National Semiconductor

# LM140A/LM140/LM340A/LM340/LM7800/LM7800C Series 3-Terminal Positive Regulators

## General Description

The LM140A/LM140/LM340A/LM340/LM7800/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 entire series of regulators is available in the steel TO-3 power package. The LM340A/LM340/LM7800/LM7800C series is also available in the TO-220 plastic power package.

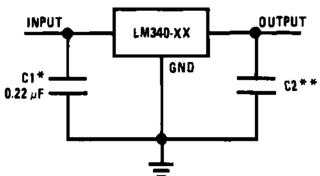
## Features

- Complete specifications at 1A load
- Output voltage tolerances of ±2% at $T_j$ = 25°C and ±4% over the temperature range (LM140A/LM340A)
- Line regulation of 0.01% of $V_{OUT}$/V of $\Delta V_{IN}$ at 1A load (LM140A/LM340A)
- Load regulation of 0.3% of $V_{OUT}$/A (LM140A/LM340A)
- Internal thermal overload protection
- Internal short-circuit current limit
- Output transistor safe area protection
- $P^+$ Product Enhancement tested

| Device | Output Voltages | Packages |
|---|---|---|
| LM140A/LM140 | 5, 12, 15 | TO-3 (K) |
| LM340A/LM340 | 5, 12, 15 | TO-3 (K), TO-220 (T) |
| LM7800 | 8, 18, 24 | TO-3 (K), TO-220 (T) |
| LM7800C | 5, 6, 8, 12, 15, 18, 24 | TO-3 (K), TO-220 (T) |

## Typical Applications

**Fixed Output Regulator**

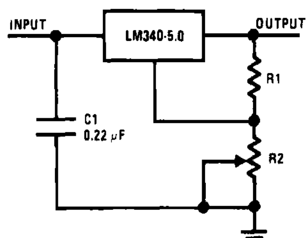



TL/H/7781-1

*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).

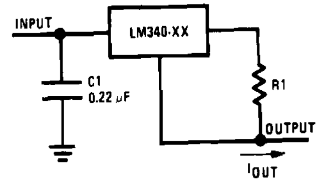
**Adjustable Output Regulator**




TL/H/7781-2

$V_{OUT}$ = 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**




TL/H/7781-3

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

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

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## 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, KC) | 300°C |
| TO-220 Package (T) | 230°C |
| ESD Susceptibility (Note 3) | 2 kV |

## Operating Conditions (Note 1)

| | |
|---|---|
| Temperature Range ($T_A$) (Note 2) | |
| LM140A, LM140, LM7808, LM7818, LM7824 | −55°C to +125°C |
| LM340A, LM340, LM7805C, LM7812C, LM7815C | 0°C to +70°C |
| LM7806C, LM7808C, LM7818C, LM7824C | 0°C to +125°C |

