National Semiconductor

February 2005

# 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.

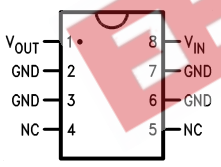
The LM78LXX is available in the plastic TO-92 (Z) package, the plastic SO-8 (M) package and a chip sized package (8-Bump micro SMD) using National's micro SMD package technology. With adequate heat sinking the regulator can deliver 100mA output current. Current limiting is included to limit the peak 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 100mA
- 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
- See AN-1112 for micro SMD considerations

## Connection Diagrams

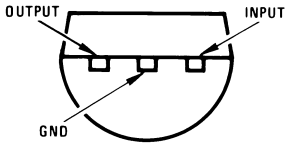
**SO-8 Plastic (M)**
**(Narrow Body)**




00774402

**Top View**

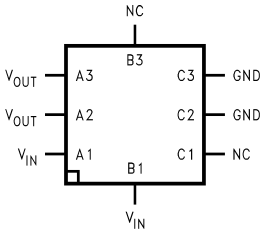
**(TO-92)**
**Plastic Package (Z)**




00774403

**Bottom View**

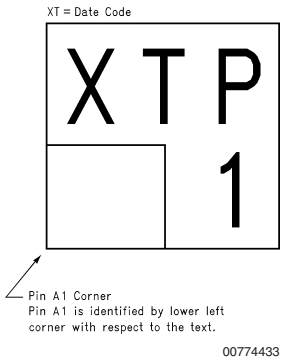
**8-Bump micro SMD**




00774424

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

**micro SMD Marking Orientation**




00774433

**Top View**

## Ordering Information

| Package | Order Number | Output Voltage | NSC Drawing | Supplied As |
|---|---|---|---|---|
| microSMD | LM78L05IBP | 5V | BPA08AAB | Reel of 250 |
| | LM78L05IBPX | 5V | BPA08AAB | Reel of 3000 |
| | LM78L09ITP | 9V | TPA08AAA | Reel of 250 |
| | LM78L09ITPX | 9V | TPA08AAA | Reel of 3000 |
| SOIC Narrow | LM78L05ACM | 5V | M08A | Rail of 95 |
| | LM78L05ACMX | 5V | M08A | Reel of 2500 |
| | LM78L12ACM | 12V | M08A | Rail of 95 |
| | LM78L12ACMX | 12V | M08A | Reel of 2500 |
| | LM78L15ACM | 15V | M08A | Rail of 95 |
| | LM78L15ACMX | 15V | M08A | Reel of 2500 |
| TO-92 | LM78L05ACZ | 5V | Z03A | Box of 1800 |
| | LM78L62ACZ | 6.2V | Z03A | Box of 1800 |
| | LM78L82ACZ | 8.2V | Z03A | Box of 1800 |
| | LM78L09ACZ | 9V | Z03A | Box of 1800 |
| | LM78L12ACZ | 12V | Z03A | Box of 1800 |
| | LM78L15ACZ | 15V | Z03A | Box of 1800 |

## 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 |
| ESD Susceptibility (Note 2) | 1kV |

Operating Junction Temperature

| | |
|---|---|
| SO-8, TO-92 | 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) |

## 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 and TO-92 packages, 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: $I_O$ = 40mA, $C_I$ = 0.33µF, $C_O$ = 0.1µF.

### 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>1mA ≤ $I_O$ ≤ 40mA<br>(Note 3) | **4.75** | | **5.25** | |
| | | 1mA ≤ $I_O$ ≤ 70mA<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 | 1mA ≤ $I_O$ ≤ 100mA | | 20 | 60 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 5 | 30 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 8V ≤ $V_{IN}$ ≤ 20V | | | **1.0** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | −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>1mA ≤ $I_O$ ≤ 40mA<br>(Note 3) | **5.9** | | **6.5** | |
| | | 1mA ≤ $I_O$ ≤ 70mA<br>(Note 3) | **5.9** | | **6.5** | |

## 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 and TO-92 packages, 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: $I_O$ = 40mA, $C_I$ = 0.33µF, $C_O$ = 0.1µF. (Continued)

