

## MC14022B

### Octal Counter

The MC14022B is a four-stage Johnson octal counter with built-in code converter. High-speed operation and spike-free outputs are obtained by use of a Johnson octal counter design. The eight decoded outputs are normally low, and go high only at their appropriate octal time period. The output changes occur on the positive-going edge of the clock pulse. This part can be used in frequency division applications as well as octal counter or octal decode display applications.

- Fully Static Operation
- DC Clock Input Circuit Allows Slow Rise Times
- Carry Out Output for Cascading
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4022B
- Triple Diode Protection on All Inputs

#### 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   |

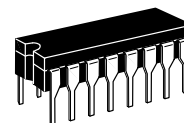
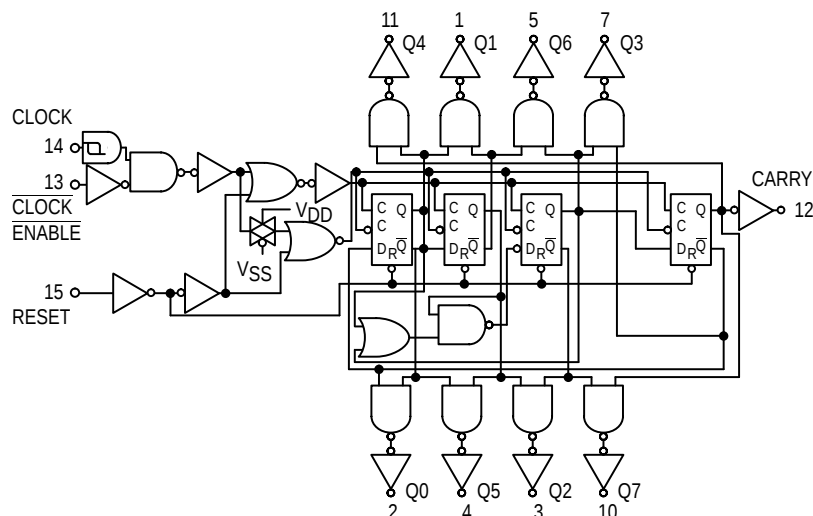
\* Maximum Ratings are those values beyond which damage to the device may occur.

† Temperature Derating:

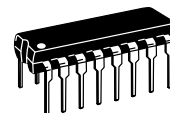
Plastic "P and D/DW" Packages: − 7.0 mW/°C From 65°C To 125°C

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

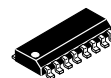
#### LOGIC DIAGRAM



**L SUFFIX**  
CERAMIC  
CASE 620



**P SUFFIX**  
PLASTIC  
CASE 648



**D SUFFIX**  
SOIC  
CASE 751B

#### ORDERING INFORMATION

|            |         |
|------------|---------|
| MC14XXXBCP | Plastic |
| MC14XXXBCL | Ceramic |
| MC14XXXBD  | SOIC    |

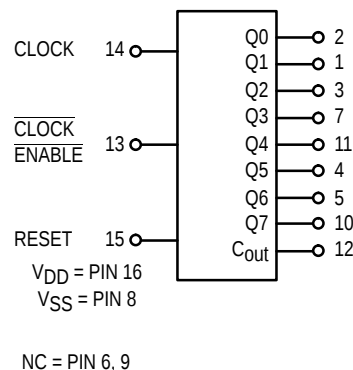
T<sub>A</sub> = − 55° to 125°C for all packages.

#### FUNCTIONAL TRUTH TABLE (Positive Logic)

| Clock | Clock Enable | Reset | Output=n |
|-------|--------------|-------|----------|
| 0     | X            | 0     | n        |
| X     | 1            | 0     | n        |
| ↗     | 0            | 0     | n+1      |
| ↘     | X            | 0     | n        |
| 1     | ↘            | 0     | n+1      |
| X     | ↗            | 0     | n        |
| X     | X            | 1     | Q0       |

X = Don't Care. If n < 4 Carry = 1, Otherwise = 0.