## LM140A/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 |
| | 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) $-55^\circ C \le T_J \le +150^\circ C$ 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 | |
| $V_O$ | Output Voltage | $T_J = 25^\circ C$, $5\ mA \le I_O \le 1A$ | 4.8 | 5 | 5.2 | 11.5 | 12 | 12.5 | 14.4 | 15 | 15.6 | V |
| | | $P_D \le 15W$, $5\ mA \le I_O \le 1A$ | 4.75 | | 5.25 | 11.4 | | 12.6 | 14.25 | | 15.75 | V |
| | | $V_{MIN} \le V_{IN} \le V_{MAX}$ | $(8 \le V_{IN} \le 20)$ | | | $(15.5 \le V_{IN} \le 27)$ | | | $(18.5 \le V_{IN} \le 30)$ | | | V |
| $\Delta V_O$ | Line Regulation | $I_O = 500\ mA$, $T_J = 25^\circ C$ | | 3 | 50 | | 4 | 120 | | 4 | 150 | mV |
| | | $\Delta V_{IN}$ | $(7 \le V_{IN} \le 25)$ | | | $(14.5 \le V_{IN} \le 30)$ | | | $(17.5 \le V_{IN} \le 30)$ | | | V |
| | | $I_O = 500\ mA$, $-55^\circ C \le T_J \le +150^\circ C$ | | | 50 | | | 120 | | | 150 | mV |
| | | $\Delta V_{IN}$ | $(8 \le V_{IN} \le 20)$ | | | $(15 \le V_{IN} \le 27)$ | | | $(18.5 \le V_{IN} \le 30)$ | | | V |
| | | $I_O \le 1A$, $T_J = 25^\circ C$ | | | 50 | | | 120 | | | 150 | mV |
| | | $\Delta V_{IN}$ | $(7.5 \le V_{IN} \le 20)$ | | | $(14.6 \le V_{IN} \le 27)$ | | | $(17.7 \le V_{IN} \le 30)$ | | | V |
| | | $I_O \le 1A$, $-55^\circ C \le T_J \le +150^\circ C$ | | | 25 | | | 60 | | | 75 | mV |
| | | $\Delta V_{IN}$ | $(8 \le V_{IN} \le 12)$ | | | $(16 \le V_{IN} \le 22)$ | | | $(20 \le V_{IN} \le 26)$ | | | V |
| $\Delta V_O$ | Load Regulation | $T_J = 25^\circ C$, $5\ mA \le I_O \le 1.5A$ | | 10 | 50 | | 12 | 120 | | 12 | 150 | mV |
| | | $T_J = 25^\circ C$, $250\ mA \le I_P \le 750\ mA$ | | | 25 | | | 60 | | | 75 | mV |
| | | $-55^\circ C \le T_J \le +150^\circ C$, $5\ mA \le I_O \le 1A$ | | | 50 | | | 120 | | | 150 | mV |
| $I_Q$ | Quiescent Current | $I_O \le 1A$, $T_J = 25^\circ C$ | | | 6 | | | 6 | | | 6 | mA |
| | | $I_O \le 1A$, $-55^\circ C \le T_J \le +150^\circ C$ | | | 7 | | | 7 | | | 7 | mA |
| $\Delta I_Q$ | Quiescent Current Change | $5\ mA \le I_O \le 1A$ | | | 0.5 | | | 0.5 | | | 0.5 | mA |
| | | $T_J = 25^\circ C$, $I_O \le 1A$ | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN} \le V_{IN} \le V_{MAX}$ | $(8 \le V_{IN} \le 20)$ | | | $(15 \le V_{IN} \le 27)$ | | | $(18.5 \le V_{IN} \le 30)$ | | | V |
| | | $I_O = 500\ mA$, $-55^\circ C \le T_J \le +150^\circ C$ | | | 0.8 | | | 0.8 | | | 0.8 | mA |
| | | $V_{MIN} \le V_{IN} \le V_{MAX}$ | $(8 \le V_{IN} \le 25)$ | | | $(15 \le V_{IN} \le 30)$ | | | $(18.5 \le V_{IN} \le 30)$ | | | V |
| $V_N$ | Output Noise Voltage | $T_A = 25^\circ C$, $10\ Hz \le f \le 100\ kHz$ | | 40 | | | 75 | | | 90 | | $\mu V$ |
| $\frac{\Delta V_{IN}}{\Delta V_{OUT}}$ | Ripple Rejection | $f = 120\ Hz$, $I_O \le 1A$, $T_J = 25^\circ C$ or | 68 | 80 | | 61 | 72 | | 60 | 70 | | dB |
| | | $f = 120\ Hz$, $I_O \le 500\ mA$, $-55^\circ C \le T_J \le +150^\circ C$ | 68 | | | 61 | | | 60 | | | dB |
| | | $V_{MIN} \le V_{IN} \le V_{MAX}$ | $(8 \le V_{IN} \le 18)$ | | | $(15 \le V_{IN} \le 25)$ | | | $(18.5 \le V_{IN} \le 28.5)$ | | | 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 | | $m\Omega$ |
| | 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 $V_{OUT}$ | $0^\circ C \le T_J \le +150^\circ C$, $I_O = 5\ mA$ | | −0.6 | | | −1.5 | | | −1.8 | | mV/°C |
| $V_{IN}$ | Input Voltage Required to Maintain Line Regulation | $T_J = 25^\circ C$, $I_O \le 1A$ | 7.5 | | | 14.6 | | | 17.7 | | | V |

