National Semiconductor

November 2002

# LM340/LM78XX Series
# 3-Terminal Positive Regulators

## General Description

The LM140/LM340A/LM340/LM7800C monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Considerable effort was expended to make the entire series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

The 5V, 12V, and 15V regulator options are available in the steel TO-3 power package. The LM340A/LM340/LM7800C series is available in the TO-220 plastic power package, and the LM340-5.0 is available in the SOT-223 package, as well as the LM340-5.0 and LM340-12 in the surface-mount TO-263 package.

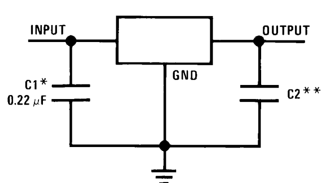
## Features

- Complete specifications at 1A load
- Output voltage tolerances of ±2% at $T_j$ = 25˚C and ±4% over the temperature range (LM340A)
- Line regulation of 0.01% of $V_{OUT}$/V of $\Delta V_{IN}$ at 1A load (LM340A)
- Load regulation of 0.3% of $V_{OUT}$/A (LM340A)
- Internal thermal overload protection
- Internal short-circuit current limit
- Output transistor safe area protection
- $P^+$ Product Enhancement tested

| Device | Output Voltages | Packages |
|---|---|---|
| LM140 | 5, 12, 15 | TO-3 (K) |
| LM340A/LM340 | 5, 12, 15 | TO-3 (K), TO-220 (T), SOT-223 (MP), TO-263 (S) (5V and 12V only) |
| LM7800C | 5, 8, 12, 15 | TO-220 (T) |

## Typical Applications

### Fixed Output Regulator

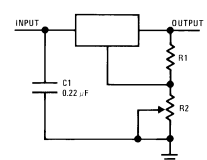



00778101

*Required if the regulator is located far from the power supply filter.

**Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1 μF, ceramic disc).

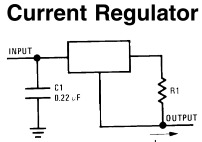
### Adjustable Output Regulator




00778102

$V_{OUT}$ = 5V + (5V/R1 + $I_Q$) R2 5V/R1 > 3 $I_Q$,
load regulation ($L_r$) ≈ [(R1 + R2)/R1] ($L_r$ of LM340-5).

### Current Regulator

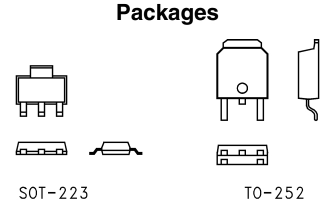



00778103

$$I_{OUT} = \frac{V2\text{-}3}{R1} + I_Q$$

$\Delta I_Q$ = 1.3 mA over line and load changes.

### Comparison between SOT-223 and D-Pak (TO-252) Packages




00778138

**Scale 1:1**

 DS007781 

## Absolute Maximum Ratings (Note 1)

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

(Note 5)

| | |
|---|---|
| DC Input Voltage | |
| All Devices except LM7824/LM7824C | 35V |
| LM7824/LM7824C | 40V |
| Internal Power Dissipation (Note 2) | Internally Limited |
| Maximum Junction Temperature | 150˚C |
| Storage Temperature Range | −65˚C to +150˚C |
| Lead Temperature (Soldering, 10 sec.) | |
| TO-3 Package (K) | 300˚C |
| TO-220 Package (T), TO-263 Package (S) | 230˚C |
| ESD Susceptibility (Note 3) | 2 kV |

## Operating Conditions (Note 1)

| | |
|---|---|
| Temperature Range ($T_A$) (Note 2) | |
| LM140A, LM140 | −55˚C to +125˚C |
| LM340A, LM340, LM7805C, LM7812C, LM7815C, LM7808C | 0˚C to +125˚C |

## LM340A Electrical Characteristics

$I_{OUT}$ = 1A, −55˚C ≤ $T_J$ ≤ +150˚C (LM140A), or 0˚C ≤ $T_J$ ≤ + 125˚C (LM340A) unless otherwise specified (Note 4)

| Symbol | Output Voltage | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | $T_J$ = 25˚C | 4.9 | 5 | 5.1 | 11.75 | 12 | 12.25 | 14.7 | 15 | 15.3 | V |
| | | $P_D$ ≤ 15W, 5 mA ≤ $I_O$ ≤ 1A | 4.8 | | 5.2 | 11.5 | | 12.5 | 14.4 | | 15.6 | V |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.8 ≤ $V_{IN}$ ≤ 27) | | | (17.9 ≤ $V_{IN}$ ≤ 30) | | | V |
| $\Delta V_O$ | Line Regulation | $I_O$ = 500 mA | | | 10 | | | 18 | | | 22 | mV |
| | | $\Delta V_{IN}$ | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.8 ≤ $V_{IN}$ ≤ 27) | | | (17.9 ≤ $V_{IN}$ ≤ 30) | | | V |
| | | $T_J$ = 25˚C | | 3 | 10 | | 4 | 18 | | 4 | 22 | mV |
| | | $\Delta V_{IN}$ | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.5 ≤ $V_{IN}$ ≤ 27) | | | (17.5 ≤ $V_{IN}$ ≤ 30) | | | V |
| | | $T_J$ = 25˚C | | | 4 | | | 9 | | | 10 | mV |
| | | Over Temperature | | | 12 | | | 30 | | | 30 | mV |
| | | $\Delta V_{IN}$ | (8 ≤ $V_{IN}$ ≤ 12) | | | (16 ≤ $V_{IN}$ ≤ 22) | | | (20 ≤ $V_{IN}$ ≤ 26) | | | V |
| $\Delta V_O$ | Load Regulation | $T_J$ = 25˚C, 5 mA ≤ $I_O$ ≤ 1.5A | | 10 | 25 | | 12 | 32 | | 12 | 35 | mV |
| | | $T_J$ = 25˚C, 250 mA ≤ $I_O$ ≤ 750 mA | | | 15 | | | 19 | | | 21 | mV |
| | | Over Temperature, 5 mA ≤ $I_O$ ≤ 1A | | | 25 | | | 60 | | | 75 | mV |
| $I_Q$ | Quiescent Current | $T_J$ = 25˚C | | | 6 | | | 6 | | | 6 | mA |
| | | Over Temperature | | | 6.5 | | | 6.5 | | | 6.5 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 5 mA ≤ $I_O$ ≤ 1A | | 0.5 | | | 0.5 | | | 0.5 | | mA |
| | | $T_J$ = 25˚C, $I_O$ = 1A | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.8 ≤ $V_{IN}$ ≤ 27) | | | (17.9 ≤ $V_{IN}$ ≤ 30) | | | V |
| | | $I_O$ = 500 mA | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | (8 ≤ $V_{IN}$ ≤ 25) | | | (15 ≤ $V_{IN}$ ≤ 30) | | | (17.9 ≤ $V_{IN}$ ≤ 30) | | | V |
| $V_N$ | Output Noise Voltage | $T_A$ = 25˚C, 10 Hz ≤ f ≤ 100 kHz | | 40 | | | 75 | | | 90 | | µV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | $T_J$ = 25˚C, f = 120 Hz, $I_O$ = 1A | 68 | 80 | | 61 | 72 | | 60 | 70 | | dB |
| | | or f = 120 Hz, $I_O$ = 500 mA, Over Temperature, | 68 | | | 61 | | | 60 | | | dB |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | (8 ≤ $V_{IN}$ ≤ 18) | | | (15 ≤ $V_{IN}$ ≤ 25) | | | (18.5 ≤ $V_{IN}$ ≤ 28.5) | | | V |
| $R_O$ | Dropout Voltage | $T_J$ = 25˚C, $I_O$ = 1A | | 2.0 | | | 2.0 | | | 2.0 | | V |

## LM340A Electrical Characteristics (Continued)

$I_{OUT}$ = 1A, –55˚C ≤ $T_J$ ≤ +150˚C (LM140A), or 0˚C ≤ $T_J$ ≤ + 125˚C (LM340A) unless otherwise specified (Note 4)

| Symbol | Output Voltage | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| | Output Resistance | f = 1 kHz | | 8 | | | 18 | | | 19 | | mΩ |
| | Short-Circuit Current | $T_J$ = 25˚C | | 2.1 | | | 1.5 | | | 1.2 | | A |
| | Peak Output Current | $T_J$ = 25˚C | | 2.4 | | | 2.4 | | | 2.4 | | A |
| | Average TC of $V_O$ | Min, $T_J$ = 0˚C, $I_O$ = 5 mA | | –0.6 | | | –1.5 | | | –1.8 | | mV/˚C |
| $V_{IN}$ | Input Voltage Required to Maintain Line Regulation | $T_J$ = 25˚C | 7.5 | | | 14.5 | | | 17.5 | | | V |

