

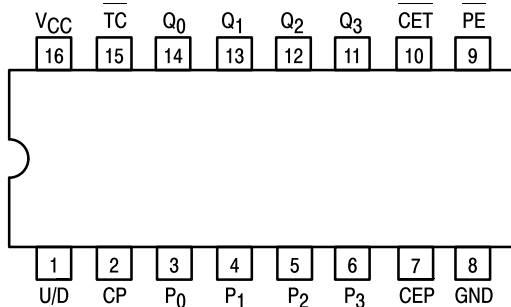


# BCD DECADE/MODULO 16 BINARY SYNCHRONOUS BI-DIRECTIONAL COUNTERS

The SN54/74LS168 and SN54/74LS169 are fully synchronous 4-stage up/down counters featuring a preset capability for programmable operation, carry lookahead for easy cascading and a U/D input to control the direction of counting. The SN54/74LS168 counts in a BCD decade (8, 4, 2, 1) sequence, while the SN54/74LS169 operates in a Modulo 16 binary sequence. All state changes, whether in counting or parallel loading, are initiated by the LOW-to-HIGH transition of the clock.

- Low Power Dissipation 100 mW Typical
- High-Speed Count Frequency 30 MHz Typical
- Fully Synchronous Operation
- Full Carry Lookahead for Easy Cascading
- Single Up/Down Control Input
- Positive Edge-Trigger Operation
- Input Clamp Diodes Limit High-Speed Termination Effects

CONNECTION DIAGRAM DIP (TOP VIEW)



NOTE:  
The Flatpak version  
has the same pinouts  
(Connection Diagram) as  
the Dual In-Line Package.

## PIN NAMES

|              |                                                |
|--------------|------------------------------------------------|
| <u>CEP</u>   | Count Enable Parallel (Active LOW) Input       |
| <u>CET</u>   | Count Enable Trickle (Active LOW) Input        |
| <u>CP</u>    | Clock Pulse (Active positive going edge) Input |
| <u>PE</u>    | Parallel Enable (Active LOW) Input             |
| <u>U/D</u>   | Up-Down Count Control Input                    |
| <u>P0-P3</u> | Parallel Data Inputs                           |
| <u>Q0-Q3</u> | Flip-Flop Outputs                              |
| <u>TC</u>    | Terminal Count (Active LOW) Output             |

## LOADING (Note a)

| HIGH     | LOW          |
|----------|--------------|
| 0.5 U.L. | 0.25 U.L.    |
| 1.0 U.L. | 0.5 U.L.     |
| 0.5 U.L. | 0.25 U.L.    |
| 0.5 U.L. | 0.25 U.L.    |
| 0.5 U.L. | 0.25 U.L.    |
| 0.5 U.L. | 0.25 U.L.    |
| 10 U.L.  | 5 (2.5) U.L. |
| 10 U.L.  | 5 (2.5) U.L. |

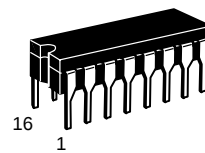
## NOTES:

- a. 1 TTL Unit Load (U.L.) = 40  $\mu$ A HIGH/1.6 mA LOW.  
b. The Output LOW drive factor is 2.5 U.L. for Military (54) and 5 U.L. for Commercial (74)  
Temperature Ranges.

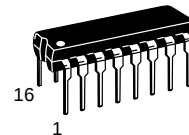
## SN54/74LS168 SN54/74LS169

## BCD DECADE/MODULO 16 BINARY SYNCHRONOUS BI-DIRECTIONAL COUNTERS

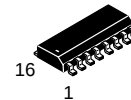
## LOW POWER SCHOTTKY



J SUFFIX  
CERAMIC  
CASE 620-09



N SUFFIX  
PLASTIC  
CASE 648-08

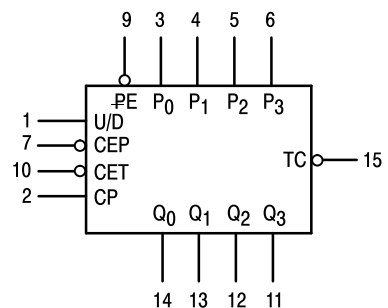


D SUFFIX  
SOIC  
CASE 751B-03

## ORDERING INFORMATION

|            |         |
|------------|---------|
| SN54LSXXXJ | Ceramic |
| SN74LSXXXN | Plastic |
| SN74LSXXXD | SOIC    |