## LM340/LM7800C

## Electrical Characteristics (Note 4) 0°C ≤ $T_J$ ≤ +125°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 |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | | (7.5 ≤ $V_{IN}$ ≤ 20) | | | (14.5 ≤ $V_{IN}$ ≤ 27) | | | (17.5 ≤ $V_{IN}$ ≤ 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 |
| | | | 0°C ≤ $T_J$ ≤ +125°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 |
| | | | 0°C ≤ $T_J$ ≤ +125°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 ≤ $I_O$ ≤ 750 mA | | | 25 | | | 60 | | | 75 | mV |
| | | 5 mA ≤ $I_O$ ≤ 1A, 0°C ≤ $T_J$ ≤ +125°C | | | | 50 | | | 120 | | | 150 | mV |
| $I_Q$ | Quiescent Current | $I_O$ ≤ 1A | $T_J$ = 25°C | | | 8 | | | 8 | | | 8 | mA |
| | | | 0°C ≤ $T_J$ ≤ +125°C | | | 8.5 | | | 8.5 | | | 8.5 | 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 | | | | 1.0 | | | 1.0 | | | 1.0 | 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°C ≤ $T_J$ ≤ +125°C | | | | 1.0 | | | 1.0 | | | 1.0 | mA |
| | | $V_{MIN}$ ≤ $V_{IN}$ ≤ $V_{MAX}$ | | (7 ≤ $V_{IN}$ ≤ 25) | | | (14.5 ≤ $V_{IN}$ ≤ 30) | | | (17.5 ≤ $V_{IN}$ ≤ 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 | f = 120 Hz | $I_O$ ≤ 1A, $T_J$ = 25°C | 62 | 80 | | 55 | 72 | | 54 | 70 | | dB |
| | | | or $I_O$ ≤ 500 mA, 0°C ≤ $T_J$ ≤ +125°C | 62 | | | 55 | | | 54 | | | 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 |
| | 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 $V_{OUT}$ | 0°C ≤ $T_J$ ≤ +125°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, $I_O$ ≤ 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.

**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 ($t_w$ ≤ 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.

## LM7806C
## Electrical Characteristics

$0^\circ C \leq T_J \leq +150^\circ C$, $V_I = 11V$, $I_O = 500$ mA, $C_I = 0.33$ $\mu F$, $C_O = 0.1$ $\mu F$, unless otherwise specified

| Symbol | Parameter | | Conditions (Note 4) | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|
| $V_O$ | Output Voltage | | $T_J = 25^\circ C$ | | 5.75 | 6.0 | 6.25 | V |
| $\Delta V_O$ | Line Regulation | | $T_J = 25^\circ C$ | $8.0V \leq V_I \leq 25V$ | | 5.0 | 120 | mV |
| | | | | $9.0V \leq V_I \leq 13V$ | | 1.5 | 60 | |
| $\Delta V_O$ | Load Regulation | | $T_J = 25^\circ C$ | $5.0\text{ mA} \leq I_O \leq 1.5A$ | | 14 | 120 | mV |
| | | | | $250\text{ mA} \leq I_O \leq 750\text{ mA}$ | | 4.0 | 60 | |
| $V_O$ | Output Voltage | | $8.0V \leq V_I \leq 21V$, $5.0\text{ mA} \leq I_O \leq 1.0A$, $P \leq 15W$ | | 5.7 | | 6.3 | V |
| $I_Q$ | Quiescent Current | | $T_J = 25^\circ C$ | | | 4.3 | 8.0 | mA |
| $\Delta I_Q$ | Quiescent Current Change | With Line | $8.0V \leq V_I \leq 25V$ | | | | 1.3 | mA |
| | | With Load | $5.0\text{ mA} \leq I_O \leq 1.0A$ | | | | 0.5 | |
| $V_N$ | Noise | | $T_A = 25^\circ C$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$ | | | 45 | | $\mu V$ |
| $\Delta V_I/\Delta V_O$ | Ripple Rejection | | $f = 120$ Hz, $I_O = 350$ mA, $T_J = 25^\circ C$ | | 59 | 75 | | 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 | | | 9 | | $m\Omega$ |
| $I_{OS}$ | Output Short Circuit Current | | $T_J = 25^\circ C$, $V_I = 35V$ | | | 550 | | mA |
| $I_{PK}$ | 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, $0^\circ C \leq T_A \leq +125^\circ C$ | | | 0.8 | | $mV/^\circ C$ |

## LM7808/LM7808C
## Electrical Characteristics

$-55^\circ C \leq T_J \leq +150^\circ C$ (LM7808) or $0^\circ C \leq T_J \leq +150^\circ C$ (LM7808C), $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33$ $\mu F$, $C_O = 0.1$ $\mu F$, unless otherwise specified

