National Semiconductor

January 2000

# LM78LXX Series
# 3-Terminal Positive Regulators

## General Description

The LM78LXX series of three terminal positive regulators is available with several fixed output voltages making them useful in a wide range of applications. When used as a zener diode/resistor combination replacement, the LM78LXX usually results in an effective output impedance improvement of two orders of magnitude, and lower quiescent current. These regulators can provide local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow the LM78LXX to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment.

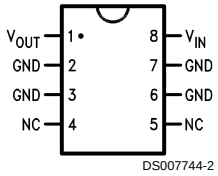
The LM78LXX is available in the plastic TO-92 (Z) package, the plastic SO-8 (M) package and a chip sized package (8-Bump micro SMD) using National's micro SMD package technology. With adequate heat sinking the regulator can deliver 100 mA output current. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistors is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

## Features

- LM78L05 in micro SMD package
- Output voltage tolerances of ±5% over the temperature range
- Output current of 100 mA
- Internal thermal overload protection
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-92 and plastic SO-8 low profile packages
- No external components
- Output voltages of 5.0V, 6.2V, 8.2V, 9.0V, 12V, 15V

## Connection Diagrams

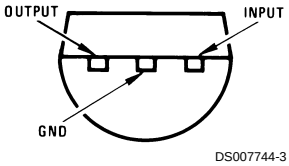
**SO-8 Plastic (M)**
**(Narrow Body)**




DS007744-2

**Top View**

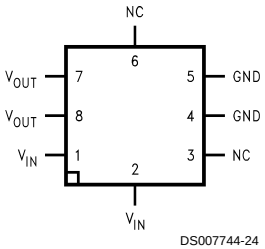
**(TO-92)**
**Plastic Package (Z)**




DS007744-3

**Bottom View**

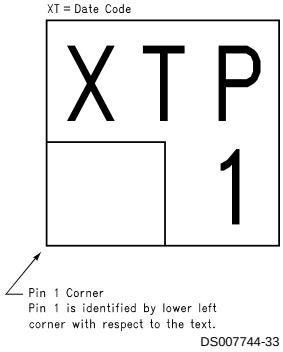
**8-Bump micro SMD**




DS007744-24

**Top View**
**(Bump Side Down)**

**micro SMD Marking Orientation**




DS007744-33

**Top View**

## Absolute Maximum Ratings (Note 1)

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

| | |
|---|---|
| Power Dissipation (Note 5) | Internally Limited |
| Input Voltage | 35V |
| Storage Temperature | −65˚C to +150˚C |
| Operating Junction Temperature | |
| SO-8 | 0˚C to 125˚C |
| micro SMD | −40˚C to 85˚C |
| Soldering Information | |
| Infrared or Convection (20 sec.) | 235˚C |
| Wave Soldering (10 sec.) | 260˚C (lead time) |
| ESD Susceptibility (Note 2) | 1kV |

## LM78LXX Electrical Characteristics

Limits in standard typeface are for $T_J$ = 25˚C, **Bold typeface applies over 0˚C to 125˚C for SO-8 package and −40˚C to 85˚C for micro SMD package.** Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise specified: $I_O$ = 40 mA, $C_I$ = 0.33 µF, $C_O$ = 0.1 µF.

### LM78L05

Unless otherwise specified, $V_{IN}$ = 10V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 4.8 | 5 | 5.2 | V |
| | | 7V ≤ $V_{IN}$ ≤ 20V<br>1 mA ≤ $I_O$ ≤ 40 mA<br>(Note 3) | **4.75** | | **5.25** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA<br>(Note 3) | **4.75** | | **5.25** | |
| $\Delta V_O$ | Line Regulation | 7V ≤ $V_{IN}$ ≤ 20V | | 18 | 75 | mV |
| | | 8V ≤ $V_{IN}$ ≤ 20V | | 10 | 54 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 20 | 60 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 5 | 30 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 8V ≤ $V_{IN}$ ≤ 20V | | | **1.0** | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | f = 10 Hz to 100 kHz<br>(Note 4) | | 40 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz<br>8V ≤ $V_{IN}$ ≤ 16V | 47 | 62 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −0.65 | | mV/˚C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 6.7 | 7 | V |
| $\theta_{JA}$ | Thermal Resistance (8-Bump micro SMD) | | | 230.9 | | ˚C/W |