### LM78L62AC (Continued)

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

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $\Delta V_O$ | Line Regulation | 8.5V ≤ $V_{IN}$ ≤ 20V | | 65 | 175 | mV |
| | | 9V ≤ $V_{IN}$ ≤ 20V | | 55 | 125 | |
| $\Delta V_O$ | Load Regulation | 1mA ≤ $I_O$ ≤ 100mA | | 13 | 80 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 6 | 40 | |
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 8V ≤ $V_{IN}$ ≤ 20V | | | **1.5** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | –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 1mA ≤ $I_O$ ≤ 40mA (Note 3) | **7.8** | | **8.6** | |
| | | 1mA ≤ $I_O$ ≤ 70mA (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 | 1mA ≤ $I_O$ ≤ 100mA | | 15 | 80 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 8 | 40 | |
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 12V ≤ $V_{IN}$ ≤ 23V | | | **1.5** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | –0.8 | | mV/˚C |
| $V_{IN}$ (Min) | Minimum Value of Input Voltage Required to Maintain Line Regulation | | | 9.9 | | V |

## 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 and TO-92 packages, 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: $I_O$ = 40mA, $C_I$ = 0.33µF, $C_O$ = 0.1µF. (Continued)

### 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<br>1mA ≤ $I_O$ ≤ 40mA<br>(Note 3) | **8.55** | | **9.45** | |
| | | 1mA ≤ $I_O$ ≤ 70mA<br>(Note 3) | **8.55** | | **9.45** | |
| $\Delta V_O$ | Line Regulation | 11.5V ≤ $V_{IN}$ ≤ 24V | | 100 | 200 | mV |
| | | 13V ≤ $V_{IN}$ ≤ 24V | | 90 | 150 | |
| $\Delta V_O$ | Load Regulation | 1mA ≤ $I_O$ ≤ 100mA | | 20 | 90 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 10 | 45 | |
| $I_Q$ | Quiescent Current | | | 2 | 5.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 11.5V ≤ $V_{IN}$ ≤ 24V | | | **1.5** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | –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>1mA ≤ $I_O$ ≤ 40mA<br>(Note 3) | **11.4** | | **12.6** | |
| | | 1mA ≤ $I_O$ ≤ 70mA<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 | 1mA ≤ $I_O$ ≤ 100mA | | 30 | 100 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 10 | 50 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 16V ≤ $V_{IN}$ ≤ 27V | | | **1** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | –1.0 | | mV/˚C |

## 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 and TO-92 packages, 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: $I_O$ = 40mA, $C_I$ = 0.33µF, $C_O$ = 0.1µF. (Continued)

### LM78L12AC (Continued)

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

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ (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>1mA ≤ $I_O$ ≤ 40mA<br>(Note 3) | **14.25** | | **15.75** | |
| | | 1mA ≤ $I_O$ ≤ 70mA<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 | 1mA ≤ $I_O$ ≤ 100mA | | 35 | 150 | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | 12 | 75 | |
| $I_Q$ | Quiescent Current | | | 3 | 5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 20V ≤ $V_{IN}$ ≤ 30V | | | **1** | |
| | | 1mA ≤ $I_O$ ≤ 40mA | | | **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 | $I_O$ = 5mA | | –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 100pF.

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

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

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

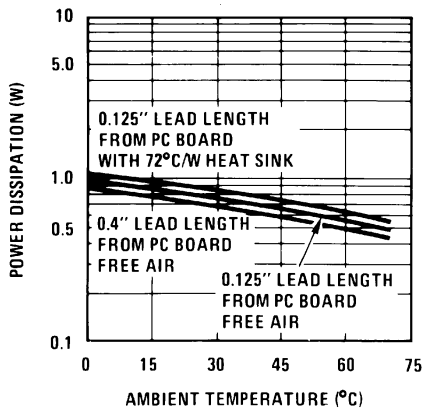
**Z** Package: $\theta_{JC}$ = 60 ˚C/W, = $\theta_{JA}$ = 230 ˚C/W