| Symbol | Parameter | | Conditions (Note 4) | | | LM7808 | | | LM7808C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | | $T_J = 25^\circ C$ | | | 7.7 | 8.0 | 8.3 | 7.7 | 8.0 | 8.3 | V |
| $\Delta V_O$ | Line Regulation | | $T_J = 25^\circ C$ | | $10.5V \leq V_I \leq 25V$ | | 6.0 | 80 | | 6.0 | 160 | mV |
| | | | | | $11.0V \leq V_I \leq 17V$ | | 2.0 | 40 | | 2.0 | 80 | |
| $\Delta V_O$ | Load Regulation | | $T_J = 25^\circ C$ | | $5.0\text{ mA} \leq I_O \leq 1.5A$ | | 12 | 100 | | 12 | 160 | mV |
| | | | | | $250\text{ mA} \leq I_O \leq 750\text{ mA}$ | | 4.0 | 40 | | 4.0 | 80 | |
| $V_O$ | Output Voltage | | $11.5V \leq V_I \leq 23V$, $5.0\text{ mA} \leq I_O \leq 1.0A$, $P \leq 15W$ | | | 7.6 | | 8.4 | 7.6 | | 8.4 | V |
| $I_Q$ | Quiescent Current | | $T_J = 25^\circ C$ | | | | 4.3 | 6.0 | | 4.3 | 8.0 | mA |
| $\Delta I_Q$ | Quiescent Current Change | With Line | $11.5V \leq V_I \leq 25V$ | | | | | 0.8 | | | 1.0 | mA |
| | | With Load | $5.0\text{ mA} \leq I_O \leq 1.0A$ | | | | | 0.5 | | | 0.5 | |
| $V_N$ | Noise | | $T_A = 25^\circ C$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$ | | | | 64 | 320 | | 52 | | $\mu V$ |
| $\Delta V_I/\Delta V_O$ | Ripple Rejection | | $f = 120$ Hz, $I_O = 350$ mA, $T_J = 25^\circ C$ | | | 62 | 72 | | 56 | 72 | | dB |
| $V_{DO}$ | Dropout Voltage | | $I_O = 1.0A$, $T_J = 25^\circ C$ | | | | 2.0 | 2.5 | | 2.0 | | V |
| $R_O$ | Output Resistance | | $f = 1.0$ kHz | | | | 16 | | | 16 | | $m\Omega$ |
| $I_{OS}$ | Output Short Circuit Current | | $T_J = 25^\circ C$, $V_I = 35V$ | | | | 0.75 | 1.2 | | 0.45 | | A |
| $I_{PK}$ | Peak Output Current | | $T_J = 25^\circ C$ | | | 1.3 | 2.2 | 3.3 | | 2.2 | | A |
| $\Delta V_O/\Delta T$ | Average Temperature Coefficient of Output Voltage | | $I_O = 5.0$ mA | LM7808 | $-55^\circ C \leq T_A \leq +25^\circ C$ | | | 0.4 | | | | $mV/^\circ C/V_O$ |
| | | | | LM7808 | $+25^\circ C \leq T_A \leq +125^\circ C$ | | | 0.3 | | | | |
| | | | | LM7808C | | | | | | 0.8 | | $mV/^\circ C$ |

**Note 4:** All characteristics are measured with a 0.22 $\mu F$ capacitor from input to ground and a 0.1 $\mu F$ 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 $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

## LM7818/LM7818C

### Electrical Characteristics

$-55°C \leq T_J \leq +150°C$ (LM7818) or $0°C \leq T_J \leq +150°C$ (LM7818C), $V_I = 27V$, $I_O = 500$ mA, $C_I = 0.33$ µF, $C_O = 0.1$ µF, unless otherwise specified

