National Semiconductor

November 1994

# LM741 Operational Amplifier

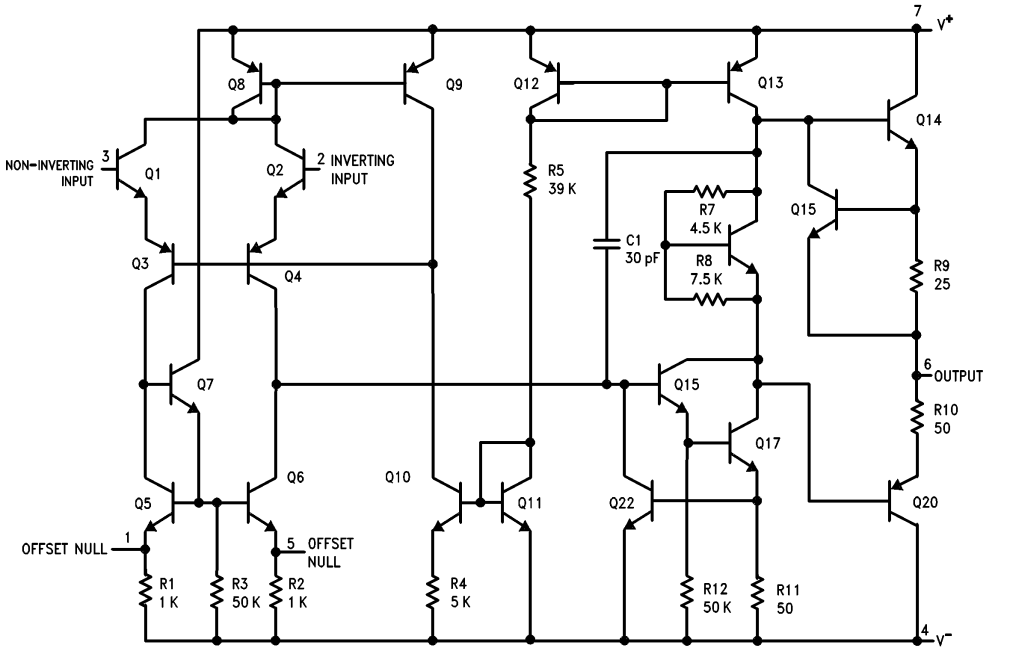
## General Description

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C/LM741E are identical to the LM741/LM741A except that the LM741C/LM741E have their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

## Schematic Diagram

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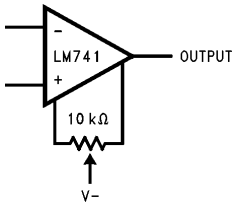
**Offset Nulling Circuit**

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## Absolute Maximum Ratings

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**
**(Note 5)**

| | LM741A | LM741E | LM741 | LM741C |
|---|---|---|---|---|
| Supply Voltage | ±22V | ±22V | ±22V | ±18V |
| Power Dissipation (Note 1) | 500 mW | 500 mW | 500 mW | 500 mW |
| Differential Input Voltage | ±30V | ±30V | ±30V | ±30V |
| Input Voltage (Note 2) | ±15V | ±15V | ±15V | ±15V |
| Output Short Circuit Duration | Continuous | Continuous | Continuous | Continuous |
| Operating Temperature Range | −55°C to +125°C | 0°C to +70°C | −55°C to +125°C | 0°C to +70°C |
| Storage Temperature Range | −65°C to +150°C | −65°C to +150°C | −65°C to +150°C | −65°C to +150°C |
| Junction Temperature | 150°C | 100°C | 150°C | 100°C |
| Soldering Information | | | | |
| N-Package (10 seconds) | 260°C | 260°C | 260°C | 260°C |
| J- or H-Package (10 seconds) | 300°C | 300°C | 300°C | 300°C |
| M-Package | | | | |
| Vapor Phase (60 seconds) | 215°C | 215°C | 215°C | 215°C |
| Infrared (15 seconds) | 215°C | 215°C | 215°C | 215°C |
| See AN-450 ''Surface Mounting Methods and Their Effect on Product Reliability'' for other methods of soldering surface mount devices. | | | | |
| ESD Tolerance (Note 6) | 400V | 400V | 400V | 400V |

