

# CMOS Hex Buffers/Converters

High-Voltage Types (20-Volt Rating)

Inverting Type: CD4009UB

Non-Inverting Type: CD4010B

■ CD4009UB and CD4010B Hex Buffer/Converters may be used as CMOS to TTL or DTL logic-level converters or CMOS high-sink-current drivers.

The CD4049UB and CD4050B are preferred hex buffer replacements for the CD4009UB and CD4010B, respectively, in all applications except multiplexers. For applications not requiring high sink current or voltage conversion, the CD4069UB Hex Inverter is recommended.

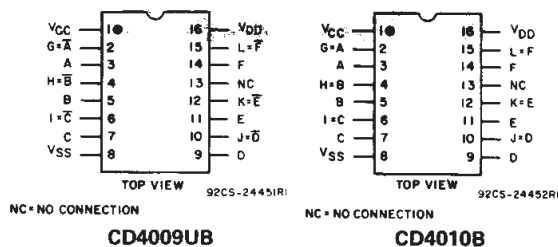
The CD4009UB and CD4010B types are supplied in 16-lead hermetic dual-in-line ceramic packages (F3A suffix), 16-lead dual-in-line plastic packages (E suffix), 16-lead small-outline packages (M, M96, MT, and NSR suffixes), and 16-lead thin shank small-outline packages (PW and PWR suffixes).

## Features:

- 100% tested for quiescent current at 20 V
- Maximum input current of 1  $\mu$ A at 18 V over full package-temperature range; 100 nA at 18 V and 25°C
- 5-V, 10-V, and 15-V parametric ratings

## Applications:

- CMOS to DTL/TTL hex converter
- CMOS current “sink” or “source” driver
- CMOS high-to-low logic-level converter
- Multiplexer — 1 to 6 or 6 to 1



TERMINAL ASSIGNMENTS

## MAXIMUM RATINGS, Absolute-Maximum Values:

### DC SUPPLY-VOLTAGE RANGE, ( $V_{DD}$ )

Voltages referenced to  $V_{SS}$  Terminal) ..... -0.5V to +20V

INPUT VOLTAGE RANGE, ALL INPUTS ..... -0.5V to  $V_{DD}$  +0.5V

DC INPUT CURRENT, ANY ONE INPUT .....  $\pm 10$ mA

### POWER DISSIPATION PER PACKAGE ( $P_D$ ):

For  $T_A = -55^\circ\text{C}$  to  $+100^\circ\text{C}$  ..... 500mW

For  $T_A = +100^\circ\text{C}$  to  $+125^\circ\text{C}$  ..... Derate Linearly at 12mW/ $^\circ\text{C}$  to 200mW

### DEVICE DISSIPATION PER OUTPUT TRANSISTOR

FOR  $T_A = \text{FULL PACKAGE-TEMPERATURE RANGE (All Package Types)}$  ..... 100mW

OPERATING-TEMPERATURE RANGE ( $T_A$ ) .....  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$

STORAGE TEMPERATURE RANGE ( $T_{stg}$ ) .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$

### LEAD TEMPERATURE (DURING SOLDERING):

At distance 1/16  $\pm$  1/32 inch (1.59  $\pm$  0.79mm) from case for 10s max .....  $+265^\circ\text{C}$

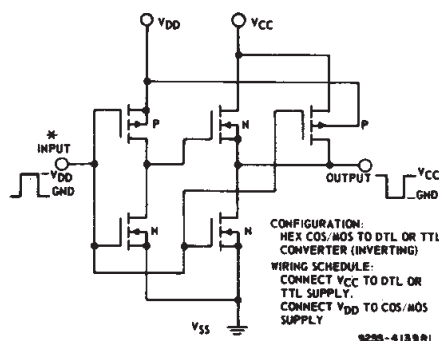


Fig. 1 – Schematic diagram of CD4009UB—  
1 of 6 identical stages.

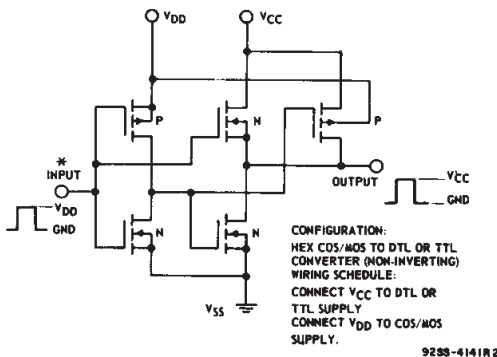


Fig. 2 – Schematic diagram of CD4010B—  
1 of 6 identical stages.