| Symbol | Parameter | | Conditions (Note 4) | | LM7818 | | | LM7818C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | | $T_J = 25°C$ | | 17.3 | 18.0 | 18.7 | 17.3 | 18.0 | 18.7 | V |
| $\Delta V_O$ | Line Regulation | | $T_J = 25°C$ | $21V \leq V_I \leq 33V$ | | 15 | 180 | | 15 | 360 | mV |
| | | | | $24V \leq V_I \leq 30V$ | | 5.0 | 90 | | 5.0 | 180 | |
| $\Delta V_O$ | Load Regulation | | $T_J = 25°C$ | $5.0\ mA \leq I_O \leq 1.5A$ | | 12 | 180 | | 12 | 360 | mV |
| | | | | $250\ mA \leq I_O \leq 750\ mA$ | | 4.0 | 90 | | 4.0 | 180 | |
| $V_O$ | Output Voltage | | $22V \leq V_I \leq 33V$, $5.0\ mA \leq I_O \leq 1.0A$, $P \leq 15W$ | | 17.1 | | 18.9 | 17.1 | | 18.9 | V |
| $I_Q$ | Quiescent Current | | $T_J = 25°C$ | | | 4.5 | 6.0 | | 4.5 | 8.0 | mA |
| $\Delta I_Q$ | Quiescent Current Change | With Line | $22V \leq V_I \leq 33V$ | | | | 0.8 | | | 1.0 | mA |
| | | With Load | $5.0\ mA \leq I_O \leq 1.0A$ | | | | 0.5 | | | 0.5 | |
| $V_N$ | Noise | | $T_A = 25°C$, $10\ Hz \leq f \leq 100\ kHz$ | | | 144 | 720 | | 110 | | µV |
| $\Delta V_I/\Delta V_O$ | Ripple Rejection | | $f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$ | | 59 | 69 | | 53 | 69 | | dB |
| $V_{DO}$ | Dropout Voltage | | $I_O = 1.0A$, $T_J = 25°C$ | | | 2.0 | | | 2.0 | | V |
| $R_O$ | Output Resistance | | $f = 1.0\ kHz$ | | | 22 | | | 22 | | mΩ |
| $I_{OS}$ | Output Short Circuit Current | | $T_J = 25°C$, $V_I = 35V$ | | | 0.75 | | | 0.20 | | A |
| $I_{PK}$ | Peak Output Current | | $T_J = 25°C$ | | 1.3 | 2.2 | 3.3 | | 2.1 | | A |
| $\Delta V_O/\Delta T$ | Average Temperature Coefficient of Output Voltage | | $I_O = 5.0\ mA$, LM7818 | $-55°C \leq T_A \leq +25°C$ | | | 0.4 | | | | mV/°C/$V_O$ |
| | | | LM7818 | $+25°C \leq T_A \leq +125°C$ | | | 0.3 | | | | |
| | | | LM7818C | | | | | | 1.0 | | mV/°C |

## LM7824/LM7824C

### Electrical Characteristics

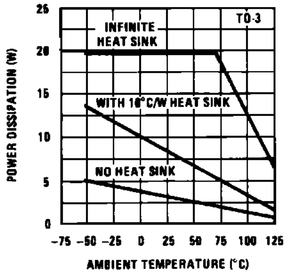
$-55°C \leq T_J \leq +150°C$ (LM7824) or $0°C \leq T_J \leq +150°C$ (LM7824C), $V_I = 33V$, $I_O = 500$ mA, $C_I = 0.33$ µF, $C_O = 0.1$ µF, unless otherwise specified

| Symbol | Parameter | | Conditions (Note 4) | | LM7824 | | | LM7824C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ | Max | Min | Typ | Max | |
| $V_O$ | Output Voltage | | $T_J = 25°C$ | | 23.0 | 24.0 | 25.0 | 23.0 | 24.0 | 25.0 | V |
| $\Delta V_O$ | Line Regulation | | $T_J = 25°C$ | $27V \leq V_I \leq 38V$ | | 18 | 240 | | 18 | 480 | mV |
| | | | | $30V \leq V_I \leq 36V$ | | 6.0 | 120 | | 6.0 | 240 | |
| $\Delta V_O$ | Load Regulation | | $T_J = 25°C$ | $5.0\ mA \leq I_O \leq 1.5A$ | | 12 | 240 | | 12 | 480 | mV |
| | | | | $250\ mA \leq I_O \leq 750\ mA$ | | 4.0 | 120 | | 4.0 | 240 | |
| $V_O$ | Output Voltage | | $28V \leq V_I \leq 38V$, $5.0\ mA \leq I_O \leq 1.0A$, $P \leq 15W$ | | 22.8 | | 25.2 | 22.8 | | 25.2 | V |
| $I_Q$ | Quiescent Current | | $T_J = 25°C$ | | | 4.6 | 6.0 | | 4.6 | 8.0 | mA |
| $\Delta I_Q$ | Quiescent Current Change | With Line | $28V \leq V_I \leq 38V$ | | | | 0.8 | | | 1.0 | mA |
| | | With Load | $5.0\ mA \leq I_O \leq 1.0A$ | | | | 0.5 | | | 0.5 | |
| $V_N$ | Noise | | $T_A = 25°C$, $10\ Hz \leq f \leq 100\ kHz$ | | | 192 | 960 | | 170 | | µV |
| $\Delta V_I/\Delta V_O$ | Ripple Rejection | | $f = 120\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$ | | 56 | 66 | | 50 | 66 | | dB |
| $V_{DO}$ | Dropout Voltage | | $I_O = 1.0A$, $T_J = 25°C$ | | | 2.0 | 2.5 | | 2.0 | | V |
| $R_O$ | Output Resistance | | $f = 1.0\ kHz$ | | | 28 | | | 28 | | mΩ |
| $I_{OS}$ | Output Short Circuit Current | | $T_J = 25°C$, $V_I = 35V$ | | | 0.75 | 1.2 | | 0.15 | | A |
| $I_{PK}$ | Peak Output Current | | $T_J = 25°C$ | | 1.3 | 2.2 | 3.3 | | 2.1 | | A |
| $\Delta V_O/\Delta T$ | Average Temperature Coefficient of Output Voltage | | $I_O = 5.0\ mA$, LM7824 | $-55°C \leq T_A \leq +25°C$ | | | 0.4 | | | | mV/°C/$V_O$ |
| | | | LM7824 | $+25°C \leq T_A \leq +125°C$ | | | 0.3 | | | | |
| | | | LM7824C | | | | | | 1.5 | | mV/°C |