## Electrical Characteristics (Note 3)

| Parameter | Conditions | LM741A/LM741E | | | LM741 | | | LM741C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Input Offset Voltage | $T_A = 25°C$<br>$R_S \le 10\ k\Omega$<br>$R_S \le 50\Omega$ | | <br>0.8 | <br>3.0 | | 1.0 | 5.0 | | 2.0 | 6.0 | <br>mV<br>mV |
| | $T_{AMIN} \le T_A \le T_{AMAX}$<br>$R_S \le 50\Omega$<br>$R_S \le 10\ k\Omega$ | | | 4.0 | | | <br>6.0 | | | <br>7.5 | <br>mV<br>mV |
| Average Input Offset Voltage Drift | | | | 15 | | | | | | | μV/°C |
| Input Offset Voltage Adjustment Range | $T_A = 25°C$, $V_S = \pm 20V$ | ±10 | | | | ±15 | | | ±15 | | mV |
| Input Offset Current | $T_A = 25°C$ | | 3.0 | 30 | | 20 | 200 | | 20 | 200 | nA |
| | $T_{AMIN} \le T_A \le T_{AMAX}$ | | | 70 | | 85 | 500 | | | 300 | nA |
| Average Input Offset Current Drift | | | | 0.5 | | | | | | | nA/°C |
| Input Bias Current | $T_A = 25°C$ | | 30 | 80 | | 80 | 500 | | 80 | 500 | nA |
| | $T_{AMIN} \le T_A \le T_{AMAX}$ | | | 0.210 | | | 1.5 | | | 0.8 | μA |
| Input Resistance | $T_A = 25°C$, $V_S = \pm 20V$ | 1.0 | 6.0 | | 0.3 | 2.0 | | 0.3 | 2.0 | | MΩ |
| | $T_{AMIN} \le T_A \le T_{AMAX}$,<br>$V_S = \pm 20V$ | 0.5 | | | | | | | | | MΩ |
| Input Voltage Range | $T_A = 25°C$ | | | | | | | ±12 | ±13 | | V |
| | $T_{AMIN} \le T_A \le T_{AMAX}$ | | | | ±12 | ±13 | | | | | V |
| Large Signal Voltage Gain | $T_A = 25°C$, $R_L \ge 2\ k\Omega$<br>$V_S = \pm 20V$, $V_O = \pm 15V$<br>$V_S = \pm 15V$, $V_O = \pm 10V$ | <br>50 | | | <br>50 | <br>200 | | <br>20 | <br>200 | | <br>V/mV<br>V/mV |
| | $T_{AMIN} \le T_A \le T_{AMAX}$,<br>$R_L \ge 2\ k\Omega$,<br>$V_S = \pm 20V$, $V_O = \pm 15V$<br>$V_S = \pm 15V$, $V_O = \pm 10V$<br>$V_S = \pm 5V$, $V_O = \pm 2V$ | <br><br>32<br><br>10 | | | <br><br><br>25 | <br><br><br> | | <br><br><br>15 | <br><br><br> | | <br><br>V/mV<br>V/mV<br>V/mV |

