National Semiconductor

LP2954/LP2954A 5V Micropower Low-Dropout Voltage Regulators

General Description

The LP2954 is a three-terminal, 5V micropower voltage regulator with very low quiescent current (90 μA typical at 1 mA load) and very low dropout voltage (typically 60 mV at light loads and 470 mV at 250 mA load current).

The quiescent current increases only slightly at dropout (120 μA typical), which prolongs battery life.

The LP2954 is available in the three-lead TO-220 package, which makes heatsinking very simple.

Reverse battery protection is provided.

The tight line and load regulation (0.04% typical), as well as very low output temperature coefficient make the LP2954 well suited for use as a low-power voltage reference.

The accuracy of the 5V output is guaranteed at both room temperature and over the entire operating temperature range.

Features

- 5V output within 1.2% over temperature (A grade)
- Guaranteed 250 mA output current
- Extremely low quiescent current
- Low dropout voltage
- Reverse battery protection
- Extremely tight line and load regulation
- Very low temperature coefficient
- Current and thermal limiting
- Pin compatible with LM2940 and LM340

Applications

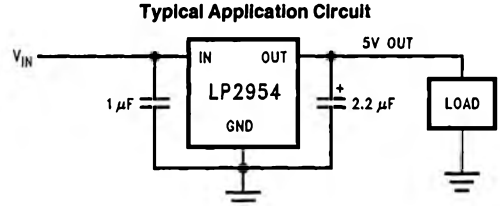
- High-efficiency linear regulator
- Low dropout battery-powered regulator

Package Outline and Ordering Information

Ordering Information

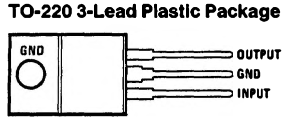
Order Number	Temp. Range (T_J) °C	Package (JEDEC)	NS Package Number
LP2954AIT	−40 to +125	TO-220	TO3B
LP2954IT			

Typical Application Circuit



TL/H/11128-1

TO-220 3-Lead Plastic Package



TL/H/11128-2

Front View

Absolute Maximum Ratings (Note 1)

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

Operating Junction Temperature Range	
LP2954AI/LP2954I	−40°C to +125°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature	
(Soldering, 5 seconds)	260°C
Power Dissipation (Note 2)	Internally Limited
Input Supply Voltage	−20V to +30V
ESD Rating	2 kV

Electrical Characteristics

Limits in standard typeface are for T_J = 25°C, **bold typeface applies over the −40°C to +125°C temperature range**. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise noted: V_{IN} = 6V, I_L = 1 mA, C_L = 2.2 μF.

Symbol	Parameter	Conditions	Typical	2954AI		2954I		Units
				Min	Max	Min	Max	
V_O	Output Voltage		5.0	4.975 **4.940**	5.025 **5.060**	4.950 **4.900**	5.050 **5.100**	V
		1 mA ≤ I_L ≤ 250 mA	5.0	**4.930**	**5.070**	**4.880**	**5.120**	V
$\frac{\Delta V_O}{\Delta T}$	Output Voltage Temp. Coefficient	(Note 3)	**20**		**100**		**150**	ppm/°C
$\frac{\Delta V_O}{V_O}$	Line Regulation	V_{IN} = 6V to 30V	0.03		0.10 **0.20**		0.20 **0.40**	%
$\frac{\Delta V_O}{V_O}$	Load Regulation	I_L = 1 to 250 mA I_L = 0.1 to 1 mA (Note 4)	0.04		0.16 **0.20**		0.20 **0.30**	%
$V_{IN}-V_O$	Dropout Voltage (Note 5)	I_L = 1 mA	60		100 **150**		100 **150**	mV
		I_L = 50 mA	240		300 **420**		300 **420**	mV
		I_L = 100 mA	310		400 **520**		400 **520**	mV
		I_L = 250 mA	470		600 **800**		600 **800**	mV
I_{GND}	Ground Pin Current (Note 6)	I_L = 1 mA	90		150 **180**		150 **180**	μA
		I_L = 50 mA	1.1		2 **2.5**		2 **2.5**	mA
		I_L = 100 mA	4.5		6 **8**		6 **8**	mA
		I_L = 250 mA	21		28 **33**		28 **33**	mA
I_{GND}	Ground Pin Current at Dropout (Note 6)	V_{IN} = 4.5V	120		170 **210**		170 **210**	μA
I_{LIMIT}	Current Limit	V_{OUT} = 0V	380		500 **530**		500 **530**	mA
$\frac{\Delta V_O}{\Delta Pd}$	Thermal Regulation	(Note 7)	0.05		0.2		0.2	%/W
e_n	Output Noise Voltage (10 Hz to 100 kHz) I_L = 100 mA	C_L = 2.2 μF	400					μV RMS
		C_L = 33 μF	260					μV RMS