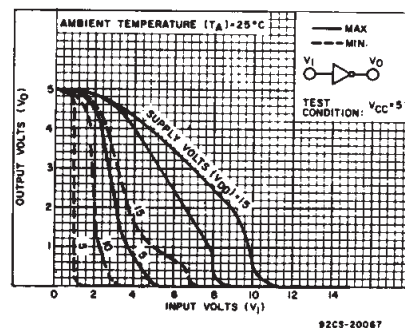
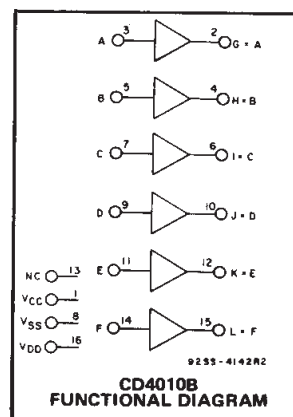
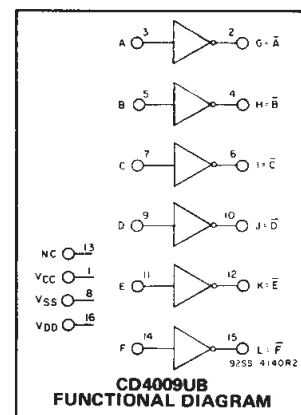
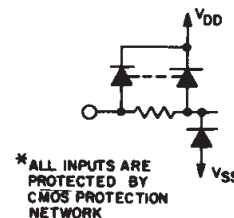


Fig. 3 – Minimum and maximum voltage transfer  
characteristics—CD4009UB.



\*ALL INPUTS ARE  
PROTECTED BY  
CMOS PROTECTION  
NETWORK

## CD4009UB, CD4010B Types

### RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

| CHARACTERISTIC                                                              | LIMITS     |          | UNITS |
|-----------------------------------------------------------------------------|------------|----------|-------|
|                                                                             | MIN.       | MAX.     |       |
| Supply-Voltage Range (For $T_A$ = Full Package Temperature Range), $V_{DD}$ | 3          | 18       | V     |
| $V_{CC}^*$                                                                  | 3          | $V_{DD}$ |       |
| Input Voltage Range ( $V_I$ )                                               | $V_{CC}^*$ | $V_{DD}$ | V     |

\*The CD4009UB and CD4010B have high-to-low level voltage conversion capability but not low-to-high level, therefore it is recommended that  $V_{DD} > V_I > V_{CC}$ .

