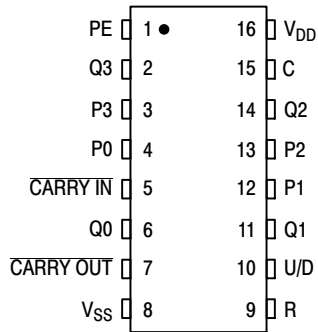
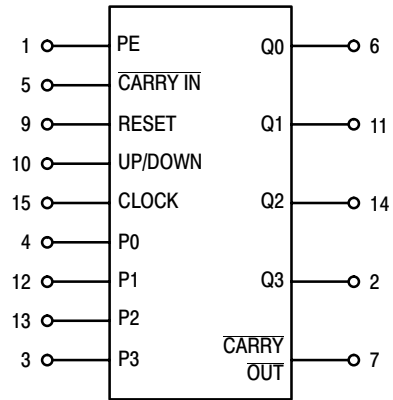


# MC14516B

## PIN ASSIGNMENT



## BLOCK DIAGRAM



V<sub>DD</sub> = PIN 16  
V<sub>SS</sub> = PIN 8

## TRUTH TABLE

| Carry In | Up/Down | Preset Enable | Reset | Clock | Action     |
|----------|---------|---------------|-------|-------|------------|
| 1        | X       | 0             | 0     | X     | No Count   |
| 0        | 1       | 0             | 0     | ↗     | Count Up   |
| 0        | 0       | 0             | 0     | ↘     | Count Down |
| X        | X       | 1             | 0     | X     | Preset     |
| X        | X       | X             | 1     | X     | Reset      |

X = Don't Care

NOTE: When counting up, the  $\overline{\text{Carry Out}}$  signal is normally high and is low only when Q0 through Q3 are high and  $\overline{\text{Carry In}}$  is low. When counting down,  $\overline{\text{Carry Out}}$  is low only when Q0 through Q3 and  $\overline{\text{Carry In}}$  are low.

## ORDERING INFORMATION

| Device         | Package              | Shipping†          |
|----------------|----------------------|--------------------|
| MC14516BDG     | SOIC-16<br>(Pb-Free) | 48 Units / Rail    |
| MC14516BDR2G   | SOIC-16<br>(Pb-Free) | 2500 / Tape & Reel |
| NLV14516BDR2G* |                      |                    |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*NLV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

