

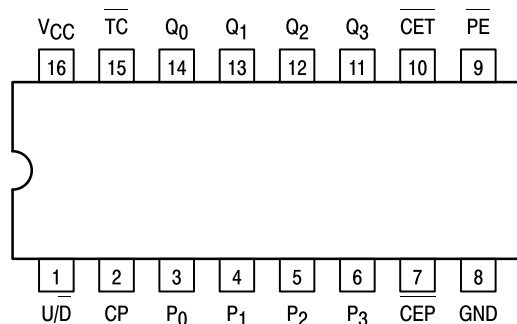


# 4-STAGE SYNCHRONOUS BIDIRECTIONAL COUNTERS

The MC54/74F168 and MC54/74F169 are fully synchronous 4-stage up/down counters. The F168 is a BCD decade counter; the F169 is a modulo-16 binary counter. Both feature a preset capability for programmable operation, carry lookahead for easy cascading, and a U/D input to control the direction of counting. All state changes, whether in counting or parallel loading, are initiated by the LOW-to-HIGH transition of the clock.

- Asynchronous Counting and Loading
- Built-In Lookahead Carry Capability
- Presetable for Programmable Operation

CONNECTION DIAGRAM (TOP VIEW)

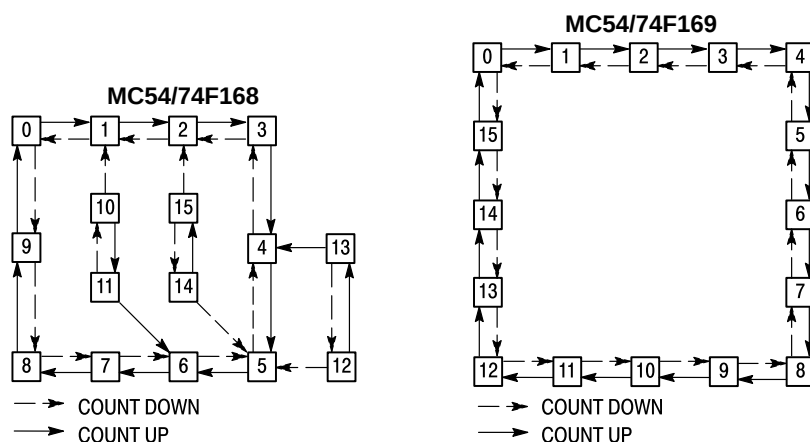


MODE SELECT TABLE

| PE | CEP | CET | U/D | Action on Rising Clock Edge |
|----|-----|-----|-----|-----------------------------|
| L  | X   | X   | X   | Load ( $P_n$ $Q_n$ )        |
| 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 = Don't Care