#### BLOCK DIAGRAM



# 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 #     | 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>                                                                                                                                             | 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  |      |
|                                                                                                                                                                                                                                                    | 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)  | 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   |      |
|                                                                                                                                                                                                                                                    | 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>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>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<br>(V <sub>in</sub> = 0)                                                                                                                                                                                                         | C <sub>in</sub>           | —                      | —                                                                                                                                                           | —     | —      | 5.0       | 7.5   | —      | —     | pF   |
| Quiescent Current<br>(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**†<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<br>10<br>15        | I <sub>T</sub> = (0.28 μA/kHz)f + I <sub>DD</sub><br>I <sub>T</sub> = (0.56 μA/kHz)f + I <sub>DD</sub><br>I <sub>T</sub> = (0.85 μA/kHz)f + I <sub>DD</sub> |       |        |           |       |        |       | μAdc |

#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:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

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 = 0.00125.

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.

## PIN ASSIGNMENT

|                 |   |    |                  |
|-----------------|---|----|------------------|
| Q1              | 1 | 16 | V <sub>DD</sub>  |
| Q0              | 2 | 15 | R                |
| Q2              | 3 | 14 | C                |
| Q5              | 4 | 13 | C <sub>E</sub>   |
| Q6              | 5 | 12 | C <sub>out</sub> |
| NC              | 6 | 11 | Q4               |
| Q3              | 7 | 10 | Q7               |
| V <sub>SS</sub> | 8 | 9  | NC               |

NC = NO CONNECTION

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

| Characteristic                                                                                                                                                                                                                                          | Symbol             | V <sub>DD</sub><br>V <sub>dc</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>$t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$                          | $t_{TLH}, t_{THL}$ | 5.0<br>10<br>15                    | —<br>—<br>—       | 100<br>50<br>40   | 200<br>100<br>80   | ns   |
| Propagation Delay Time<br>Reset to Decode Output<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$    | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15                    | —<br>—<br>—       | 500<br>230<br>175 | 1000<br>460<br>350 | ns   |
| Propagation Delay Time<br>Clock to C <sub>out</sub><br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$ | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15                    | —<br>—<br>—       | 400<br>175<br>125 | 800<br>350<br>250  | ns   |
| Propagation Delay Time<br>Clock to Decode Output<br>$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$<br>$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$    | $t_{PLH}, t_{PHL}$ | 5.0<br>10<br>15                    | —<br>—<br>—       | 275<br>125<br>95  | 1000<br>460<br>350 | ns   |
| Turn-Off Delay Time<br>Reset to C <sub>out</sub><br>$t_{PLH} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$<br>$t_{PLH} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$<br>$t_{PLH} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$                               | $t_{PLH}$          | 5.0<br>10<br>15                    | —<br>—<br>—       | 400<br>175<br>125 | 800<br>350<br>250  | ns   |
| Clock Pulse Width                                                                                                                                                                                                                                       | $t_{WH}$           | 5.0<br>10<br>15                    | 250<br>100<br>75  | 125<br>50<br>35   | —<br>—<br>—        | ns   |
| Clock Frequency                                                                                                                                                                                                                                         | $f_{cl}$           | 5.0<br>10<br>15                    | —<br>—<br>—       | 5.0<br>12<br>16   | 2.0<br>5.0<br>6.7  | MHz  |
| Reset Pulse Width                                                                                                                                                                                                                                       | $t_{WH}$           | 5.0<br>10<br>15                    | 500<br>250<br>190 | 250<br>125<br>95  | —<br>—<br>—        | ns   |
| Reset Removal Time                                                                                                                                                                                                                                      | $t_{rem}$          | 5.0<br>10<br>15                    | 750<br>275<br>210 | 375<br>135<br>105 | —<br>—<br>—        | ns   |
| Clock Input Rise and Fall Time                                                                                                                                                                                                                          | $t_{TLH}, t_{THL}$ | 5.0<br>10<br>15                    | No Limit          |                   |                    | —    |
| Clock Enable Setup Time                                                                                                                                                                                                                                 | $t_{su}$           | 5.0<br>10<br>15                    | 350<br>150<br>115 | 175<br>75<br>52   | —<br>—<br>—        | ns   |
| Clock Enable Removal Time                                                                                                                                                                                                                               | $t_{rem}$          | 5.0<br>10<br>15                    | 420<br>200<br>140 | 260<br>100<br>70  | —<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.