# MC14516B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

| Characteristic   | Symbol                                | V <sub>DD</sub><br>Vdc | - 55° C  |       | 25° C |                 |       | 125° C |       | Unit |
|--|---------------------------------------|------------------------|--|-------|-------|-----------------|-------|--------|-------|------|
|  |                                       |                        | Min  | Max   | Min   | Typ<br>(Note 2) | Max   | Min    | Max   |      |
| Output Voltage<br>V <sub>in</sub> = V <sub>DD</sub> or 0<br><br>V <sub>in</sub> = 0 or V <sub>DD</sub>   | "0" Level<br><br>V <sub>OL</sub>      | 5.0                    | -  | 0.05  | -     | 0               | 0.05  | -      | 0.05  | Vdc  |
|  |                                       | 10                     | -  | 0.05  | -     | 0               | 0.05  | -      | 0.05  |      |
|  |                                       | 15                     | -  | 0.05  | -     | 0               | 0.05  | -      | 0.05  |      |
|  | "1" Level<br><br>V <sub>OH</sub>      | 5.0                    | 4.95   | -     | 4.95  | 5.0             | -     | 4.95   | -     | Vdc  |
|  |                                       | 10                     | 9.95   | -     | 9.95  | 10              | -     | 9.95   | -     |      |
|  |                                       | 15                     | 14.95  | -     | 14.95 | 15              | -     | 14.95  | -     |      |
| Input Voltage<br>(V <sub>O</sub> = 4.5 or 0.5 Vdc)<br>(V <sub>O</sub> = 9.0 or 1.0 Vdc)<br>(V <sub>O</sub> = 13.5 or 1.5 Vdc)<br><br>(V <sub>O</sub> = 0.5 or 4.5 Vdc)<br>(V <sub>O</sub> = 1.0 or 9.0 Vdc)<br>(V <sub>O</sub> = 1.5 or 13.5 Vdc)  | "0" Level<br><br>V <sub>IL</sub>      | 5.0                    | -  | 1.5   | -     | 2.25            | 1.5   | -      | 1.5   | Vdc  |
|  |                                       | 10                     | -  | 3.0   | -     | 4.50            | 3.0   | -      | 3.0   |      |
|  |                                       | 15                     | -  | 4.0   | -     | 6.75            | 4.0   | -      | 4.0   |      |
|  | "1" Level<br><br>V <sub>IH</sub>      | 5.0                    | 3.5  | -     | 3.5   | 2.75            | -     | 3.5    | -     | Vdc  |
|  |                                       | 10                     | 7.0  | -     | 7.0   | 5.50            | -     | 7.0    | -     |      |
|  |                                       | 15                     | 11   | -     | 11    | 8.25            | -     | 11     | -     |      |
| Output Drive Current<br>(V <sub>OH</sub> = 2.5 Vdc)<br>(V <sub>OH</sub> = 4.6 Vdc)<br>(V <sub>OH</sub> = 9.5 Vdc)<br>(V <sub>OH</sub> = 13.5 Vdc)<br><br>(V <sub>OL</sub> = 0.4 Vdc)<br>(V <sub>OL</sub> = 0.5 Vdc)<br>(V <sub>OL</sub> = 1.5 Vdc) | Source<br><br><br><br>I <sub>OH</sub> | 5.0                    | -3.0   | -     | -2.4  | -4.2            | -     | -1.7   | -     | mAdc |
|  |                                       | 5.0                    | -0.64  | -     | -0.51 | -0.88           | -     | -0.36  | -     |      |
|  |                                       | 10                     | -1.6   | -     | -1.3  | -2.25           | -     | -0.9   | -     |      |
|  |                                       | 15                     | -4.2   | -     | -3.4  | -8.8            | -     | -2.4   | -     |      |
|  | Sink<br><br><br><br>I <sub>OL</sub>   | 5.0                    | 0.64   | -     | 0.51  | 0.88            | -     | 0.36   | -     | mAdc |
|  |                                       | 10                     | 1.6  | -     | 1.3   | 2.25            | -     | 0.9    | -     |      |
| 15   |                                       | 4.2                    | -  | 3.4   | 8.8   | -               | 2.4   | -      |       |      |
| Input Current  | I <sub>in</sub>                       | 15                     | -  | ± 0.1 | -     | ± 0.00001       | ± 0.1 | -      | ± 1.0 | μAdc |
| Input Capacitance (V <sub>in</sub> = 0)  | C <sub>in</sub>                       | -                      | -  | -     | -     | 5.0             | 7.5   | -      | -     | pF   |
| Quiescent Current (Per Package)  | I <sub>DD</sub>                       | 5.0                    | -  | 5.0   | -     | 0.005           | 5.0   | -      | 150   | μAdc |
|  |                                       | 10                     | -  | 10    | -     | 0.010           | 10    | -      | 300   |      |
|  |                                       | 15                     | -  | 20    | -     | 0.015           | 20    | -      | 600   |      |
| Total Supply Current (Note 3, 4)<br>(Dynamic plus Quiescent,<br>Per Package)<br>(C <sub>L</sub> = 50 pF on all outputs, all<br>buffers switching)  | I <sub>T</sub>                        | 5.0                    | I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub> |       |       |                 |       |        |       | μAdc |
|  |                                       | 10                     | I <sub>T</sub> = (1.20 μA/kHz) f + I <sub>DD</sub> |       |       |                 |       |        |       |      |
|  |                                       | 15                     | I <sub>T</sub> = (1.70 μA/kHz) f + I <sub>DD</sub> |       |       |                 |       |        |       |      |

2. Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.
3. The formulas given are for the typical characteristics only at 25° C.
4. To calculate total supply current at loads other than 50 pF: I<sub>T</sub>(C<sub>L</sub>) = I<sub>T</sub>(50 pF) + (C<sub>L</sub> - 50) Vfk where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