## Electrical Characteristics (Note 3) (Continued)

| Parameter | Conditions | LM741A/LM741E | | | LM741 | | | LM741C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Output Voltage Swing | $V_S = \pm 20V$ | | | | | | | | | | |
| | $R_L \geq 10\ k\Omega$ | $\pm 16$ | | | | | | | | | V |
| | $R_L \geq 2\ k\Omega$ | $\pm 15$ | | | | | | | | | V |
| | $V_S = \pm 15V$ | | | | | | | | | | |
| | $R_L \geq 10\ k\Omega$ | | | | $\pm 12$ | $\pm 14$ | | $\pm 12$ | $\pm 14$ | | V |
| | $R_L \geq 2\ k\Omega$ | | | | $\pm 10$ | $\pm 13$ | | $\pm 10$ | $\pm 13$ | | V |
| Output Short Circuit Current | $T_A = 25°C$ | 10 | 25 | 35 | | 25 | | | 25 | | mA |
| | $T_{AMIN} \leq T_A \leq T_{AMAX}$ | 10 | | 40 | | | | | | | mA |
| Common-Mode Rejection Ratio | $T_{AMIN} \leq T_A \leq T_{AMAX}$ | | | | | | | | | | |
| | $R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$ | | | | 70 | 90 | | 70 | 90 | | dB |
| | $R_S \leq 50\Omega$, $V_{CM} = \pm 12V$ | 80 | 95 | | | | | | | | dB |
| Supply Voltage Rejection Ratio | $T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$ to $V_S = \pm 5V$ | | | | | | | | | | |
| | $R_S \leq 50\Omega$ | 86 | 96 | | | | | | | | dB |
| | $R_S \leq 10\ k\Omega$ | | | | 77 | 96 | | 77 | 96 | | dB |
| Transient Response | $T_A = 25°C$, Unity Gain | | | | | | | | | | |
| Rise Time | | | 0.25 | 0.8 | | 0.3 | | | 0.3 | | $\mu s$ |
| Overshoot | | | 6.0 | 20 | | 5 | | | 5 | | % |
| Bandwidth (Note 4) | $T_A = 25°C$ | 0.437 | 1.5 | | | | | | | | MHz |
| Slew Rate | $T_A = 25°C$, Unity Gain | 0.3 | 0.7 | | | 0.5 | | | 0.5 | | $V/\mu s$ |
| Supply Current | $T_A = 25°C$ | | | | | 1.7 | 2.8 | | 1.7 | 2.8 | mA |
| Power Consumption | $T_A = 25°C$ | | | | | | | | | | |
| | $V_S = \pm 20V$ | | 80 | 150 | | | | | | | mW |
| | $V_S = \pm 15V$ | | | | | 50 | 85 | | 50 | 85 | mW |
| LM741A | $V_S = \pm 20V$ | | | | | | | | | | |
| | $T_A = T_{AMIN}$ | | | 165 | | | | | | | mW |
| | $T_A = T_{AMAX}$ | | | 135 | | | | | | | mW |
| LM741E | $V_S = \pm 20V$ | | | | | | | | | | |
| | $T_A = T_{AMIN}$ | | | 150 | | | | | | | mW |
| | $T_A = T_{AMAX}$ | | | 150 | | | | | | | mW |
| LM741 | $V_S = \pm 15V$ | | | | | | | | | | |
| | $T_A = T_{AMIN}$ | | | | | 60 | 100 | | | | mW |
| | $T_A = T_{AMAX}$ | | | | | 45 | 75 | | | | mW |

**Note 1:** For operation at elevated temperatures, these devices must be derated based on thermal resistance, and $T_j$ max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.

| Thermal Resistance | Cerdip (J) | DIP (N) | HO8 (H) | SO-8 (M) |
|---|---|---|---|---|
| $\theta_{jA}$ (Junction to Ambient) | 100°C/W | 100°C/W | 170°C/W | 195°C/W |
| $\theta_{jC}$ (Junction to Case) | N/A | N/A | 25°C/W | N/A |

**Note 2:** For supply voltages less than $\pm 15V$, the absolute maximum input voltage is equal to the supply voltage.

**Note 3:** Unless otherwise specified, these specifications apply for $V_S = \pm 15V$, $-55°C \leq T_A \leq +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \leq T_A \leq +70°C$.

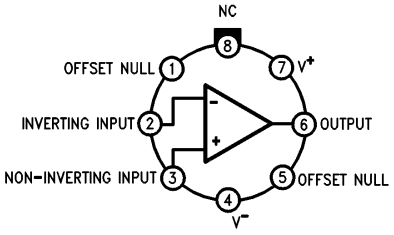
**Note 4:** Calculated value from: BW (MHz) = 0.35/Rise Time($\mu s$).

