

## Presettable 4-Bit Down Counters

The MC14522B BCD counter and the MC14526B binary counter are constructed with MOS P-channel and N-channel enhancement mode devices in a monolithic structure.

These devices are presettable, cascadable, synchronous down counters with a decoded "0" state output for divide-by-N applications. In single stage applications the "0" output is applied to the Preset Enable input. The Cascade Feedback input allows cascade divide-by-N operation with no additional gates required. The Inhibit input allows disabling of the pulse counting function. Inhibit may also be used as a negative edge clock.

These complementary MOS counters can be used in frequency synthesizers, phase-locked loops, and other frequency division applications requiring low power dissipation and/or high noise immunity.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Edge-Clocked Design — Incremented on Positive Transition of Clock or Negative Transition of Inhibit
- Asynchronous Preset Enable
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

| Symbol                             | Parameter  | Value                          | Unit |
|------------------------------------|--|--------------------------------|------|
| V <sub>DD</sub>                    | DC Supply Voltage                                  | - 0.5 to + 18.0                | V    |
| V <sub>in</sub> , V <sub>out</sub> | Input or Output Voltage (DC or Transient)          | - 0.5 to V <sub>DD</sub> + 0.5 | V    |
| I <sub>in</sub> , I <sub>out</sub> | Input or Output Current (DC or Transient), per Pin | ± 10                           | mA   |
| P <sub>D</sub>                     | Power Dissipation, per Package†                    | 500                            | mW   |
| T <sub>stg</sub>                   | Storage Temperature                                | - 65 to + 150                  | °C   |
| T <sub>L</sub>                     | Lead Temperature (8-Second Soldering)              | 260                            | °C   |

\* Maximum Ratings are those values beyond which damage to the device may occur.

† Temperature Derating:

Plastic "P and D/DW" Packages: - 7.0 mW/°C From 65°C To 125°C

Ceramic "L" Packages: - 12 mW/°C From 100°C To 125°C

### FUNCTION TABLE

| Inputs |       |         |               |                  | Output | Resulting Function          |
|--------|-------|---------|---------------|------------------|--------|-----------------------------|
| Clock  | Reset | Inhibit | Preset Enable | Cascade Feedback | "0"    |                             |
| X      | H     | X       | L             | L                | L      | Asynchronous reset*         |
| X      | H     | X       | H             | L                | H      | Asynchronous reset          |
| X      | H     | X       | X             | H                | H      | Asynchronous reset          |
| X      | L     | X       | H             | X                | L      | Asynchronous preset         |
|        | L     | H       | L             | X                | L      | Decrement inhibited         |
| L      | L     |         | L             | X                | L      | Decrement inhibited         |
|        | L     | L       | L             | L                | L      | No change** (inactive edge) |
| H      | L     |         | L             | L                | L      | No change** (inactive edge) |
|        | L     | L       | L             | L                | L      | Decrement**                 |
| H      | L     |         | L             | L                | L      | Decrement**                 |

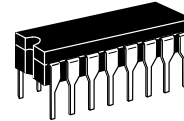
X = Don't Care

NOTES:

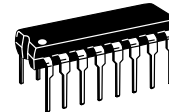
\* Output "0" is low when reset goes high only if PE and CF are low.

\*\* Output "0" is high when reset is low, only if CF is high and count is 0000.

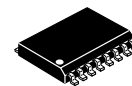
## MC14522B MC14526B



**L SUFFIX**  
CERAMIC  
CASE 620



**P SUFFIX**  
PLASTIC  
CASE 648



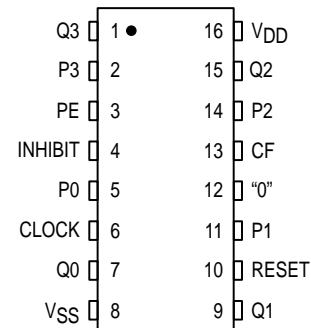
**DW SUFFIX**  
SOIC  
CASE 751G

### ORDERING INFORMATION

MC14XXXBCP Plastic  
MC14XXXBCL Ceramic  
MC14XXXBDW SOIC

T<sub>A</sub> = - 55° to 125°C for all packages.