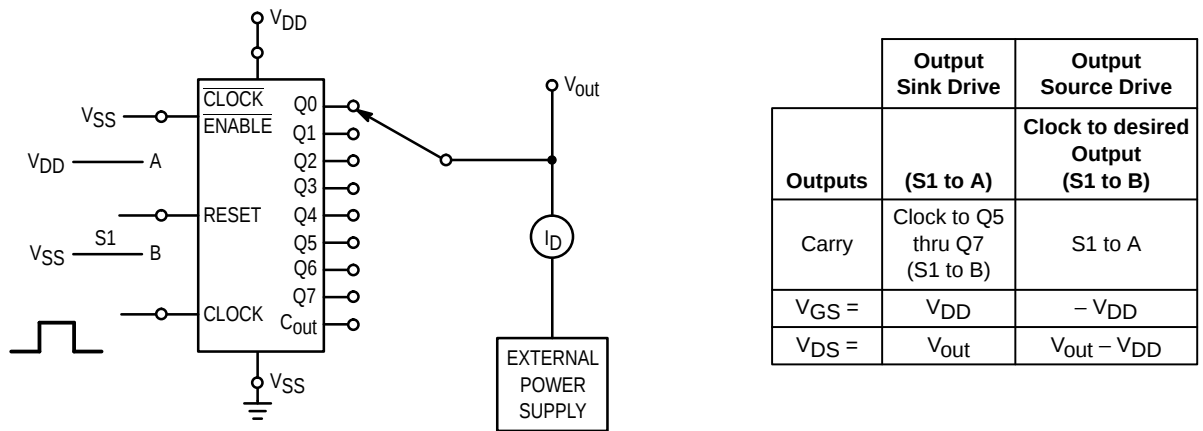


Figure 1. Typical Output Source and Output Sink Characteristics Test Circuit

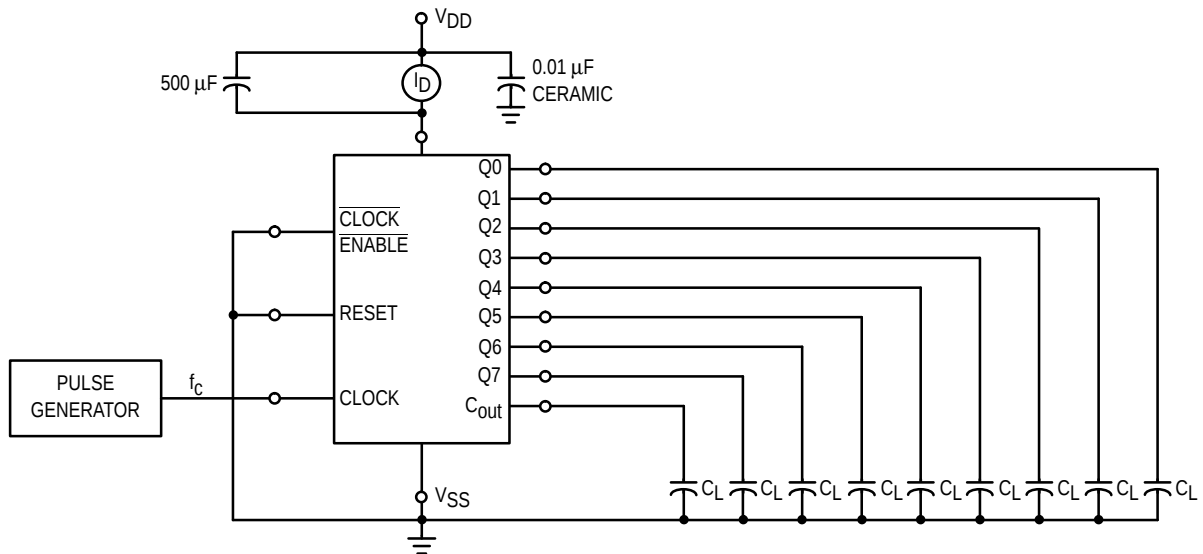


Figure 2. Typical Power Dissipation Test Circuit

## APPLICATIONS INFORMATION

Figure 3 shows a technique for extending the number of decoded output states for the MC14022B. Decoded outputs are sequential within each stage and from stage to stage, with no dead time (except propagation delay).