### LM78L62AC

Unless otherwise specified, $V_{IN}$ = 12V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 5.95 | 6.2 | 6.45 | V |
| | | 8.5V ≤ $V_{IN}$ ≤ 20V<br>1 mA ≤ $I_O$ ≤ 40 mA<br>(Note 3) | **5.9** | | **6.5** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA<br>(Note 3) | **5.9** | | **6.5** | |
| $\Delta V_O$ | Line Regulation | 8.5V ≤ $V_{IN}$ ≤ 20V | | 65 | 175 | mV |
| | | 9V ≤ $V_{IN}$ ≤ 20V | | 55 | 125 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 13 | 80 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 6 | 40 | |

## LM78L62AC (Continued)

Unless otherwise specified, $V_{IN}$ = 12V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 8V ≤ $V_{IN}$ ≤ 20V | | | **1.5** | mA |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | f = 10 Hz to 100 kHz (Note 4) | | 50 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz 10V ≤ $V_{IN}$ ≤ 20V | 40 | 46 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −0.75 | | mV/°C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 7.9 | | V |

## LM78L82AC

Unless otherwise specified, $V_{IN}$ = 14V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 7.87 | 8.2 | 8.53 | V |
| | | 11V ≤ $V_{IN}$ ≤ 23V 1 mA ≤ $I_O$ ≤ 40 mA (Note 3) | **7.8** | | **8.6** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA (Note 3) | **7.8** | | **8.6** | |
| $\Delta V_O$ | Line Regulation | 11V ≤ $V_{IN}$ ≤ 23V | | 80 | 175 | mV |
| | | 12V ≤ $V_{IN}$ ≤ 23V | | 70 | 125 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 15 | 80 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 8 | 40 | |
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 12V ≤ $V_{IN}$ ≤ 23V | | | **1.5** | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | f = 10 Hz to 100 kHz (Note 4) | | 60 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz 12V ≤ $V_{IN}$ ≤ 22V | 39 | 45 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −0.8 | | mV/°C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 9.9 | | V |

## LM78L09AC

Unless otherwise specified, $V_{IN}$ = 15V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 8.64 | 9.0 | 9.36 | V |
| | | 11.5V ≤ $V_{IN}$ ≤ 24V 1 mA ≤ $I_O$ ≤ 40 mA (Note 3) | **8.55** | | **9.45** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA (Note 3) | **8.55** | | **9.45** | |

## LM78L09AC (Continued)

Unless otherwise specified, $V_{IN}$ = 15V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $\Delta V_O$ | Line Regulation | 11.5V ≤ $V_{IN}$ ≤ 24V | | 100 | 200 | mV |
| | | 13V ≤ $V_{IN}$ ≤ 24V | | 90 | 150 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 20 | 90 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 10 | 45 | |
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 11.5V ≤ $V_{IN}$ ≤ 24V | | | **1.5** | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | | | 70 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz<br>15V ≤ $V_{IN}$ ≤ 25V | 38 | 44 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −0.9 | | mV/°C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 10.7 | | V |

## LM78L12AC

Unless otherwise specified, $V_{IN}$ = 19V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 11.5 | 12 | 12.5 | V |
| | | 14.5V ≤ $V_{IN}$ ≤ 27V<br>1 mA ≤ $I_O$ ≤ 40 mA<br>(Note 3) | **11.4** | | **12.6** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA<br>(Note 3) | **11.4** | | **12.6** | |
| $\Delta V_O$ | Line Regulation | 14.5V ≤ $V_{IN}$ ≤ 27V | | 30 | 180 | mV |
| | | 16V ≤ $V_{IN}$ ≤ 27V | | 20 | 110 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 30 | 100 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 10 | 50 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 16V ≤ $V_{IN}$ ≤ 27V | | | **1** | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | | | 80 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz<br>15V ≤ $V_{IN}$ ≤ 25 | 40 | 54 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −1.0 | | mV/°C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 13.7 | 14.5 | V |