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

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

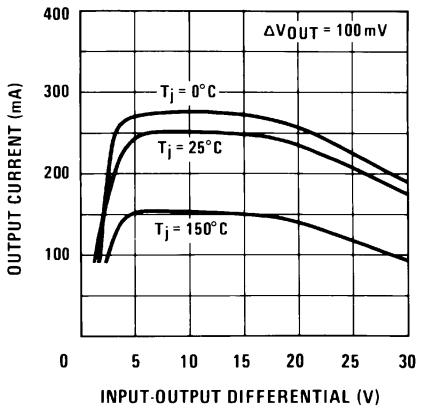
# Typical Performance Characteristics

### Maximum Average Power Dissipation (Z Package)



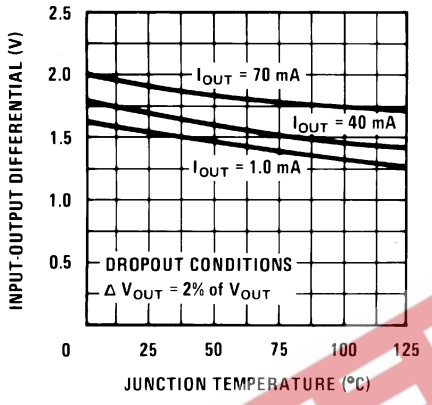

00774414

### Peak Output Current



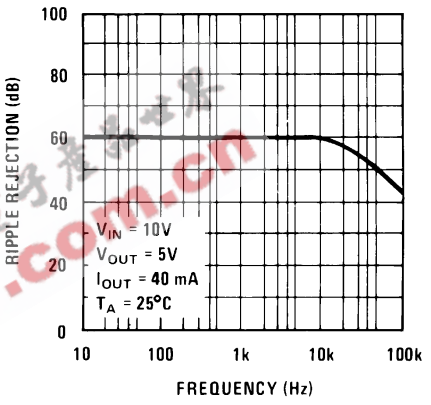

00774416

### Dropout Voltage



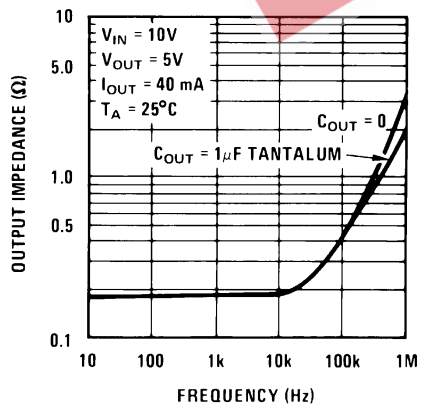

00774417

### Ripple Rejection



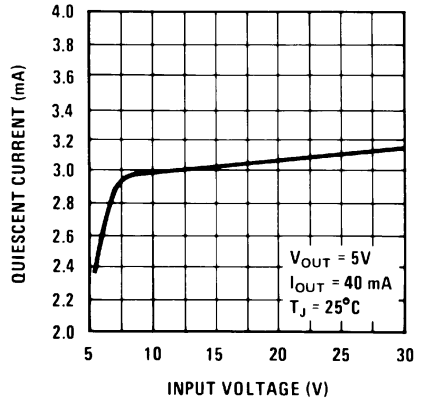

00774418