## LOGIC SYMBOL

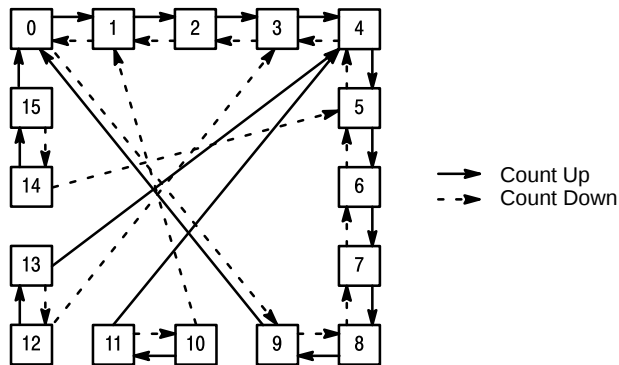


V<sub>CC</sub> = PIN 16  
GND = PIN 8

# SN54/74LS168 • SN54/74LS169

## STATE DIAGRAMS

**SN54/74LS168**  
UP/DOWN DECADE COUNTER

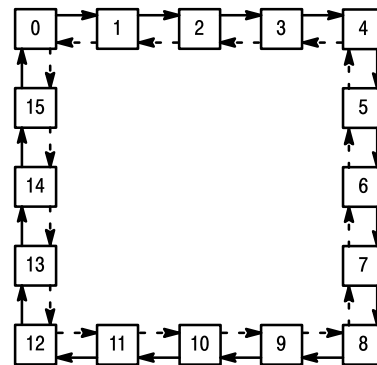


**SN54/74LS168**

UP:  $TC = \overline{Q_0} \cdot \overline{Q_3} \cdot (\overline{U/D})$

DOWN:  $TC = Q_0 \cdot Q_1 \cdot Q_2 \cdot Q_3 \cdot (U/D)$