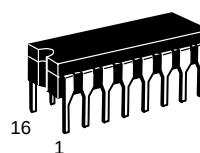
STATE DIAGRAMS



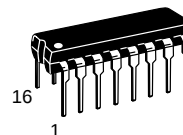
## MC54/74F168 MC54/74F169

### 4-STAGE SYNCHRONOUS BIDIRECTIONAL COUNTERS

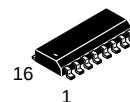
FAST™ SCHOTTKY TTL



J SUFFIX  
CERAMIC  
CASE 620-09



N SUFFIX  
PLASTIC  
CASE 648-08

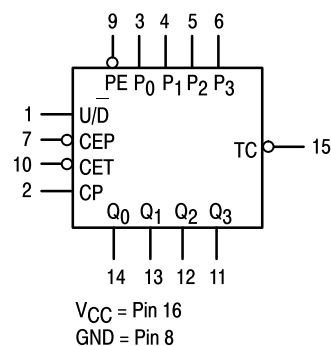


D SUFFIX  
SOIC  
CASE 751B-03

### ORDERING INFORMATION

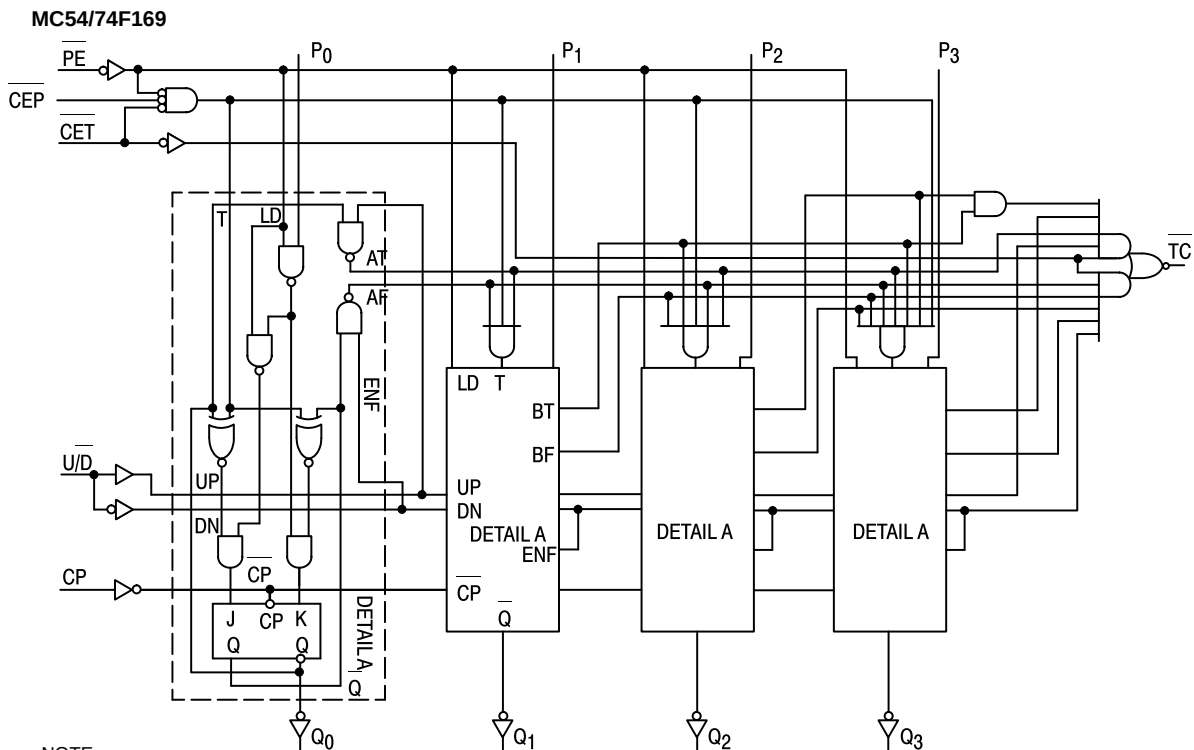
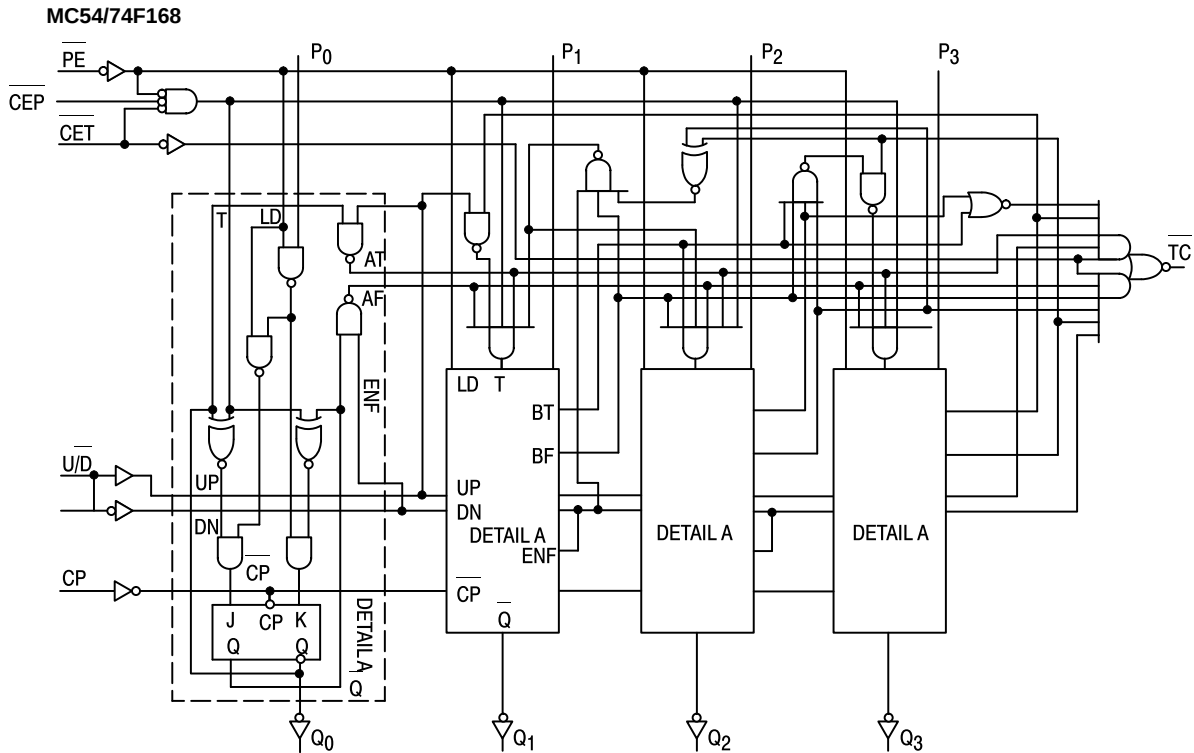
MC54FXXXJ Ceramic  
MC74FXXXN Plastic  
MC74FXXXD SOIC

