# LM2990 Negative Low Dropout Regulator

Check for Samples: LM2990

## FEATURES

- 5% Output Accuracy over Entire Operating Range
- Output Current in Excess of 1A
- Dropout Voltage Typically 0.6V at 1A Load
- Low Quiescent Current
- Internal Short Circuit Current Limit
- Internal Thermal Shutdown with Hysteresis
- Functional Complement to the LM2940 Series

## APPLICATIONS

- Post Switcher Regulator
- Local, On-Card, Regulation
- Battery Operated Equipment

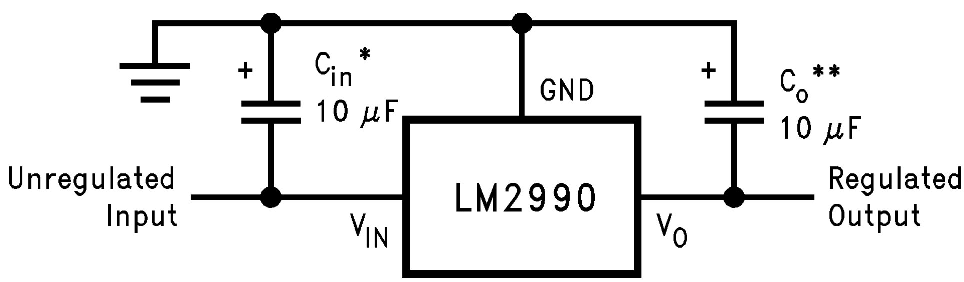
## DESCRIPTION

The LM2990 is a three-terminal, low dropout, 1 ampere negative voltage regulator available with fixed output voltages of −5, −5.2, −12, and −15V.

The LM2990 uses new circuit design techniques to provide low dropout and low quiescent current. The dropout voltage at 1A load current is typically 0.6V and an ensured worst-case maximum of 1V over the entire operating temperature range. The quiescent current is typically 1 mA with 1A load current and an input-output voltage differential greater than 3V. A unique circuit design of the internal bias supply limits the quiescent current to only 9 mA (typical) when the regulator is in the dropout mode ($V_{OUT} - V_{IN} \leq 3V$). Output voltage accuracy is ensured to ±5% over load, and temperature extremes.

The LM2990 is short-circuit proof, and thermal shutdown includes hysteresis to enhance the reliability of the device when overloaded for an extended period of time. The LM2990 is available in a 3-lead package and is rated for operation over the automotive temperature range of −40°C to +125°C.

## Typical Application




*Required if the regulator is located further than 6 inches from the power supply filter capacitors. A 1 µF solid tantalum or a 10 µF aluminum electrolytic capacitor is recommended.
**Required for stability. Must be at least a 10 µF aluminum electrolytic or a 1 µF solid tantalum to maintain stability. May be increased without bound to maintain regulation during transients. Locate the capacitor as close as possible to the regulator. The equivalent series resistance (ESR) is critical, and should be less than 10Ω over the same operating temperature range as the regulator.

## Connection Diagrams

**Front View**

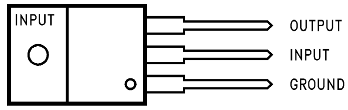



**Figure 1. 3-Lead TO-220 Package**
**See Package Number NDE0003B**

**Top View**

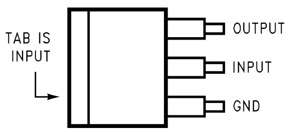



**Figure 2. Surface-Mount DDPAK/TO-263 Package**
**See Package Number KTT0003B**

**Side View**

**Figure 3. Surface-Mount DDPAK/TO-263 Package**
**See Package Number KTT0003B**

**Top View**

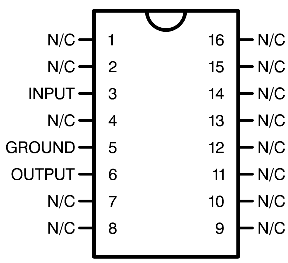



**Figure 4. 16-Lead CDIP Package**
**See Package Number NFE0016A**

**Top View**

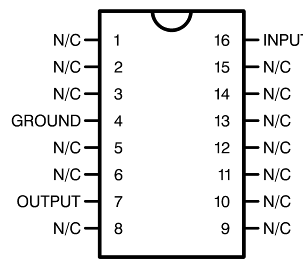



**Figure 5. 16-Lead CLGA Package**
**See Package Number NAC0016A**

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings(1)(2)