## LM78L15AC

Unless otherwise specified, $V_{IN}$ = 23V

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | 14.4 | 15.0 | 15.6 | V |
| | | 17.5V ≤ $V_{IN}$ ≤ 30V<br>1 mA ≤ $I_O$ ≤ 40 mA<br>(Note 3) | **14.25** | | **15.75** | |
| | | 1 mA ≤ $I_O$ ≤ 70 mA<br>(Note 3) | **14.25** | | **15.75** | |
| $\Delta V_O$ | Line Regulation | 17.5V ≤ $V_{IN}$ ≤ 30V | | 37 | 250 | mV |
| | | 20V ≤ $V_{IN}$ ≤ 30V | | 25 | 140 | |
| $\Delta V_O$ | Load Regulation | 1 mA ≤ $I_O$ ≤ 100 mA | | 35 | 150 | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | 12 | 75 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 20V ≤ $V_{IN}$ ≤ 30V | | | **1** | |
| | | 1 mA ≤ $I_O$ ≤ 40 mA | | | **0.1** | |
| $V_n$ | Output Noise Voltage | | | 90 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz<br>18.5V ≤ $V_{IN}$ ≤ 28.5V | 37 | 51 | | dB |
| $I_{PK}$ | Peak Output Current | | | 140 | | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Average Output Voltage Tempco | $I_O$ = 5 mA | | −1.3 | | mV/˚C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 16.7 | 17.5 | V |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device outside of its stated operating conditions.

**Note 2:** Human body model, 1.5 kΩ in series with 100 pF.

**Note 3:** Power dissipation ≤ 0.75W.

**Note 4:** Recommended minimum load capacitance of 0.01 µF to limit high frequency noise.

**Note 5:** Typical thermal resistance values for the packages are:

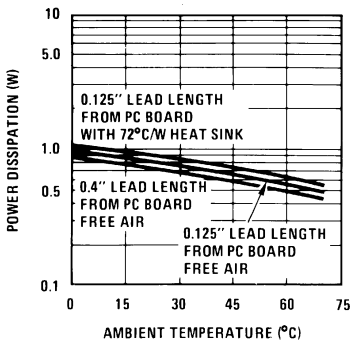
**Z** Package: $\theta_{JC}$ = 60 ˚C/W, = $\theta_{JA}$ = 230 ˚C/W