### LOGIC SYMBOL



# MC54/74F168 • MC54/74F169

## LOGIC DIAGRAMS



NOTE:  
These diagrams are provided only for the understanding of logic operations and should not be used to estimate propagation delays.

# MC54/74F168 • MC54/74F169

## FUNCTIONAL DESCRIPTION

The F168 and F169 use edge-triggered J-K type flip-flops and 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 setup time before the rising edge of the clock and remain valid for the recommended hold time thereafter. The parallel load operation takes precedence over 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  $\overline{\text{CEP}}$  and CET must be LOW and PE must be HIGH; the U/D input then determines the direction of counting. The Terminal Count (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 9 (15 for the F169) in the Count Up mode. The TC

output state is not a function of the Count Enable Parallel (CEP) input level. The TC output of the F168 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 an illegal state occurs, the F168 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 (see logic equations below).

- 1) Count Enable =  $\overline{\text{CEP}} \cdot \overline{\text{CET}} \cdot \text{PE}$
- 2) Up: (F168):  $\text{TC} = \text{Q}_0 \cdot \text{Q}_1 \cdot \text{Q}_2 \cdot \text{Q}_3 \cdot (\text{Up}) \cdot \overline{\text{CET}}$   
(F169):  $\text{TC} = \text{Q}_0 \cdot \text{Q}_1 \cdot \text{Q}_2 \cdot \text{Q}_3 \cdot (\text{Up}) \cdot \overline{\text{CET}}$
- 3) Down:  $\text{TC} = \text{Q}_0 \cdot \text{Q}_1 \cdot \text{Q}_2 \cdot \text{Q}_3 \cdot (\text{Down}) \cdot \text{CET}$

## GUARANTEED OPERATING RANGES

| Symbol          | Parameter                           |        | Min | Typ | Max  | Unit |
|-----------------|-------------------------------------|--------|-----|-----|------|------|
| V <sub>CC</sub> | Supply Voltage                      | 54, 74 | 4.5 | 5.0 | 5.5  | V    |
| T <sub>A</sub>  | Operating Ambient Temperature Range | 54     | -55 | 25  | 125  | °C   |
|                 |                                     | 74     | 0   | 25  | 70   |      |
| I <sub>OH</sub> | Output Current — High               | 54, 74 |     |     | -1.0 | mA   |
| I <sub>OL</sub> | Output Current — Low                | 54, 74 |     |     | 20   | mA   |