### Output Impedance




00774419

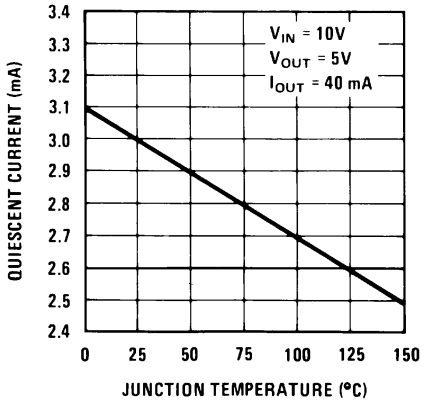
### Quiescent Current




00774420

## Typical Performance Characteristics (Continued)

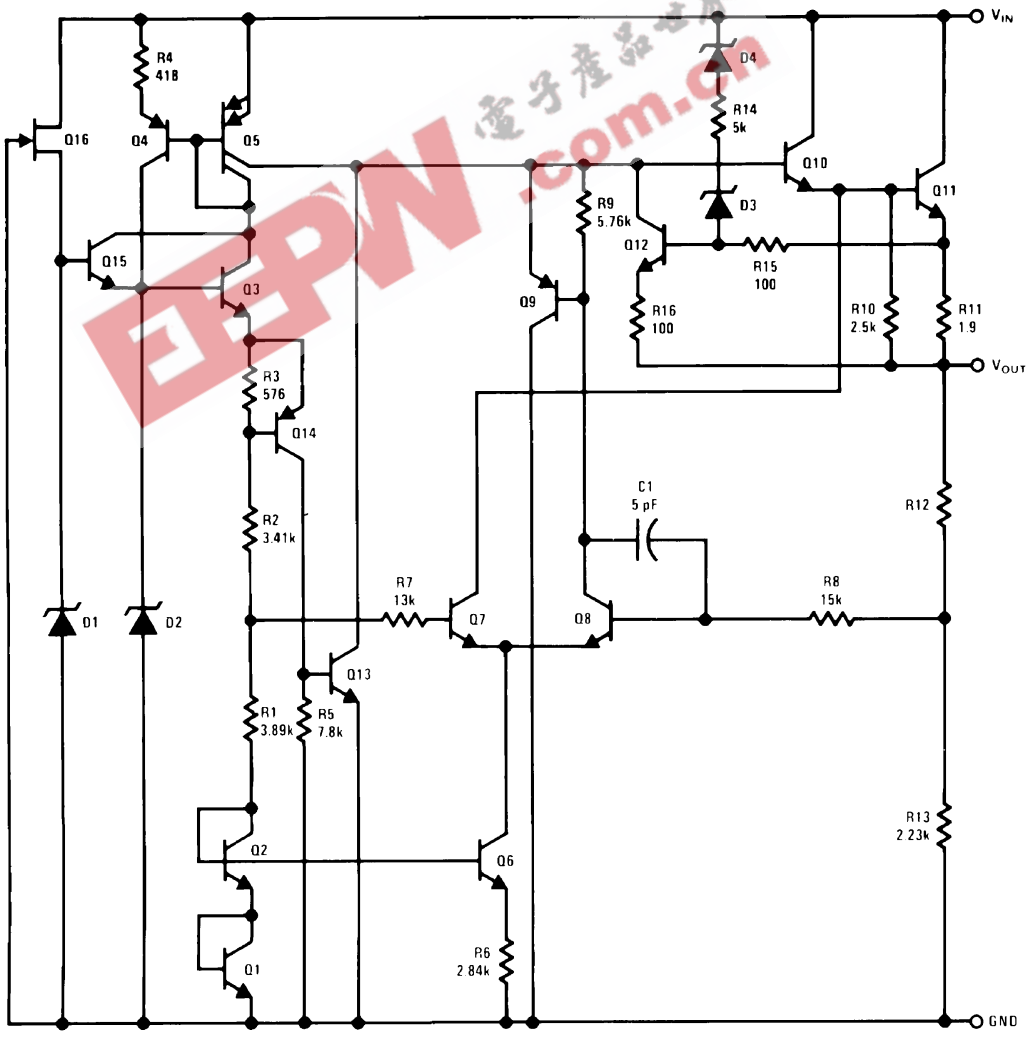
**Quiescent Current**




00774421

## Equivalent Circuit

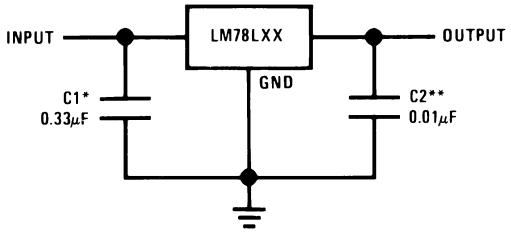
**LM78LXX**




00774407

# Typical Applications

### Fixed Output Regulator

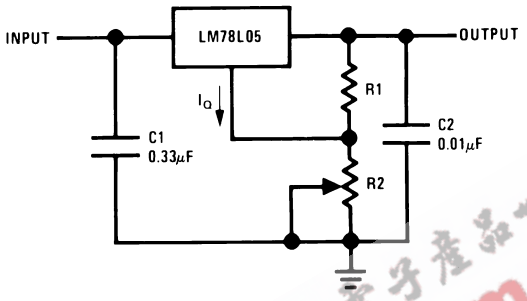



00774408

*Required if the regulator is located more than 3" from the power supply filter.