**M** Package: $\theta_{JA}$ = 180 ˚C/W

**micro SMD** Package: $\theta_{JA}$ = 230.9˚C/W

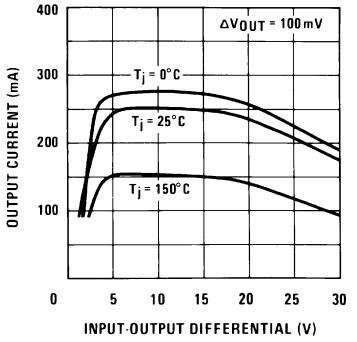
# Typical Performance Characteristics

### Maximum Average Power Dissipation (Z Package)



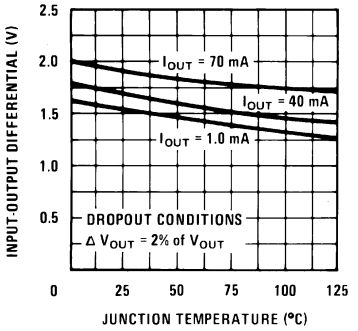

DS007744-14

### Peak Output Current



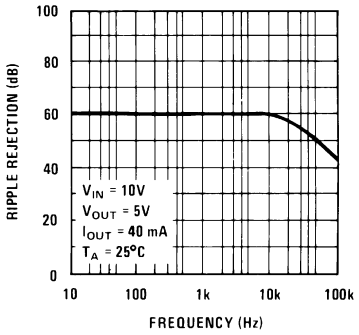

DS007744-16

### Dropout Voltage



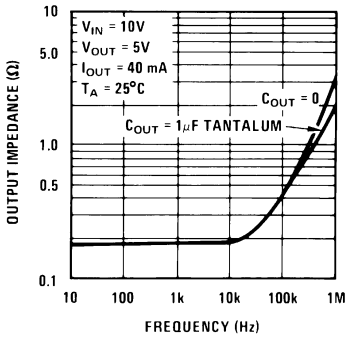

DS007744-17

### Ripple Rejection



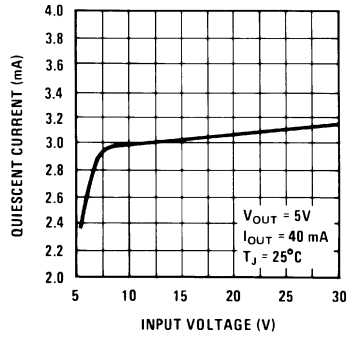

DS007744-18

### Output Impedance



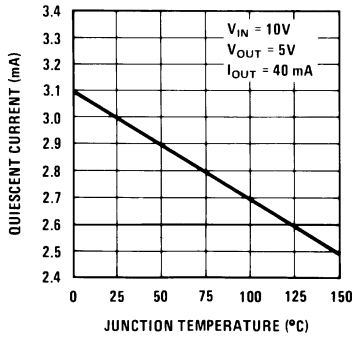

DS007744-19

### Quiescent Current




DS007744-20