### STATIC ELECTRICAL CHARACTERISTICS

| CHARAC-<br>TERISTIC                                        | CONDITIONS            |                        |                        | LIMITS AT INDICATED TEMPERATURES (°C) |       |       |       |       |                   |      | UNITS |
|------------------------------------------------------------|-----------------------|------------------------|------------------------|---------------------------------------|-------|-------|-------|-------|-------------------|------|-------|
|                                                            | V <sub>O</sub><br>(V) | V <sub>IN</sub><br>(V) | V <sub>DD</sub><br>(V) | -55                                   | -40   | +85   | +125  | +25   |                   |      |       |
|                                                            |                       |                        |                        |                                       |       |       |       | Min.  | Typ.              | Max. |       |
| Quiescent<br>Device<br>Current, I <sub>DD</sub><br>Max.    | —                     | 0,5                    | 5                      | 1                                     | 1     | 30    | 30    | —     | 0.02              | 1    | μA    |
|                                                            | —                     | 0,10                   | 10                     | 2                                     | 2     | 60    | 60    | —     | 0.02              | 2    |       |
|                                                            | —                     | 0,15                   | 15                     | 4                                     | 4     | 120   | 120   | —     | 0.02              | 4    |       |
|                                                            | —                     | 0,20                   | 20                     | 20                                    | 20    | 600   | 600   | —     | 0.04              | 20   |       |
| Output Low<br>(Sink)<br>Current<br>I <sub>OL</sub> Min.    | 0.4                   | 0,5                    | 4.5                    | 3.2                                   | 3.1   | 2.1   | 1.8   | 2.6   | 3.4               | —    | mA    |
|                                                            | 0.4                   | 0,5                    | 5                      | 3.75                                  | 3.6   | 2.4   | 2.1   | 3     | 4                 | —    |       |
|                                                            | 0.5                   | 0,10                   | 10                     | 10                                    | 9.6   | 6.4   | 5.6   | 8     | 10                | —    |       |
|                                                            | 1.5                   | 0,15                   | 15                     | 30                                    | 40    | 19    | 16    | 24    | 36                | —    |       |
| Output High<br>(Source)<br>Current<br>I <sub>OH</sub> Min. | 4.6                   | 0,5                    | 5                      | -0.25                                 | -0.23 | -0.18 | -0.15 | -0.2  | -0.4              | —    | mA    |
|                                                            | 2.5                   | 0,5                    | 5                      | -1                                    | -0.9  | -0.65 | -0.58 | -0.8  | -1.6              | —    |       |
|                                                            | 9.5                   | 0,10                   | 10                     | -0.55                                 | -0.5  | -0.38 | -0.33 | -0.45 | -0.9              | —    |       |
|                                                            | 13.5                  | 0,15                   | 15                     | -1.65                                 | -1.6  | -1.25 | -1.1  | -1.5  | -3                | —    |       |
| Output Voltage:<br>Low-Level,<br>V <sub>OL</sub> Max.      | —                     | 0,5                    | 5                      | 0.05                                  |       |       |       | —     | 0                 | 0.05 | V     |
|                                                            | —                     | 0,10                   | 10                     | 0.05                                  |       |       |       | —     | 0                 | 0.05 |       |
|                                                            | —                     | 0,15                   | 15                     | 0.05                                  |       |       |       | —     | 0                 | 0.05 |       |
| Output Voltage:<br>High-Level,<br>V <sub>OH</sub> Min.     | —                     | 0,5                    | 5                      | 4.95                                  |       |       |       | 4.95  | 5                 | —    | V     |
|                                                            | —                     | 0,10                   | 10                     | 9.95                                  |       |       |       | 9.95  | 10                | —    |       |
|                                                            | —                     | 0,15                   | 15                     | 14.95                                 |       |       |       | 14.95 | 15                | —    |       |
| Input Low<br>Voltage:<br>V <sub>IL</sub> Max.<br>CD4009UB  | 4.5                   | —                      | 5                      | 1                                     |       |       |       | —     | —                 | 1    | V     |
|                                                            | 9                     | —                      | 10                     | 2                                     |       |       |       | —     | —                 | 2    |       |
|                                                            | 13.5                  | —                      | 15                     | 2.5                                   |       |       |       | —     | —                 | 2.5  |       |
| Input Low<br>Voltage:<br>V <sub>IL</sub> Max.<br>CD4010B   | 0.5                   | —                      | 5                      | 1.5                                   |       |       |       | —     | —                 | 1.5  | V     |
|                                                            | 1                     | —                      | 10                     | 3                                     |       |       |       | —     | —                 | 3    |       |
|                                                            | 1.5                   | —                      | 15                     | 4                                     |       |       |       | —     | —                 | 4    |       |
| Input High<br>Voltage:<br>V <sub>IH</sub> Min.<br>CD4009UB | 0.5                   | —                      | 5                      | 4                                     |       |       |       | 4     | —                 | —    | V     |
|                                                            | 1                     | —                      | 10                     | 8                                     |       |       |       | 8     | —                 | —    |       |
|                                                            | 1.5                   | —                      | 15                     | 12.5                                  |       |       |       | 12.5  | —                 | —    |       |
| Input High<br>Voltage:<br>V <sub>IH</sub> Min.<br>CD4010B  | 4.5                   | —                      | 5                      | 3.5                                   |       |       |       | 3.5   | —                 | —    | V     |
|                                                            | 9                     | —                      | 10                     | 7                                     |       |       |       | 7     | —                 | —    |       |
|                                                            | 13.5                  | —                      | 15                     | 11                                    |       |       |       | 11    | —                 | —    |       |
| Input Current,<br>I <sub>IN</sub> Max.                     | —                     | 0,18                   | 18                     | ±0.1                                  | ±0.1  | ±1    | ±1    | —     | ±10 <sup>-5</sup> | ±0.1 | μA    |



Fig. 4 — Typical voltage transfer characteristics as function of temp.—CD4009UB.



Fig. 5 — Minimum and maximum voltage transfer characteristics ( $V_{DD}=5$ )—CD4010B.



Fig. 6 — Minimum and maximum voltage transfer characteristics ( $V_{DD}=10$ )—CD4010B.



Fig. 7 — Minimum and maximum voltage transfer characteristics ( $V_{DD}=15$ )—CD4010B.