**SN54/74LS169**



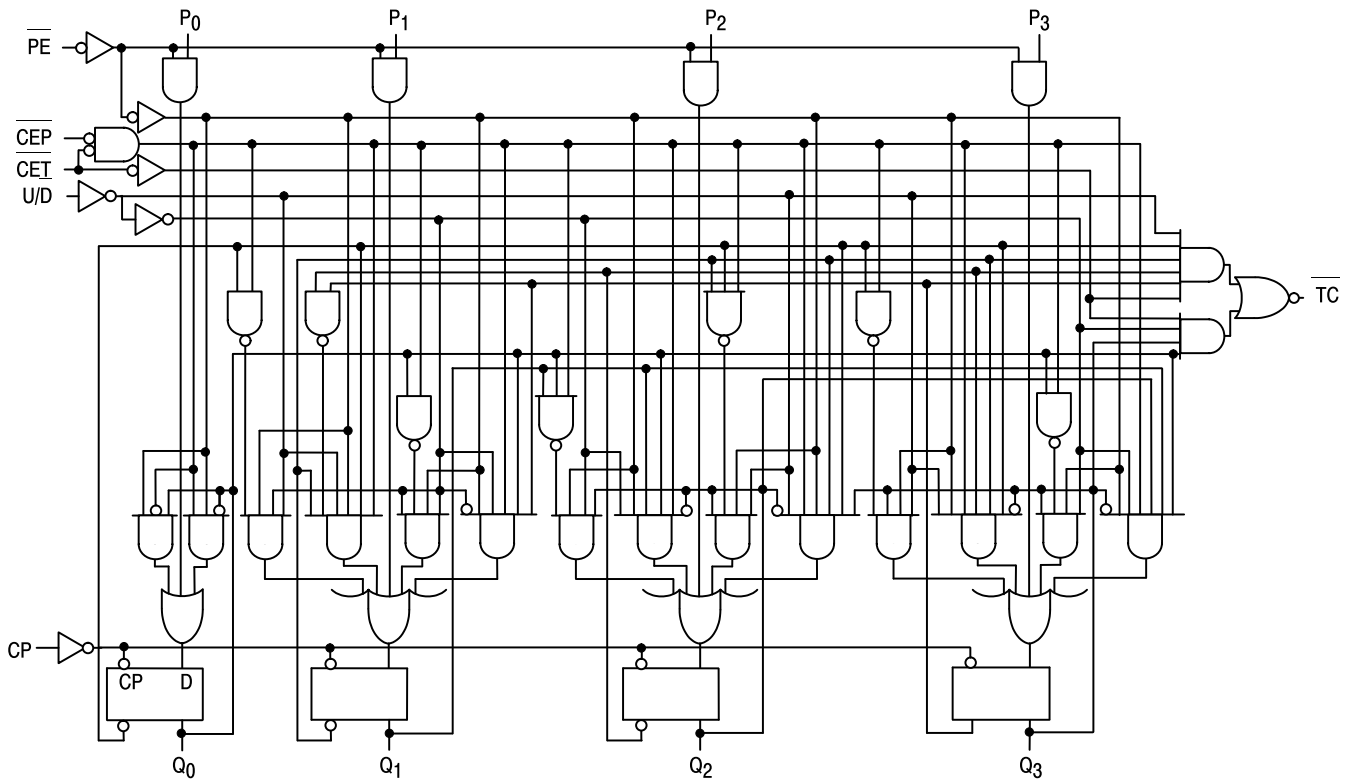
**SN54/74LS169**

UP:  $TC = \overline{Q_0} \cdot \overline{Q_1} \cdot \overline{Q_2} \cdot \overline{Q_3} \cdot (\overline{U/D})$

DOWN:  $TC = Q_0 \cdot Q_1 \cdot Q_2 \cdot Q_3 \cdot (U/D)$

## LOGIC DIAGRAMS

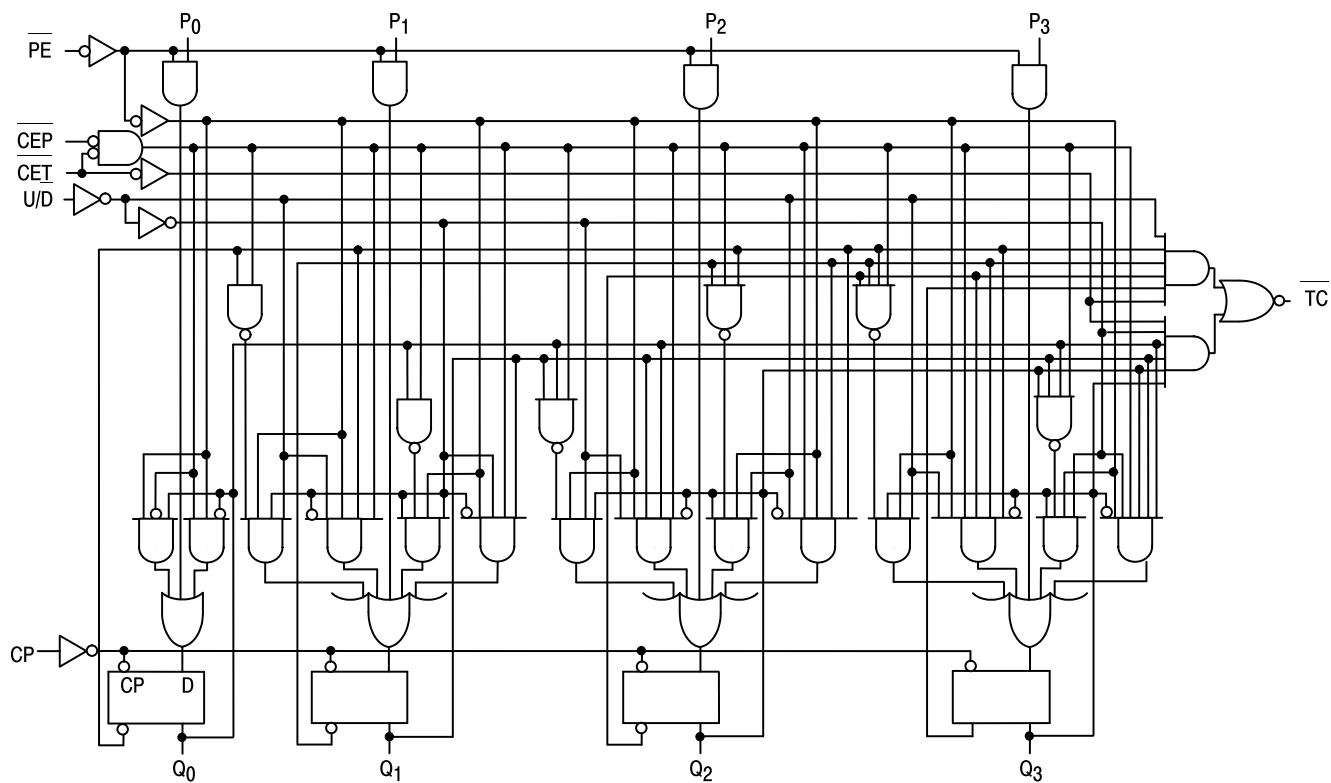
**SN54/74LS168**



SN54/74LS168 • SN54/74LS169

LOGIC DIAGRAMS (continued)