Electrical Characteristics (Continued)

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

Note 2: The maximum allowable power dissipation is a function of the maximum junction temperature, T_J (MAX), the junction-to-ambient thermal resistance, $\theta_{J\text{-}A}$, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using: $P(MAX) = \frac{T_J\,(MAX) - T_A}{\theta_{J\text{-}A}}$.

Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown. The junction-to-ambient thermal resistance of the LP2954 (without external heatsink) is 60° C/W. The junction-to-case thermal resistance is 3 °C/W. If an external heatsink is used, the effective junction-to-ambient thermal resistance is the sum of the junction-to-case resistance (3 °C/W), the specified thermal resistance of the heatsink selected, and the thermal resistance of the interface between the heatsink and the LP2954. Some typical values are listed for interface materials used with TO-220 packages:

Typical Values of Case-to-Heatsink Thermal Resistance (°C/W)

TABLE I. (Data from AAVID Eng.)

Silicone grease	1.0
Dry interface	1.3
Mica with grease	1.4

TABLE II. (Data from Thermalloy)

Thermasil III	1.3
Thermasil II	1.5
Thermalfilm (0.002) with grease	2.2

Note 3: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested separately for load regulation in the load ranges 0.1–1 mA and 1–250 mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below the value measured with a 1V differential.

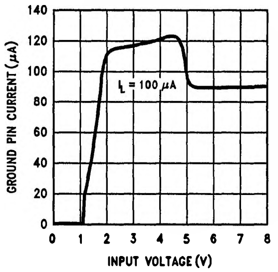
Note 6: Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the load current plus the ground pin current.

Note 7: Thermal regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for 200 mA load pulse at V_{IN} = 20V (3W pulse) for T = 10 ms.

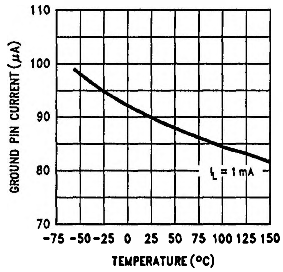
Note 8: When used in dual-supply systems where the regulator load is returned to a negative supply, the output voltage must be diode-clamped to ground.