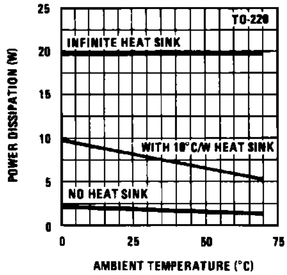
**Note 4:** All characteristics are measured with a 0.22 µF capacitor from input to ground and a 0.1 µF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes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

## Typical Performance Characteristics

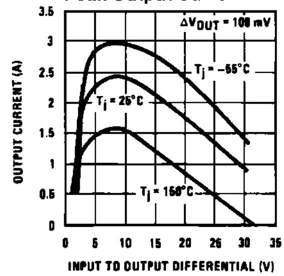
### Maximum Average Power Dissipation



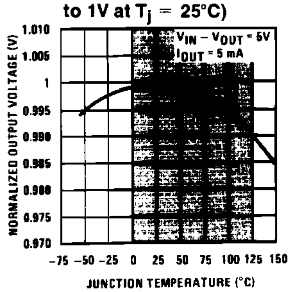

### Maximum Average Power Dissipation




### Peak Output Current

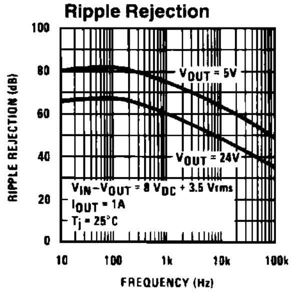



### Output Voltage (Normalized to 1V at $T_j = 25°C$)

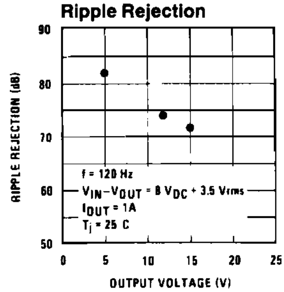



**Note:** Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

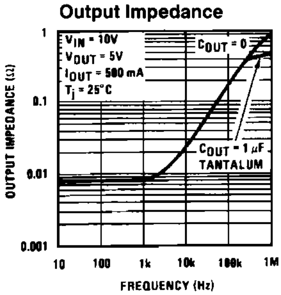
### Ripple Rejection



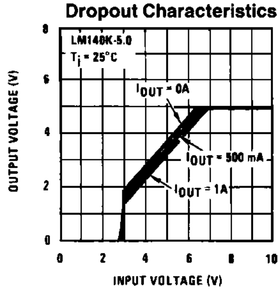

### Ripple Rejection



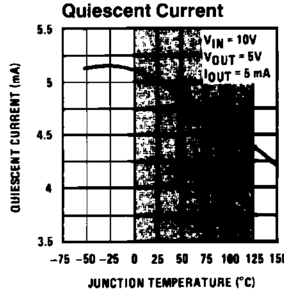

### Output Impedance




### Dropout Characteristics

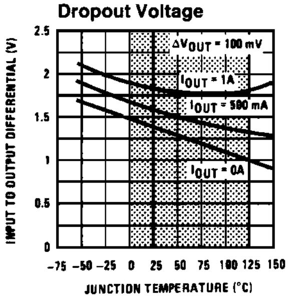



### Quiescent Current



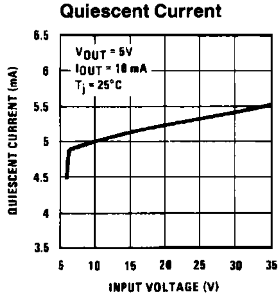

**Note:** Shaded area refers to LM340A/LM340, LM7805C, LM7812C and LM7815C.

### Dropout Voltage




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

### Quiescent Current

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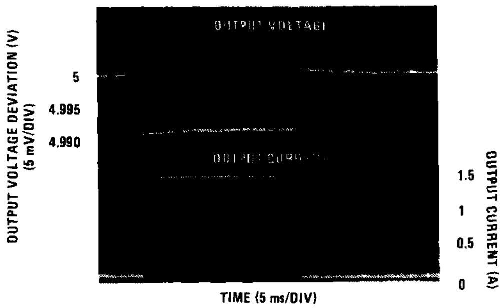
## Typical Performance Characteristics (Continued)