### PIN ASSIGNMENT



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

**ELECTRICAL CHARACTERISTICS** (Voltages Referenced to  $V_{SS}$ )

| Characteristic  | Symbol                    | $V_{DD}$<br>Vdc | - 55°C   |           | 25°C   |               |           | 125°C  |           | Unit      |      |
|---|---------------------------|-----------------|--|-----------|--------|---------------|-----------|--------|-----------|-----------|------|
|   |                           |                 | Min  | Max       | Min    | Typ #         | Max       | Min    | Max       |           |      |
| Output Voltage<br>$V_{in} = V_{DD}$ or 0<br><br>$V_{in} = 0$ or $V_{DD}$  | "0" Level<br><br>$V_{OL}$ | 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>$V_{OH}$ | 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><br>"0" Level<br>( $V_O = 4.5$ or $0.5$ Vdc)<br>( $V_O = 9.0$ or $1.0$ Vdc)<br>( $V_O = 13.5$ or $1.5$ Vdc)<br><br>"1" Level<br>( $V_O = 0.5$ or $4.5$ Vdc)<br>( $V_O = 1.0$ or $9.0$ Vdc)<br>( $V_O = 1.5$ or $13.5$ Vdc) | $V_{IL}$                  | 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       |           |      |
|   | $V_{IH}$                  | 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><br>Source<br><br><br>Sink  | $I_{OH}$                  | 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  | —         |           |      |
|   | $I_{OL}$                  | 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   | $I_{in}$                  | 15              | —  | $\pm 0.1$ | —      | $\pm 0.00001$ | $\pm 0.1$ | —      | $\pm 1.0$ | $\mu$ Adc |      |
| Input Capacitance<br>( $V_{in} = 0$ )   | $C_{in}$                  | —               | —  | —         | —      | 5.0           | 7.5       | —      | —         | pF        |      |
| Quiescent Current<br>(Per Package)  | $I_{DD}$                  | 5.0             | —  | 5.0       | —      | 0.005         | 5.0       | —      | 150       | $\mu$ Adc |      |
|   |                           | 10              | —  | 10        | —      | 0.010         | 10        | —      | 300       |           |      |
|   |                           | 15              | —  | 20        | —      | 0.015         | 20        | —      | 600       |           |      |
| Total Supply Current**†<br>(Dynamic plus Quiescent,<br>Per Package)<br>( $C_L = 50$ pF on all outputs, all<br>buffers switching)  | $I_T$                     | 5.0             | $I_T = (1.7 \mu\text{A/kHz}) f + I_{DD}$<br>$I_T = (3.4 \mu\text{A/kHz}) f + I_{DD}$<br>$I_T = (5.1 \mu\text{A/kHz}) f + I_{DD}$ |           |        |               |           |        |           | $\mu$ Adc |      |

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

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) Vfk$$

where:  $I_T$  is in  $\mu\text{A}$  (per package),  $C_L$  in pF,  $V = (V_{DD} - V_{SS})$  in volts,  $f$  in kHz is input frequency, and  $k = 0.001$ .