**See (Note 4) in the electrical characteristics table.

### Adjustable Output Regulator

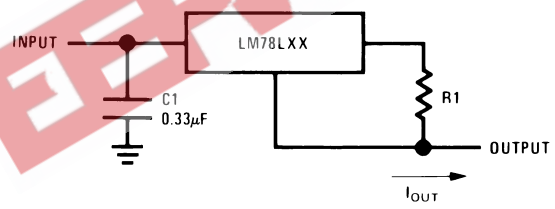



00774409

$V_{OUT}$ = 5V + (5V/R1 + $I_Q$) R2

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

### Current Regulator

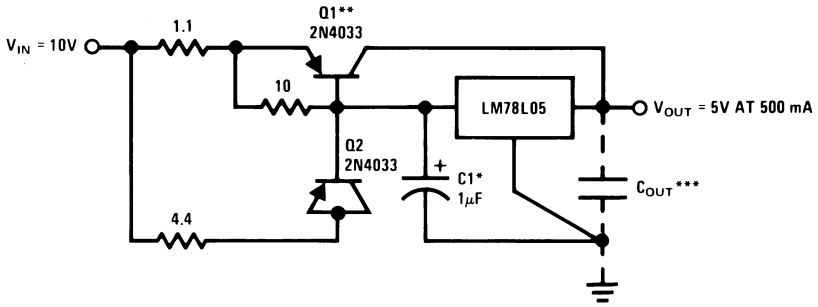



00774410

$I_{OUT}$ = ($V_{OUT}$/R1) + $I_Q$

>$I_Q$ = 1.5mA over line and load changes

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




00774411

*Solid tantalum.

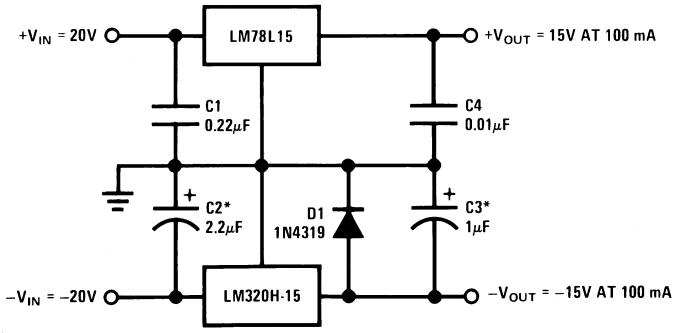
**Heat sink Q1.

***Optional: Improves ripple rejection and transient response.

Load Regulation: 0.6% 0 ≤ $I_L$ ≤ 250mA pulsed with $t_{ON}$ = 50ms.

## Typical Applications (Continued)

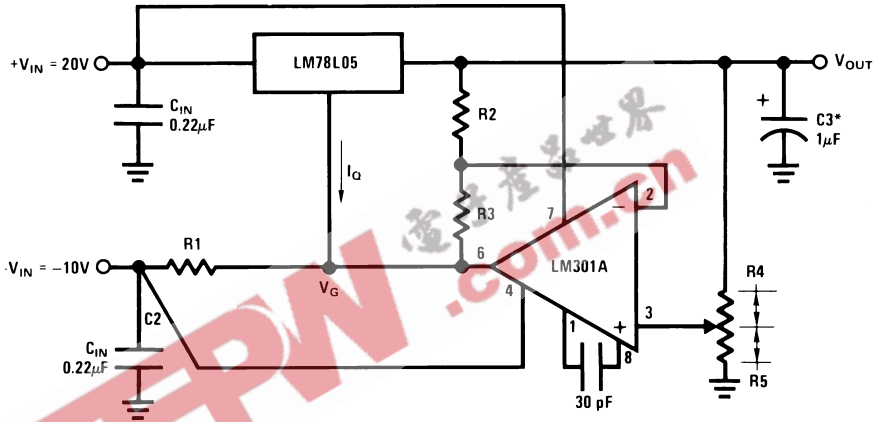
**±15V, 100mA Dual Power Supply**




00774412

*Solid tantalum.