## CD4009UB, CD4010B Types

**DYNAMIC ELECTRICAL CHARACTERISTICS** at  $T_A=25^\circ\text{C}$ ; Input  $t_r, t_f=20\text{ ns}$ ,  
 $C_L=50\text{ pF}$ ,  $R_L=200\text{ K}\Omega$

| CHARACTERISTIC                                    | CONDITIONS      |              |                 | LIMITS<br>ALL PKGS |      | UNIT |
|---------------------------------------------------|-----------------|--------------|-----------------|--------------------|------|------|
|                                                   | $V_{DD}$<br>(V) | $V_I$<br>(V) | $V_{CC}$<br>(V) | TYP.               | MAX. |      |
| Propagation Delay Time:<br>Low-to-High, $t_{PLH}$ | 5               | 5            | 5               | 70                 | 140  | ns   |
|                                                   | 10              | 10           | 10              | 40                 | 80   |      |
|                                                   | 10              | 10           | 5               | 35                 | 70   |      |
|                                                   | 15              | 15           | 15              | 30                 | 60   |      |
|                                                   | 15              | 15           | 5               | 30                 | 60   |      |
| CD4010B                                           | 5               | 5            | 5               | 100                | 200  | ns   |
|                                                   | 10              | 10           | 10              | 50                 | 100  |      |
|                                                   | 10              | 10           | 5               | 50                 | 100  |      |
|                                                   | 15              | 15           | 15              | 35                 | 70   |      |
|                                                   | 15              | 15           | 5               | 35                 | 70   |      |
| High-to-Low, $t_{PHL}$                            | 5               | 5            | 5               | 30                 | 60   | ns   |
|                                                   | 10              | 10           | 10              | 20                 | 40   |      |
|                                                   | 10              | 10           | 5               | 15                 | 30   |      |
|                                                   | 15              | 15           | 15              | 15                 | 30   |      |
|                                                   | 15              | 15           | 5               | 10                 | 20   |      |
| CD4010B                                           | 5               | 5            | 5               | 65                 | 130  | ns   |
|                                                   | 10              | 10           | 10              | 35                 | 70   |      |
|                                                   | 10              | 10           | 5               | 30                 | 70   |      |
|                                                   | 15              | 15           | 15              | 25                 | 50   |      |
|                                                   | 15              | 15           | 5               | 20                 | 40   |      |
| Transition Time:<br>Low-to-High, $t_{TLH}$        | 5               | 5            | 5               | 150                | 350  | ns   |
|                                                   | 10              | 10           | 10              | 75                 | 150  |      |
|                                                   | 15              | 15           | 15              | 55                 | 110  |      |
| High-to-Low, $t_{THL}$                            | 5               | 5            | 5               | 35                 | 70   | ns   |
|                                                   | 10              | 10           | 10              | 20                 | 40   |      |
|                                                   | 15              | 15           | 15              | 15                 | 30   |      |
| Input Capacitance, $C_{IN}$                       |                 |              |                 |                    |      | pF   |
|                                                   |                 |              |                 |                    |      |      |
| CD4009UB                                          | —               | —            | —               | 15                 | 22.5 | pF   |
| CD4010B                                           | —               | —            | —               | 5                  | 7.5  |      |

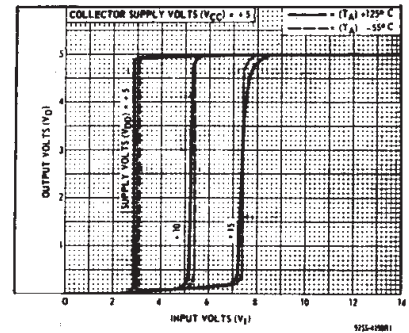


Fig. 8 - Typical voltage transfer characteristics as a function of temperature—CD4010B.

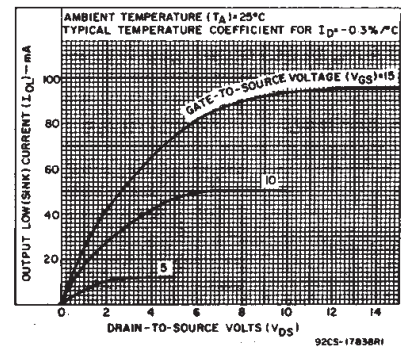


Fig. 9 - Typical output low (sink) current characteristics.