# MC14516B

## SWITCHING CHARACTERISTICS (Note 5) ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

| Characteristic  | Symbol             | $V_{DD}$        | All Types         |                    |                    | Unit          |
|---|--------------------|-----------------|-------------------|--------------------|--------------------|---------------|
|   |                    |                 | Min               | Typ (Note 6)       | Max                |               |
| Output Rise and Fall Time<br>$t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$<br>$t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$<br>$t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$  | $t_{TLH}, t_{THL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 100<br>50<br>40    | 200<br>100<br>80   | ns            |
| Propagation Delay Time<br>Clock to Q<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$<br><br>Clock to $\overline{\text{Carry Out}}$<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$<br><br>$\overline{\text{Carry In}}$ to $\overline{\text{Carry Out}}$<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$<br><br>Preset or Reset to Q<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$<br><br>Preset or Reset to $\overline{\text{Carry Out}}$<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 192 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 125 \text{ ns}$ | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 315<br>130<br>100  | 630<br>260<br>200  | ns            |
|   | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 315<br>130<br>100  | 630<br>260<br>200  | ns            |
|   | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 180<br>80<br>60    | 360<br>160<br>120  | ns            |
|   | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 315<br>130<br>100  | 630<br>360<br>200  | ns            |
|   | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | 550<br>225<br>150  | 1100<br>450<br>300 | ns            |
| Reset Pulse Width   | $t_w$              | 5.0<br>10<br>15 | 380<br>200<br>160 | 190<br>100<br>80   | –<br>–<br>–        | ns            |
| Clock Pulse Width   | $t_{WH}$           | 5.0<br>10<br>15 | 350<br>170<br>140 | 200<br>100<br>75   | –<br>–<br>–        | ns            |
| Clock Pulse Frequency   | $f_{cl}$           | 5.0<br>10<br>15 | –<br>–<br>–       | 3.0<br>6.0<br>8.0  | 1.5<br>3.0<br>4.0  | MHz           |
| Preset or Reset Removal Time<br>The Preset or Reset signal must be low prior to a positive-going transition of the clock.   | $t_{rem}$          | 5.0<br>10<br>15 | 650<br>230<br>180 | 325<br>115<br>90   | –<br>–<br>–        | ns            |
| Clock Rise and Fall Time  | $t_{TLH}, t_{THL}$ | 5.0<br>10<br>15 | –<br>–<br>–       | –<br>–<br>–        | 15<br>5<br>4       | $\mu\text{s}$ |
| Setup Time<br>Carry In to Clock   | $t_{su}$           | 5.0<br>10<br>15 | 260<br>120<br>100 | 130<br>60<br>50    | –<br>–<br>–        | ns            |
| Hold Time<br>Clock to $\overline{\text{Carry In}}$  | $t_h$              | 5.0<br>10<br>15 | 0<br>20<br>20     | –60<br>–20<br>0    | –<br>–<br>–        | ns            |
| Setup Time<br>Up/Down to Clock  | $t_{su}$           | 5.0<br>10<br>15 | 500<br>200<br>150 | 250<br>100<br>75   | –<br>–<br>–        | ns            |
| Hold Time<br>Clock to Up/Down   | $t_h$              | 5.0<br>10<br>15 | –70<br>–10<br>0   | –160<br>–60<br>–40 | –<br>–<br>–        | ns            |
| Setup Time<br>Pn to PE  | $t_{su}$           | 5.0<br>10<br>15 | –40<br>–30<br>–25 | –120<br>–70<br>–50 | –<br>–<br>–        | ns            |
| Hold Time<br>PE to Pn   | $t_h$              | 5.0<br>10<br>15 | 480<br>420<br>420 | 240<br>210<br>210  | –<br>–<br>–        | ns            |
| Preset Enable Pulse Width   | $t_{WH}$           | 5.0<br>10<br>15 | 200<br>100<br>80  | 100<br>50<br>40    | –<br>–<br>–        | ns            |

5. The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

6. Data labelled "Typ" is not to be used for design purposes but is intended as an Indication of the IC's potential performance.