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




00774413

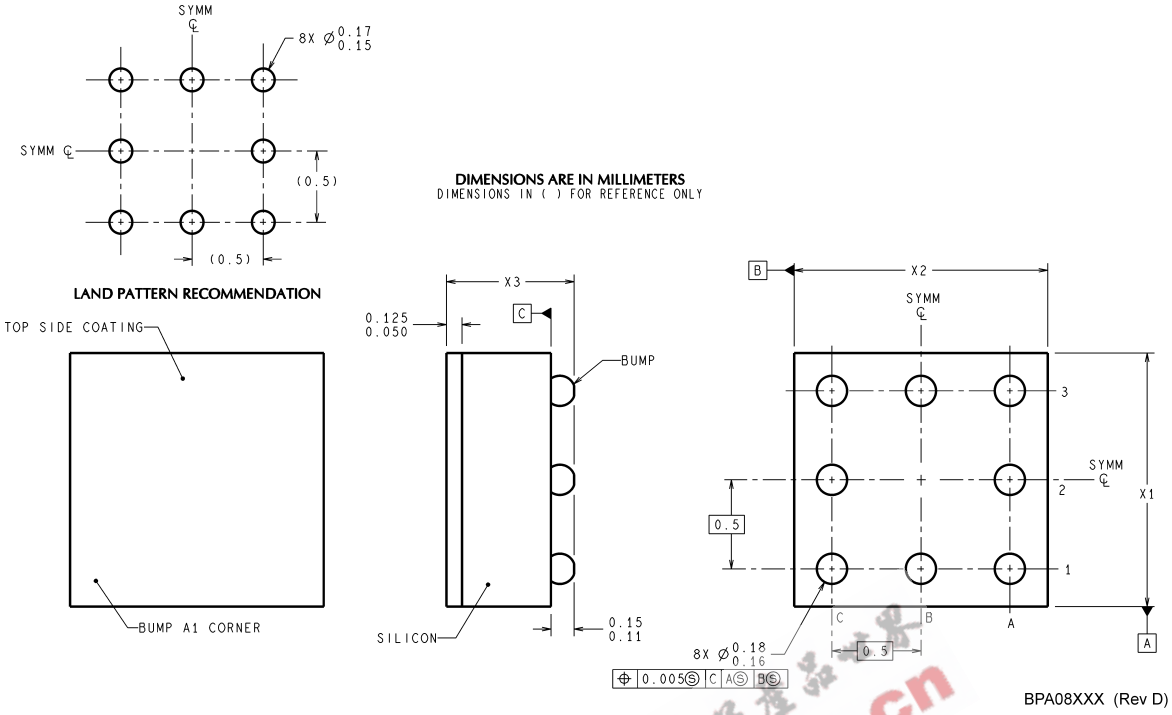
*Solid tantalum.