SN54/74LS169



GUARANTEED OPERATING RANGES

| Symbol          | Parameter                           |          | Min         | Typ        | Max         | Unit |
|-----------------|-------------------------------------|----------|-------------|------------|-------------|------|
| V <sub>CC</sub> | Supply Voltage                      | 54<br>74 | 4.5<br>4.75 | 5.0<br>5.0 | 5.5<br>5.25 | V    |
| T <sub>A</sub>  | Operating Ambient Temperature Range | 54<br>74 | -55<br>0    | 25<br>25   | 125<br>70   | °C   |
| I <sub>OH</sub> | Output Current — High               | 54, 74   |             |            | -0.4        | mA   |
| I <sub>OL</sub> | Output Current — Low                | 54<br>74 |             |            | 4.0<br>8.0  | mA   |

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## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

| Symbol          | Parameter                                       |        | Limits |       |              | Unit | Test Conditions                                                                                                    |                                                                                                             |
|-----------------|-------------------------------------------------|--------|--------|-------|--------------|------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
|                 |                                                 |        | Min    | Typ   | Max          |      |                                                                                                                    |                                                                                                             |
| V <sub>IH</sub> | Input HIGH Voltage                              |        | 2.0    |       |              | V    | Guaranteed Input HIGH Voltage for All Inputs                                                                       |                                                                                                             |
| V <sub>IL</sub> | Input LOW Voltage                               | 54     |        |       | 0.7          | V    | Guaranteed Input LOW Voltage for All Inputs                                                                        |                                                                                                             |
|                 |                                                 | 74     |        |       | 0.8          |      |                                                                                                                    |                                                                                                             |
| V <sub>IK</sub> | Input Clamp Diode Voltage                       |        |        | −0.65 | −1.5         | V    | V <sub>CC</sub> = MIN, I <sub>IN</sub> = −18 mA                                                                    |                                                                                                             |
| V <sub>OH</sub> | Output HIGH Voltage                             | 54     | 2.5    | 3.5   |              | V    | V <sub>CC</sub> = MIN, I <sub>OH</sub> = MAX, V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> per Truth Table |                                                                                                             |
|                 |                                                 | 74     | 2.7    | 3.5   |              | V    |                                                                                                                    |                                                                                                             |
| V <sub>OL</sub> | Output LOW Voltage                              | 54, 74 |        | 0.25  | 0.4          | V    | I <sub>OL</sub> = 4.0 mA                                                                                           | V <sub>CC</sub> = V <sub>CC</sub> MIN, V <sub>IN</sub> = V <sub>IL</sub> or V <sub>IH</sub> per Truth Table |
|                 |                                                 | 74     |        | 0.35  | 0.5          | V    | I <sub>OL</sub> = 8.0 mA                                                                                           |                                                                                                             |
| I <sub>IH</sub> | Input HIGH Current<br>Other Inputs<br>CET Input |        |        |       | 20<br>40     | μA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 2.7 V                                                                     |                                                                                                             |
|                 | Other Input<br>CET Input                        |        |        |       | 0.1<br>0.2   | mA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 7.0 V                                                                     |                                                                                                             |
| I <sub>IL</sub> | Input LOW Current<br>Other Input<br>CET Input   |        |        |       | −0.4<br>−0.8 | mA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 0.4 V                                                                     |                                                                                                             |
| I <sub>OS</sub> | Short Circuit Current (Note 1)                  |        | −20    |       | −100         | mA   | V <sub>CC</sub> = MAX                                                                                              |                                                                                                             |
| I <sub>CC</sub> | Power Supply Current                            |        |        |       | 34           | mA   | V <sub>CC</sub> = MAX                                                                                              |                                                                                                             |

Note 1: Not more than one output should be shorted at one time, nor for more than 1 second.