# MC14516B

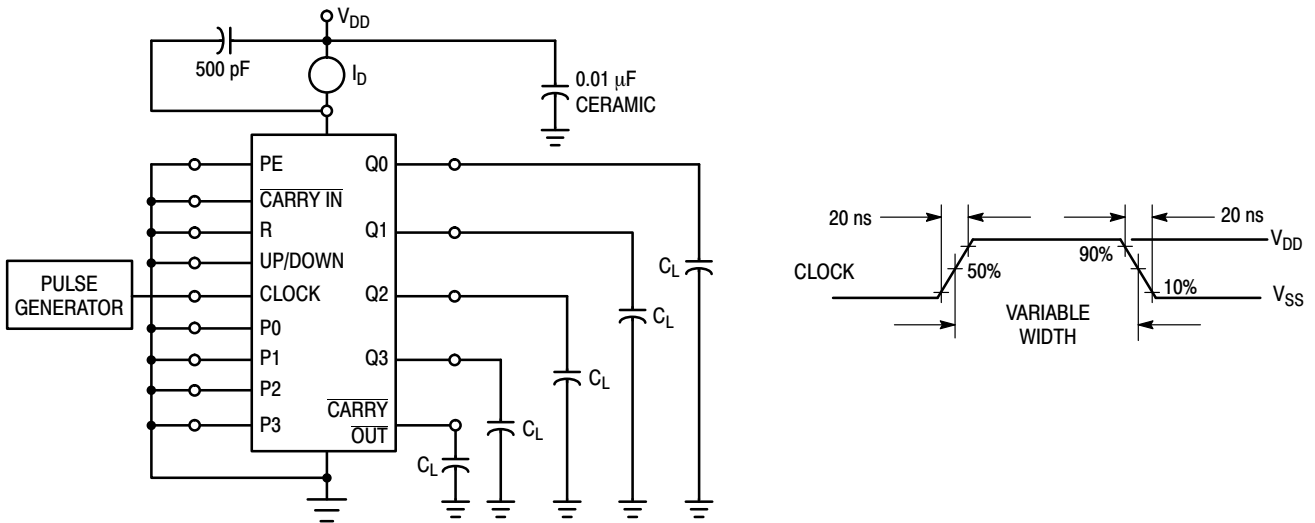
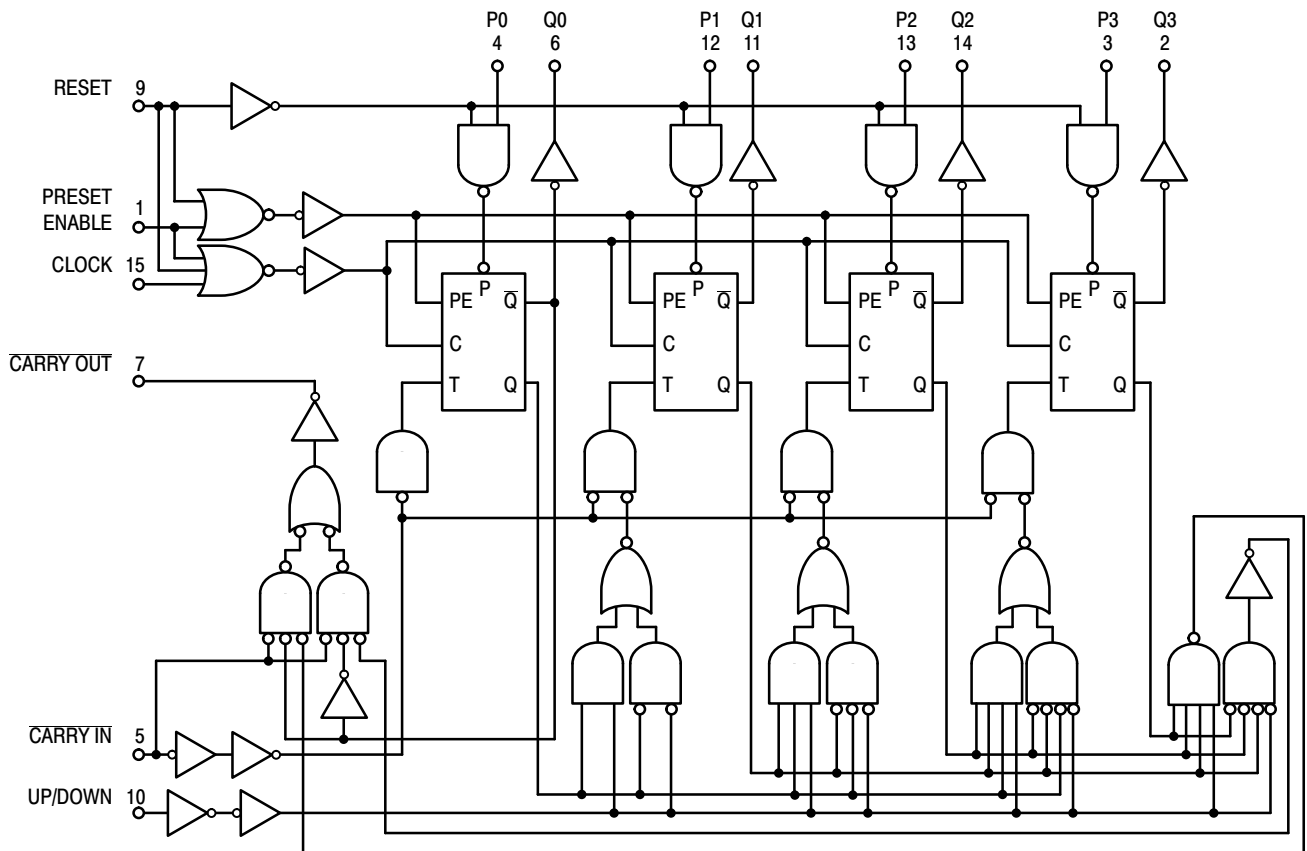


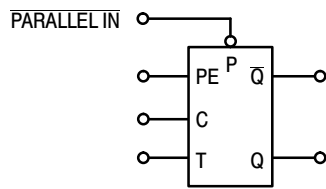
Figure 1. Power Dissipation Test Circuit and Waveform

## LOGIC DIAGRAM



# MC14516B

## TOGGLE FLIP-FLOP



## FLIP-FLOP FUNCTIONAL TRUTH TABLE

| Preset Enable | Clock | T | $Q_{n+1}$   |
|---------------|-------|---|-------------|
| 1             | X     | X | Parallel In |
| 0             |       | 0 | $Q_n$       |
| 0             |       | 1 | $\bar{Q}_n$ |
| 0             |       | X | $Q_n$       |