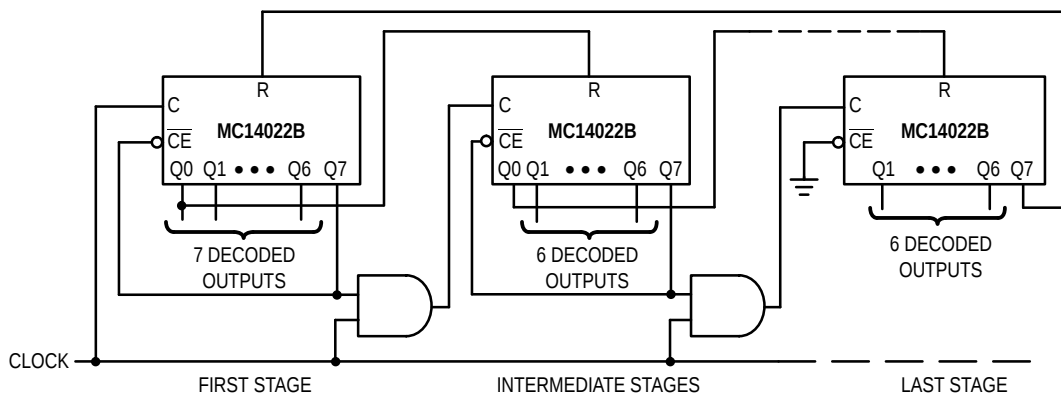


Figure 3. Counter Expansion

