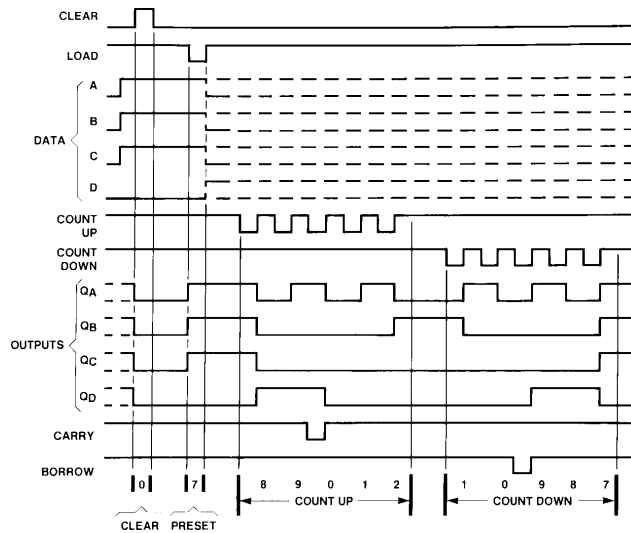
MM54HC193 Synchronous 4-Bit Up/Down Binary Counter



TL/F/5011-3

## Logic Waveforms

### 'HC192 Synchronous Decade Counters Typical Clear, Load, and Count Sequences

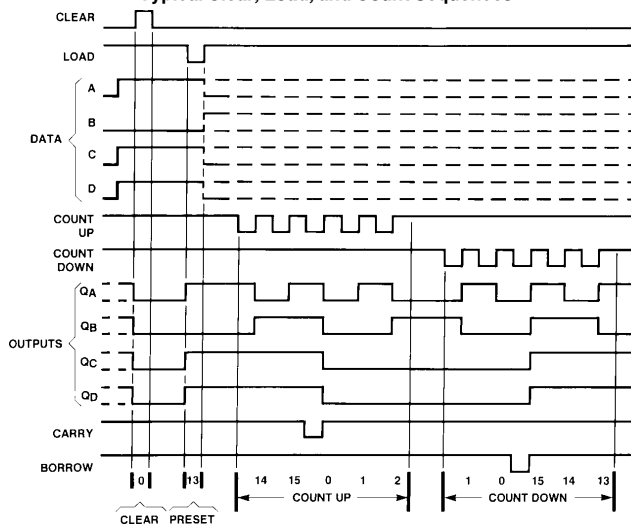


TL/F/5011-4

#### Sequences:

- (1) Clear outputs to zero
- (2) Load (preset) to BCD seven.
- (3) Count up to eight, nine, carry, zero, one and two.
- (4) Count down to one, zero, borrow, nine, eight, and seven.

### 'HC193 Synchronous Binary Counters Typical Clear, Load, and Count Sequences



TL/F/5011-5

#### Sequence:

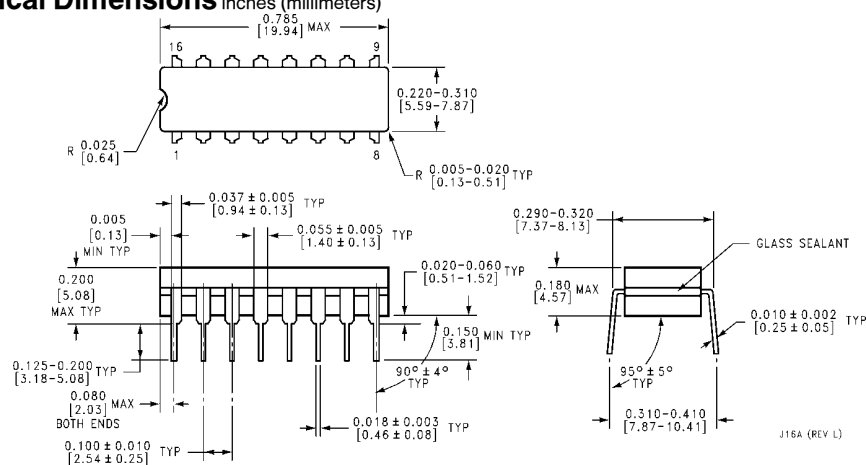
- (1) Clear outputs to zero.
- (2) Load (preset) to binary thirteen
- (3) Count up to fourteen, fifteen, carry, zero, one, and two.
- (4) Count down to one, zero, borrow, fifteen, fourteen, and thirteen.

**Note A:** Clear overrides load data, and count inputs.

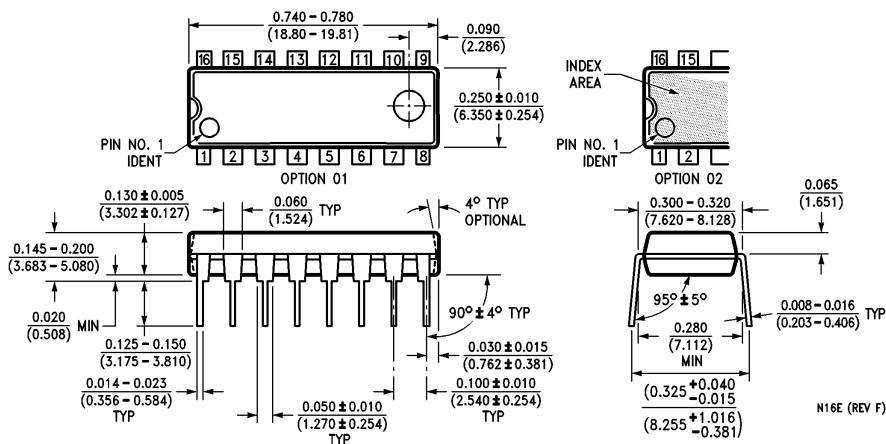
**Note B:** When counting up, count-down input must be high; when counting down, count-up input must be high.

# MM54HC192/MM74HC192 Synchronous Decade Up/Down Counters MM54HC193/MM74HC193 Synchronous Binary Up/Down Counters

## Physical Dimensions inches (millimeters)



Order Number MM54HC192J, MM54HC193J, MM74HC192J or MM74HC193J  
NS Package J16A



Order Number MM74HC192N or MM74HC193N  
NS Package N16E

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**National Semiconductor Corporation**  
1111 West Bardin Road  
Arlington, TX 76017  
Tel: (800) 272-9959  
Fax: (800) 737-7018

**National Semiconductor Europe**  
Fax: (+49) 0-180-530 85 86  
Email: [cnjwge@tevm2.nsc.com](mailto:cnjwge@tevm2.nsc.com)  
Deutsch Tel: (+49) 0-180-530 85 85  
English Tel: (+49) 0-180-532 78 32  
Français Tel: (+49) 0-180-532 93 58  
Italiano Tel: (+49) 0-180-534 16 80

**National Semiconductor Hong Kong Ltd.**  
19th Floor, Straight Block,  
Ocean Centre, 5 Canton Rd.  
Tsimshatsui, Kowloon  
Hong Kong  
Tel: (852) 2737-1600  
Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
Tel: 81-043-299-2309  
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