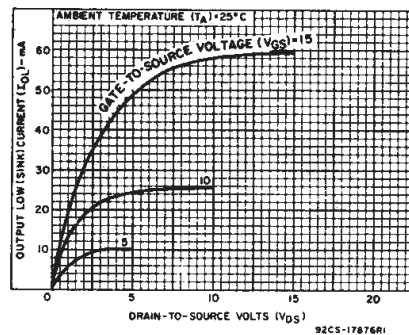


Fig. 10 - Minimum output low (sink) current characteristics.

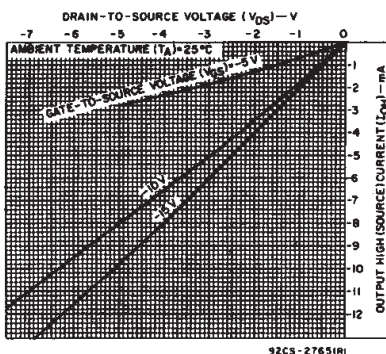


Fig. 11 - Typical output high (source) current characteristics.

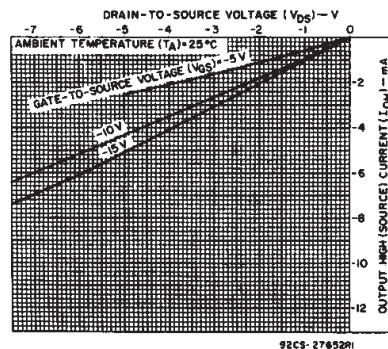


Fig. 12 - Minimum output high (source) current characteristics.

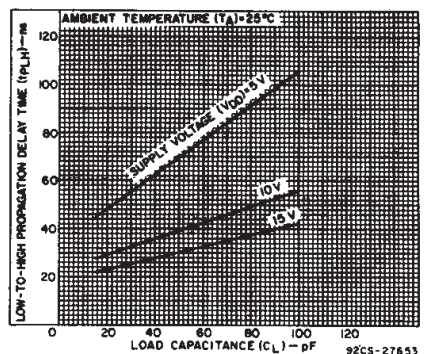


Fig. 13 - Typical low-to-high propagation time vs. load capacitance (CD4009UB).

# CD4009UB, CD4010B Types

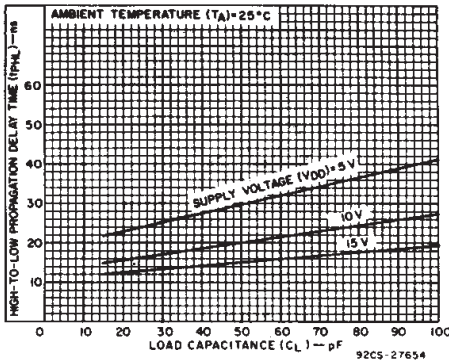


Fig. 14 - Typical high-to-low propagation delay time vs. load capacitance (CD4009UB).

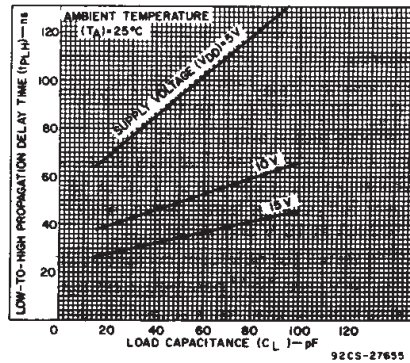


Fig. 15 - Typical low-to-high propagation delay time vs. load capacitance (CD4010B).

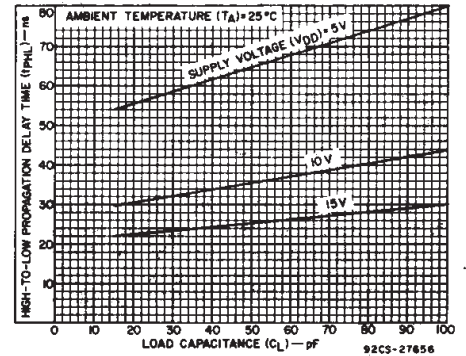


Fig. 16 - Typical high-to-low propagation delay time vs. load capacitance (CD4010B).

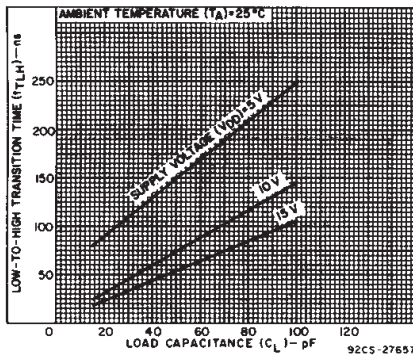


Fig. 17 - Typical low-to-high transition time vs. load capacitance.