| | | |
|---|---|---|
| Input Voltage | | −26V to +0.3V |
| ESD Susceptibility(3) | | 2 kV |
| Power Dissipation(4) | | Internally Limited |
| Junction Temperature ($T_{Jmax}$) | | 125°C |
| Storage Temperature | | −65°C to +150°C |
| Soldering Temperature | TO-220 (T), Wave | 260°C, 10 sec |
| | DDPAK/TO-263 (S) | 235°C, 30 sec |

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) Human body model, 100 pF discharged through a 1.5 kΩ resistor.
(4) The maximum power dissipation is a function of $T_{Jmax}$, $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 125°C, and the LM2990 will eventually go into thermal shutdown at a $T_J$ of approximately 160°C. For the LM2990, the junction-to-ambient thermal resistance, is 53°C/W, 73°C/W for the DDPAK/TO-263, and the junction-to-case thermal resistance is 3°C. If the DD[AK/TO-263 package is used, the thermal resistance can be reduced by increasing the P.C. 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 square inches of copper area, $\theta_{JA}$ is 32°C/W.

## Operating Ratings[1]

| | |
|---|---|
| Junction Temperature Range ($T_J$) | −40°C to +125°C |
| Maximum Input Voltage (Operational) | −26V |

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics.

## Electrical Characteristics

$V_{IN}$ = −5V + $V_{O(NOM)}$[1], $I_O$ = 1A, $C_O$ = 47 μF, unless otherwise specified. **Boldface** limits apply over the entire operating temperature range, −40°C ≤ $T_J$ ≤ 125°C, all other limits apply for $T_J$ = 25°C.

| Parameter | Conditions | LM2990-5.0 | | LM2990-5.2 | | Units (Limit) |
|---|---|---|---|---|---|---|
| | | Typ[2] | Limit[3] | Typ[2] | Limit[3] | |
| Output Voltage ($V_O$) | 5 mA ≤ $I_O$ ≤ 1A | | −4.90 | | −5.10 | V (max) |
| | | | −5.10 | | −5.30 | mV (min) |
| | | −5 | | −5.2 | | V |
| | 5 mA ≤ $I_O$ ≤ 1A | | **−4.75** | | **−4.94** | V (max) |
| | | | **−5.25** | | **−5.46** | V (min) |
| Line Regulation | $I_O$ = 5 mA, $V_{O(NOM)}$ −1V > $V_{IN}$ > −26V | 4 | 40 | 4 | 40 | mV (max) |
| Load Regulation | 50 mA ≤ $I_O$ ≤ 1A | 1 | 40 | 1 | 40 | mV (max) |
| Dropout Voltage | $I_O$ = 0.1A, $\Delta V_O$ ≤ 100 mV | 0.1 | **0.3** | 0.1 | **0.3** | V (max) |
| | $I_O$ = 1A, $\Delta V_O$ ≤ 100 mV | 0.6 | **1** | 0.6 | **1** | V (max) |
| Quiescent Current ($I_q$) | $I_O$ ≤ 1A | 1 | 5 | 1 | 5 | mA (max) |
| | $I_O$ = 1A, $V_{IN}$ = $V_{O(NOM)}$ | 9 | 50 | 9 | 50 | mA (max) |
| Short Circuit Current | $R_L$ = 1Ω[4] | 1.8 | 1.5 | 1.8 | 1.5 | A (min) |
| Maximum Output Current | See[4] | 1.8 | 1.5 | 1.8 | 1.5 | A (min) |
| Ripple Rejection | $V_{ripple}$ = 1 $V_{rms}$, $f_{ripple}$ = 1 kHz, $I_O$ = 5 mA | 58 | 50 | 58 | 50 | dB (min) |
| Output Noise Voltage | 10 Hz–100 kHz, $I_O$ = 5 mA | 250 | 750 | 250 | 750 | μV (max) |
| Long Term Stability | 1000 Hours | 2000 | | 2000 | | ppm |

(1) $V_{O(NOM)}$ is the nominal (typical) regulator output voltage, −5V, −5.2V, −12V or −15V.
(2) Typicals are at $T_J$ = 25°C and represent the most likely parametric norm.
(3) Limits are specified and 100% production tested.
(4) The short circuit current is less than the maximum output current with the −12V and −15V versions due to internal foldback current limiting. The −5V and −5.2V versions, tested with a lower input voltage, does not reach the foldback current limit and therefore conducts a higher short circuit current level. If the LM2990 output is pulled above ground, the maximum allowed current sunk back into the LM2990 is 1.5A.