## LM140 Electrical Characteristics (Note 4)

–55˚C ≤ $T_J$ ≤ +150˚C unless otherwise specified

| Symbol | Output Voltage | | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | $T_J$ = 25˚C, 5 mA ≤ $I_O$ ≤ 1A | | 4.8 | 5 | 5.2 | 11.5 | 12 | 12.5 | 14.4 | 15 | 15.6 | V |
| | | $P_D$ ≤ 15W, 5 mA ≤ $I_O$ ≤ 1A | | 4.75 | | 5.25 | 11.4 | | 12.6 | 14.25 | | 15.75 | V |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | | | (8 ≤ $V_{IN}$ ≤ 20) | | | (15.5 ≤ $V_{IN}$ ≤ 27) | | | (18.5 ≤ $V_{IN}$ ≤ 30) | | V |
| $\Delta V_O$ | Line Regulation | $I_O$ = 500 mA | $T_J$ = 25˚C | | 3 | 50 | | 4 | 120 | | 4 | 150 | mV |
| | | | $\Delta V_{IN}$ | | (7 ≤ $V_{IN}$ ≤ 25) | | | (14.5 ≤ $V_{IN}$ ≤ 30) | | | (17.5 ≤ $V_{IN}$ ≤ 30) | | V |
| | | | –55˚C ≤ $T_J$ ≤ +150˚C | | | 50 | | | 120 | | | 150 | mV |
| | | | $\Delta V_{IN}$ | | (8 ≤ $V_{IN}$ ≤ 20) | | | (15 ≤ $V_{IN}$ ≤ 27) | | | (18.5 ≤ $V_{IN}$ ≤ 30) | | V |
| | | $I_O$ ≤ 1A | $T_J$ = 25˚C | | | 50 | | | 120 | | | 150 | mV |
| | | | $\Delta V_{IN}$ | | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.6 ≤ $V_{IN}$ ≤ 27) | | | (17.7 ≤ $V_{IN}$ ≤ 30) | | V |
| | | | –55˚C ≤ $T_J$ ≤ +150˚C | | | 25 | | | 60 | | | 75 | mV |
| | | | $\Delta V_{IN}$ | | (8 ≤ $V_{IN}$ ≤ 12) | | | (16 ≤ $V_{IN}$ ≤ 22) | | | (20 ≤ $V_{IN}$ ≤ 26) | | V |
| $\Delta V_O$ | Load Regulation | $T_J$ = 25˚C | 5 mA ≤ $I_O$ ≤ 1.5A | | 10 | 50 | | 12 | 120 | | 12 | 150 | mV |
| | | | 250 mA ≤ $I_P$ ≤ 750 mA | | | 25 | | | 60 | | | 75 | mV |
| | | –55˚C ≤ $T_J$ ≤ +150˚C, 5 mA ≤ $I_O$ ≤ 1A | | | | 50 | | | 120 | | | 150 | mV |
| $I_Q$ | Quiescent Current | $I_O$ ≤ 1A | $T_J$ = 25˚C | | | 6 | | | 6 | | | 6 | mA |
| | | | –55˚C ≤ $T_J$ ≤ +150˚C | | | 7 | | | 7 | | | 7 | mA |
| $\Delta I_Q$ | Quiescent Current Change | 5 mA ≤ $I_O$ ≤ 1A | | | 0.5 | | | 0.5 | | | 0.5 | | mA |
| | | $T_J$ = 25˚C, $I_O$ ≤ 1A | | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | | | (8 ≤ $V_{IN}$ ≤ 20) | | | (15 ≤ $V_{IN}$ ≤ 27) | | | (18.5 ≤ $V_{IN}$ ≤ 30) | | V |
| | | $I_O$ = 500 mA, –55˚C ≤ $T_J$ ≤ +150˚C | | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | | | (8 ≤ $V_{IN}$ ≤ 25) | | | (15 ≤ $V_{IN}$ ≤ 30) | | | (18.5 ≤ $V_{IN}$ ≤ 30) | | V |

## LM140 Electrical Characteristics (Note 4) (Continued)

$-55^\circ C \leq T_J \leq +150^\circ C$ unless otherwise specified

| Symbol | Output Voltage | | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| $V_N$ | Output Noise Voltage | $T_A = 25^\circ C$, 10 Hz ≤ f ≤ 100 kHz | | | 40 | | | 75 | | | 90 | | μV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz | $I_O \leq 1A$, $T_J = 25^\circ C$ or | 68 | 80 | | 61 | 72 | | 60 | 70 | | dB |
| | | | $I_O \leq 500$ mA, $-55^\circ C \leq T_J \leq +150^\circ C$ | 68 | | | 61 | | | 60 | | | dB |
| | | $V_{MIN} \leq V_{IN} \leq V_{MAX}$ | | | $(8 \leq V_{IN} \leq 18)$ | | | $(15 \leq V_{IN} \leq 25)$ | | | $(18.5 \leq V_{IN} \leq 28.5)$ | | V |
| $R_O$ | Dropout Voltage | $T_J = 25^\circ C$, $I_O = 1A$ | | | 2.0 | | | 2.0 | | | 2.0 | | V |
| | Output Resistance | f = 1 kHz | | | 8 | | | 18 | | | 19 | | mΩ |
| | Short-Circuit Current | $T_J = 25^\circ C$ | | | 2.1 | | | 1.5 | | | 1.2 | | A |
| | Peak Output Current | $T_J = 25^\circ C$ | | | 2.4 | | | 2.4 | | | 2.4 | | A |
| | Average TC of $V_{OUT}$ | $0^\circ C \leq T_J \leq +150^\circ C$, $I_O = 5$ mA | | | −0.6 | | | −1.5 | | | −1.8 | | mV/°C |
| $V_{IN}$ | Input Voltage Required to Maintain Line Regulation | $T_J = 25^\circ C$, $I_O \leq 1A$ | | 7.5 | | | 14.6 | | | 17.7 | | | V |

## LM340/LM7800C Electrical Characteristics (Note 4)

$0^\circ C \leq T_J \leq +125^\circ C$ unless otherwise specified

| Symbol | Output Voltage | | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | $T_J = 25^\circ C$, 5 mA ≤ $I_O$ ≤ 1A | | 4.8 | 5 | 5.2 | 11.5 | 12 | 12.5 | 14.4 | 15 | 15.6 | V |
| | | $P_D \leq 15W$, 5 mA ≤ $I_O$ ≤ 1A | | 4.75 | | 5.25 | 11.4 | | 12.6 | 14.25 | | 15.75 | V |
| | | $V_{MIN} \leq V_{IN} \leq V_{MAX}$ | | | $(7.5 \leq V_{IN} \leq 20)$ | | | $(14.5 \leq V_{IN} \leq 27)$ | | | $(17.5 \leq V_{IN} \leq 30)$ | | V |
| $\Delta V_O$ | Line Regulation | $I_O = 500$ mA | $T_J = 25^\circ C$ | | 3 | 50 | | 4 | 120 | | 4 | 150 | mV |
| | | | $\Delta V_{IN}$ | | $(7 \leq V_{IN} \leq 25)$ | | | $(14.5 \leq V_{IN} \leq 30)$ | | | $(17.5 \leq V_{IN} \leq 30)$ | | V |
| | | | $0^\circ C \leq T_J \leq +125^\circ C$ | | | 50 | | | 120 | | | 150 | mV |
| | | | $\Delta V_{IN}$ | | $(8 \leq V_{IN} \leq 20)$ | | | $(15 \leq V_{IN} \leq 27)$ | | | $(18.5 \leq V_{IN} \leq 30)$ | | V |
| | | $I_O \leq 1A$ | $T_J = 25^\circ C$ | | | 50 | | | 120 | | | 150 | mV |
| | | | $\Delta V_{IN}$ | | $(7.5 \leq V_{IN} \leq 20)$ | | | $(14.6 \leq V_{IN} \leq 27)$ | | | $(17.7 \leq V_{IN} \leq 30)$ | | V |
| | | | $0^\circ C \leq T_J \leq +125^\circ C$ | | | 25 | | | 60 | | | 75 | mV |
| | | | $\Delta V_{IN}$ | | $(8 \leq V_{IN} \leq 12)$ | | | $(16 \leq V_{IN} \leq 22)$ | | | $(20 \leq V_{IN} \leq 26)$ | | V |
| $\Delta V_O$ | Load Regulation | $T_J = 25^\circ C$ | 5 mA ≤ $I_O$ ≤ 1.5A | | 10 | 50 | | 12 | 120 | | 12 | 150 | mV |
| | | | 250 mA ≤ $I_O$ ≤ 750 mA | | | 25 | | | 60 | | | 75 | mV |
| | | 5 mA ≤ $I_O$ ≤ 1A, $0^\circ C \leq T_J \leq +125^\circ C$ | | | | 50 | | | 120 | | | 150 | mV |
| $I_Q$ | Quiescent Current | $I_O \leq 1A$ | $T_J = 25^\circ C$ | | | 8 | | | 8 | | | 8 | mA |
| | | | $0^\circ C \leq T_J \leq +125^\circ C$ | | | 8.5 | | | 8.5 | | | 8.5 | mA |
| $\Delta I_Q$ | Quiescent Current | 5 mA ≤ $I_O$ ≤ 1A | | | 0.5 | | | 0.5 | | | 0.5 | | mA |