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

| Characteristic   | Symbol                                       | V <sub>DD</sub>                        | Min                            | Typ #                                      | Max   | Unit          |
|--|--|--|--------------------------------|--|---|---------------|
| 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>$t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$   | $t_{TLH},$<br>$t_{THL}$<br>(Figures 4, 5)    | 5.0<br>10<br>15                        | —<br>—<br>—                    | 100<br>50<br>40                            | 200<br>100<br>80                            | ns            |
| Propagation Delay Time (Inhibit Used as Negative Edge Clock)<br>Clock or Inhibit to Q<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 135 \text{ ns}$<br>Clock or Inhibit to "0"<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 155 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 87 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$ | $t_{PLH},$<br>$t_{PHL}$<br>(Figures 4, 5, 6) | 5.0<br>10<br>15<br><br>5.0<br>10<br>15 | —<br>—<br>—<br><br>—<br>—<br>— | 550<br>225<br>160<br><br>240<br>130<br>100 | 1100<br>450<br>320<br><br>480<br>260<br>200 | ns            |
| Propagation Delay Time<br>Pn to Q  | $t_{PLH},$<br>$t_{PHL}$<br>(Figures 4, 7)    | 5.0<br>10<br>15                        | —<br>—<br>—                    | 260<br>120<br>100                          | 520<br>240<br>200                           | ns            |
| Propagation Delay Time<br>Reset to Q   | $t_{PHL}$<br><br>(Figure 8)                  | 5.0<br>10<br>15                        | —<br>—<br>—                    | 250<br>110<br>80                           | 500<br>220<br>160                           | ns            |
| Propagation Delay Time<br>Preset Enable to "0"   | $t_{PHL},$<br>$t_{PLH}$<br>(Figures 4, 9)    | 5.0<br>10<br>15                        | —<br>—<br>—                    | 220<br>100<br>80                           | 440<br>200<br>160                           | ns            |
| Clock or Inhibit Pulse Width   | $t_w$<br><br>(Figures 5, 6)                  | 5.0<br>10<br>15                        | 250<br>100<br>80               | 125<br>50<br>40                            | —<br>—<br>—                                 | ns            |
| Clock Pulse Frequency (with PE = low)  | $f_{max}$<br><br>(Figures 4, 5, 6)           | 5.0<br>10<br>15                        | —<br>—<br>—                    | 2.0<br>5.0<br>6.6                          | 1.5<br>3.0<br>4.0                           | MHz           |
| Clock or Inhibit Rise and Fall Time  | $t_r,$<br>$t_f$<br>(Figures 5, 6)            | 5.0<br>10<br>15                        | —<br>—<br>—                    | —<br>—<br>—                                | 15<br>5<br>4                                | $\mu\text{s}$ |
| Setup Time<br>Pn to Preset Enable  | $t_{su}$<br><br>(Figure 10)                  | 5.0<br>10<br>15                        | 90<br>50<br>40                 | 40<br>15<br>10                             | —<br>—<br>—                                 | ns            |
| Hold Time<br>Preset Enable to Pn   | $t_h$<br><br>(Figure 10)                     | 5.0<br>10<br>15                        | 30<br>30<br>30                 | -15<br>-5<br>0                             | —<br>—<br>—                                 | ns            |
| Preset Enable Pulse Width  | $t_w$<br><br>(Figure 10)                     | 5.0<br>10<br>15                        | 250<br>100<br>80               | 125<br>50<br>40                            | —<br>—<br>—                                 | ns            |
| Reset Pulse Width  | $t_w$<br><br>(Figure 8)                      | 5.0<br>10<br>15                        | 350<br>250<br>200              | 175<br>125<br>100                          | —<br>—<br>—                                 | ns            |
| Reset Removal Time   | $t_{rem}$<br><br>(Figure 8)                  | 5.0<br>10<br>15                        | 10<br>20<br>30                 | -110<br>-30<br>-20                         | —<br>—<br>—                                 | ns            |

\* The formulas given are for the typical characteristics only at 25°C.