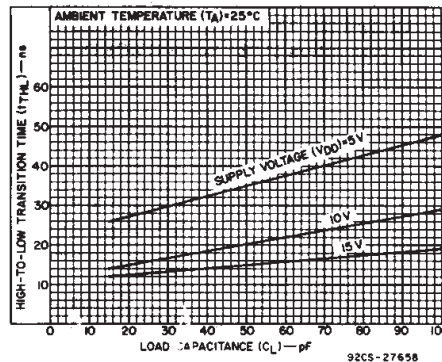


Fig. 18 - Typical high-to-low transition time vs. load capacitance.



Fig. 19 - Typical dissipation characteristics.

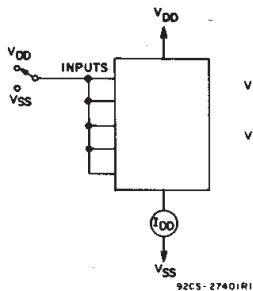


Fig. 20 - Quiescent device current test circuit.

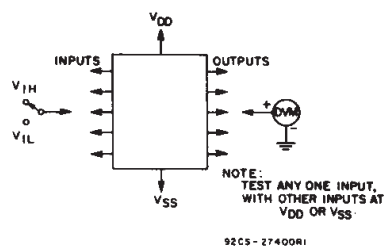


Fig. 21 - Noise immunity test circuit.

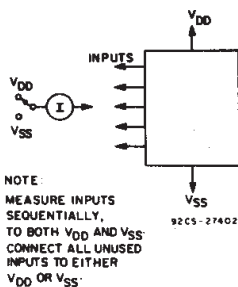
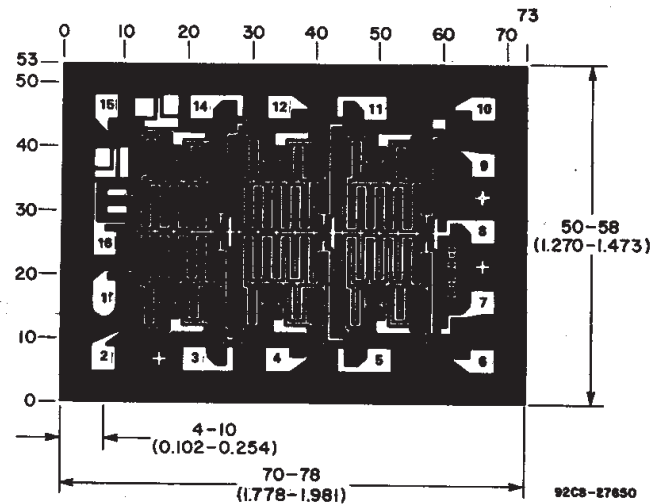


Fig. 22 - Input current test circuit.



Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid Graduations Are In Mils (10<sup>-3</sup> Inch)

Photograph of chip for CD4009UB. Dimensions and pad layout for CD4010B are identical.

3  
COMMERCIAL CMOS  
HIGH VOLTAGE ICs

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup>               |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|--------------------------------------------|
| 89264UKB3T       | OBSOLETE              | CFP          | WR              | 16   |             | None                    | Call TI          | Call TI                                    |
| CD4009UBE        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                             |
| CD4009UBF        | ACTIVE                | CDIP         | J               | 16   | 1           | None                    | Call TI          | Level-NC-NC-NC                             |
| CD4009UBF3A      | ACTIVE                | CDIP         | J               | 16   | 1           | None                    | Call TI          | Level-NC-NC-NC                             |
| CD4009UBM        | ACTIVE                | SOIC         | D               | 16   | 40          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4009UBM96      | ACTIVE                | SOIC         | D               | 16   | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4009UBMT       | ACTIVE                | SOIC         | D               | 16   | 250         | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4009UBNSR      | ACTIVE                | SO           | NS              | 16   | 2000        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4009UBPW       | ACTIVE                | TSSOP        | PW              | 16   | 90          | Pb-Free (RoHS)          | CU NIPDAU        | Level-1-250C-UNLIM                         |
| CD4009UBPWR      | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Pb-Free (RoHS)          | CU NIPDAU        | Level-1-250C-UNLIM                         |
| CD4010BE         | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                             |
| CD4010BF         | ACTIVE                | CDIP         | J               | 16   | 1           | None                    | Call TI          | Level-NC-NC-NC                             |
| CD4010BF3A       | ACTIVE                | CDIP         | J               | 16   | 1           | None                    | Call TI          | Level-NC-NC-NC                             |
| CD4010BM         | ACTIVE                | SOIC         | D               | 16   | 40          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4010BM96       | ACTIVE                | SOIC         | D               | 16   | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4010BMT        | ACTIVE                | SOIC         | D               | 16   | 250         | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4010BNSR       | ACTIVE                | SO           | NS              | 16   | 2000        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1 YEAR/<br>Level-1-235C-UNLIM |
| CD4010BPW        | ACTIVE                | TSSOP        | PW              | 16   | 90          | Pb-Free (RoHS)          | CU NIPDAU        | Level-1-250C-UNLIM                         |
| CD4010BPWR       | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Pb-Free (RoHS)          | CU NIPDAU        | Level-1-250C-UNLIM                         |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