Typical Performance Characteristics

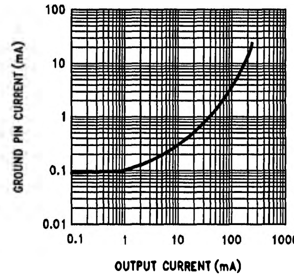
Quiescent Current



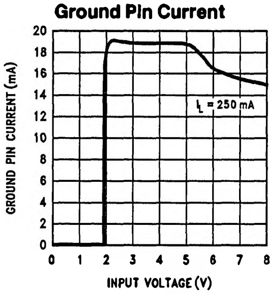
Quiescent Current



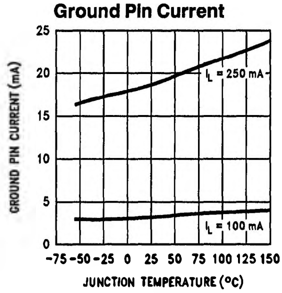
Ground Pin Current vs Load



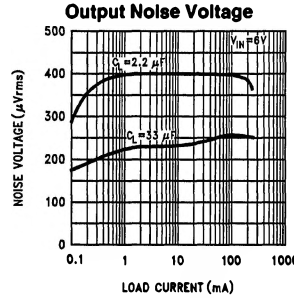
Ground Pin Current



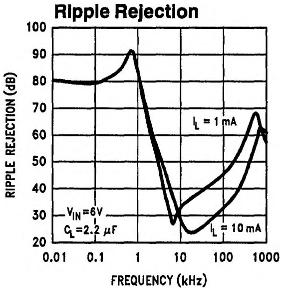
Ground Pin Current



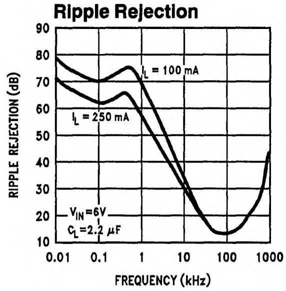
Output Noise Voltage



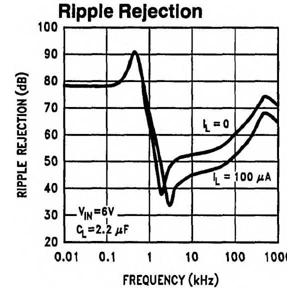
Ripple Rejection



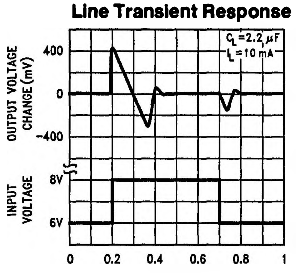
Ripple Rejection



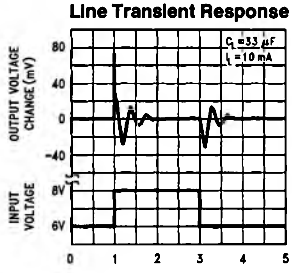
Ripple Rejection



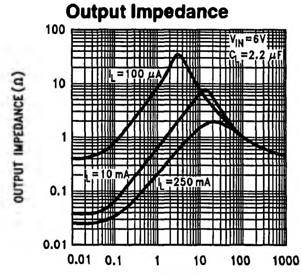
Line Transient Response



Line Transient Response



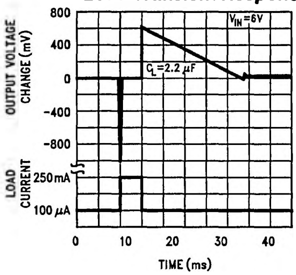
Output Impedance



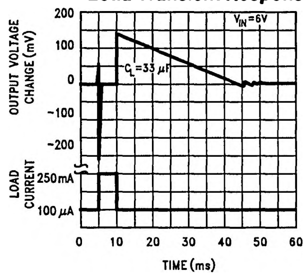
TL/H/11128–3

Typical Performance Characteristics (Continued)