## LM340/LM7800C Electrical Characteristics (Note 4) (Continued)

$0^\circ C \leq T_J \leq +125^\circ C$ unless otherwise specified

| Symbol | Output Voltage | | | 5V | | | 12V | | | 15V | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Input Voltage (unless otherwise noted) | | | 10V | | | 19V | | | 23V | | | |
| | Parameter | Conditions | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| | Change | $T_J = 25^\circ C$, $I_O \leq 1A$ | | | | 1.0 | | | 1.0 | | | 1.0 | mA |
| | | $V_{MIN} \leq V_{IN} \leq V_{MAX}$ | | $(7.5 \leq V_{IN} \leq 20)$ | | | $(14.8 \leq V_{IN} \leq 27)$ | | | $(17.9 \leq V_{IN} \leq 30)$ | | | V |
| | | $I_O \leq 500$ mA, $0^\circ C \leq T_J \leq +125^\circ C$ | | | | 1.0 | | | 1.0 | | | 1.0 | mA |
| | | $V_{MIN} \leq V_{IN} \leq V_{MAX}$ | | $(7 \leq V_{IN} \leq 25)$ | | | $(14.5 \leq V_{IN} \leq 30)$ | | | $(17.5 \leq V_{IN} \leq 30)$ | | | V |
| $V_N$ | Output Noise Voltage | $T_A = 25^\circ C$, 10 Hz $\leq f \leq$ 100 kHz | | | 40 | | | 75 | | | 90 | | μV |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | f = 120 Hz | $I_O \leq 1A$, $T_J = 25^\circ C$ | 62 | 80 | | 55 | 72 | | 54 | 70 | | dB |
| | | | or $I_O \leq 500$ mA, $0^\circ C \leq T_J \leq +125^\circ C$ | 62 | | | 55 | | | 54 | | | dB |
| | | $V_{MIN} \leq V_{IN} \leq V_{MAX}$ | | $(8 \leq V_{IN} \leq 18)$ | | | $(15 \leq V_{IN} \leq 25)$ | | | $(18.5 \leq V_{IN} \leq 28.5)$ | | | V |
| $R_O$ | Dropout Voltage | $T_J = 25^\circ C$, $I_O = 1A$ | | | 2.0 | | | 2.0 | | | 2.0 | | V |
| | Output Resistance | f = 1 kHz | | | 8 | | | 18 | | | 19 | | mΩ |
| | Short-Circuit Current | $T_J = 25^\circ C$ | | | 2.1 | | | 1.5 | | | 1.2 | | A |
| | Peak Output Current | $T_J = 25^\circ C$ | | | 2.4 | | | 2.4 | | | 2.4 | | A |
| | Average TC of $V_{OUT}$ | $0^\circ C \leq T_J \leq +125^\circ C$, $I_O = 5$ mA | | | –0.6 | | | –1.5 | | | –1.8 | | mV/°C |
| $V_{IN}$ | Input Voltage Required to Maintain Line Regulation | $T_J = 25^\circ C$, $I_O \leq 1A$ | | 7.5 | | | 14.6 | | | 17.7 | | | V |

**Note 1:** Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions see the Electrical Characteristics.

**Note 2:** The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation ($T_{JMAX}$ = 125°C or 150°C), the junction-to-ambient thermal resistance ($\theta_{JA}$), and the ambient temperature ($T_A$). $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above $T_{JMAX}$ and the electrical specifications do not apply. If the die temperature rises above 150°C, the device will go into thermal shutdown. For the TO-3 package (K, KC), the junction-to-ambient thermal resistance ($\theta_{JA}$) is 39°C/W. When using a heatsink, $\theta_{JA}$ is the sum of the 4°C/W junction-to-case thermal resistance ($\theta_{JC}$) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink. For the TO-220 package (T), $\theta_{JA}$ is 54°C/W and $\theta_{JC}$ is 4°C/W. If SOT-223 is used, the junction-to-ambient thermal resistance is 174°C/W and can be reduced by a heatsink (see Applications Hints on heatsinking).

If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package: Using 0.5 square inches of copper area, $\theta_{JA}$ is 50°C/W; with 1 square inch of copper area, $\theta_{JA}$is 37°C/W; and with 1.6 or more inches of copper area, $\theta_{JA}$ is 32°C/W.

**Note 3:** ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

**Note 4:** All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

**Note 5:** A military RETS specification is available on request. At the time of printing, the military RETS specifications for the LM140AK-5.0/883, LM140AK-12/883, and LM140AK-15/883 complied with the min and max limits for the respective versions of the LM140A. At the time of printing, the military RETS specifications for the LM140K-5.0/883, LM140K-12/883, and LM140K-15/883 complied with the min and max limits for the respective versions of the LM140. The LM140H/883, LM140K/883, and LM140AK/883 may also be procured as a Standard Military Drawing.

# LM7808C
# Electrical Characteristics

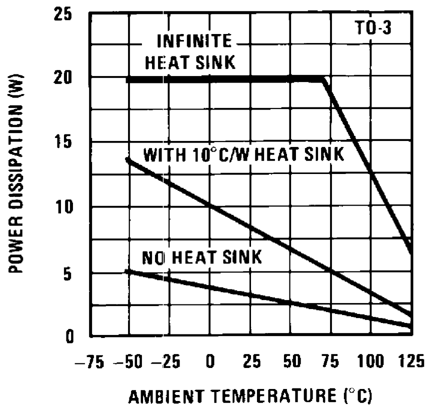
$0^\circ C \le T_J \le +150^\circ C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33$ µF, $C_O = 0.1$ µF, unless otherwise specified

| Symbol | Parameter | | Conditions (Note 6) | | LM7808C Min | LM7808C Typ | LM7808C Max | Units |
|---|---|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | $T_J = 25^\circ C$ | | 7.7 | 8.0 | 8.3 | V |
| $\Delta V_O$ | Line Regulation | | $T_J = 25^\circ C$ | $10.5V \le V_I \le 25V$ | | 6.0 | 160 | mV |
| | | | | $11.0V \le V_I \le 17V$ | | 2.0 | 80 | |
| $\Delta V_O$ | Load Regulation | | $T_J = 25^\circ C$ | $5.0\ mA \le I_O \le 1.5A$ | | 12 | 160 | mV |
| | | | | $250\ mA \le I_O \le 750\ mA$ | | 4.0 | 80 | |
| $V_O$ | Output Voltage | | $11.5V \le V_I \le 23V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$ | | 7.6 | | 8.4 | V |
| $I_Q$ | Quiescent Current | | $T_J = 25^\circ C$ | | | 4.3 | 8.0 | mA |
| $\Delta I_Q$ | Quiescent Current Change | With Line | $11.5V \le V_I \le 25V$ | | | | 1.0 | mA |
| | | With Load | $5.0\ mA \le I_O \le 1.0A$ | | | | 0.5 | |
| $V_N$ | Noise | | $T_A = 25^\circ C$, $10\ Hz \le f \le 100\ kHz$ | | | 52 | | µV |
| $\Delta V_I/\Delta V_O$ | Ripple Rejection | | $f = 120$ Hz, $I_O = 350$ mA, $T_J = 25^\circ C$ | | 56 | 72 | | dB |
| $V_{DO}$ | Dropout Voltage | | $I_O = 1.0A$, $T_J = 25^\circ C$ | | | 2.0 | | V |
| $R_O$ | Output Resistance | | f = 1.0 kHz | | | 16 | | mΩ |
| $I_{OS}$ | Output Short Circuit Current | | $T_J = 25^\circ C$, $V_I = 35V$ | | | 0.45 | | A |
| $I_{PK}$ | Peak Output Current | | $T_J = 25^\circ C$ | | | 2.2 | | A |
| $\Delta V_O/\Delta T$ | Average Temperature Coefficient of Output Voltage | | $I_O = 5.0$ mA | | | 0.8 | | mV/°C |