## FUNCTIONAL DESCRIPTION

The SN54/74LS168 and SN54/74LS169 use edge-triggered D-type flip-flops that have no constraints on changing the control or data input signals in either state of the Clock. The only requirement is that the various inputs attain the desired state at least a set-up time before the rising edge of the clock and remain valid for the recommended hold time thereafter.

The parallel load operation takes precedence over the other operations, as indicated in the Mode Select Table. When PE is LOW, the data on the P<sub>0</sub>–P<sub>3</sub> inputs enters the flip-flops on the next rising edge of the Clock. In order for counting to occur, both CEP and CET must be LOW and PE must be HIGH. The U/D input then determines the direction of counting.

The Terminal Count ( $\overline{\text{TC}}$ ) output is normally HIGH and goes LOW, provided that CET is LOW, when a counter reaches zero in the COUNT DOWN mode or reaches 15 (9 for the SN54/74LS168) in the COUNT UP mode. The  $\overline{\text{TC}}$  output state is not a function of the Count Enable Parallel (CEP) input level. The TC output of the SN54/74LS168 decade counter can also be LOW in the illegal states 11, 13 and 15, which can occur when power is turned on or via parallel loading. If illegal state occurs, the SN54/74LS168 will return to the legitimate sequence within two counts. Since the TC signal is derived by decoding the flip-flop states, there exists the possibility of decoding spikes on TC. For this reason the use of TC as a clock signal is not recommended.

MODE SELECT TABLE

| PE | CEP | CET | U/D | Action on Rising Clock Edge           |
|----|-----|-----|-----|---------------------------------------|
| L  | X   | X   | X   | Load (P <sub>n</sub> Q <sub>n</sub> ) |
| H  | L   | L   | H   | Count Up (increment)                  |
| H  | L   | L   | L   | Count Down (decrement)                |
| H  | H   | X   | X   | No Change (Hold)                      |
| H  | X   | H   | X   | No Change (Hold)                      |

H = HIGH Voltage Level

L = LOW Voltage Level

X = Immaterial

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## AC CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , $V_{CC} = 5.0\text{ V}$ )

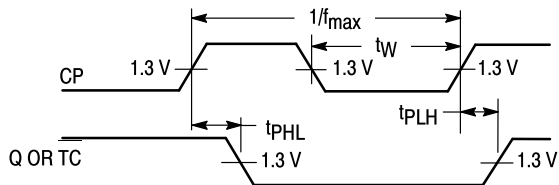
| Symbol                 | Parameter                            | Limits |          |          | Unit | Test Conditions                                 |
|------------------------|--------------------------------------|--------|----------|----------|------|-------------------------------------------------|
|                        |                                      | Min    | Typ      | Max      |      |                                                 |
| $f_{MAX}$              | Maximum Clock Frequency              | 25     | 32       |          | MHz  | $V_{CC} = 5.0\text{ V}$<br>$C_L = 15\text{ pF}$ |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay,<br>Clock to TC    |        | 23<br>23 | 35<br>35 | ns   |                                                 |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay,<br>Clock to any Q |        | 13<br>15 | 20<br>23 | ns   |                                                 |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay,<br>CET to TC      |        | 15<br>15 | 20<br>20 | ns   |                                                 |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay,<br>U/D to TC      |        | 17<br>19 | 25<br>29 | ns   |                                                 |

## AC SETUP REQUIREMENTS ( $T_A = 25^\circ\text{C}$ )

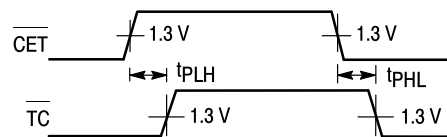
| Symbol | Parameter                     | Limits |     |     | Unit | Test Conditions         |
|--------|-------------------------------|--------|-----|-----|------|-------------------------|
|        |                               | Min    | Typ | Max |      |                         |
| $t_W$  | Clock Pulse Width             | 25     |     |     | ns   | $V_{CC} = 5.0\text{ V}$ |
| $t_s$  | Setup Time,<br>Data or Enable | 20     |     |     | ns   |                         |
| $t_s$  | Setup Time<br>PE              | 25     |     |     | ns   |                         |
| $t_s$  | Setup Time<br>U/D             | 30     |     |     | ns   |                         |
| $t_h$  | Hold Time<br>Any Input        | 0      |     |     | ns   |                         |