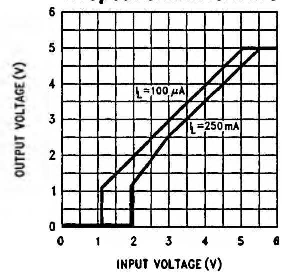
Load Transient Response



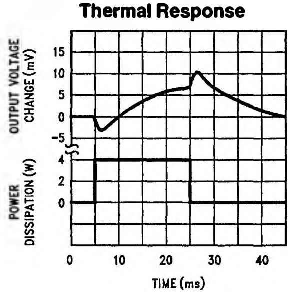
Load Transient Response



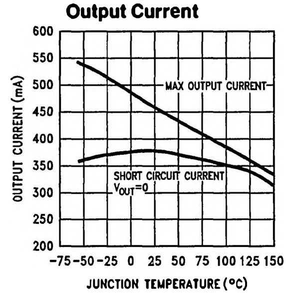
Dropout Characteristics



Thermal Response



Short-Circuit Output Current and Maximum Output Current



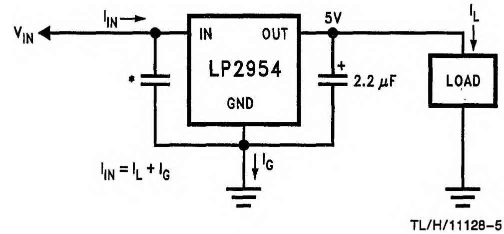
TL/H/11128-4

Application Hints

EXTERNAL CAPACITORS

A 2.2 μF (or greater) capacitor is **required** between the output pin and the ground to assure stability (refer to *Figure 1*). Without this capacitor, the part may oscillate. Most types of tantalum or aluminum electrolytics will work here. Film types will work, but are more expensive. Many aluminum electrolytics contain electrolytes which freeze at −30°C, which requires the use of solid tantalums below −25°C. The important parameters of the capacitor are an ESR of about 5Ω or less and a resonant frequency above 500 kHz (the ESR may increase by a factor of **20** or **30** as the temperature is reduced from 25°C to −30°C). The value of this capacitor may be increased without limit. At lower values of output current, less output capacitance is required for stability. The capacitor can be reduced to 0.68 μF for currents below 10 mA or 0.22 μF for currents below 1 mA.

A 1 μF capacitor should be placed from the input pin to ground if there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery input is used.



*See External Capacitors

$P_{Total} = (V_{IN} - 5)\, I_L + (V_{IN})\, I_G$

FIGURE 1. Basic 5V Regulator Circuit

MINIMUM LOAD

It should be noted that a minimum load current is specified in several of the electrical characteristic test conditions, so this value must be used to obtain correlation on these tested limits. The part is parametrically tested down to 100 μA, but is functional with no load.

DROPOUT VOLTAGE

The dropout voltage of the regulator is defined as the minimum input-to-output voltage differential required for the output voltage to stay within 100 mV of the output voltage measured with a 1V differential. The dropout voltages for various values of load current are listed under Electrical Characteristics.

If the regulator is powered from a rectified AC source with a capacitive filter, the minimum AC line voltage and maximum load current must be used to calculate the minimum voltage at the input of the regulator. The minimum input voltage, **including AC ripple on the filter capacitor**, must not drop below the voltage required to keep the LP2954 in regulation. It is also advisable to verify operating at **minimum** operating ambient temperature, since the increasing ESR of the filter capacitor makes this a worst-case test for dropout voltage due to increased ripple amplitude.

HEATSINK REQUIREMENTS

A heatsink may be required with the LP2954 depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under Absolute Maximum Ratings.

To determine if a heatsink is required, the maximum power dissipated by the regulator, P(max), must be calculated. it is important to remember that if the regulator is powered from a transformer connected to the AC line, the **maximum specified AC input voltage** must be used (since this produces the maximum DC input voltage to the regulator). *Figure 1* shows the voltages and currents which are present in the circuit. The formula for calculating the power dissipated in the regulator is also shown in *Figure 1*.

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max). This is calculated by using the formula:

$$T_R(\text{max}) = T_J(\text{max}) - T_A(\text{max})$$

where: T_J(max) is the maximum allowable junction temperature

T_A(max) is the maximum ambient temperature

Using the calculated values for T_R(max) and P(max), the required value for junction-to-ambient thermal resistance, $\theta_{(J\text{-}A)}$, can now be found:

$$\theta_{(J\text{-}A)} = T_R(\text{max})/P(\text{max})$$

If the calculated value is 60° C/W **or higher**, the regulator may be operated without an external heatsink. If the calculated value is **below** 60° C/W, an external heatsink is required. The required thermal resistance for this heatsink can be calculated using the formula:

$$\theta_{(H\text{-}A)} = \theta_{(J\text{-}A)} - \theta_{(J\text{-}C)} - \theta_{(C\text{-}H)}$$

where:

$\theta_{(J\text{-}C)}$ is the junction-to-case thermal resistance, which is specified as 3° C/W maximum for the LP2954.