## Electrical Characteristics

$V_{IN}$ = −5V + $V_{O(NOM)}$[1], $I_O$ = 1A, $C_O$ = 47 μF, unless otherwise specified. **Boldface** limits apply over the entire operating temperature range, −40°C ≤ $T_J$ ≤ 125°C, all other limits apply for $T_J$ = 25°C.

| Parameter | Conditions | LM2990-12 | | LM2990-15 | | Units (Limit) |
|---|---|---|---|---|---|---|
| | | Typ[2] | Limit[3] | Typ[2] | Limit[3] | |
| Output Voltage ($V_O$) | 5 mA ≤ $I_O$ ≤ 1A | | −11.76 | | −14.70 | V (max) |
| | | | −12.24 | | −15.30 | V (min) |
| | | −12 | | −15 | | V |
| | 5 mA ≤ $I_O$ ≤ 1A | | **−11.40** | | **−14.25** | V (max) |
| | | | **−12.60** | | **−15.75** | V (min) |
| Line Regulation | $I_O$ = 5 mA, $V_{O(NOM)}$ −1V > $V_{IN}$ > −26V | 6 | 60 | 6 | 60 | mV (max) |
| Load Regulation | 50 mA ≤ $I_O$ ≤ 1A | 3 | 50 | 3 | 50 | mV (max) |
| Dropout Voltage | $I_O$ = 0.1A, $\Delta V_O$ ≤ 100 mV | 0.1 | **0.3** | 0.1 | **0.3** | V (max) |
| | $I_O$ = 1A, $\Delta V_O$ ≤ 100 mV | 0.6 | **1** | 0.6 | **1** | V (max) |
| Quiescent Current ($I_q$) | $I_O$ ≤ 1A | 1 | 5 | 1 | 5 | mA (max) |
| | $I_O$ = 1A, $V_{IN}$ = $V_{O(NOM)}$ | 9 | 50 | 9 | 50 | mA (max) |
| Short Circuit Current | $R_L$ = 1Ω[4] | 1.2 | 0.9 | 1.0 | 0.75 | A (min) |
| Maximum Output Current | See[4] | 1.8 | 1.4 | 1.8 | 1.4 | A (min) |
| Ripple Rejection | $V_{ripple}$ = 1 $V_{rms}$, $f_{ripple}$ = 1 kHz, $I_O$ = 5 mA | 52 | 42 | 52 | 42 | dB (min) |
| Output Noise Voltage | 10 Hz–100 kHz, $I_O$ = 5 mA | 500 | 1500 | 600 | 1800 | μV (max) |
| Long Term Stability | 1000 Hours | 2000 | | 2000 | | ppm |

(1) $V_{O(NOM)}$ is the nominal (typical) regulator output voltage, −5V, −5.2V, −12V or −15V.
(2) Typicals are at $T_J$ = 25°C and represent the most likely parametric norm.
(3) Limits are specified and 100% production tested.
(4) The short circuit current is less than the maximum output current with the −12V and −15V versions due to internal foldback current limiting. The −5V and −5.2V versions, tested with a lower input voltage, does not reach the foldback current limit and therefore conducts a higher short circuit current level. If the LM2990 output is pulled above ground, the maximum allowed current sunk back into the LM2990 is 1.5A.

## Definition of Terms

**Dropout Voltage:** The input-output voltage differential at which the circuit ceases to regulate against further reduction in input voltage. Measured when the output voltage has dropped 100 mV from the nominal value obtained at ($V_O$ + 5V) input, dropout voltage is dependent upon load current and junction temperature.