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

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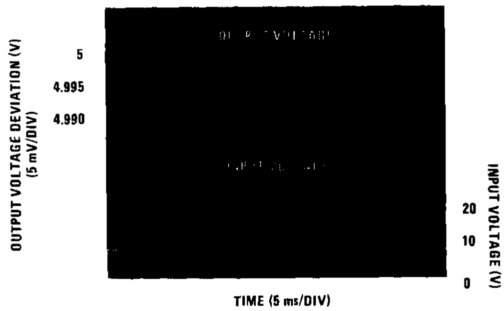
**Line Regulation**
**140AK-5.0, $I_{OUT}$ = 1A, $T_A$ = 25°C**

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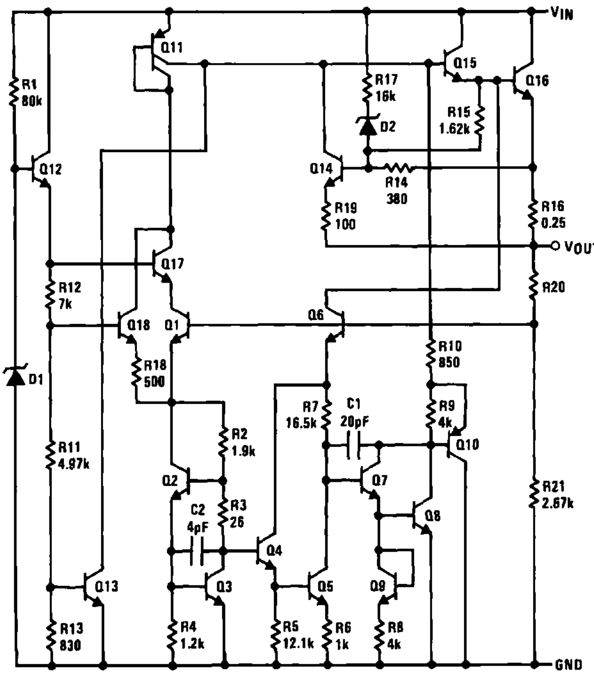
## Equivalent Schematic

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## 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 $\leq$ 10 $\mu$F.

**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.

**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.

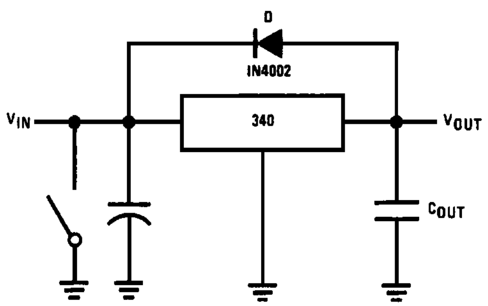


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**FIGURE 1. Input Short**

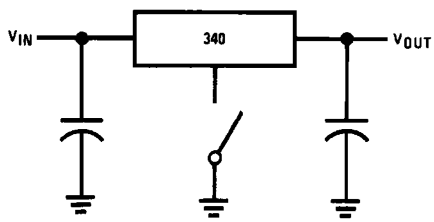


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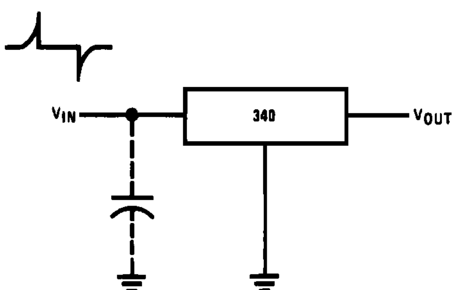
**FIGURE 2. Regulator Floating Ground**