# SN54/74LS168 • SN54/74LS169

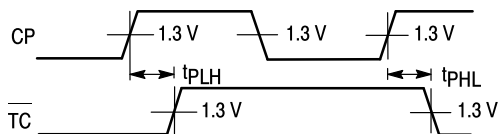
## AC WAVEFORMS



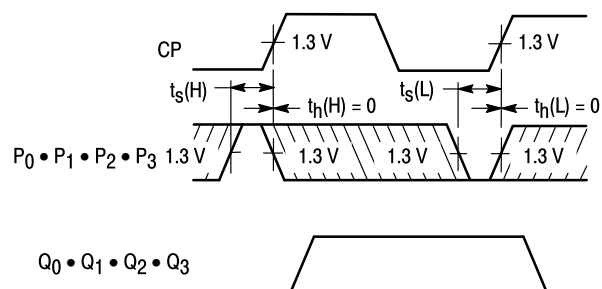
**Figure 1. Clock to Output Delays, Count Frequency, and Clock Pulse Width**



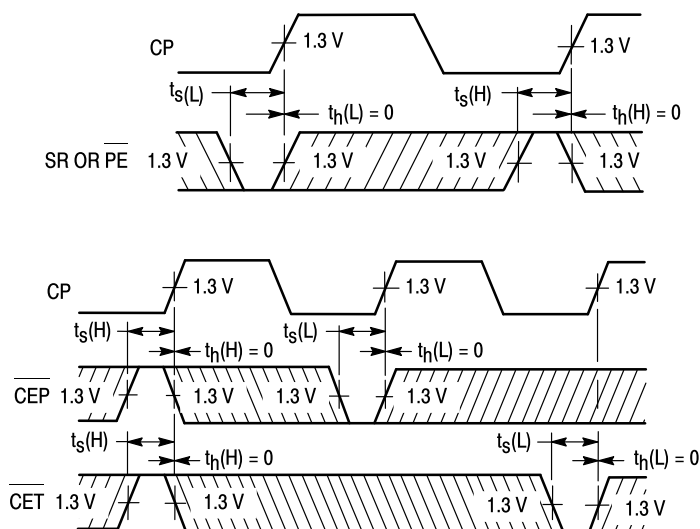
**Figure 2. Count Enable Trickle Input To Terminal Count Output Delays**



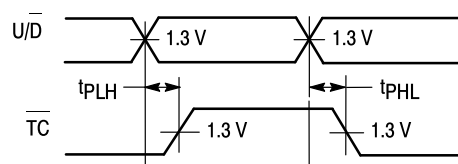
**Figure 3. Clock to Terminal Delays**



**Figure 4. Setup Time ( $t_s$ ) and Hold ( $t_h$ ) for Parallel Data Inputs**



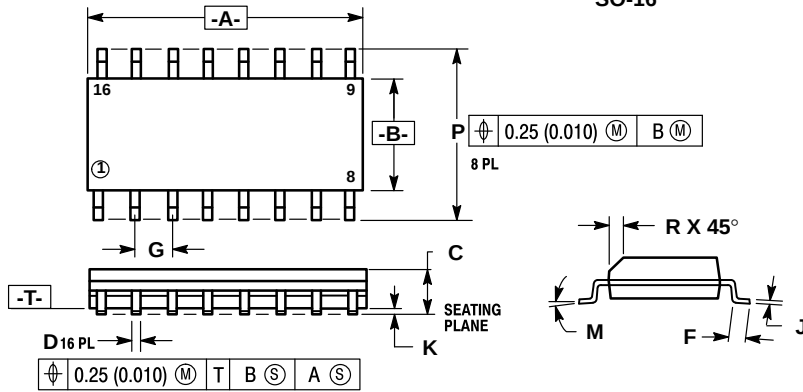
**Figure 5. Setup Time and Hold Time for Count Enable and Parallel Enable Inputs, and Up-Down Control Inputs**



**Figure 6. Up-Down Input to Terminal Count Output Delays**

The shaded areas indicate when the input is permitted to change for predictable output performance.