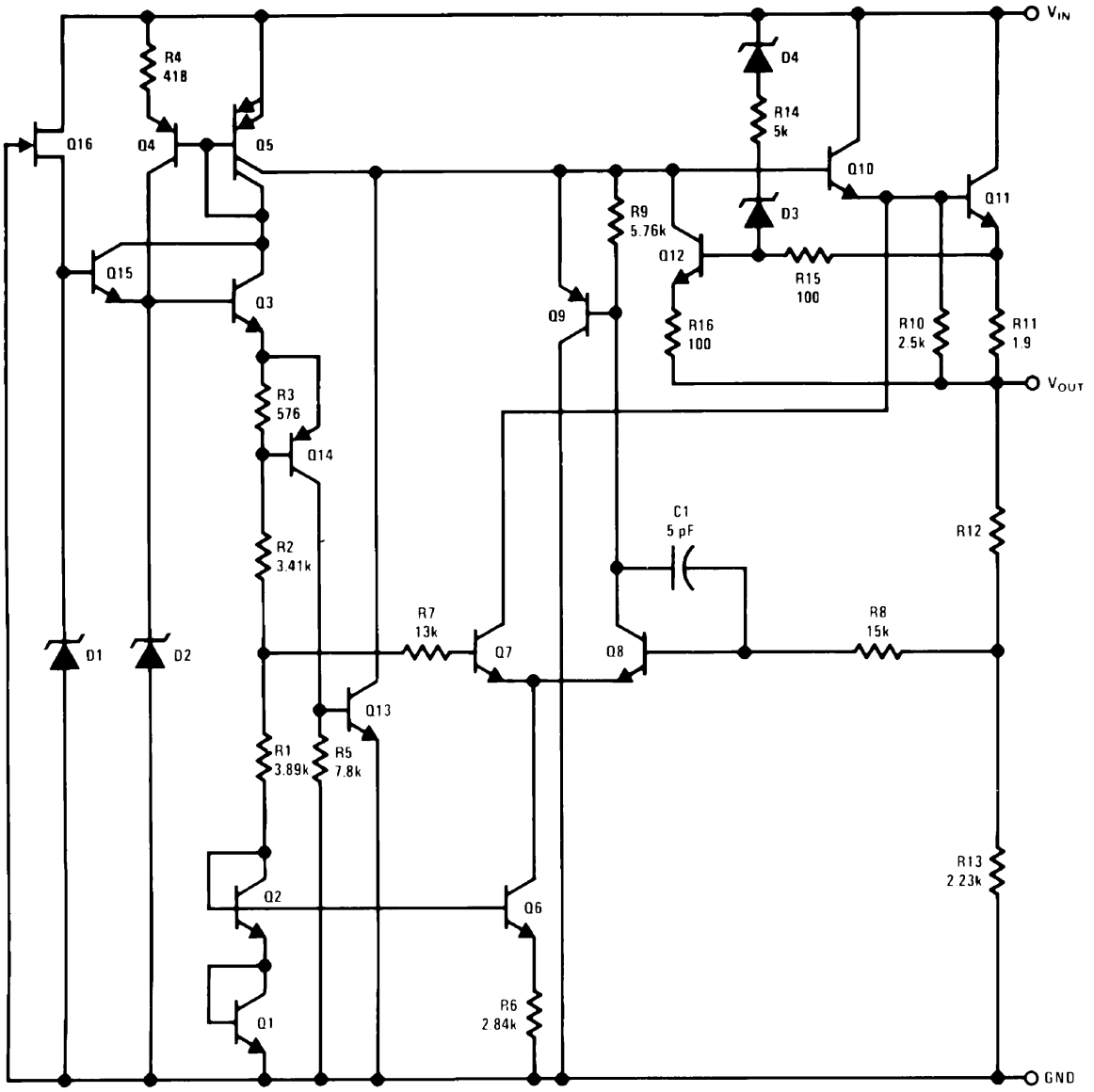
### Quiescent Current




DS007744-21

## Equivalent Circuit

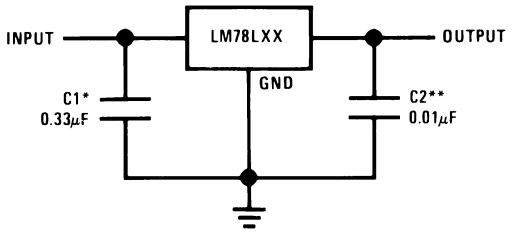
**LM78LXX**




DS007744-7

## Typical Applications

**Fixed Output Regulator**

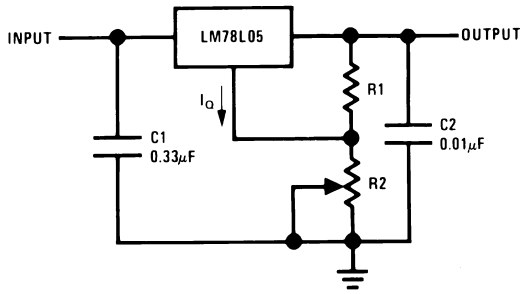



DS007744-8

*Required if the regulator is located more than 3" from the power supply filter.
**See (Note 4) in the electrical characteristics table.

## Typical Applications (Continued)

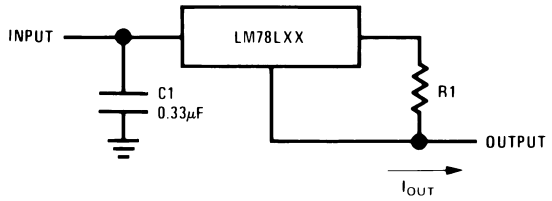
**Adjustable Output Regulator**




DS007744-9

$V_{OUT}$ = 5V + (5V/R1 + $I_Q$) R2
5V/R1 > 3 $I_Q$, load regulation ($L_r$) ≈ [(R1 + R2)/R1] ($L_r$ of LM78L05)