**Note 6:** All characteristics are measured with a 0.22 µF capacitor from input to ground and a 0.1 µF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \le 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

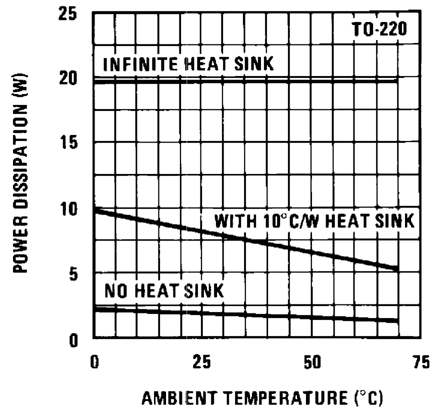
## Typical Performance Characteristics

**Maximum Average Power Dissipation**



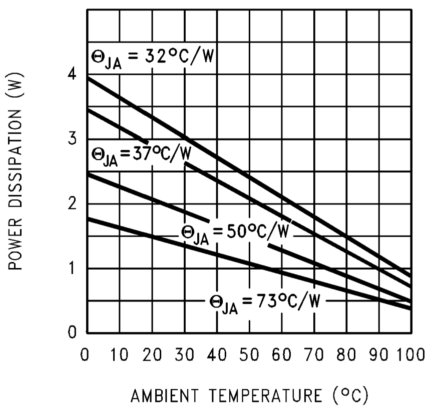

00778122

**Maximum Average Power Dissipation**



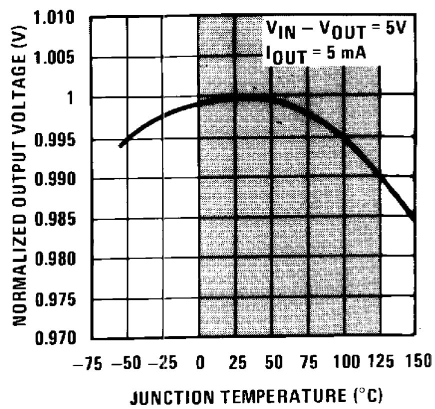

00778123

**Maximum Power Dissipation (TO-263)**
**(See Note 2)**




00778124

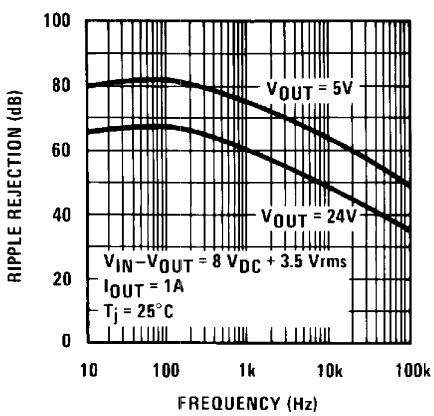
**Output Voltage (Normalized to 1V at $T_J$ = 25˚C)**




00778125

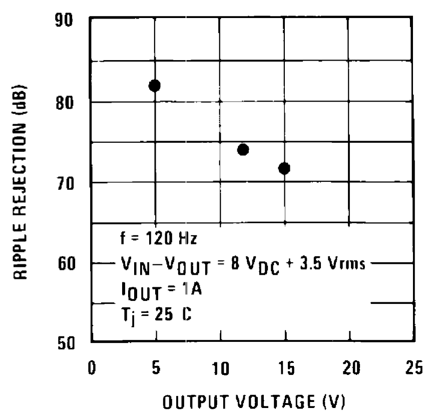
**Note:** Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

**Ripple Rejection**




00778126

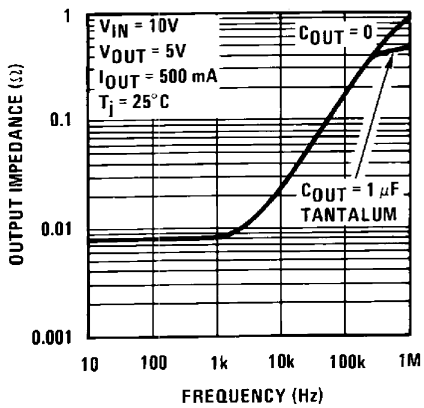
**Ripple Rejection**




00778127

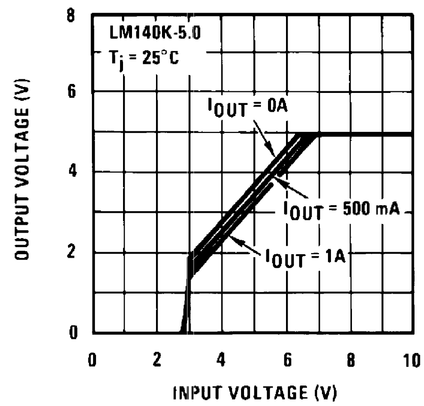
## Typical Performance Characteristics (Continued)

**Output Impedance**



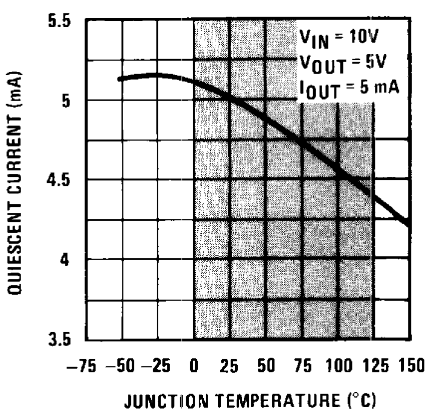

00778128

**Dropout Characteristics**




00778129

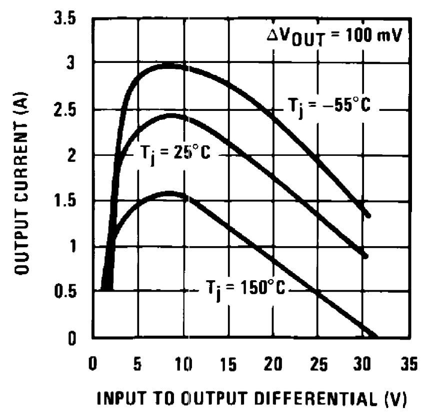
**Quiescent Current**




00778130

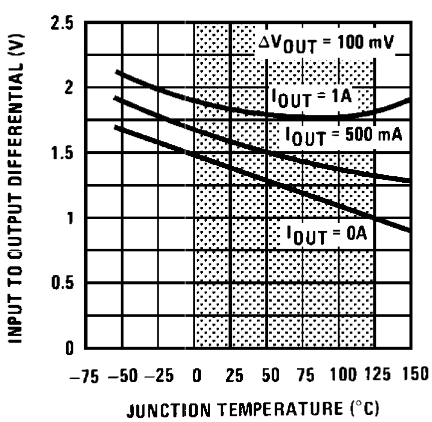
**Note:** Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

**Peak Output Current**




00778131

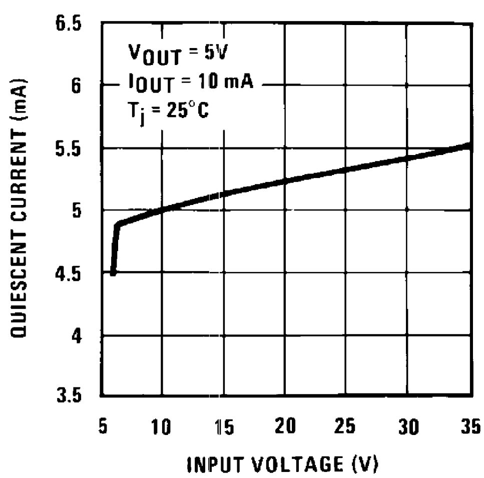
**Dropout Voltage**




00778132

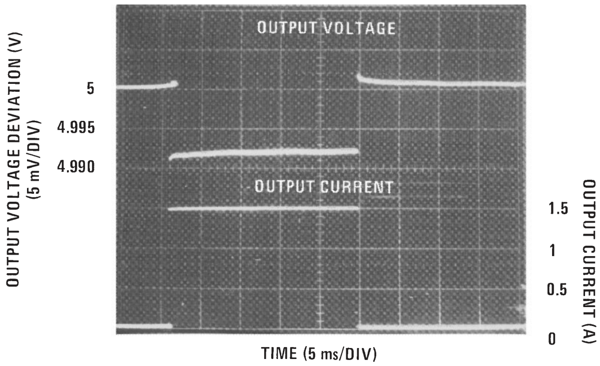
**Note:** Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