**Note 5:** For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

**Note 6:** Human body model, 1.5 $k\Omega$ in series with 100 pF.

## Connection Diagrams

**Metal Can Package**

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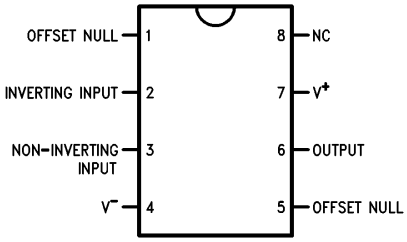
**Order Number LM741H, LM741H/883*, LM741AH/883 or LM741CH**
**See NS Package Number H08C**

**Dual-In-Line or S.O. Package**

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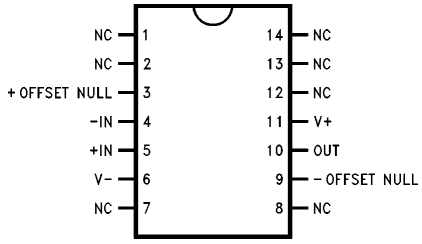
**Order Number LM741J, LM741J/883, LM741CM, LM741CN or LM741EN**
**See NS Package Number J08A, M08A or N08E**

**Ceramic Dual-In-Line Package**

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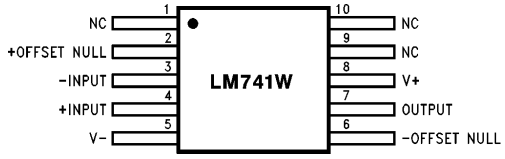
**Order Number LM741J-14/883*, LM741AJ-14/883****
**See NS Package Number J14A**

*also available per JM38510/10101

**also available per JM38510/10102

**Ceramic Flatpak**

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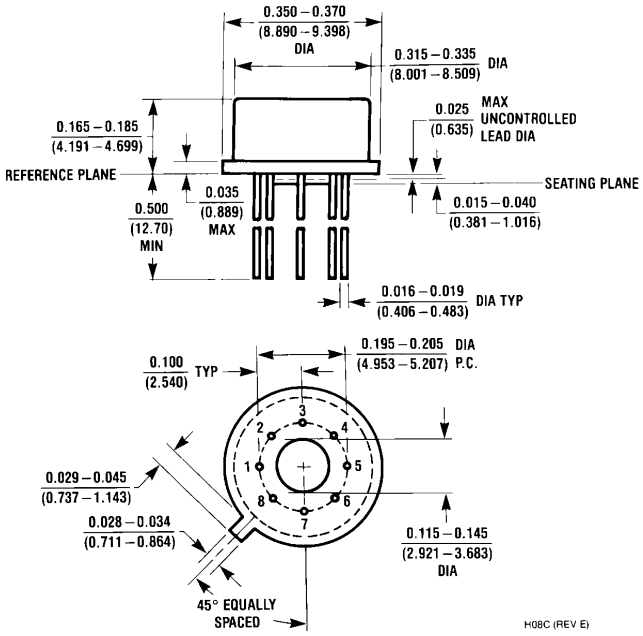
**Order Number LM741W/883**
**See NS Package Number W10A**