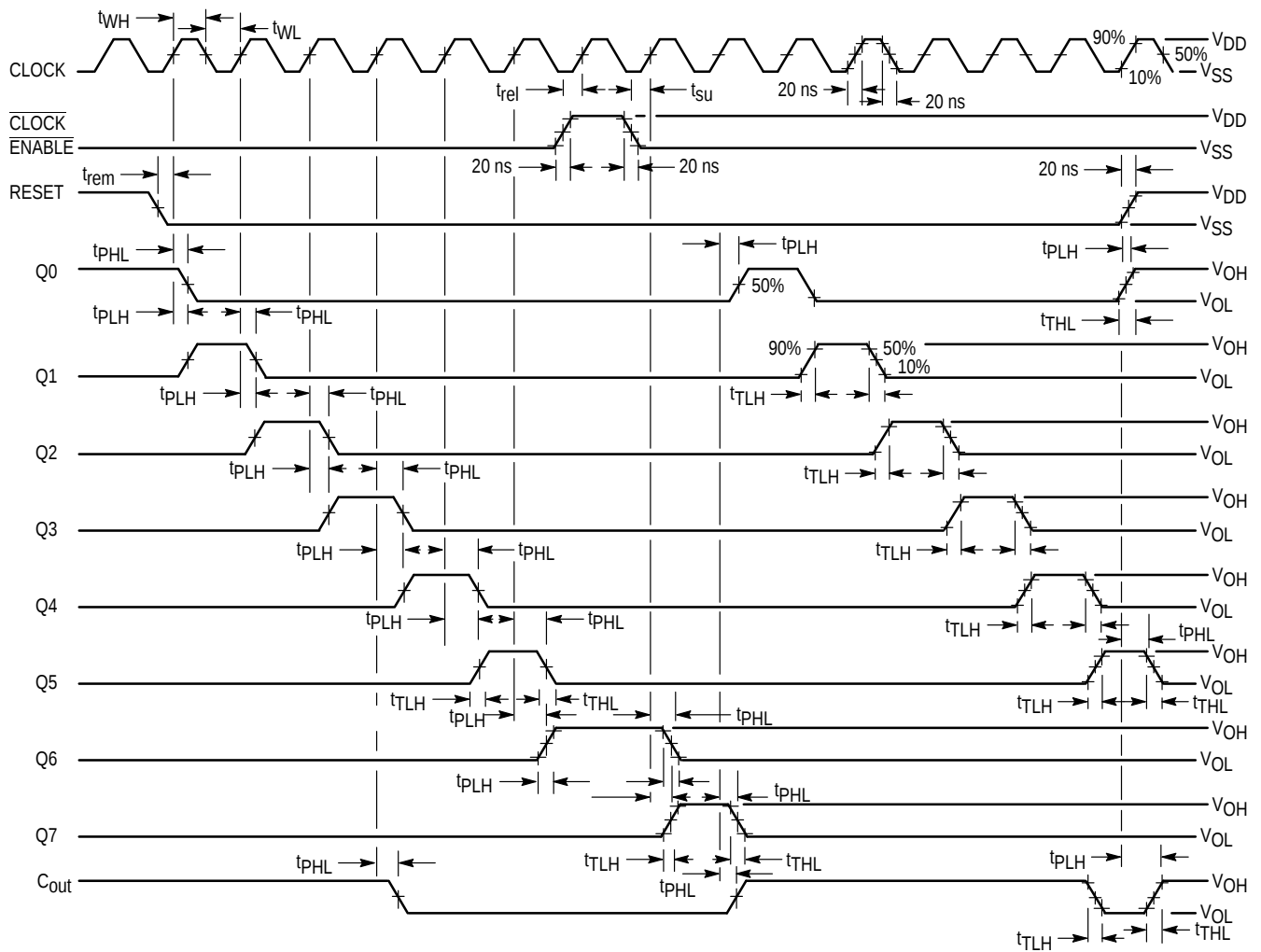
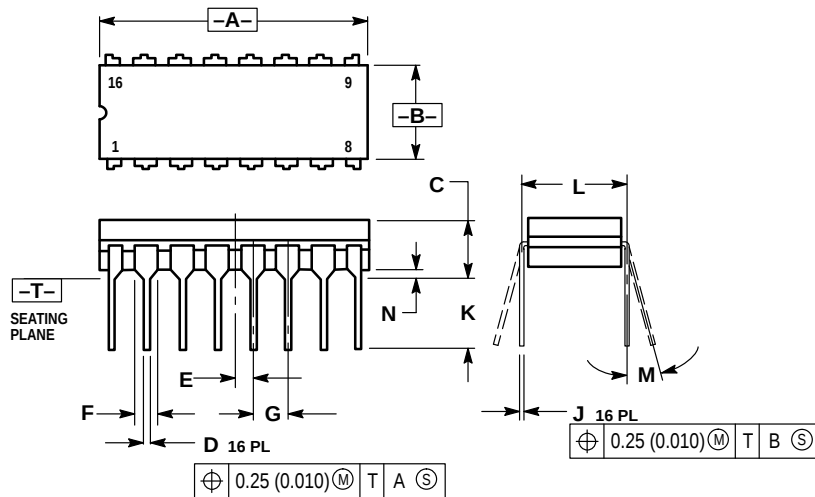