| PINS **<br>DIM | 14                     | 16                     | 18                     | 20                     |
|----------------|------------------------|------------------------|------------------------|------------------------|
| A              | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC |
| B MAX          | 0.785<br>(19,94)       | .840<br>(21,34)        | 0.960<br>(24,38)       | 1.060<br>(26,92)       |
| B MIN          | —                      | —                      | —                      | —                      |
| C MAX          | 0.300<br>(7,62)        | 0.300<br>(7,62)        | 0.310<br>(7,87)        | 0.300<br>(7,62)        |
| C MIN          | 0.245<br>(6,22)        | 0.245<br>(6,22)        | 0.220<br>(5,59)        | 0.245<br>(6,22)        |



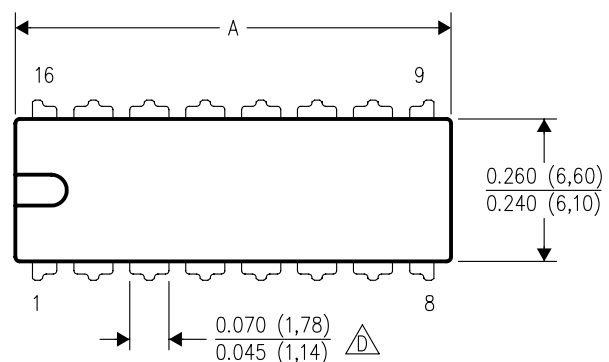
4040083/F 03/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package is hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

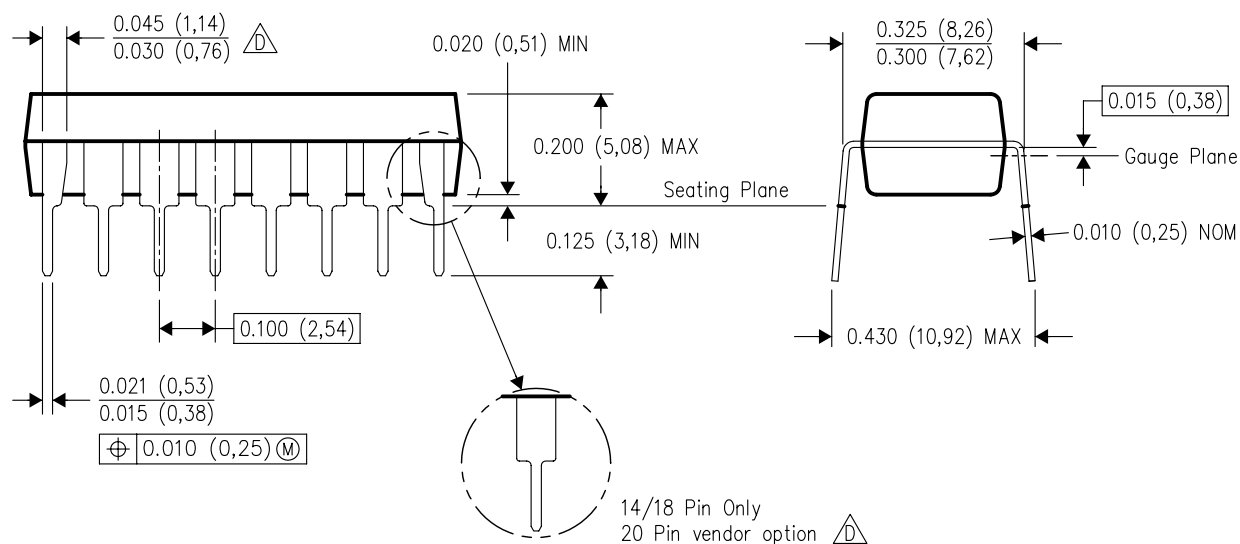
## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **             | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| DIM                 |                  |                  |                  |                  |
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |