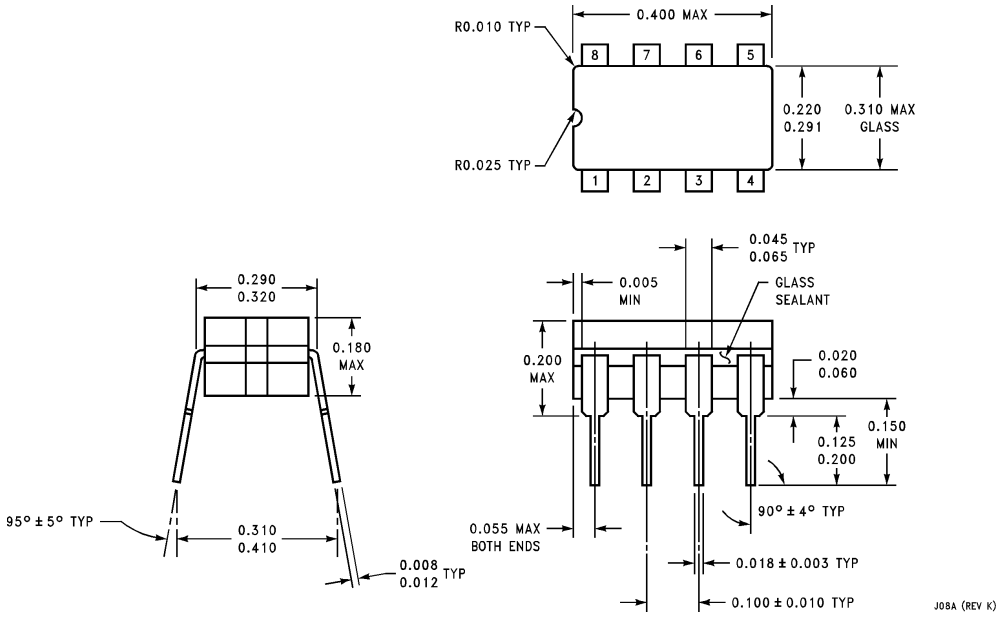
*LM741H is available per JM38510/10101

## Physical Dimensions inches (millimeters)

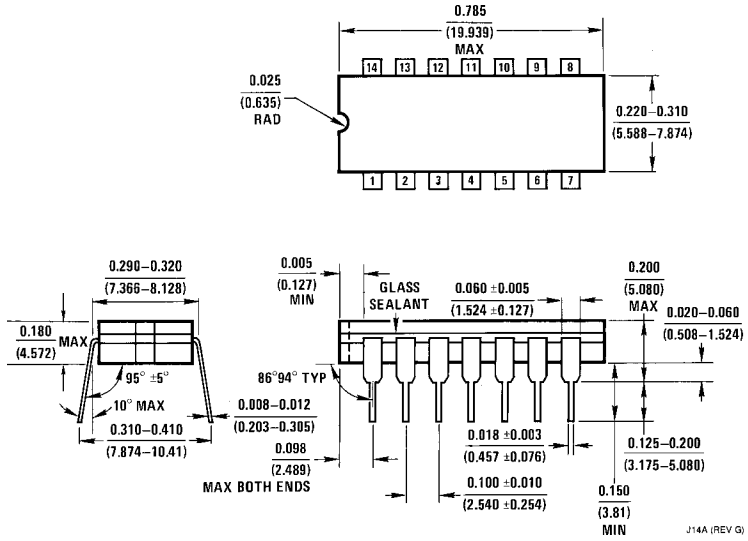



**Metal Can Package (H)**
**Order Number LM741H, LM741H/883, LM741AH/883, LM741CH or LM741EH**
**NS Package Number H08C**