## 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                        |        |      | 0.8          | V    | Guaranteed Input LOW Voltage for All Inputs         |
| V <sub>IK</sub> | Input Clamp Diode Voltage                |        |      | -1.2         | V    | V <sub>CC</sub> = MIN, I <sub>IN</sub> = -18 mA     |
| V <sub>OH</sub> | Output HIGH Voltage                      | 54, 74 | 2.5  | 3.4          | V    | I <sub>OH</sub> = -1.0 mA, V <sub>CC</sub> = 4.50 V |
|                 |                                          | 74     | 2.7  | 3.4          | V    | I <sub>OH</sub> = -1.0 mA, V <sub>CC</sub> = 4.75 V |
| V <sub>OL</sub> | Output LOW Voltage                       |        | 0.35 | 0.5          | V    | I <sub>OL</sub> = 20 mA, V <sub>CC</sub> = MIN      |
| I <sub>IH</sub> | Input HIGH Current                       |        |      | 20           | μA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 2.7 V      |
|                 |                                          |        |      | 0.1          | mA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 7.0 V      |
| I <sub>IL</sub> | Input LOW Current<br>CET<br>Other Inputs |        |      | -1.2<br>-0.6 | mA   | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 0.5 V      |
| I <sub>OS</sub> | Output Short Circuit Current (Note 2)    | -60    |      | -150         | mA   | V <sub>CC</sub> = MAX, V <sub>OUT</sub> = 0 V       |
| I <sub>CC</sub> | Power Supply Current                     |        |      | 52           | mA   | V <sub>CC</sub> = MAX                               |

### NOTES:

1. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.
2. Not more than one output should be shorted at a time, nor for more than 1 second.