**Quiescent Current**



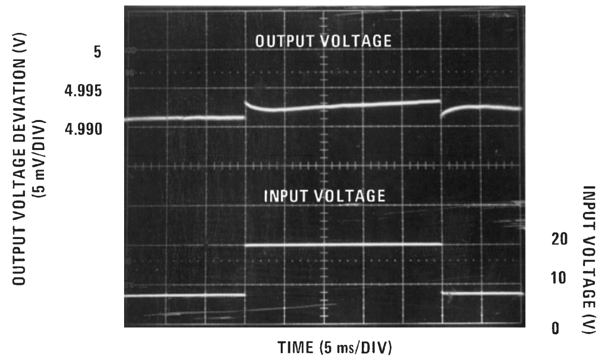

00778133

**Line Regulation**
**140AK-5.0, $I_{OUT}$ = 1A, $T_A$ = 25˚C**



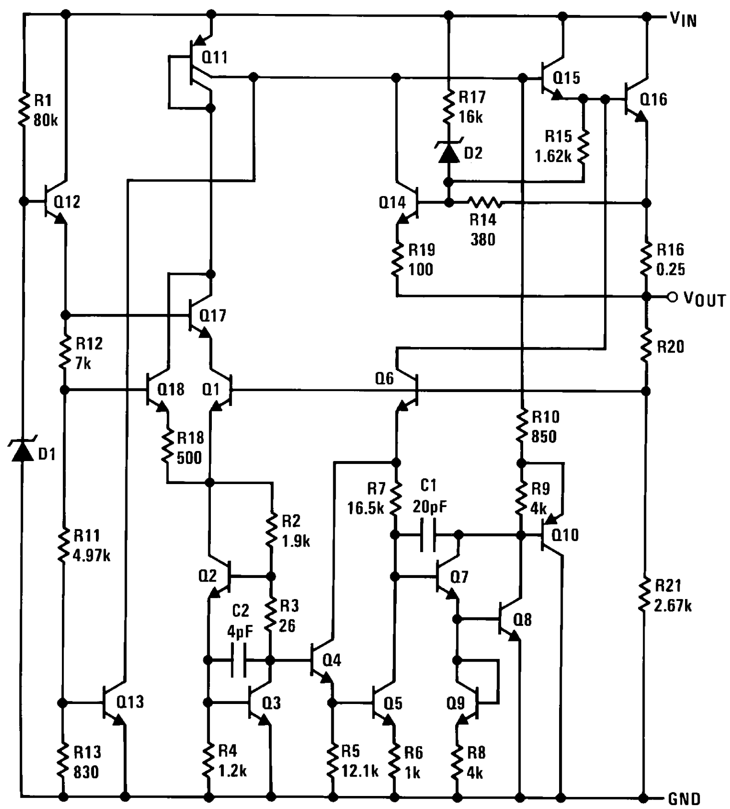

00778105

**Line Regulation**
**140AK-5.0, $V_{IN}$ = 10V, $T_A$ = 25˚C**




00778106

## Equivalent Schematic




00778107

## Application Hints

The LM340/LM78XX series is designed with thermal protection, output short-circuit protection and output transistor safe area protection. However, as with *any* IC regulator, it becomes necessary to take precautions to assure that the regulator is not inadvertently damaged. The following describes possible misapplications and methods to prevent damage to the regulator.

**Shorting the Regulator Input:** When using large capacitors at the output of these regulators, a protection diode connected input to output (*Figure 1*) may be required if the input is shorted to ground. Without the protection diode, an input short will cause the input to rapidly approach ground potential, while the output remains near the initial $V_{OUT}$because of the stored charge in the large output capacitor. The capacitor will then discharge through a large internal input to output diode and parasitic transistors. If the energy released by the capacitor is large enough, this diode, low current metal and the regulator will be destroyed. The fast diode in *Figure 1* will shunt most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance ≤ 10 µF.

**Raising the Output Voltage above the Input Voltage:** Since the output of the device does not sink current, forcing the output high can cause damage to internal low current paths in a manner similar to that just described in the "Shorting the Regulator Input" section.

## Application Hints (Continued)

**Regulator Floating Ground** (*Figure 2*): When the ground pin alone becomes disconnected, the output approaches the unregulated input, causing possible damage to other circuits connected to $V_{OUT}$. If ground is reconnected with power "ON", damage may also occur to the regulator. This fault is most likely to occur when plugging in regulators or modules with on card regulators into powered up sockets. Power should be turned off first, thermal limit ceases operating, or ground should be connected first if power must be left on.

**Transient Voltages:** If transients exceed the maximum rated input voltage of the device, or reach more than 0.8V below ground and have sufficient energy, they will damage the regulator. The solution is to use a large input capacitor, a series input breakdown diode, a choke, a transient suppressor or a combination of these.

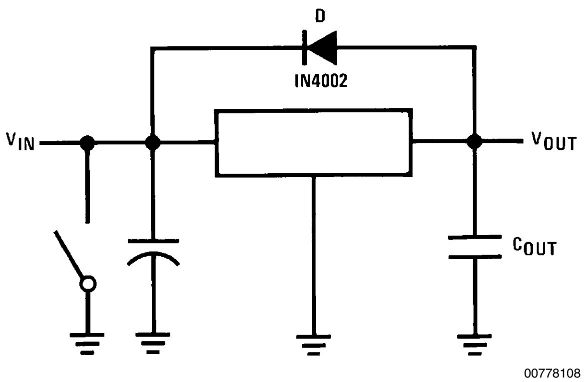



**FIGURE 1. Input Short**

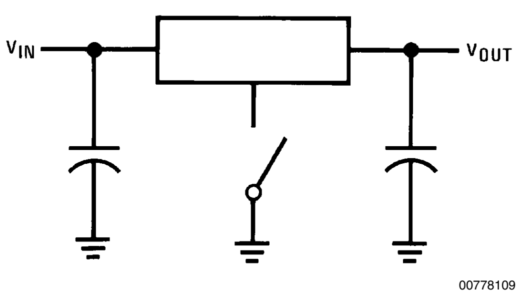



**FIGURE 2. Regulator Floating Ground**

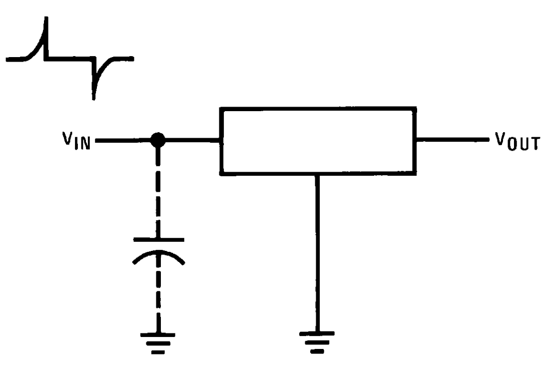



**FIGURE 3. Transients**

When a value for $\theta_{(H-A)}$ is found using the equation shown, a heatsink must be selected that has *a value that is less than or equal to this number.*

$\theta_{(H-A)}$ is specified numerically by the heatsink manufacturer in this catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

### HEATSINKING TO-263 AND SOT-223 PACKAGE PARTS

Both the TO-263 ("S") and SOT-223 ("MP") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the plane.

shows for the TO-263 the measured values of $\theta_{(J-A)}$ for different copper area sizes using a typical PCB with 1 ounce copper *and no solder mask over the copper area used for heatsinking*.

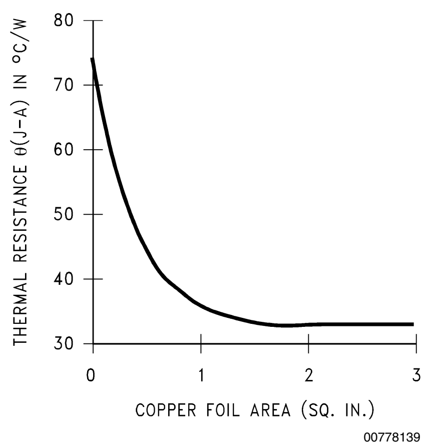



**FIGURE 4. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package**

As shown in the figure, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(J-A)}$ for the TO-263 package mounted to a PCB is 32˚C/W.