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

$V_{OUT} = 5V\ (R2/R4)$ 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



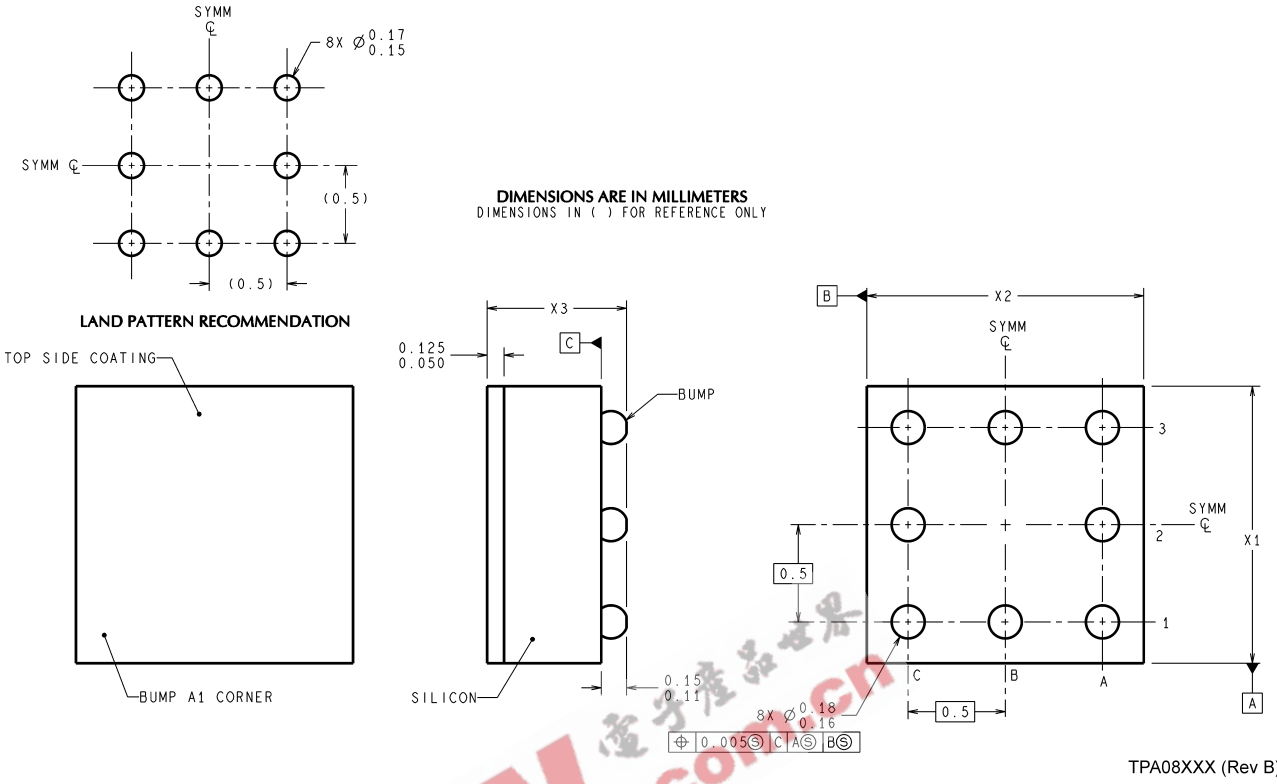

BPA08XXX (Rev D)

NOTES: UNLESS OTHERWISE SPECIFIED

1. EPOXY COATING
2. 63Sn/37Pb EUTECTIC BUMP
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN A1 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.

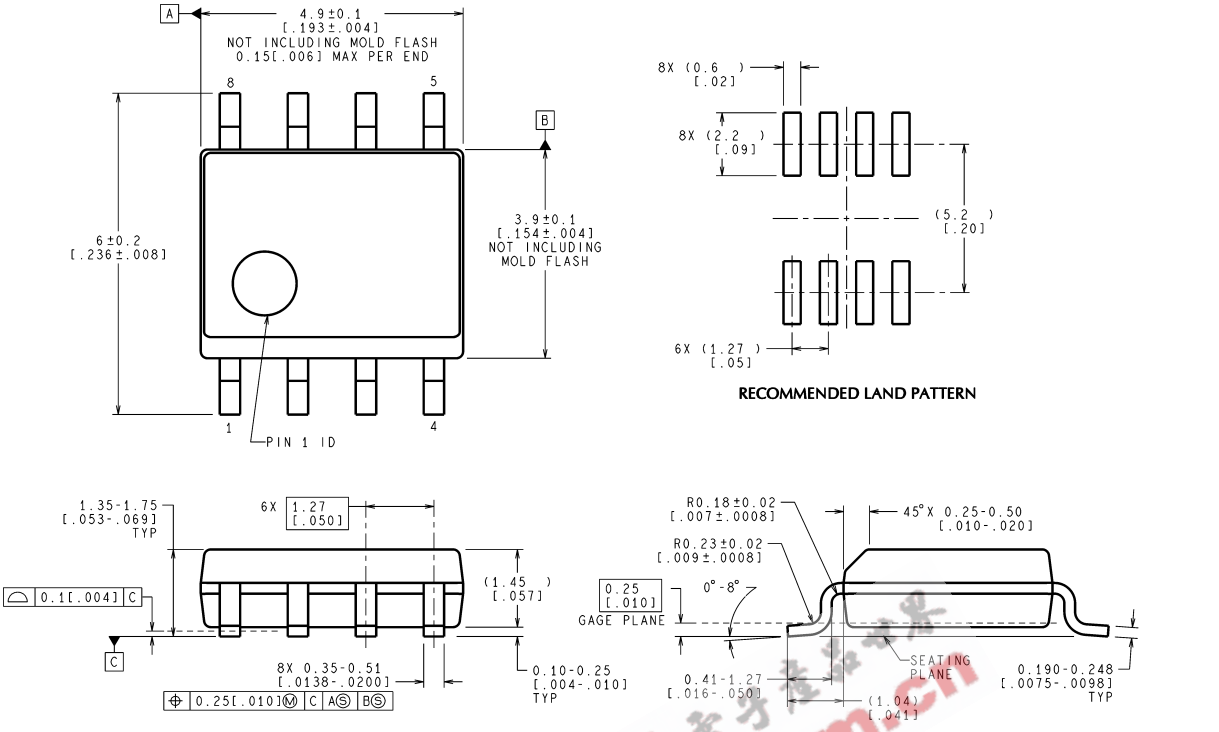
**8-Bump micro SMD for LM78L05IBP Only**
**NS Package Number BPA08AAB**
**X1 = 1.285mm X2 = 1.285mm X3 = 0.850mm**