X = Don't Care

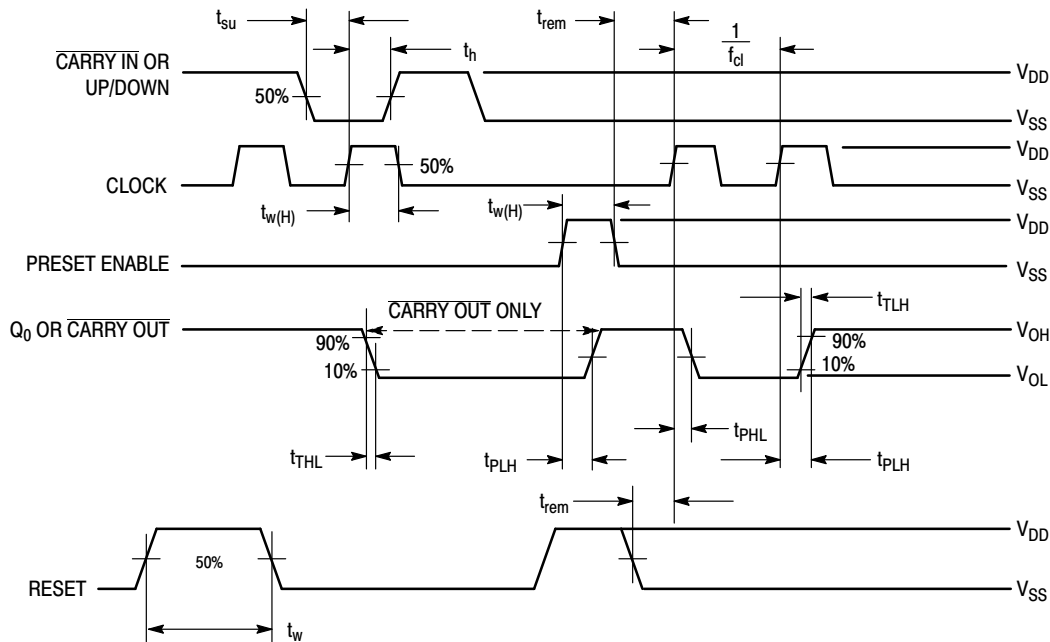


Figure 2. Switching Time Waveforms

## PIN DESCRIPTIONS

### INPUTS

**P0, P1, P2, P3, Preset Inputs (Pins 4, 12, 13, 3)** — Data on these inputs is loaded into the counter when PE is taken high.

**Carry In, (Pin 5)** — This active-low input is used when Cascading stages. Carry In is usually connected to Carry Out of the previous stage. While high, Clock is inhibited.

**Clock, (Pin 15)** — Binary data is incremented or decremented, depending on the direction of count, on the positive transition of this input.

### OUTPUTS

**Q0, Q1, Q2, Q3, Binary outputs (Pins 6, 11, 14, 2)** — Binary data is present on these outputs with Q0 corresponding to the least significant bit.

**Carry Out, (Pin 7)** — Used when cascading stages, Carry Out is usually connected to Carry In of the next stage. This synchronous output is active low and may also be used to indicate terminal count.

### CONTROLS

**PE, Preset Enable, (Pin 1)** — Asynchronously loads data on the Preset Inputs. This pin is active high and inhibits the clock when high.

**R, Reset, (Pin 9)** — Asynchronously resets the Q outputs to a low state. This pin is active high and inhibits the clock when high.

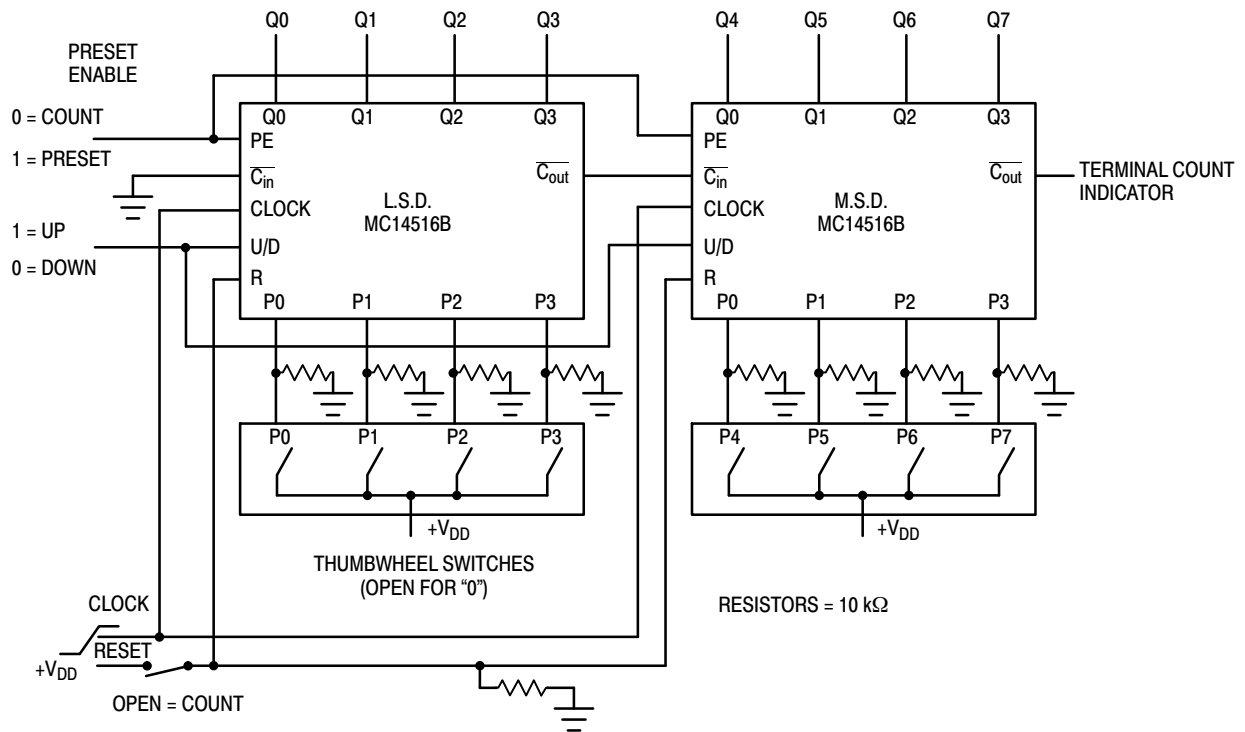
**Up/Down, (Pin 10)** — Controls the direction of count, high for up count, low for down count.