As a design aid, *Figure 5* shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming $\theta_{(J-A)}$ is 35˚C/W and the maximum junction temperature is 125˚C).

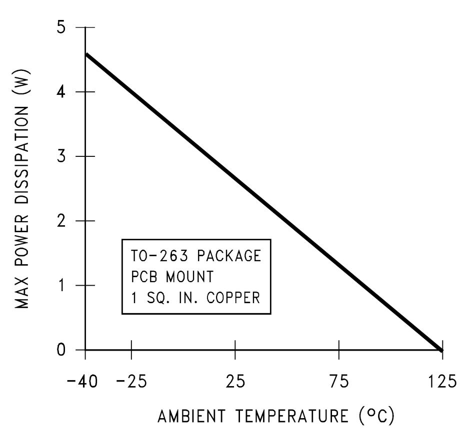



**FIGURE 5. Maximum Power Dissipation vs $T_{AMB}$ for the TO-263 Package**

## Application Hints (Continued)

*Figures 6, 7* show the information for the SOT-223 package. *Figure 6* assumes a $\theta_{(J-A)}$ of 74˚C/W for 1 ounce copper and 51˚C/W for 2 ounce copper and a maximum junction temperature of 125˚C.

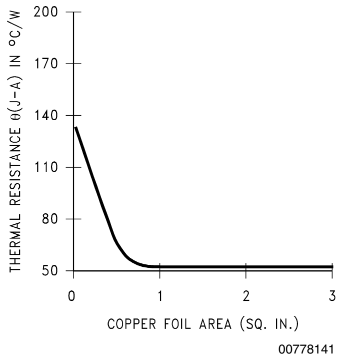



**FIGURE 6. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package**

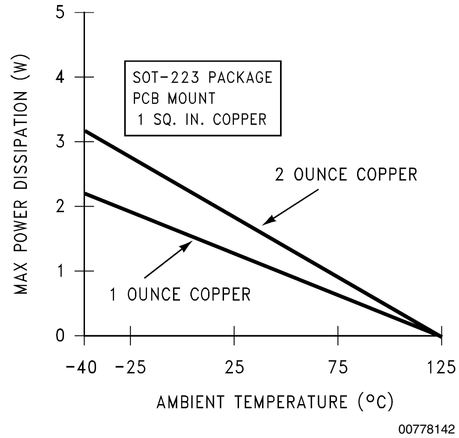
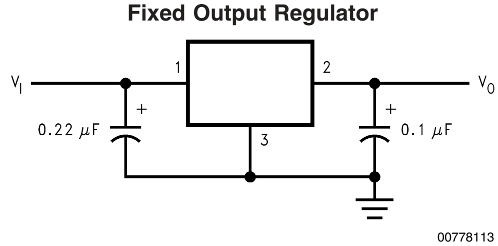



**FIGURE 7. Maximum Power Dissipation vs $T_{AMB}$ for the SOT-223 Package**

Please see AN-1028 for power enhancement techniques to be used with the SOT-223 package.

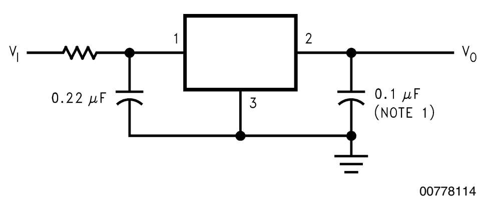
## Typical Applications

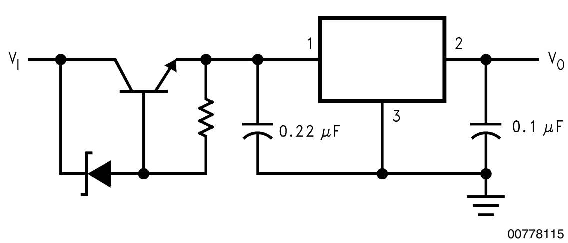
**Fixed Output Regulator**




**Note:** Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

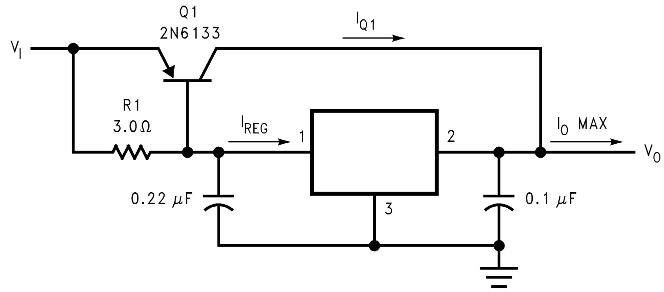
**High Input Voltage Circuits**



## Typical Applications (Continued)

### High Current Voltage Regulator

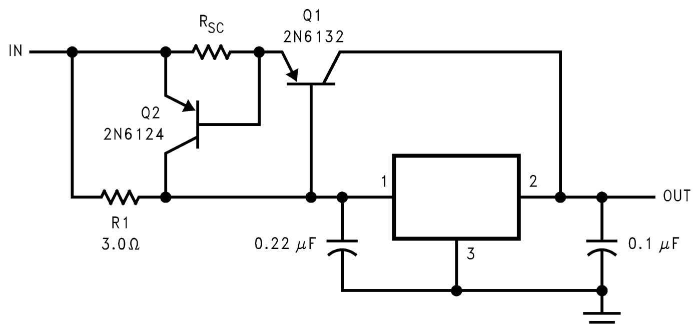



00778116

$$\beta(Q1) \geq \frac{I_{O\ Max}}{I_{REG\ Max}}$$

$$R1 = \frac{0.9}{I_{REG}} = \frac{\beta(Q1)\ V_{BE(Q1)}}{I_{REG\ Max}\ (\beta + 1) - I_{O\ Max}}$$

### High Output Current, Short Circuit Protected

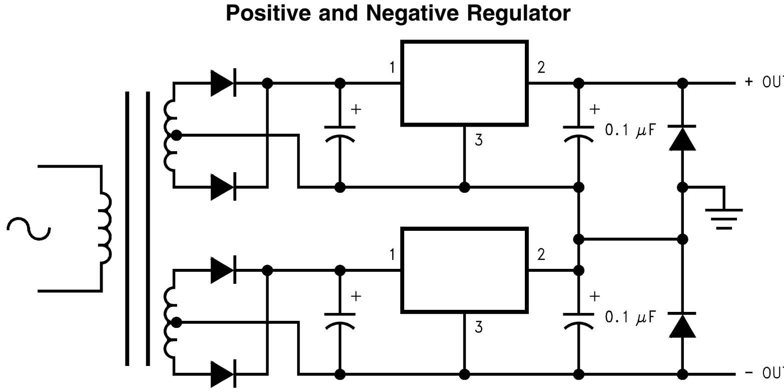



00778117

$$R_{SC} = \frac{0.8}{I_{SC}}$$

$$R1 = \frac{\beta V_{BE(Q1)}}{I_{REG\ Max}\ (\beta + 1) - I_{O\ Max}}$$

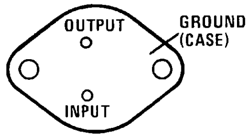
### Positive and Negative Regulator




00778118

## Connection Diagrams and Ordering Information

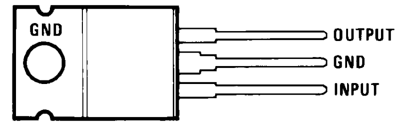
**TO-3 Metal Can Package (K)**




00778111

**Bottom View**
**Steel Package Order Numbers:**
**LM140K-5.0 LM140K-12 LM140K-15**
**LM340K-12 LM340K-15**
**LM340K-5.0**
**See Package Number K02A**
**LM140K-5.0/883 LM140K-12/883 LM140K-15/883**
**See Package Number K02C**

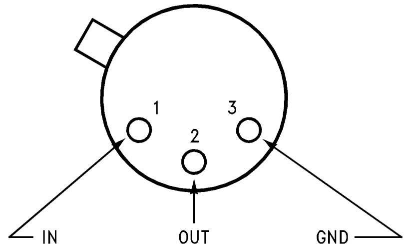
**TO-220 Power Package (T)**




00778112

**Top View**
**Plastic Package Order Numbers:**
**LM340AT-5.0 LM340T-5.0**
**LM340T-12 LM340T-15**
**LM7805CT LM7812CT**
**LM7815CT LM7808CT**
**See Package Number T03B**