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

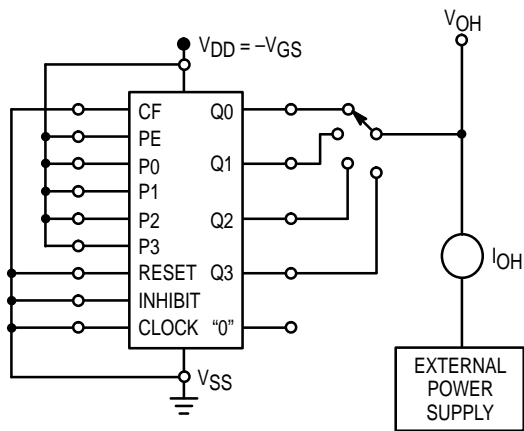


Figure 1. Typical Output Source Characteristics Test Circuit

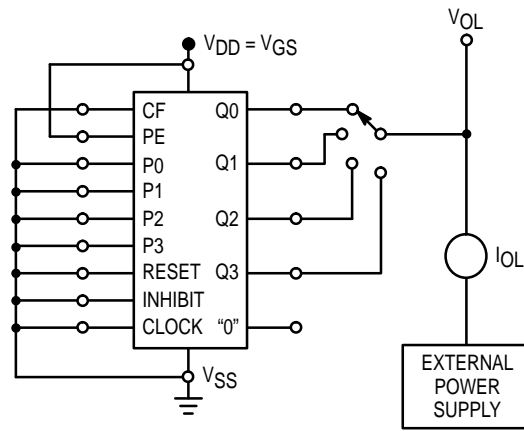


Figure 2. Typical Output Sink Characteristics Test Circuit

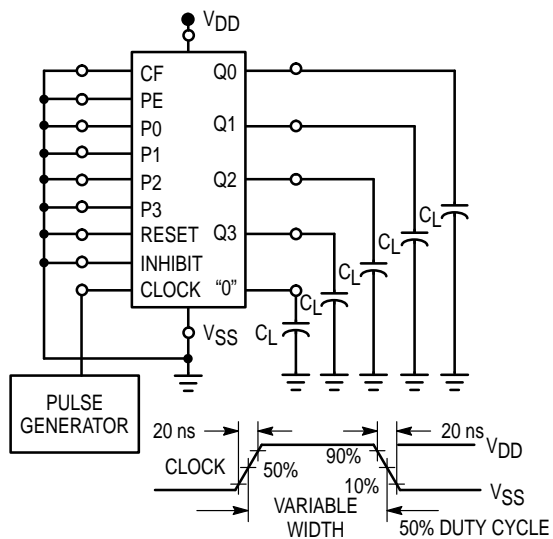
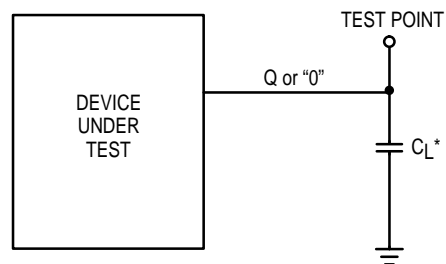


Figure 3. Power Dissipation



\* Includes all probe and jig capacitance.

Figure 4. Test Circuit

## SWITCHING WAVEFORMS

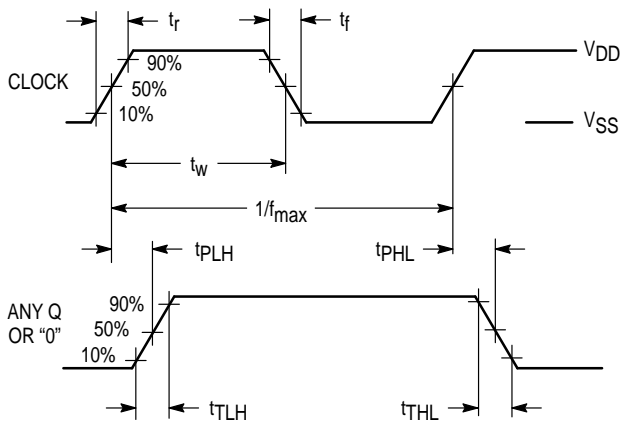


Figure 5.

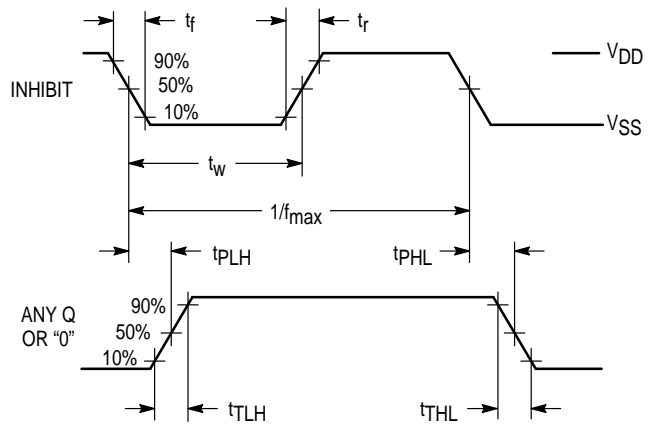


Figure 6.

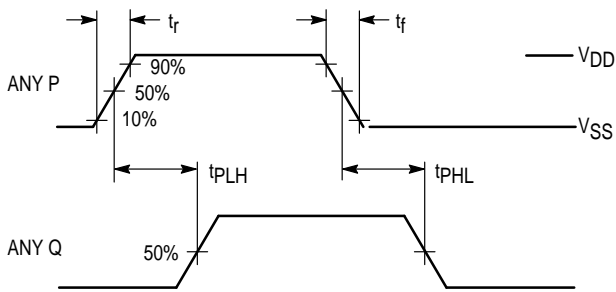


Figure 7.

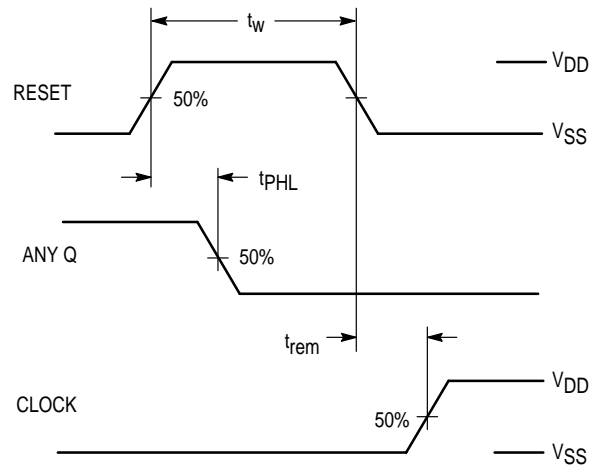


Figure 8.