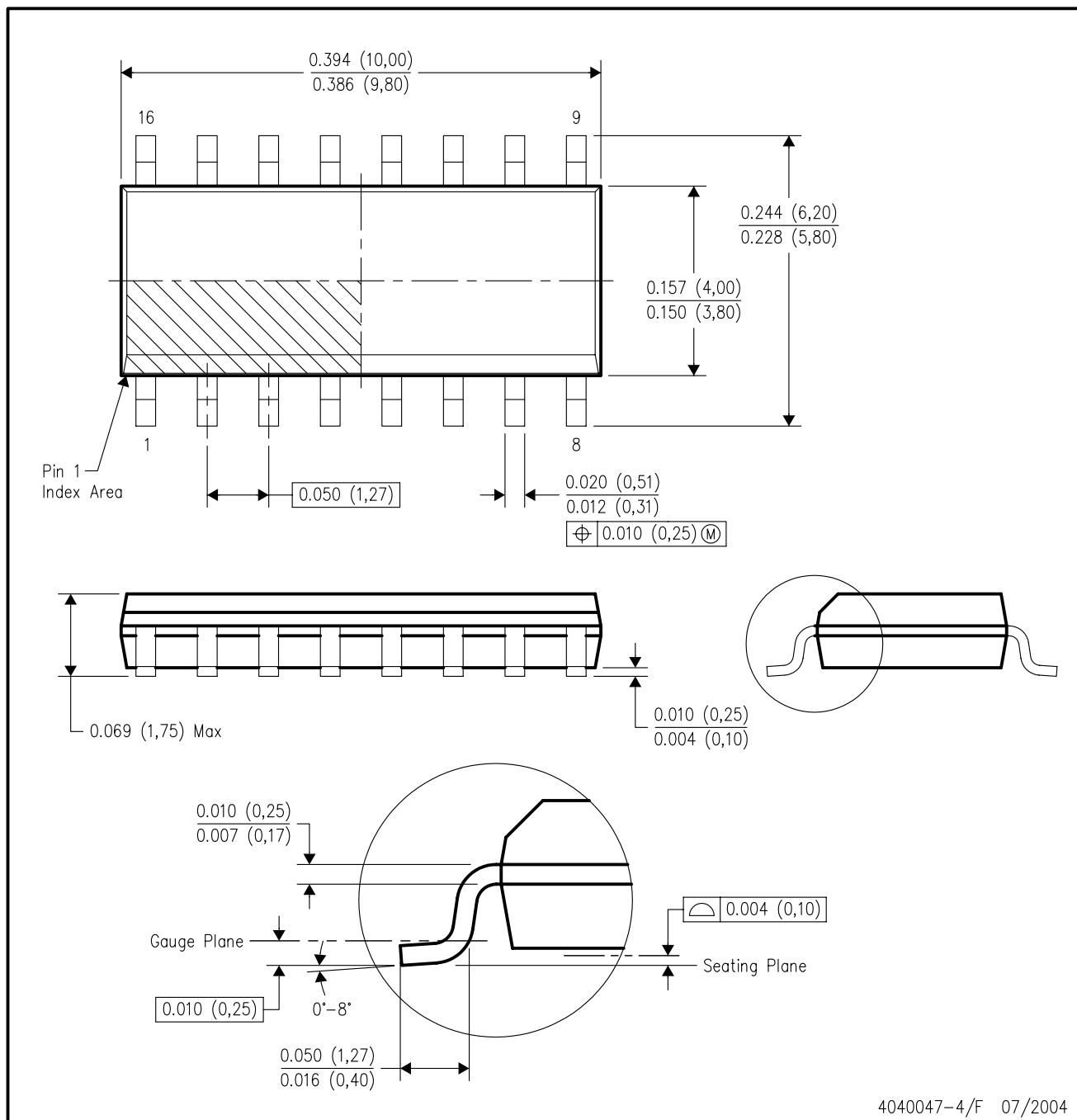


4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

## D (R-PDSO-G16)

## PLASTIC SMALL-OUTLINE PACKAGE



# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

## PW (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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