### SUPPLY PINS

**VSS, Negative Supply Voltage, (Pin 8)** — This pin is usually connected to ground.

**VDD, Positive Supply Voltage, (Pin 16)** — This pin is connected to a positive supply voltage ranging from 3.0 V to 18 V.

# MC14516B

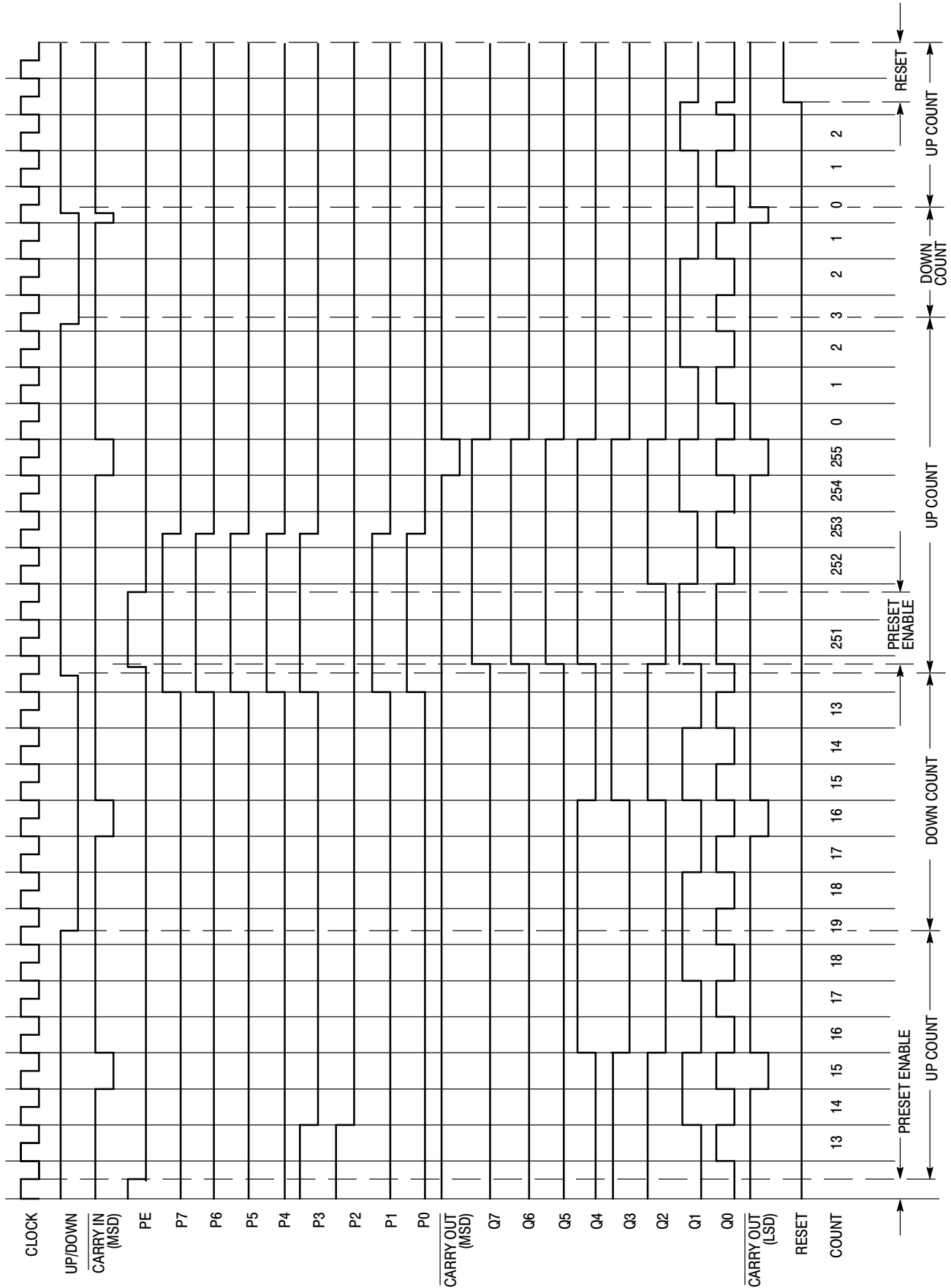


NOTE: The Least Significant Digit (L.S.D.) counts from a preset value once Preset Enable (PE) goes low. The Most Significant Digit (M.S.D.) is disabled while  $\overline{C}_{in}$  is high. When the count of the L.S.D. reaches 0 (count down mode) or reaches 15 (count up mode),  $\overline{C}_{out}$  goes low for one complete clock cycle, thus allowing the next counter to decrement/increment one count. (See Timing Diagram) The L.S.D. now counts through another cycle (15 clock pulses) and the above cycle is repeated.