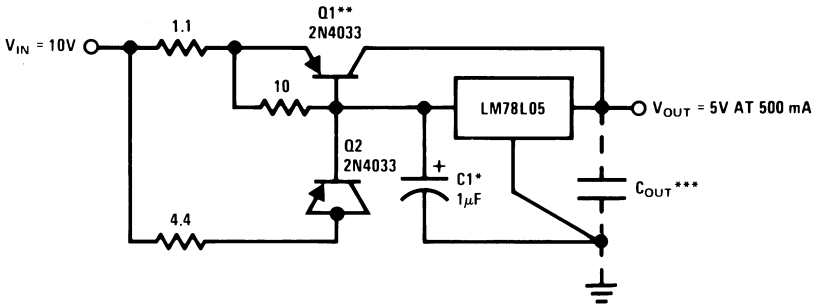
**Current Regulator**




DS007744-10

$I_{OUT}$ = ($V_{OUT}$/R1) + $I_Q$
>$I_Q$ = 1.5 mA over line and load changes

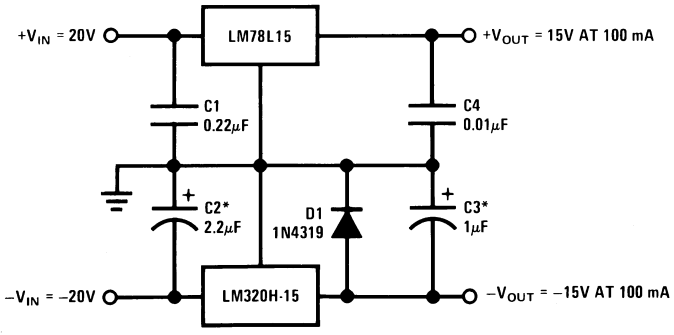
**5V, 500 mA Regulator with Short Circuit Protection**




DS007744-11

*Solid tantalum.
**Heat sink Q1.
***Optional: Improves ripple rejection and transient response.
Load Regulation: 0.6% 0 ≤ $I_L$ ≤ 250 mA pulsed with $t_{ON}$ = 50 ms.

**±15V, 100 mA Dual Power Supply**

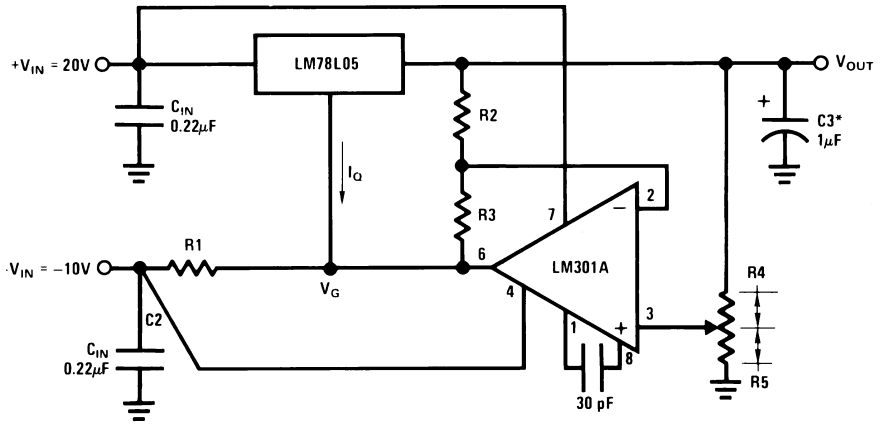



DS007744-12

*Solid tantalum.

## Typical Applications (Continued)

**Variable Output Regulator 0.5V-18V**




DS007744-13

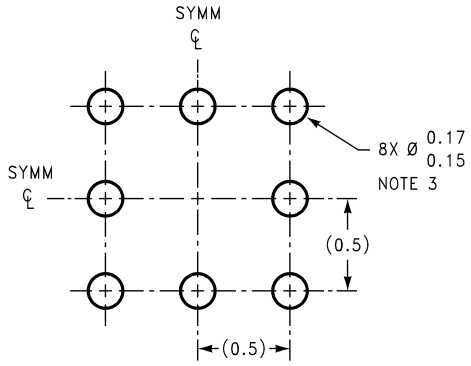
*Solid tantalum.