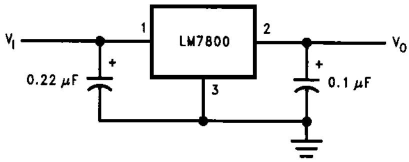

TL/H/7781-10

**FIGURE 3. Transients**

1

# Typical Applications

### Fixed Output Regulator

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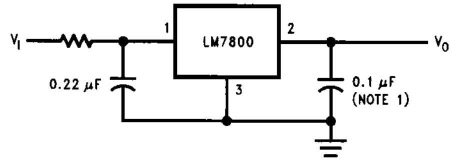
**Note 1:** Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

### High Input Voltage Circuits

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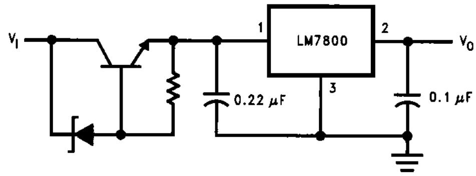


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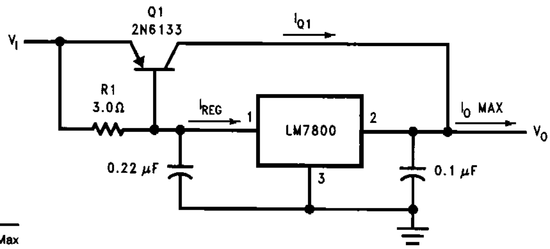
### High Current Voltage Regulator




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

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

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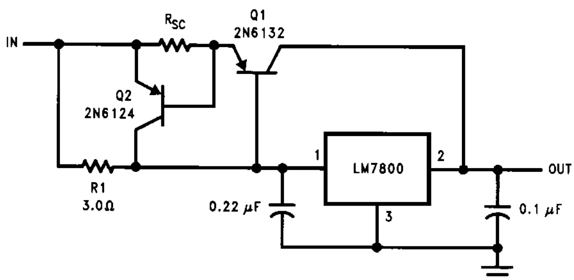
### High Output Current, Short Circuit Protected




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

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

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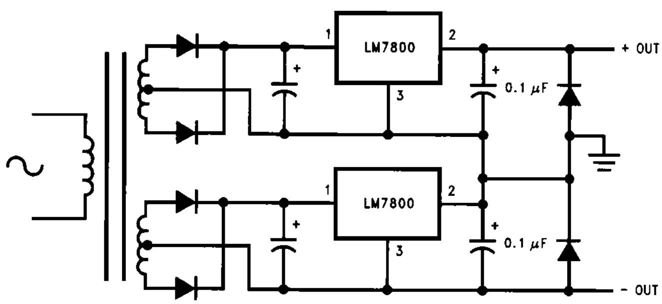
### Positive and Negative Regulator

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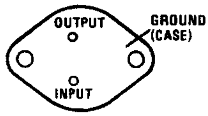
## Connection Diagrams and Ordering Information

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




TL/H/7781-11

**Bottom View**

**Steel Package Order Numbers:**

| | | |
|---|---|---|
| LM140AK-5.0 | LM140AK-12 | LM140AK-15 |
| LM140K-5.0 | LM140K-12 | LM140K-15 |
| LM140AK-5.0/883 | LM140AK-12/883 | LM140AK-15/883 |
| LM140K-5.0/883 | LM140K-12/883 | LM140K-15/883 |
| LM340AK-5.0 | LM340AK-12 | LM340AK-15 |
| LM340K-5.0 | LM340K-12 | LM340K-15 |
| LM7806CK | LM7808CK | LM7808K |
| LM7818CK | LM7818K | LM7824CK |
| | LM7824K | |

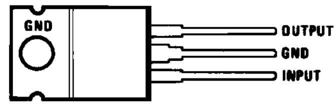
**See Package Number K02A**

**Aluminum Package Order Numbers:**

LM340KC-5.0
LM340KC-12
LM340KC-15
LM7805CK
LM7812CK
LM7815CK

**See Package Number KC02A**

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




TL/H/7781-12

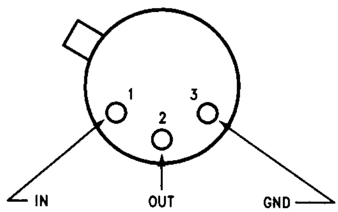
**Top View**

**Plastic Package Order Numbers:**

| | |
|---|---|
| LM340AT-5.0 | LM340T-5.0 |
| LM340AT-12 | LM340T-12 |
| LM340AT-15 | LM340T-15 |
| LM7805CT | LM7812CT |
| LM7815CT | LM7806CT |
| LM7808CT | LM7818CT |
| LM7824CT | |

**See Package Number T03B**

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




TL/H/7781-19

**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**

**†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.**