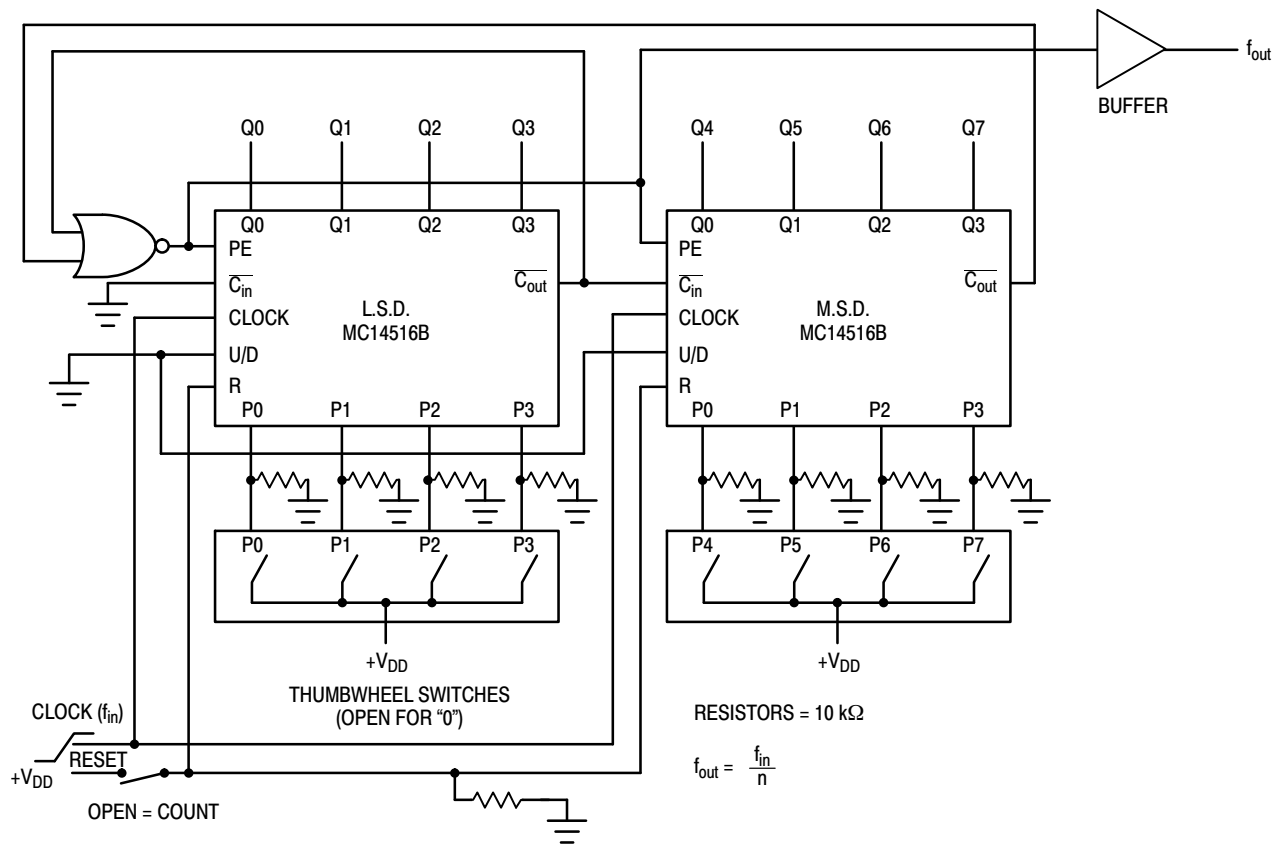
Figure 3. Presettable Cascaded 8–Bit Up/Down Counter

# MC14516B

## TIMING DIAGRAM FOR THE PRESETTABLE CASCADED 8-BIT UP/DOWN COUNTER



# MC14516B



NOTE: The programmable frequency divider can be set by applying the desired divide ratio, in binary, to the preset inputs. For example, the maximum divide ratio of 255 may be obtained by applying a 1111 1111 to the preset inputs P0 to P7. For this divide operation, both counters should be configured in the count down mode. The divide ratio of zero is an undefined state and should be avoided.