**Input Voltage:** The DC voltage applied to the input terminals with respect to ground.

**Input-Output Differential:** The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate.

**Line Regulation:** The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

**Load Regulation:** The change in output voltage for a change in load current at constant chip temperature.

**Long Term Stability:** Output voltage stability under accellerated life-test conditions after 1000 hours with maximum rated voltage and junction temperature.

**Output Noise Voltage:** The rms AC voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

**Quiescent Current:** That part of the positive input current that does not contribute to the positive load current. The regulator ground lead current.

**Ripple Rejection:** The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage.

**Temperature Stability of $V_O$:** The percentage change in output voltage for a thermal variation from room temperature to either temperature extreme.

## Typical Performance Characteristics

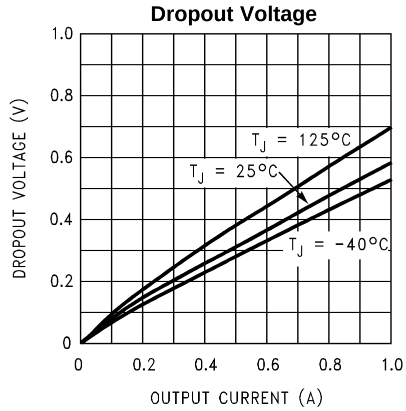



**Figure 6.**

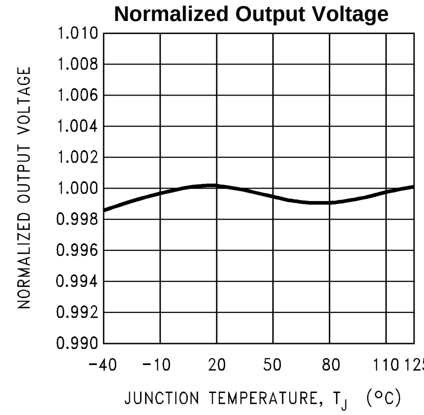



**Figure 7.**

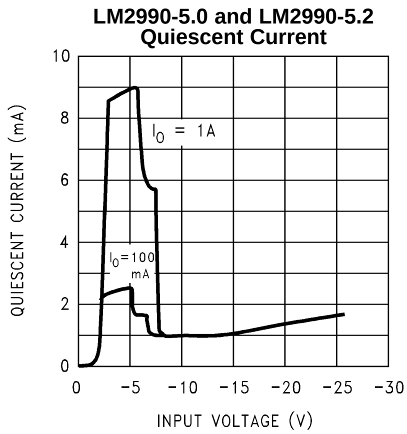



**Figure 8.**

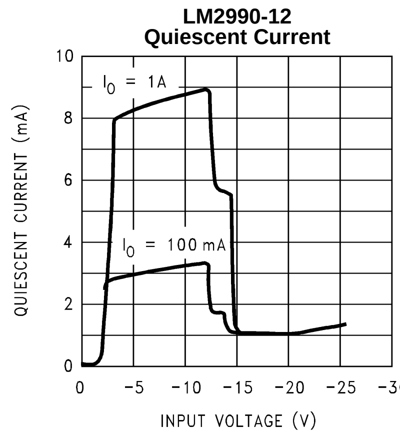



**Figure 9.**

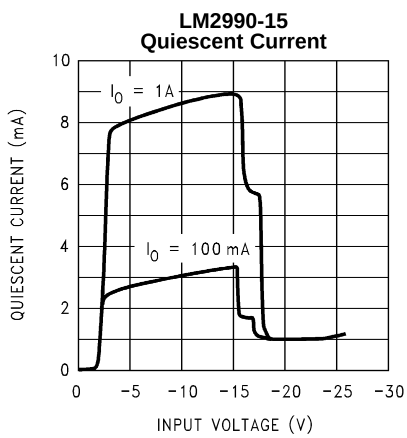



**Figure 10.**

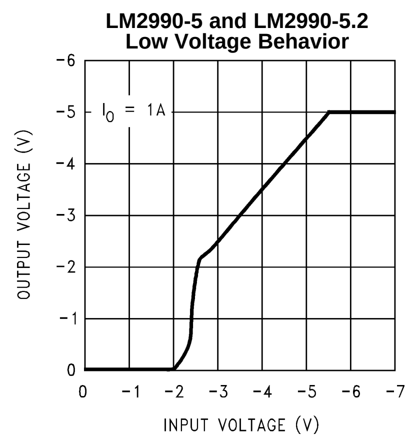



**Figure 11.**

## Typical Performance Characteristics (continued)

**LM2990-5 and LM2990-5.2**
**Line Transient Response**

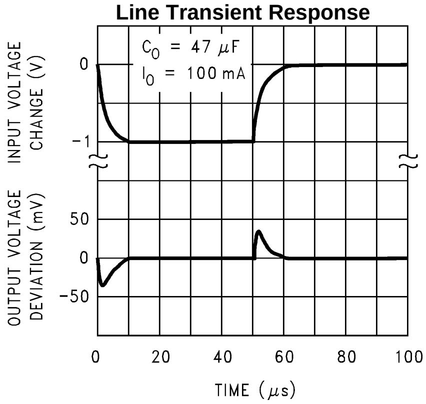



**Figure 12.**

**LM2990-5 and LM2990-5.2**
**Load Transient Response**

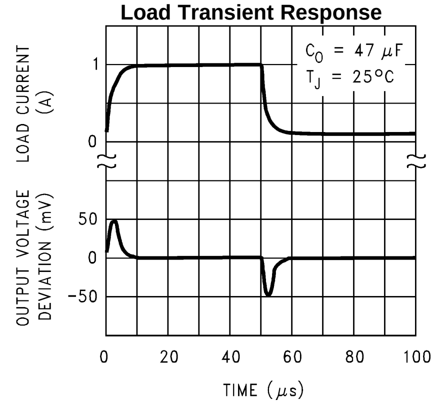



**Figure 13.**

**LM2990-12 and LM2990-15**
**Low Voltage Behavior**

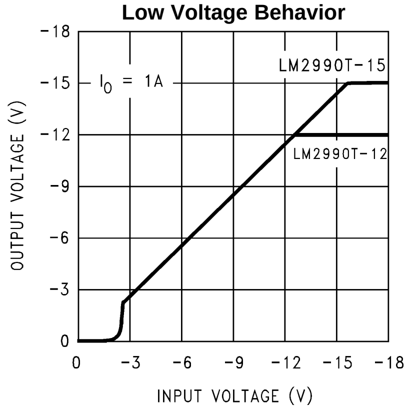



**Figure 14.**

**LM2990-12 and LM2990-15**
**Line Transient Response**

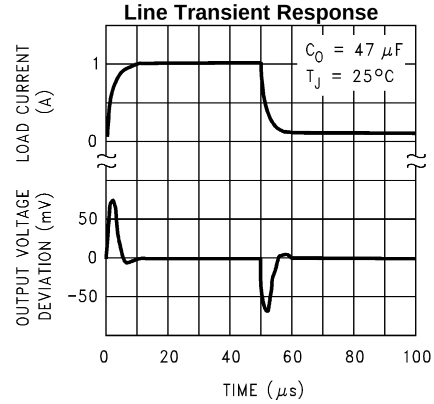