$V_{OUT} = V_G + 5V$, $R1 = (-V_{IN}/I_{Q\ LM78L05})$

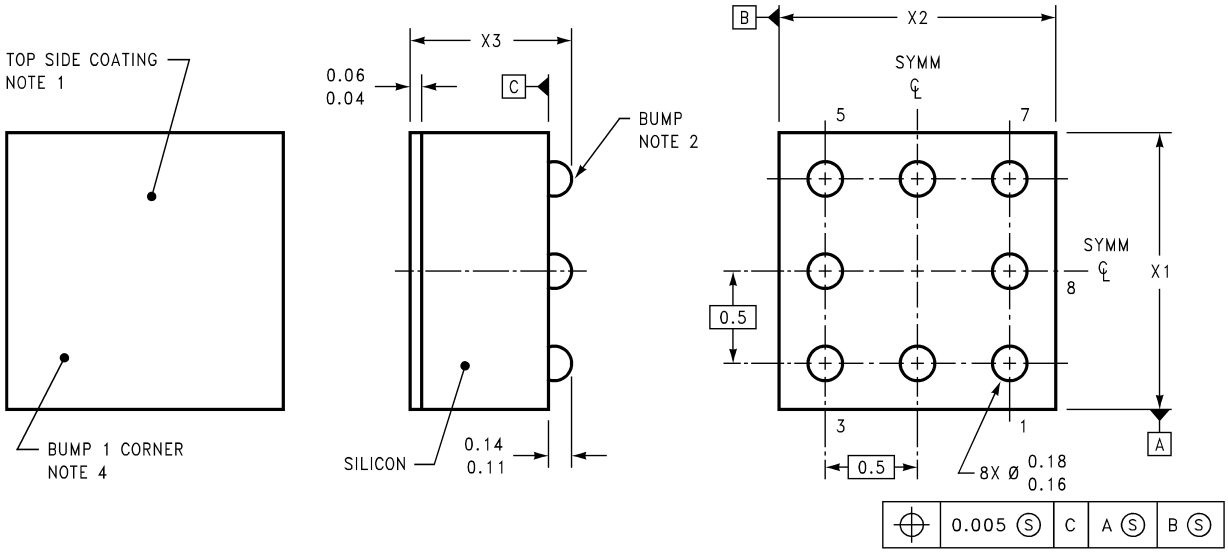
$V_{OUT} = 5V\ (R2/R4)$ for $(R2 + R3) = (R4 + R5)$