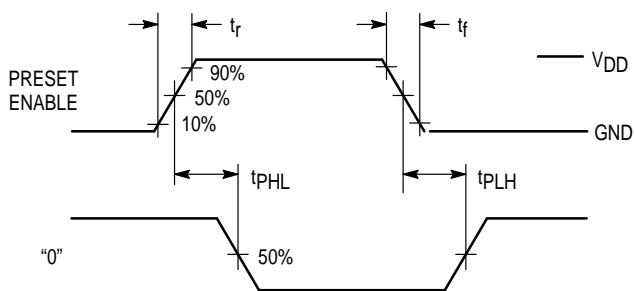


Figure 9.

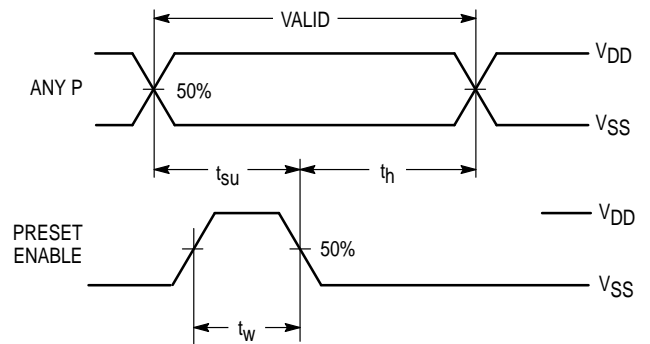


Figure 10.

## PIN DESCRIPTIONS

**Preset Enable (Pin 3)** — If Reset is low, a high level on the Preset Enable input asynchronously loads the counter with the programmed values on P0, P1, P2, and P3.

**Inhibit (Pin 4)** — A high level on the Inhibit input prevents the Clock from decrementing the counter. With Clock (pin 6) held high, Inhibit may be used as a negative edge clock input.

**Clock (Pin 6)** — The counter decrements by one for each rising edge of Clock. See the Function Table for level requirements on the other inputs.

**Reset (Pin 10)** — A high level on Reset asynchronously forces Q0, Q1, Q2, and Q3 low and, if Cascade Feedback is high, causes the “0” output to go high.

**“0” (Pin 12)** — The “0” (Zero) output issues a pulse one clock period wide when the counter reaches terminal count (Q0 = Q1 = Q2 = Q3 = low) if Cascade Feedback is high and Preset Enable is low. When presetting the counter to a value

other than all zeroes, the “0” output is valid after the rising edge of Preset Enable (when Cascade Feedback is high). See the Function Table.

**Cascade Feedback (Pin 13)** — If the Cascade Feedback input is high, a high level is generated at the “0” output when the count is all zeroes. If Cascade Feedback is low, the “0” output depends on the Preset Enable input level. See the Function Table.

**P0, P1, P2, P3 (Pins 5, 11, 14, 2)** — These are the preset data inputs. P0 is the LSB.

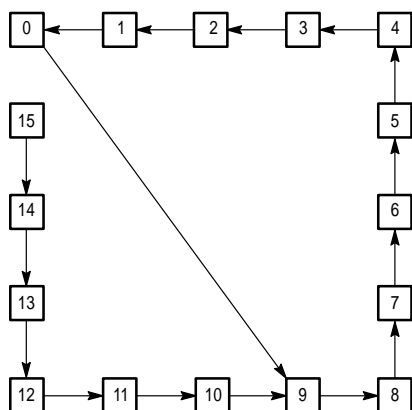
**Q0, Q1, Q2, Q3 (Pins 7, 9, 15, 1)** — These are the synchronous counter outputs. Q0 is the LSB.

**VSS (Pin 8)** — The most negative power supply potential. This pin is usually ground.

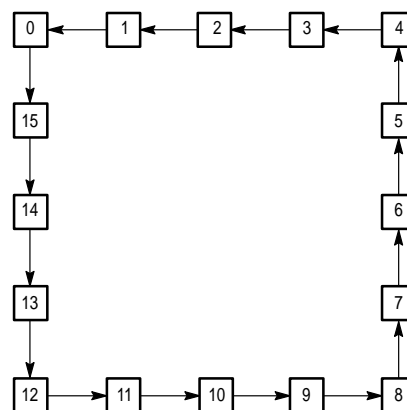
**VDD (Pin 16)** — The most positive power supply potential. VDD may range from 3 to 18 V with respect to VSS.