Figure 4. AC Measurement Definition and Functional Waveforms

## OUTLINE DIMENSIONS

### L SUFFIX CERAMIC DIP PACKAGE CASE 620-10 ISSUE V

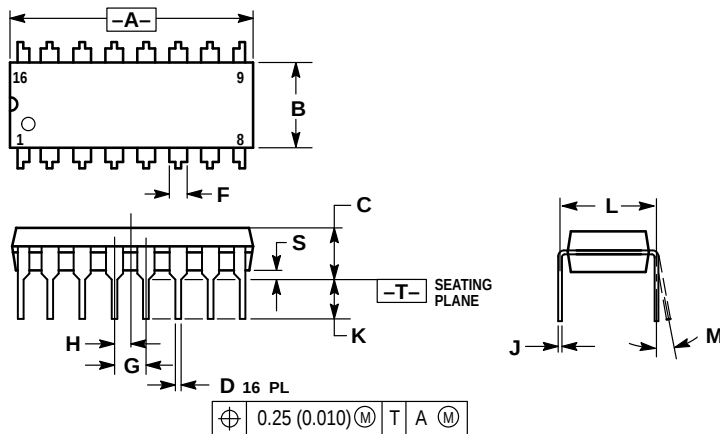


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIMENSION F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.750  | 0.785 | 19.05       | 19.93 |
| B   | 0.240  | 0.295 | 6.10        | 7.49  |
| C   | —      | 0.200 | —           | 5.08  |
| D   | 0.015  | 0.020 | 0.39        | 0.50  |
| E   | 0.050  | BSC   | 1.27        | BSC   |
| F   | 0.055  | 0.065 | 1.40        | 1.65  |
| G   | 0.100  | BSC   | 2.54        | BSC   |
| H   | 0.008  | 0.015 | 0.21        | 0.38  |
| K   | 0.125  | 0.170 | 3.18        | 4.31  |
| L   | 0.300  | BSC   | 7.62        | BSC   |
| M   | 0°     | 15°   | 0°          | 15°   |
| N   | 0.020  | 0.040 | 0.51        | 1.01  |

### P SUFFIX PLASTIC DIP PACKAGE CASE 648-08 ISSUE R



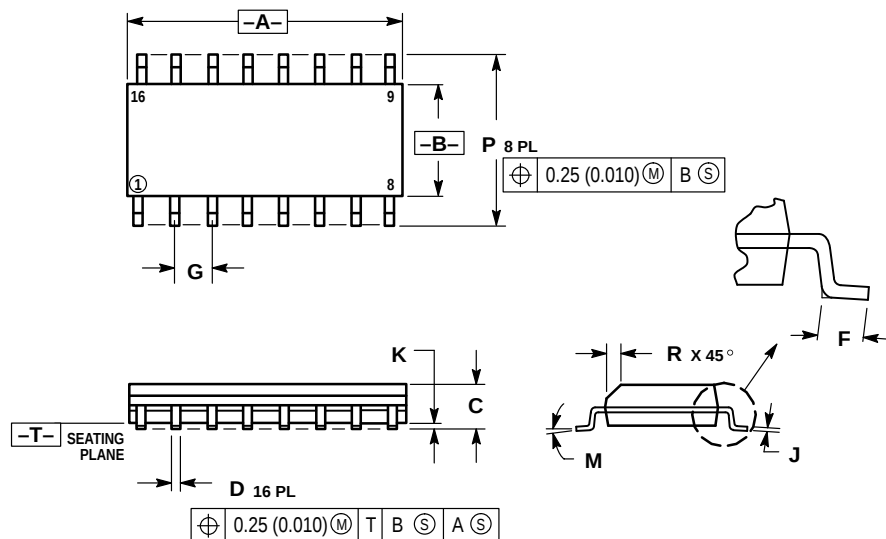
#### NOTES:

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.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.740  | 0.770 | 18.80       | 19.55 |
| B   | 0.250  | 0.270 | 6.35        | 6.85  |
| C   | 0.145  | 0.175 | 3.69        | 4.44  |
| D   | 0.015  | 0.021 | 0.39        | 0.53  |
| F   | 0.040  | 0.70  | 1.02        | 1.77  |
| G   | 0.100  | BSC   | 2.54        | BSC   |
| H   | 0.050  | BSC   | 1.27        | BSC   |
| J   | 0.008  | 0.015 | 0.21        | 0.38  |
| K   | 0.110  | 0.130 | 2.80        | 3.30  |
| L   | 0.295  | 0.305 | 7.50        | 7.74  |
| M   | 0°     | 10°   | 0°          | 10°   |
| S   | 0.020  | 0.040 | 0.51        | 1.01  |

## OUTLINE DIMENSIONS

### D SUFFIX PLASTIC SOIC PACKAGE CASE 751B-05 ISSUE J



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**MOTOROLA**

MC14022B/D