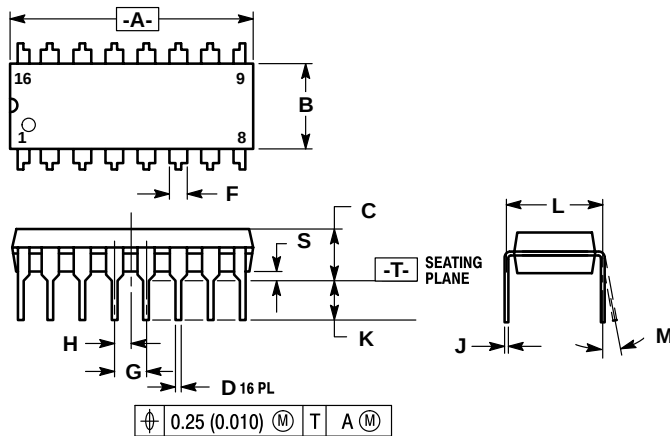
**Case 751B-03 D Suffix**  
**16-Pin Plastic**  
**SO-16**



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. 751B-01 IS OBSOLETE, NEW STANDARD 751B-03.

| 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 |

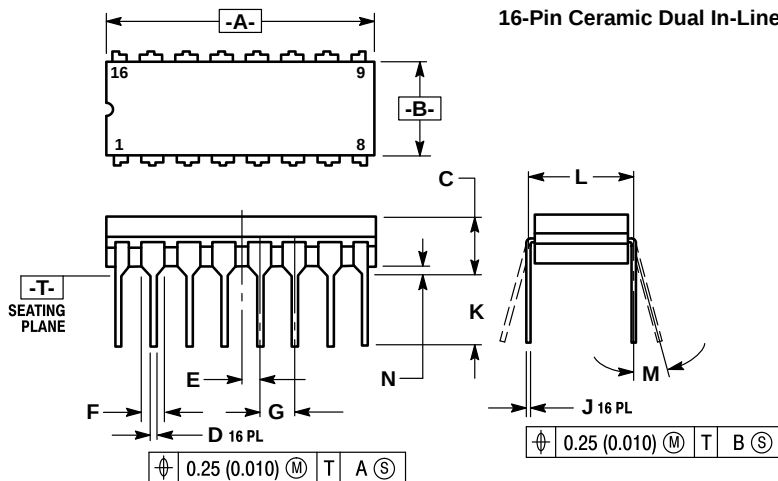
**Case 648-08 N Suffix**  
**16-Pin Plastic**



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
  4. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
  5. ROUNDED CORNERS OPTIONAL.
  6. 648-01 THRU -07 OBSOLETE, NEW STANDARD 648-08.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 18.80       | 19.55 | 0.740     | 0.770 |
| B   | 6.35        | 6.85  | 0.250     | 0.270 |
| C   | 3.69        | 4.44  | 0.145     | 0.175 |
| D   | 0.39        | 0.53  | 0.015     | 0.021 |
| F   | 1.02        | 1.77  | 0.040     | 0.070 |
| G   | 2.54 BSC    |       | 0.100 BSC |       |
| H   | 1.27 BSC    |       | 0.050 BSC |       |
| J   | 0.21        | 0.38  | 0.008     | 0.015 |
| K   | 2.80        | 3.30  | 0.110     | 0.130 |
| L   | 7.50        | 7.74  | 0.295     | 0.305 |
| M   | 0°          | 10°   | 0°        | 10°   |
| S   | 0.51        | 1.01  | 0.020     | 0.040 |

**Case 620-09 J Suffix**  
**16-Pin Ceramic Dual In-Line**



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
  4. DIM F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.
  5. 620-01 THRU -08 OBSOLETE, NEW STANDARD 620-09.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 19.05       | 19.55 | 0.750     | 0.770 |
| B   | 6.10        | 7.36  | 0.240     | 0.290 |
| C   | —           | 4.19  | —         | 0.165 |
| D   | 0.39        | 0.53  | 0.015     | 0.021 |
| E   | 1.27 BSC    |       | 0.050 BSC |       |
| F   | 1.40        | 1.77  | 0.055     | 0.070 |
| G   | 2.54 BSC    |       | 0.100 BSC |       |
| J   | 0.23        | 0.27  | 0.009     | 0.011 |
| K   | —           | 5.08  | —         | 0.200 |
| L   | 7.62 BSC    |       | 0.300 BSC |       |
| M   | 0°          | 15°   | 0°        | 15°   |
| N   | 0.39        | 0.88  | 0.015     | 0.035 |

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