**Figure 15.**

**LM2990-12 and LM2990-15**
**Load Transient Response**

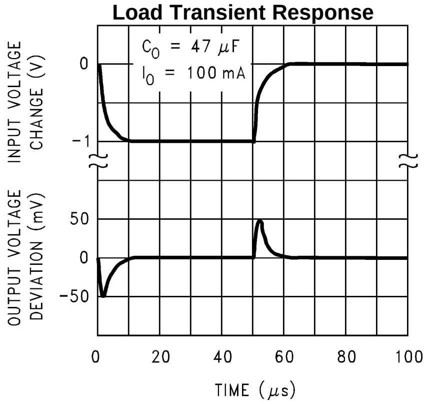



**Figure 16.**

**LM2990-5 and LM2990-5.2**
**Ripple Rejection**

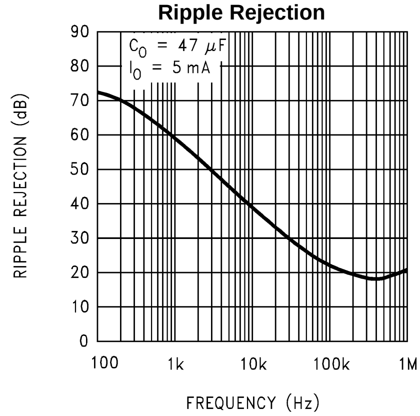



**Figure 17.**

## Typical Performance Characteristics (continued)

**LM2990-5 and LM2990-5.2**
**Output Impedance**

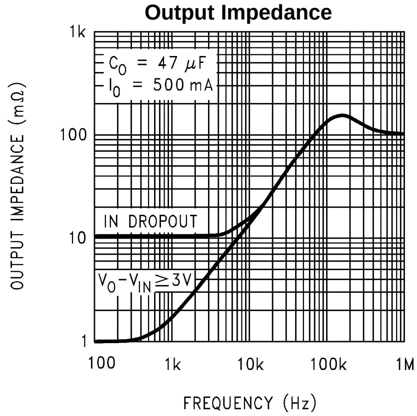



**Figure 18.**

**Maximum Output Current**

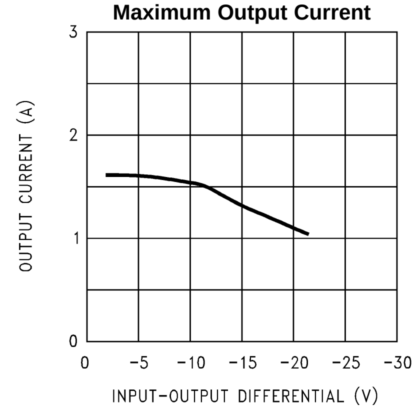



**Figure 19.**

**LM2990-12 and LM2990-15**
**Ripple Rejection**

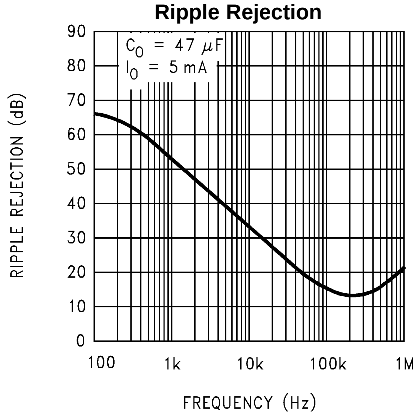



**Figure 20.**

**LM2990-12 and LM2990-15**
**Output Impedance**

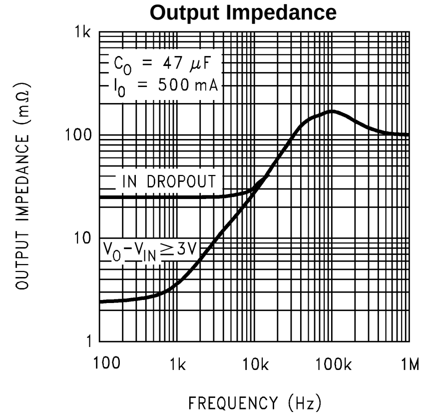



**Figure 21.**

**Maximum Output Current**

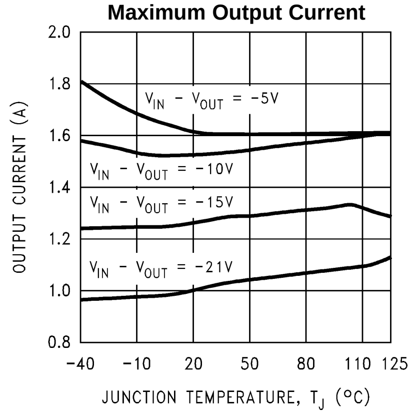



**Figure 22.**

## Typical Performance Characteristics (continued)

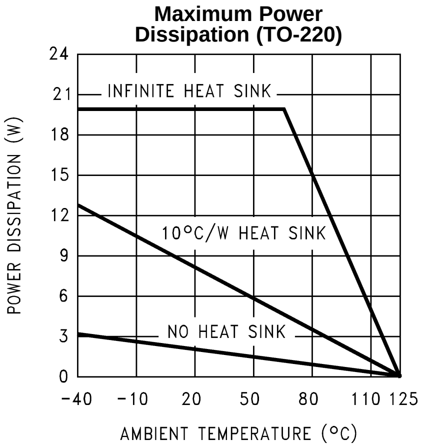



Figure 23.