**Figure 4. Programmable Cascaded Frequency Divider**



# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 1:1

## SOIC-16 CASE 751B-05 ISSUE K

DATE 29 DEC 2006



**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 9.80        | 10.00 | 0.386     | 0.393 |
| B   | 3.80        | 4.00  | 0.150     | 0.157 |
| C   | 1.35        | 1.75  | 0.054     | 0.068 |
| D   | 0.35        | 0.49  | 0.014     | 0.019 |
| F   | 0.40        | 1.25  | 0.016     | 0.049 |
| G   | 1.27 BSC    |       | 0.050 BSC |       |
| J   | 0.19        | 0.25  | 0.008     | 0.009 |
| K   | 0.10        | 0.25  | 0.004     | 0.009 |
| M   | 0°          | 7°    | 0°        | 7°    |
| P   | 5.80        | 6.20  | 0.229     | 0.244 |
| R   | 0.25        | 0.50  | 0.010     | 0.019 |

- |  |  |  |  |
|--|--|--|--|
| <p><b>STYLE 1:</b></p> <p>PIN 1. COLLECTOR<br/>2. BASE<br/>3. EMITTER<br/>4. NO CONNECTION<br/>5. EMITTER<br/>6. BASE<br/>7. COLLECTOR<br/>8. COLLECTOR<br/>9. BASE<br/>10. EMITTER<br/>11. NO CONNECTION<br/>12. EMITTER<br/>13. BASE<br/>14. COLLECTOR<br/>15. EMITTER<br/>16. COLLECTOR</p>                           | <p><b>STYLE 2:</b></p> <p>PIN 1. CATHODE<br/>2. ANODE<br/>3. NO CONNECTION<br/>4. CATHODE<br/>5. CATHODE<br/>6. NO CONNECTION<br/>7. ANODE<br/>8. CATHODE<br/>9. CATHODE<br/>10. ANODE<br/>11. NO CONNECTION<br/>12. CATHODE<br/>13. CATHODE<br/>14. NO CONNECTION<br/>15. ANODE<br/>16. CATHODE</p> | <p><b>STYLE 3:</b></p> <p>PIN 1. COLLECTOR, DYE #1<br/>2. BASE, #1<br/>3. EMITTER, #1<br/>4. COLLECTOR, #1<br/>5. COLLECTOR, #2<br/>6. BASE, #2<br/>7. EMITTER, #2<br/>8. COLLECTOR, #2<br/>9. COLLECTOR, #3<br/>10. BASE, #3<br/>11. EMITTER, #3<br/>12. COLLECTOR, #3<br/>13. COLLECTOR, #4<br/>14. BASE, #4<br/>15. EMITTER, #4<br/>16. COLLECTOR, #4</p>   | <p><b>STYLE 4:</b></p> <p>PIN 1. COLLECTOR, DYE #1<br/>2. COLLECTOR, #1<br/>3. COLLECTOR, #2<br/>4. COLLECTOR, #2<br/>5. COLLECTOR, #3<br/>6. COLLECTOR, #3<br/>7. COLLECTOR, #4<br/>8. COLLECTOR, #4<br/>9. BASE, #4<br/>10. EMITTER, #4<br/>11. BASE, #3<br/>12. EMITTER, #3<br/>13. BASE, #2<br/>14. EMITTER, #2<br/>15. BASE, #1<br/>16. EMITTER, #1</p> |
| <p><b>STYLE 5:</b></p> <p>PIN 1. DRAIN, DYE #1<br/>2. DRAIN, #1<br/>3. DRAIN, #2<br/>4. DRAIN, #2<br/>5. DRAIN, #3<br/>6. DRAIN, #3<br/>7. DRAIN, #4<br/>8. DRAIN, #4<br/>9. GATE, #4<br/>10. SOURCE, #4<br/>11. GATE, #3<br/>12. SOURCE, #3<br/>13. GATE, #2<br/>14. SOURCE, #2<br/>15. GATE, #1<br/>16. SOURCE, #1</p> | <p><b>STYLE 6:</b></p> <p>PIN 1. CATHODE<br/>2. CATHODE<br/>3. CATHODE<br/>4. CATHODE<br/>5. CATHODE<br/>6. CATHODE<br/>7. CATHODE<br/>8. CATHODE<br/>9. ANODE<br/>10. ANODE<br/>11. ANODE<br/>12. ANODE<br/>13. ANODE<br/>14. ANODE<br/>15. ANODE<br/>16. ANODE</p>                                 | <p><b>STYLE 7:</b></p> <p>PIN 1. SOURCE N-CH<br/>2. COMMON DRAIN (OUTPUT)<br/>3. COMMON DRAIN (OUTPUT)<br/>4. GATE P-CH<br/>5. COMMON DRAIN (OUTPUT)<br/>6. COMMON DRAIN (OUTPUT)<br/>7. COMMON DRAIN (OUTPUT)<br/>8. SOURCE P-CH<br/>9. SOURCE P-CH<br/>10. COMMON DRAIN (OUTPUT)<br/>11. COMMON DRAIN (OUTPUT)<br/>12. COMMON DRAIN (OUTPUT)<br/>13. GATE N-CH<br/>14. COMMON DRAIN (OUTPUT)<br/>15. COMMON DRAIN (OUTPUT)<br/>16. SOURCE N-CH</p> |  |

### SOLDERING FOOTPRINT



DIMENSIONS: MILLIMETERS

|                         |                    |   |
|-------------------------|--------------------|---|
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