## STATE DIAGRAMS

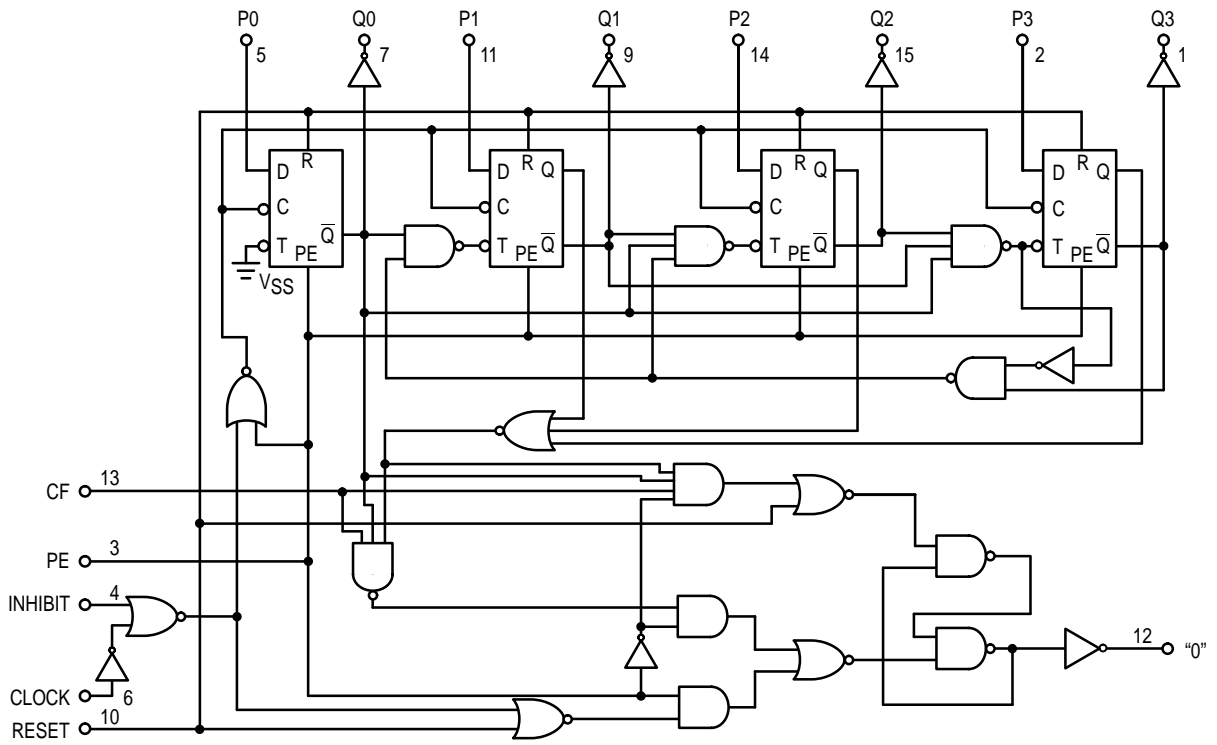
MC14522B



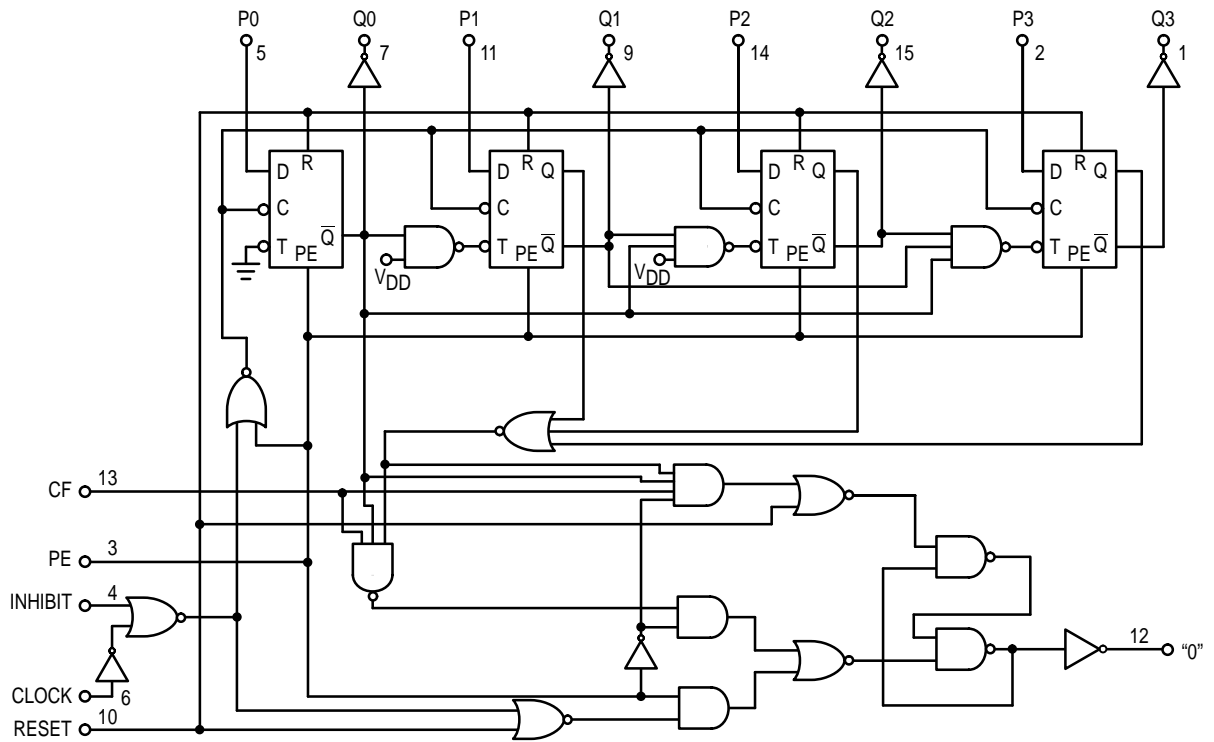
MC14526B



**MC14522B LOGIC DIAGRAM (BCD Down Counter)**



**MC14526B LOGIC DIAGRAM (Binary Down Counter)**



## APPLICATIONS INFORMATION

### Divide-By-N, Single Stage

Figure 11 shows a single stage divide-by-N application. The MC14522B (BCD version) can accept a number greater than 9 and count down in binary fashion. Hence, the BCD and binary single stage divide-by-N counters (as shown in Figure 11) function the same.

To initialize counting a number, N is set on the parallel inputs (P0, P1, P2, and P3) and reset is taken high asynchronously. A zero is forced into the master and slave of each bit and, at the same time, the "0" output goes high. Because Preset Enable is tied to the "0" output, preset is enabled. Reset must be released while the Clock is high so the slaves of each bit may receive N before the Clock goes low. When the Clock goes low and Reset is low, the "0" output goes low (if P0 through P3 are unequal to zero).

The counter downcounts with each rising edge of the Clock. When the counter reaches the zero state, an output pulse occurs on "0" which presets N. The propagation delays from the Clock's rising and falling edges to the "0" output's rising and falling edges are about equal, making the "0" output pulse approximately equal to that of the Clock pulse.

The Inhibit pin may be used to stop pulse counting. When this pin is taken high, decrementing is inhibited.

### Cascaded, Presettable Divide-By-N

Figure 12 shows a three stage cascade application. Taking Reset high loads N. Only the first stage's Reset pin (least significant counter) must be taken high to cause the preset for all stages, but all pins could be tied together, as shown.

When the first stage's Reset pin goes high, the "0" output is latched in a high state. Reset must be released while Clock is high and time allowed for Preset Enable to load N into all stages before Clock goes low.

When Preset Enable is high and Clock is low, time must be allowed for the zero digits to propagate a Cascade Feedback to the first non-zero stage. Worst case is from the most significant bit (M.S.B.) to the L.S.B., when the L.S.B. is equal to one (i.e.  $N = 1$ ).

After N is loaded, each stage counts down to zero with each rising edge of Clock. When any stage reaches zero and the leading stages (more significant bits) are zero, the "0" output goes high and feeds back to the preceding stage. When all stages are zero, the Preset Enable automatically loads N while the Clock is high and the cycle is renewed.