A 0.5V output will correspond to $(R2/R4) = 0.1\ (R3/R4) = 0.9$

## Physical Dimensions inches (millimeters) unless otherwise noted




**LAND PATTERN RECOMMENDATION**



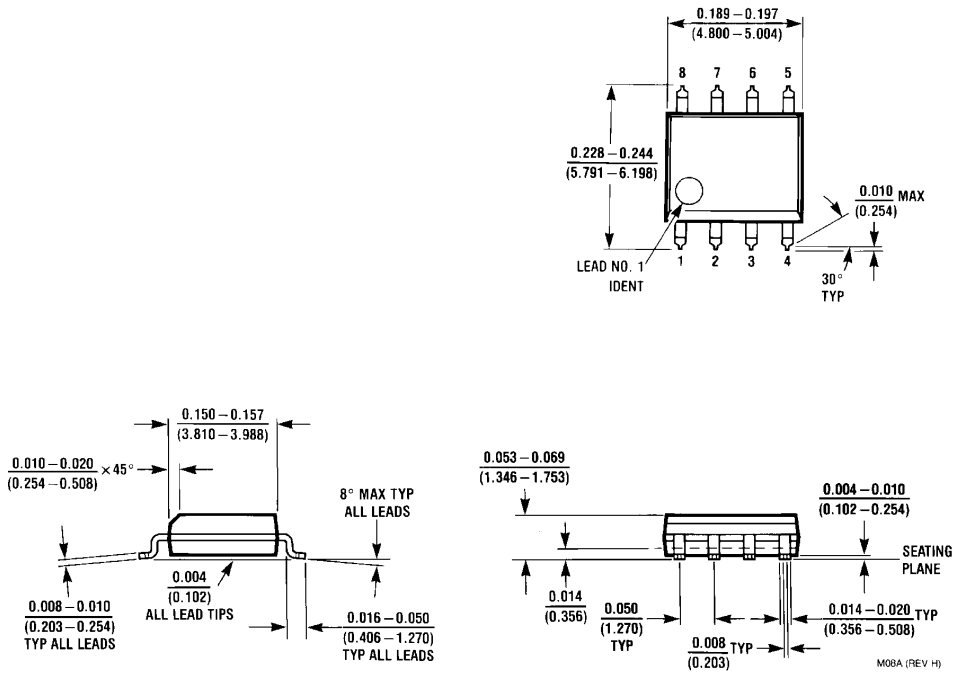

**DIMENSIONS ARE IN MILLIMETERS** BPA08XXX (REV A)

NOTES: UNLESS OTHERWISE SPECIFIED

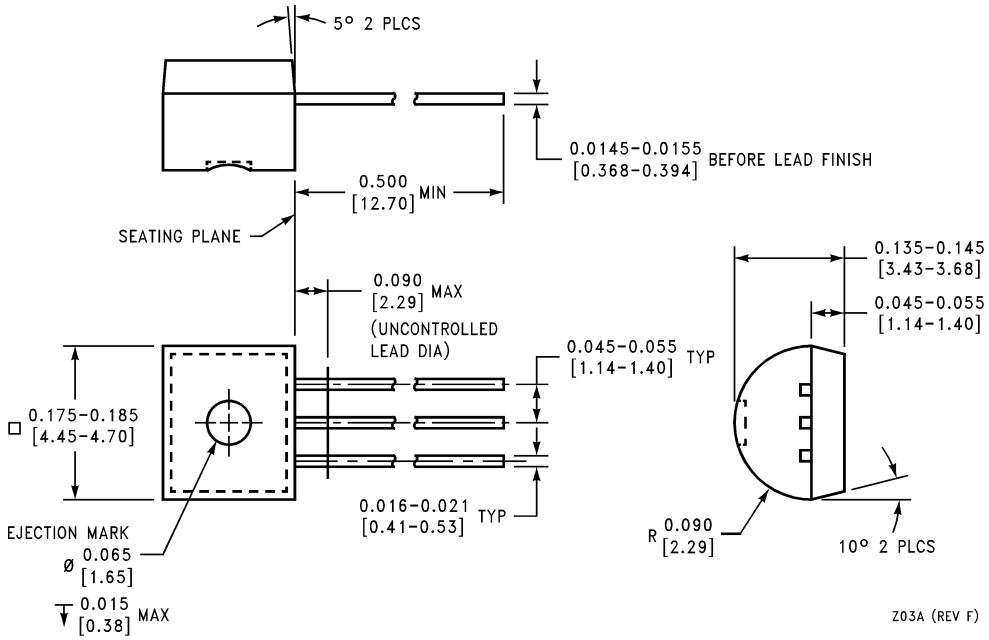
1. EPOXY COATING
2. 63Sn/37Pb EUTECTIC BUMP
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN 1 IS ESTABLISHED BY LOWER LEFT CORNER WITH RESPECT TO TEXT ORIENTATION. REMAINING PINS ARE NUMBERED COUNTERCLOCKWISE.
5. XXX IN DRAWING NUMBER REPRESENTS PACKAGE SIZE VARIATION WHERE $X_1$ IS PACKAGE WIDTH, $X_2$ IS PACKAGE LENGTH AND $X_3$ IS PACKAGE HEIGHT.
6. REFERENCE JEDEC REGISTRATION MO-211, VARIATION BC.

**8-Bump micro SMD**
**Order Number LM78L05IBP or LM78L05IBPX**
**NS Package Number BPA08AAA**
**$X_1$ = 1.285 $X_2$ = 1.285 $X_3$ = 0.7**

## Physical Dimensions inches (millimeters) unless otherwise noted (Continued)




**S.O. Package (M)**
**Order Number LM78L05ACM, LM78L12ACM or LM78L15ACM**
**NS Package Number M08A**




**Molded Offset TO-92 (Z)**
**Order Number LM78L05ACZ, LM78L09ACZ, LM78L12ACZ,**
**LM78L15ACZ, LM78L62ACZ or LM78L82ACZ**
**NS Package Number Z03A**

## Notes

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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