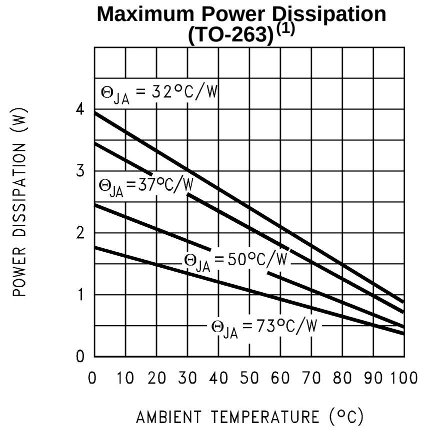



Figure 24.

(1) The maximum power dissipation is a function of $T_{Jmax}$, $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 125°C, and the LM2990 will eventually go into thermal shutdown at a $T_J$ of approximately 160°C. For the LM2990, the junction-to-ambient thermal resistance, is 53°C/W, 73°C/W for the DDPAK/TO-263, and the junction-to-case thermal resistance is 3°C. If the DD[AK/TO-263 package is used, the thermal resistance can be reduced by increasing the P.C. 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 square inches of copper area, $\theta_{JA}$ is 32°C/W.

## Typical Applications

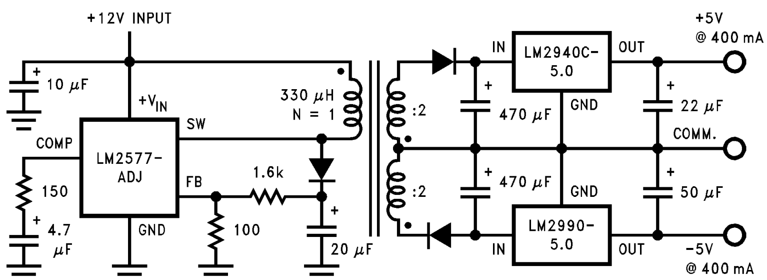



**Figure 25. Post Regulator for an Isolated Switching Power Supply**

The LM2940 is a positive 1A low dropout regulator; refer to its datasheet for further information.

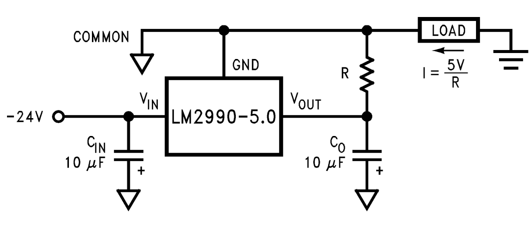



**Figure 26. Fixed Current Sink**

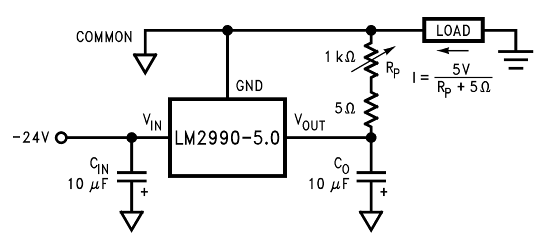



**Figure 27. Adjustable Current Sink**

## APPLICATION HINTS

## EXTERNAL CAPACITORS

The LM2990 regulator requires an output capacitor to maintain stability. The capacitor must be at least 10 µF aluminum electrolytic or 1 µF solid tantalum. The output capacitor's ESR must be less than 10Ω, or the zero added to the regulator frequency response by the ESR could reduce the phase margin, creating oscillations (refer to the graph on the right). An input capacitor, of at least 1 µF solid tantalum or 10 µF aluminum electrolytic, is also needed if the regulator is situated more than 6″ from the input power supply filter.

## FORCING THE OUTPUT POSITIVE

Due to an internal clamp circuit, the LM2990 can withstand positive voltages on its output. If the voltage source pulling the output positive is DC, the current must be limited to 1.5A. A current over 1.5A fed back into the LM2990 could damage the device. The LM2990 output can also withstand fast positive voltage transients up to 26V, without any current limiting of the source. However, if the transients have a duration of over 1 ms, the output should be clamped with a Schottky diode to ground.