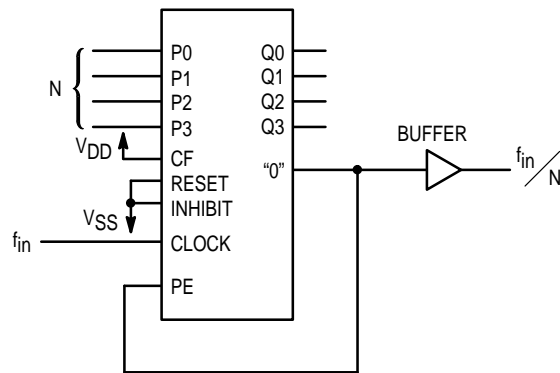


Figure 11.  $\div N$  Counter

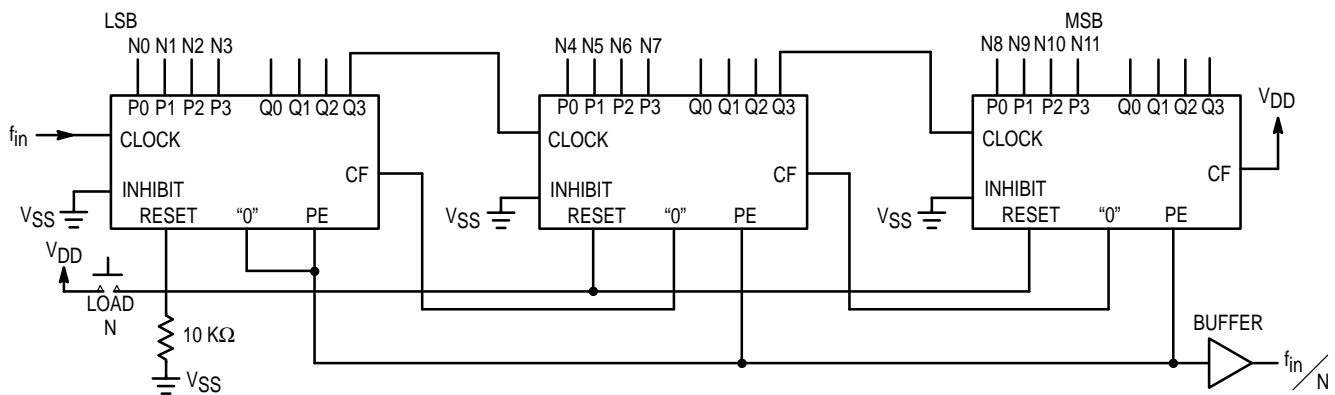


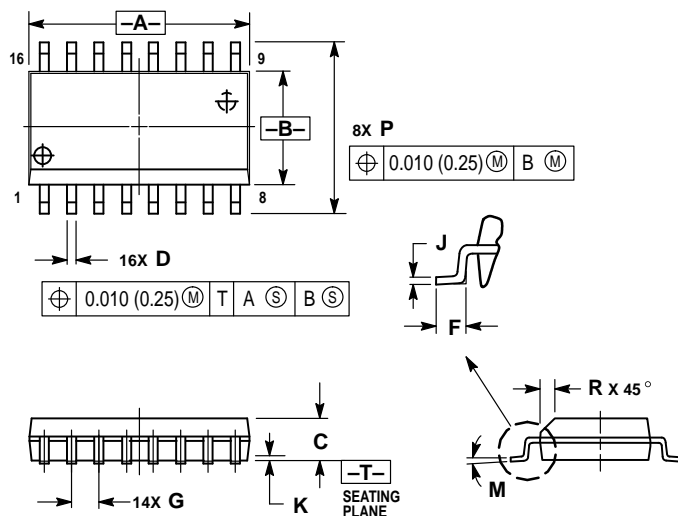
Figure 12. 3 Stages Cascaded





## OUTLINE DIMENSIONS

### DW SUFFIX PLASTIC SOIC PACKAGE CASE 751G-02 ISSUE A



**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 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 10.15       | 10.45 | 0.400     | 0.411 |
| B   | 7.40        | 7.60  | 0.292     | 0.299 |
| C   | 2.35        | 2.65  | 0.093     | 0.104 |
| D   | 0.35        | 0.49  | 0.014     | 0.019 |
| F   | 0.50        | 0.90  | 0.020     | 0.035 |
| G   | 1.27 BSC    |       | 0.050 BSC |       |
| J   | 0.25        | 0.32  | 0.010     | 0.012 |
| K   | 0.10        | 0.25  | 0.004     | 0.009 |
| M   | 0°          | 7°    | 0°        | 7°    |
| P   | 10.05       | 10.55 | 0.395     | 0.415 |
| R   | 0.25        | 0.75  | 0.010     | 0.029 |

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

**How to reach us:**

**USA/EUROPE/Locations Not Listed:** Motorola Literature Distribution;  
P.O. Box 20912; Phoenix, Arizona 85036. 1-800-441-2447 or 602-303-5454

**JAPAN:** Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center,  
3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 03-81-3521-8315

**MFAX:** RMFAX0@email.sps.mot.com – TOUCHTONE 602-244-6609  
**INTERNET:** http://Design-NET.com

**ASIA/PACIFIC:** Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,  
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298



MC14522B/D