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



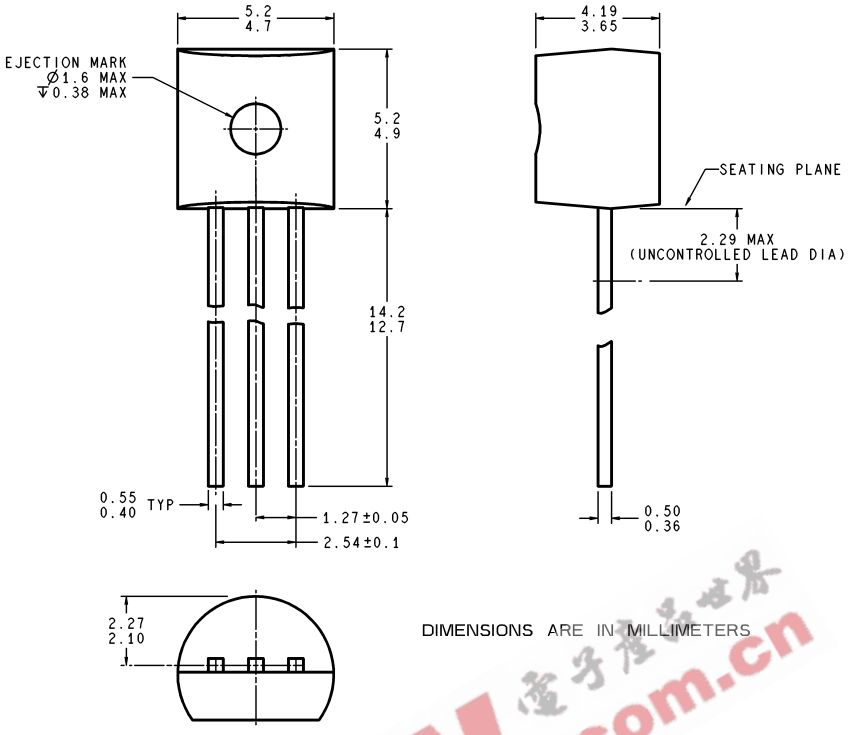

**8-Bump micro SMD for LM78L09ITP Only**
**NS Package Number TPA08AAA**
**X1 = 1.285mm X2 = 1.285mm X3 = 0.500mm**

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




**S.O. Package (M)**
**NS Package Number M08A**

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




**Molded Offset TO-92 (Z)**
**NS Package Number Z03A**



### 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.

### BANNED SUBSTANCE COMPLIANCE

National Semiconductor manufactures products and uses packing materials that meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

**National Semiconductor**
**Americas Customer**
**Support Center**
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

**National Semiconductor**
**Europe Customer Support Center**
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor**
**Asia Pacific Customer**
**Support Center**
Email: ap.support@nsc.com

**National Semiconductor**
**Japan Customer Support Center**
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560