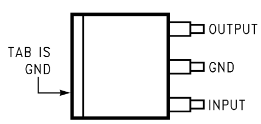
**TO-39 Metal Can Package (H)**




00778119

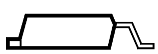
**Top View**
**Metal Can Order Numbers†:**
**LM140H-5.0/883 LM140H-6.0/883**
**LM140H-8.0/883 LM140H-12/883**
**LM140H-15/883 LM140H-24/883**
**See Package Number H03A**

**TO-263 Surface-Mount Package (S)**




00778120

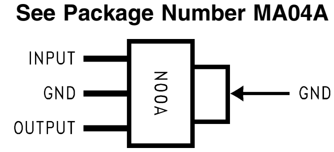
**Top View**



00778121

**Side View**
**Surface-Mount Package Order Numbers:**
**LM340S-5.0 LM340S-12**
**See Package Number TS3B**

**3-Lead SOT-223**
**(Front View)**
**Order Number LM340MP-5.0**
**Package Marked NO0A**
**See Package Number MA04A**

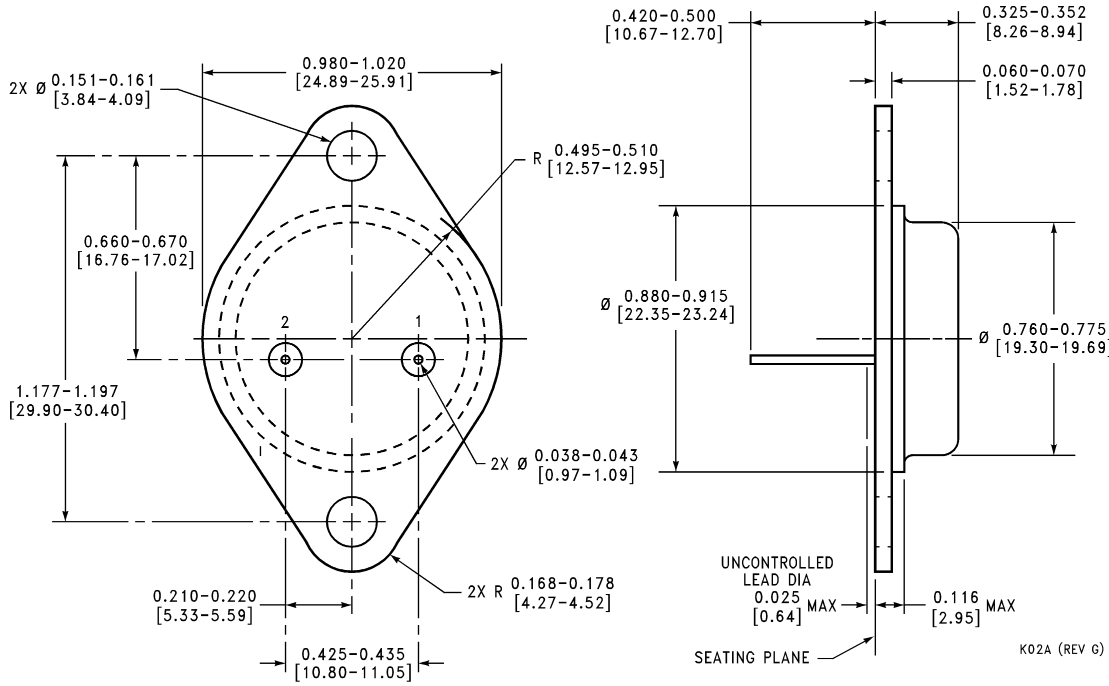



00778143

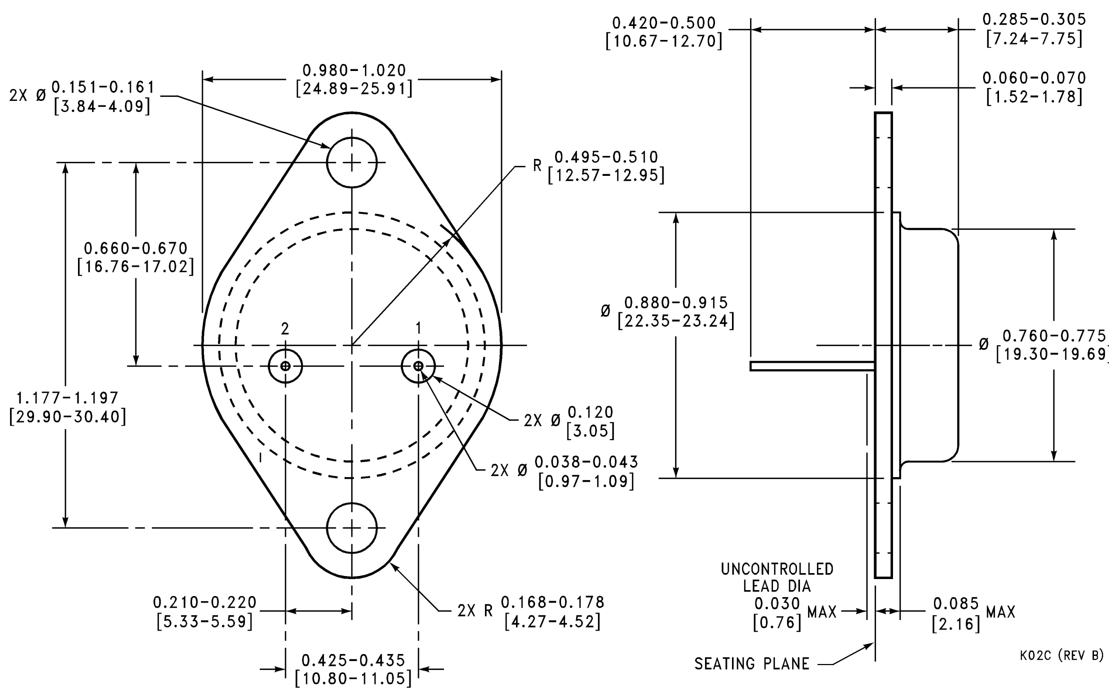
**†The specifications for the LM140H/883 devices are not contained in this datasheet. If specifications for these devices are required, contact the National Semiconductor Sales Office/Distributors.**

## Physical Dimensions inches (millimeters)

unless otherwise noted

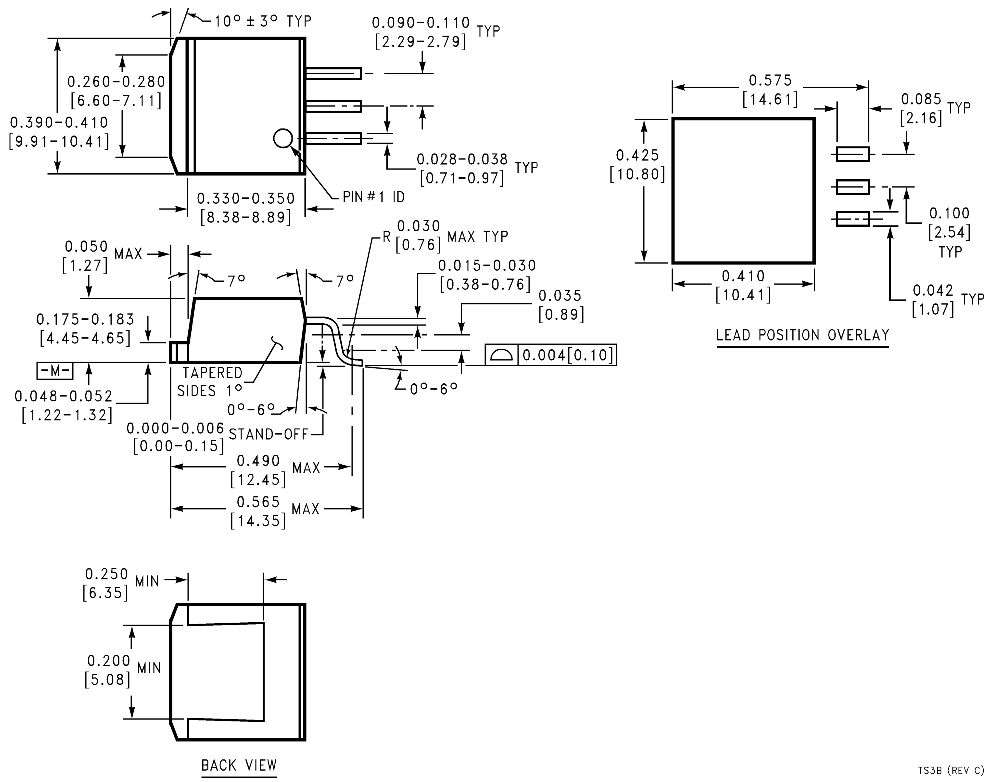



**TO-3 Metal Can Package (K)**
**Order Number LM140K-5.0, LM340K-5.0, LM140K-12, LM340K-12, LM140K-15, LM340K-15, LM7806CK, LM7808CK, LM7818CK or LM7824CK**
**NS Package Number K02A**