$\theta_{(C\text{-}H)}$ is the case-to-heatsink thermal resistance, which is dependent on the interfacing material (if used). For details and typical values, refer to Note 2 listed at the end of the ELECTRICAL CHARACTERISTICS section.

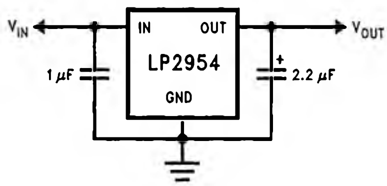
$\theta_{(H\text{-}A)}$ is the heatsink-to-ambient thermal resistance. It is this specification (listed on the heatsink manufacturers data sheet) which defines the effectiveness of the heatsink. The heatsink selected must have a thermal resistance which is **equal to or lower** than the value of $\theta_{(H\text{-}A)}$ calculated from the above listed formula.

OUTPUT ISOLATION

The regulator output can be left connected to an active voltage source (such as a battery) with the regulator input power turned off, **as long as the regulator ground pin is connected to ground.** If the ground pin is left floating, **damage to the regulator can occur** if the output is pulled up by an external voltage source.

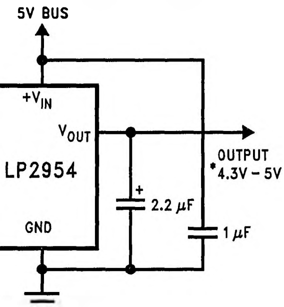
Typical Applications

5V Regulator



TL/H/11128-6

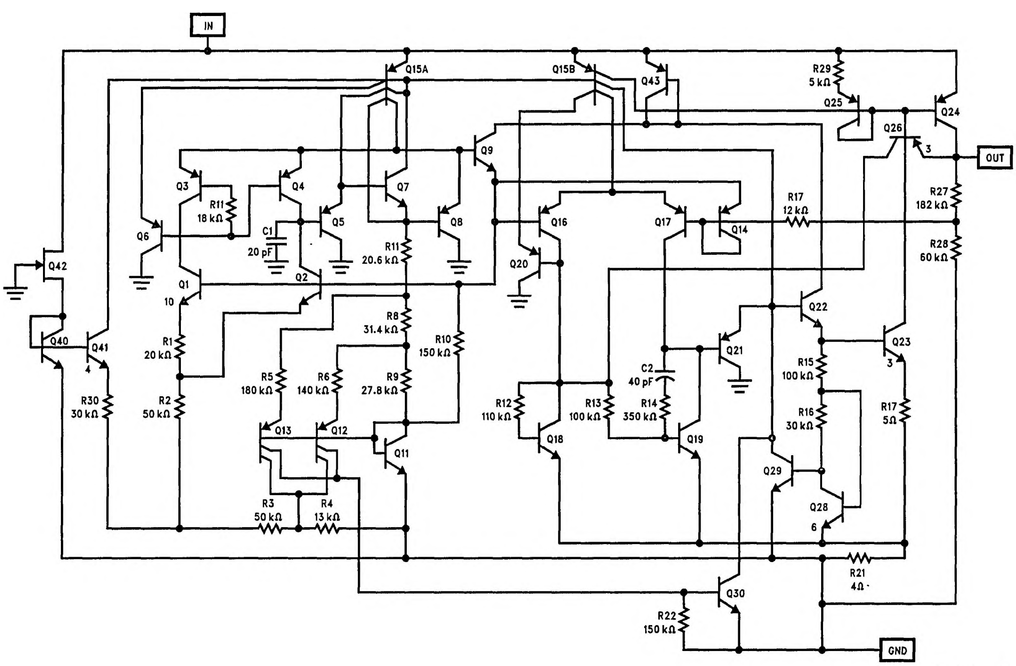
5V Current Limiter



TL/H/11128-7

*Output voltage equals $+V_{IN}$ minus dropout voltage, which varies with output current. Current limits at 380 mA (typical).

Schematic Diagram



TL/H/11128-8