## Physical Dimensions inches (millimeters) (Continued)

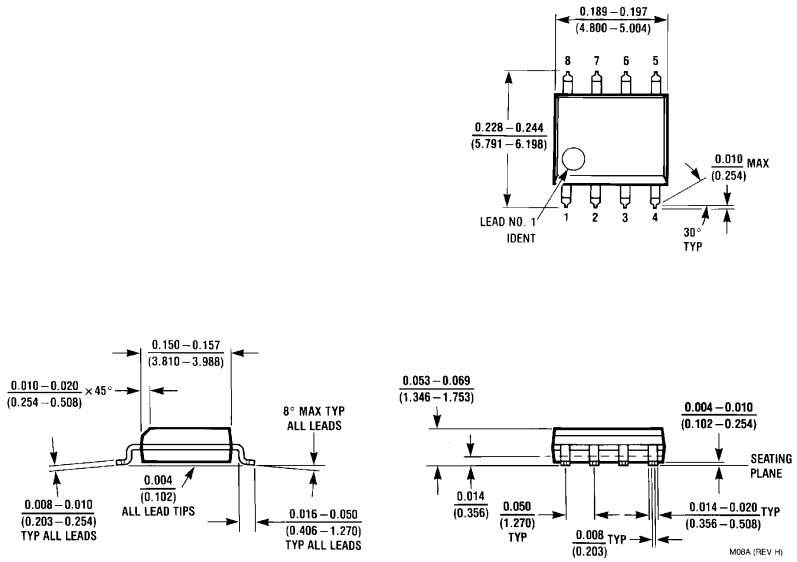



**Ceramic Dual-In-Line Package (J)**
**Order Number LM741CJ or LM741J/883**
**NS Package Number J08A**

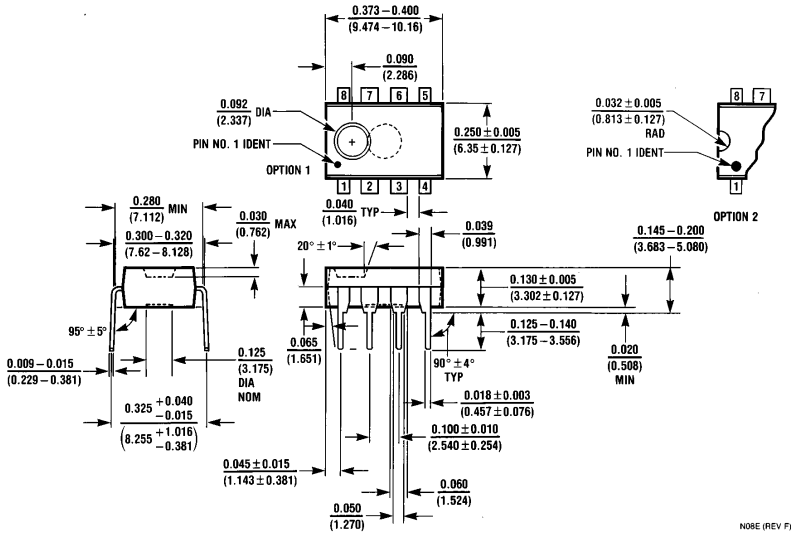



**Ceramic Dual-In-Line Package (J)**
**Order Number LM741J-14/883 or LM741AJ-14/883**
**NS Package Number J14A**

## Physical Dimensions inches (millimeters) (Continued)

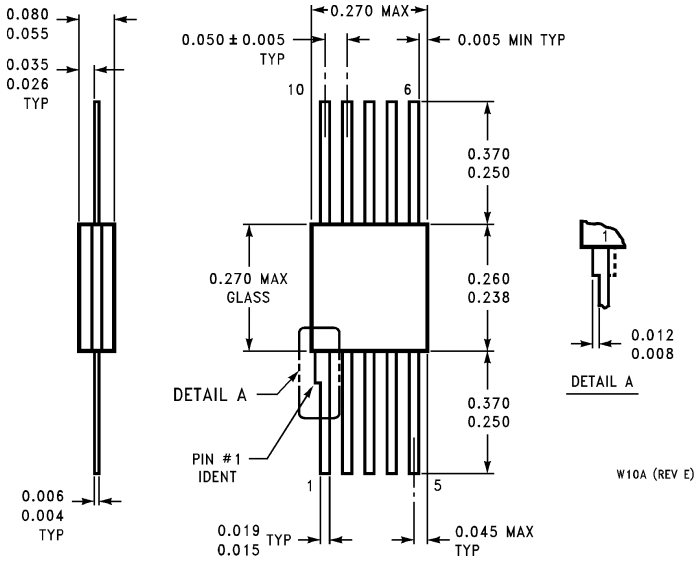



**Small Outline Package (M)**
**Order Number LM741CM**
**NS Package Number M08A**




**Dual-In-Line Package (N)**
**Order Number LM741CN or LM741EN**
**NS Package Number N08E**

## Physical Dimensions inches (millimeters) (Continued)




**10-Lead Ceramic Flatpak (W)**
**Order Number LM741W/883**
**NS Package Number W10A**

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