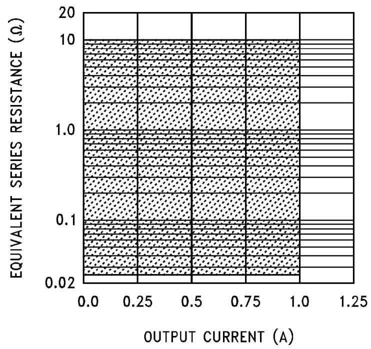
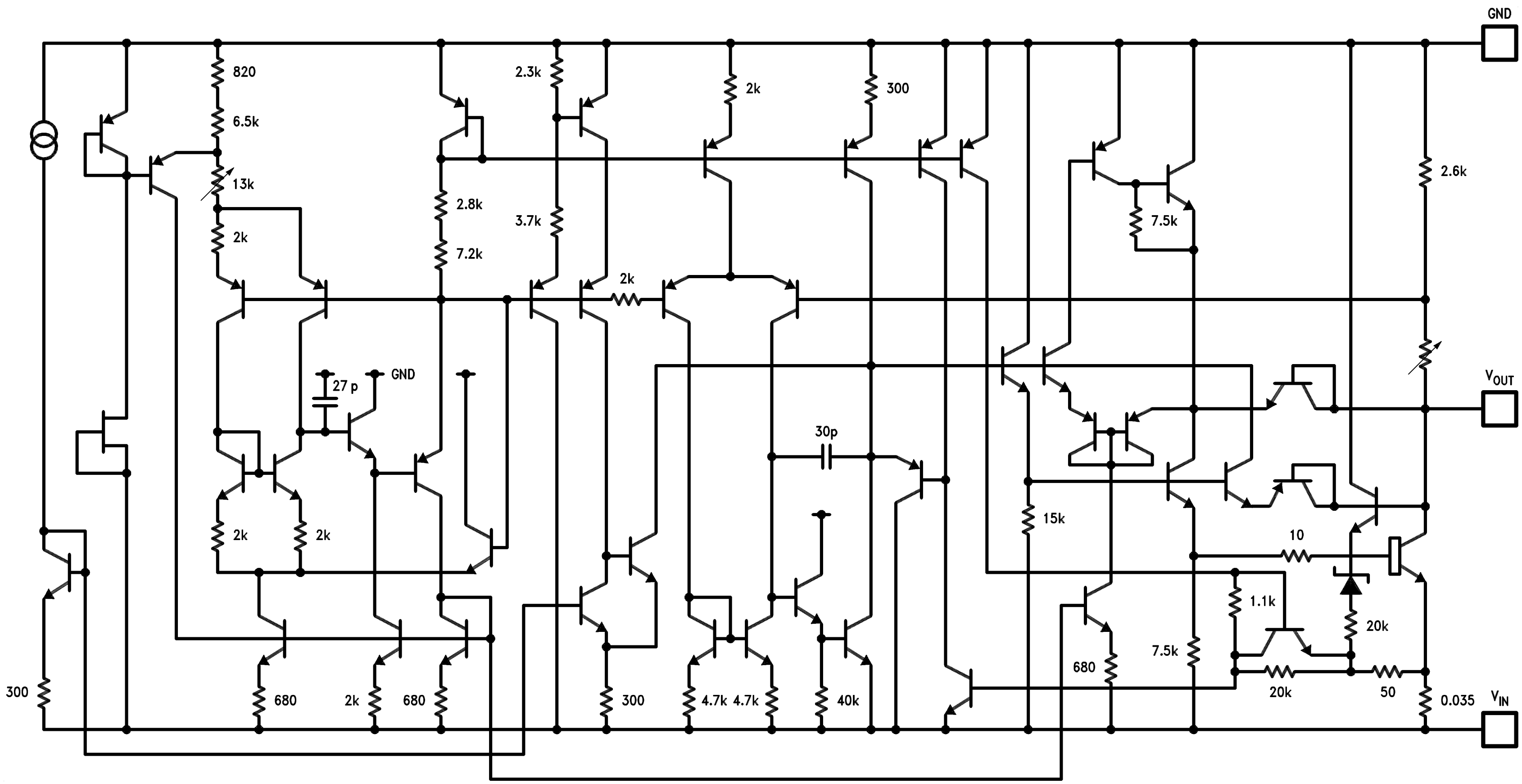



**Figure 28. Output Capacitor ESR**

## Equivalent Schematic



## REVISION HISTORY

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