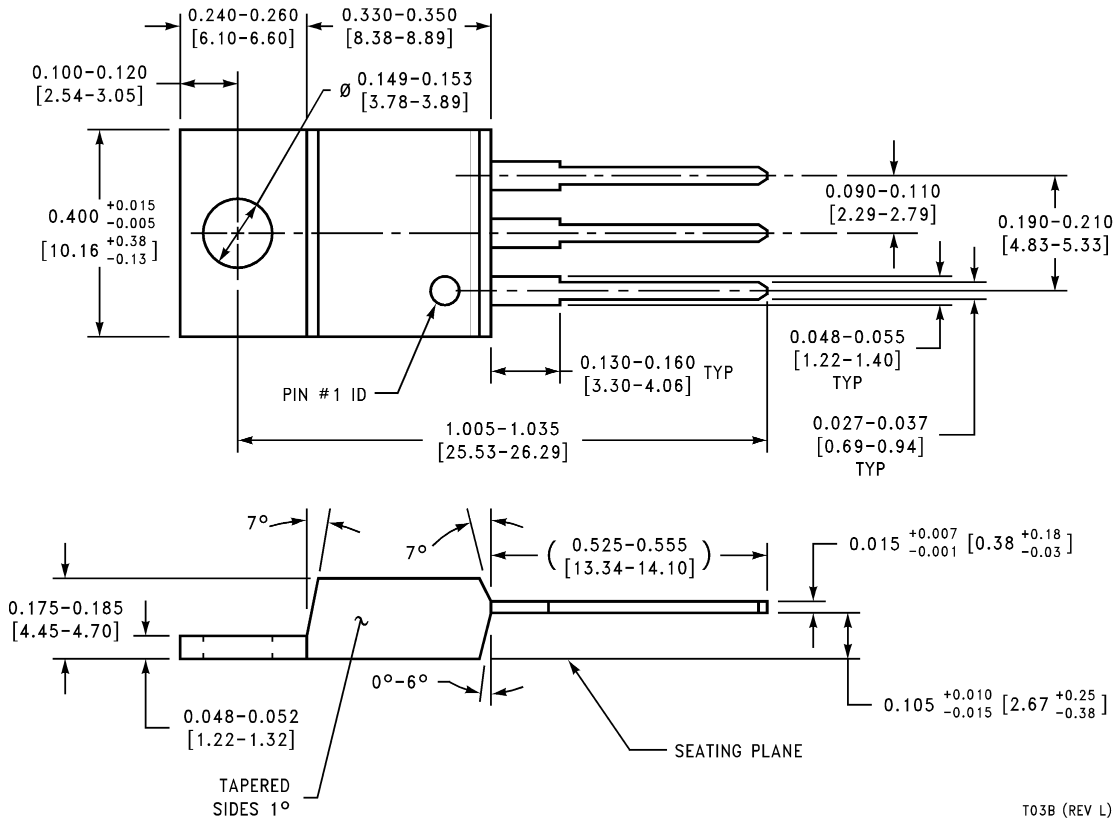

**TO-3 Metal Can Package (K)**
**Mil-Aero Products**
**Order Number LM140K-5.0/883, LM140K-12/883, or LM140K-15/883**
**NS Package Number K02C**

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



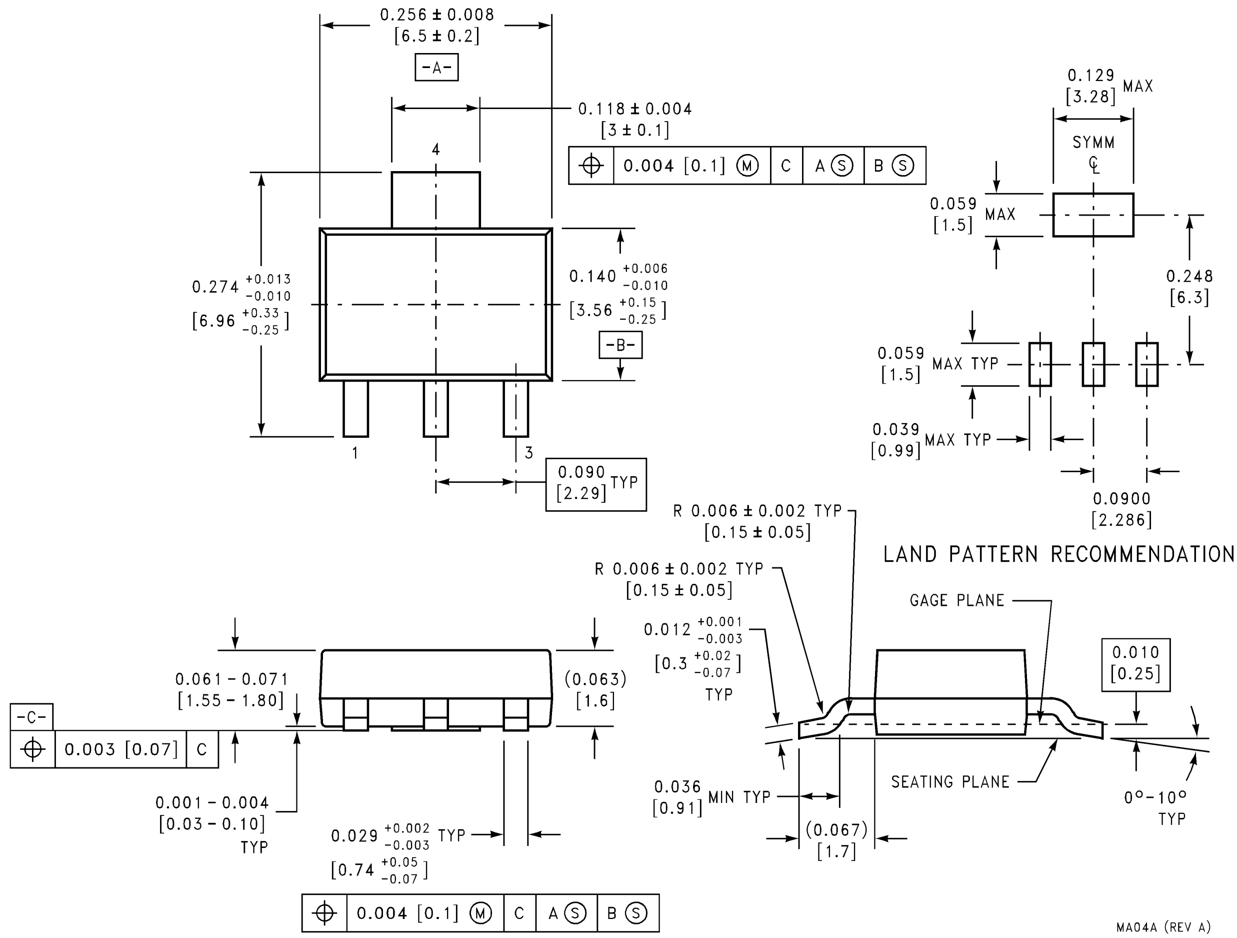

**TO-263 Surface-Mount Package (S)**
**Order Number LM340S-5.0 or LM340S-12**
**NS Package Number TS3B**

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




**TO-220 Power Package (T)**
**Order Number LM340AT/LM340T-5.0, LM340AT/LM340T-12, LM340AT/LM340T-15, LM7805CT, LM7812CT, LM7815CT, LM7806CT, LM7808CT, LM7818CT or LM7824CT**
**NS Package Number T03B**

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




**3-Lead SOT-223 Package**
**Order Part Number LM340MP-5.0**
**NS Package Number MA04A**

### 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.

**National Semiconductor Corporation**
Americas
Email: support@nsc.com

www.national.com

**National Semiconductor Europe**
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 Response Group**
Tel: 65-2544466
Fax: 65-2504466
Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507