# MC54/74F168 • MC54/74F169

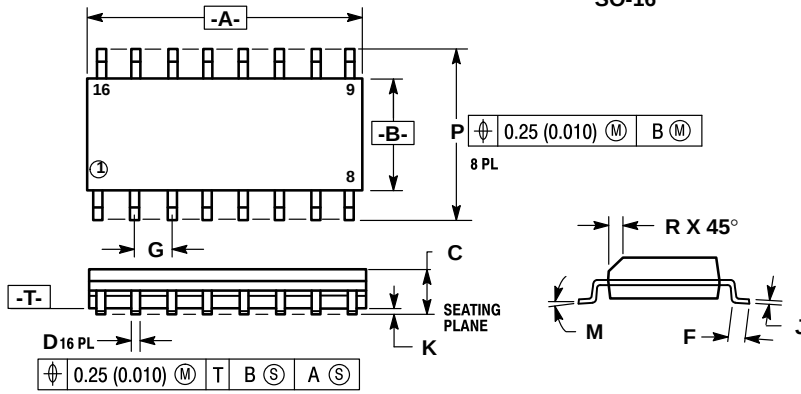
## AC CHARACTERISTICS

| Symbol                               | Parameter                                                  | 54/74F                                                                       |             | 54F                                                                                         |              | 74F                                                                                     |              | Unit |
|--------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------|--------------|------|
|                                      |                                                            | T <sub>A</sub> = +25°C<br>V <sub>CC</sub> = +5.0 V<br>C <sub>L</sub> = 50 pF |             | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0 V ± 10%<br>C <sub>L</sub> = 50 pF |              | T <sub>A</sub> = 0°C to 70°C<br>V <sub>CC</sub> = 5.0 V ± 10%<br>C <sub>L</sub> = 50 pF |              |      |
|                                      |                                                            | Min                                                                          | Max         | Min                                                                                         | Max          | Min                                                                                     | Max          |      |
|                                      |                                                            |                                                                              |             |                                                                                             |              |                                                                                         |              |      |
| f <sub>max</sub>                     | Maximum Clock Frequency                                    | 100                                                                          |             | 60                                                                                          |              | 85                                                                                      |              | MHz  |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>CP to Q <sub>n</sub> (PE HIGH or LOW) | 3.0<br>4.0                                                                   | 8.5<br>11.5 | 3.0<br>4.0                                                                                  | 10.5<br>14   | 3.0<br>4.0                                                                              | 9.5<br>13    | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>CP to TC (F168)                       | 5.5<br>4.0                                                                   | 15.5<br>11  | 5.5<br>4.0                                                                                  | 18<br>13.5   | 5.5<br>4.0                                                                              | 17<br>12.5   | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>CP to TC (F169)                       | 5.0<br>4.0                                                                   | 15.5<br>11  | 5.0<br>4.0                                                                                  | 18<br>13.5   | 5.0<br>4.0                                                                              | 17<br>12.5   | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>CET to TC                             | 2.5<br>2.5                                                                   | 6.0<br>8.0  | 2.5<br>2.5                                                                                  | 8.0<br>10    | 2.5<br>2.5                                                                              | 7.0<br>9.0   | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>U/D to TC (F168)                      | 3.5<br>4.0                                                                   | 11<br>16    | 3.5<br>4.0                                                                                  | 13.5<br>18.5 | 3.5<br>4.0                                                                              | 12.5<br>17.5 | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation Delay<br>U/D to TC (F169)                      | 3.5<br>4.0                                                                   | 11<br>10.5  | 3.5<br>4.0                                                                                  | 13.5<br>13   | 3.5<br>4.0                                                                              | 12.5<br>12   | ns   |

## AC OPERATING REQUIREMENTS

| Symbol                                   | Parameter                                       | 54/74F                                             |     | 54F                                                               |     | 74F                                                           |     | Unit |
|------------------------------------------|-------------------------------------------------|----------------------------------------------------|-----|-------------------------------------------------------------------|-----|---------------------------------------------------------------|-----|------|
|                                          |                                                 | T <sub>A</sub> = +25°C<br>V <sub>CC</sub> = +5.0 V |     | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0 V ± 10% |     | T <sub>A</sub> = 0°C to 70°C<br>V <sub>CC</sub> = 5.0 V ± 10% |     |      |
|                                          |                                                 | Min                                                | Max | Min                                                               | Max | Min                                                           | Max |      |
| t <sub>S</sub> (H)<br>t <sub>S</sub> (L) | Setup Time, HIGH or LOW<br>P <sub>n</sub> to CP | 4.0<br>4.0                                         |     | 5.5<br>5.5                                                        |     | 4.5<br>4.5                                                    |     | ns   |
| t <sub>H</sub> (H)<br>t <sub>H</sub> (L) | Hold Time, HIGH or LOW<br>P <sub>n</sub> to CP  | 3.0<br>3.0                                         |     | 3.5<br>3.5                                                        |     | 3.5<br>3.5                                                    |     | ns   |
| t <sub>S</sub> (H)<br>t <sub>S</sub> (L) | Setup Time, HIGH or LOW<br>CEP or CET to CP     | 5.0<br>5.0                                         |     | 7.0<br>7.0                                                        |     | 6.0<br>6.0                                                    |     | ns   |
| t <sub>H</sub> (H)<br>t <sub>H</sub> (L) | Hold Time HIGH or LOW<br>CEP or CET to CP       | 0<br>0                                             |     | 0<br>0                                                            |     | 0<br>0                                                        |     | ns   |
| t <sub>S</sub> (H)<br>t <sub>S</sub> (L) | Setup Time, HIGH or LOW<br>PE to CP             | 8.0<br>8.0                                         |     | 10<br>10                                                          |     | 9.0<br>9.0                                                    |     | ns   |
| t <sub>H</sub> (H)<br>t <sub>H</sub> (L) | Hold Time, HIGH or LOW<br>PE to CP              | 0<br>0                                             |     | 0<br>0                                                            |     | 0<br>0                                                        |     | ns   |
| t <sub>S</sub> (H)<br>t <sub>S</sub> (L) | Setup Time, HIGH or LOW (F168)<br>U/D to CP     | 11<br>16.5                                         |     | 13.5<br>19                                                        |     | 12.5<br>18                                                    |     | ns   |
| t <sub>S</sub> (H)<br>t <sub>S</sub> (L) | Setup Time, HIGH or LOW (F169)<br>U/D to CP     | 11<br>7.0                                          |     | 13.5<br>9.0                                                       |     | 12.5<br>8.0                                                   |     | ns   |
| t <sub>H</sub> (H)<br>t <sub>H</sub> (L) | Hold time, HIGH or LOW<br>U/D to CP             | 0<br>0                                             |     | 0<br>0                                                            |     | 0<br>0                                                        |     | ns   |
| t <sub>W</sub> (H)<br>t <sub>W</sub> (L) | CP Pulse Width<br>HIGH or LOW                   | 5.0<br>5.0                                         |     | 8.0<br>8.0                                                        |     | 5.5<br>5.5                                                    |     | ns   |

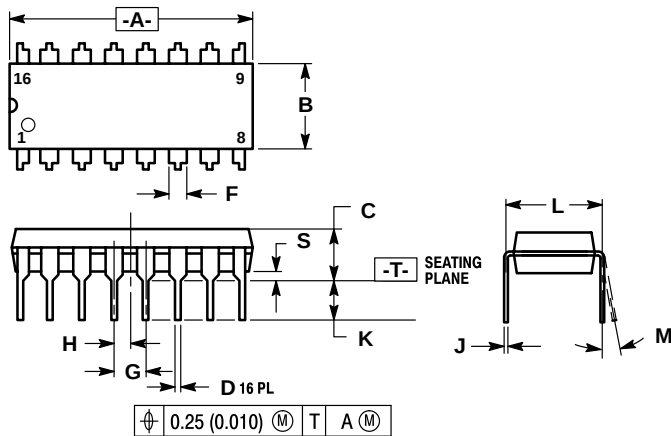
**Case 751B-03 D Suffix**  
**16-Pin Plastic**  
**SO-16**



- 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 |

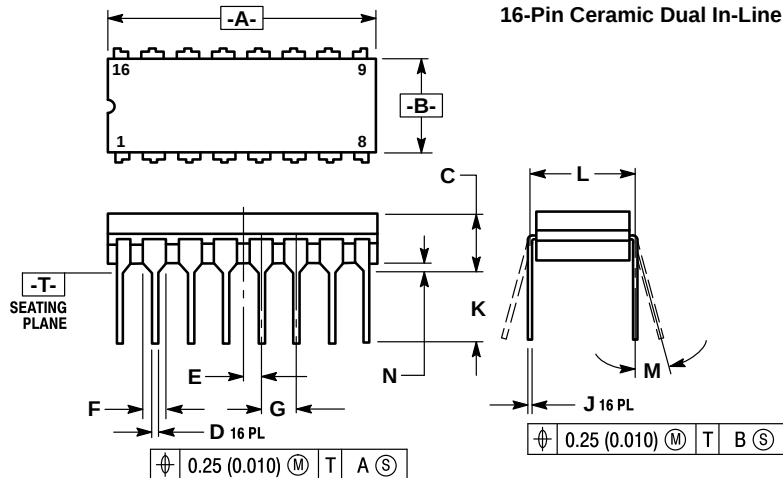
**Case 648-08 N Suffix**  
**16-Pin Plastic**



- 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 |

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 can and do vary in different applications. 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.

**Literature Distribution Centers:**

USA: Motorola Literature Distribution; P.O. Box 20912; Phoenix, Arizona 85036.

EUROPE: Motorola Ltd.; European Literature Centre; 88 Tanners Drive, Blakelands, Milton Keynes, MK14 5BP, England.

JAPAN: Nippon Motorola Ltd.; 4-32-1, Nishi-Gotanda, Shinagawa-ku, Tokyo 141, Japan.

ASIA PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Center, No. 2 Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong.

