LT137A/LM137
LT337A/LM337

Negative Adjustable Regulator

FEATURES

- **Guaranteed 1% Initial Voltage Tolerance**
- **Guaranteed 0.01%/V Line Regulation**
- **Guaranteed 0.5% Load Regulation**
- Guaranteed 0.02%/W Thermal Regulation
- 100% Burn-in in Thermal Limit

APPLICATIONS

- Adjustable Power Supplies
- System Power Supplies
- Precision Voltage/Current Regulators
- On-Card Regulators

DESCRIPTION

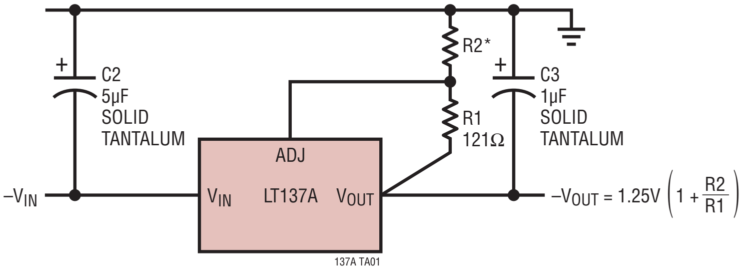
The LT®137A/LT337A negative adjustable regulators will deliver up to 1.5A output current over an output voltage range of –1.2V to –37V. Linear Technology has made significant improvements in these regulators compared to previous devices, such as better line and load regulation, and a maximum output voltage error of 1%.

Every effort has been made to make these devices easy to use and difficult to damage. Internal current and power limiting coupled with true thermal limiting prevents device damage due to overloads or shorts, even if the regulator is not fastened to a heat sink.

Maximum reliability is attained with Linear Technology's advanced processing techniques combined with a 100% burn-in in the thermal limit mode. This assures that all device protection circuits are working and eliminates field failures experienced with other regulators that receive only standard electrical testing.

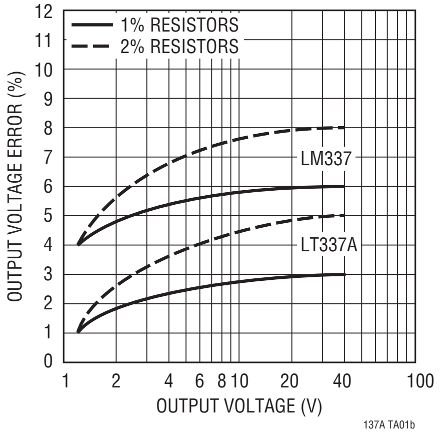
TYPICAL APPLICATION

Negative Regulator



$$^{*}R2 = R1\left(\frac{|V_{OUT}|}{1.25V} - 1\right)$$

Output Voltage Error



ABSOLUTE MAXIMUM RATINGS

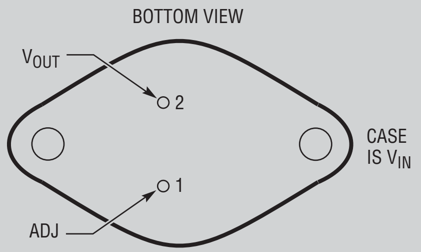
(Note 1)

Power Dissipation .... Internally Limited
Input to Output Voltage Differential 40V
Operating Junction Temperature Range
  LT137A/LM137 .... –55°C to 150°C
  LT337A/LM337 .... 0°C to 125°C
Storage Temperature Range
  LT137A/LM137 .... –65°C to 150°C
  LT337A/LM337 .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.) .... 300°C

PRECONDITIONING

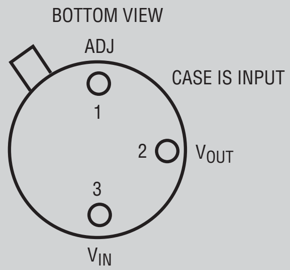
100% Thermal Limit Burn-In

PIN CONFIGURATION



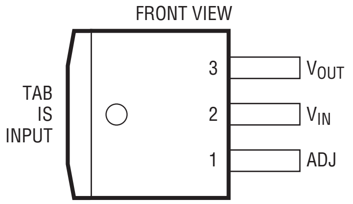
K PACKAGE
2-LEAD TO-3 METAL CAN
θ_{JA} = 35°C/W, θ_{JC} = 3°C/W

OBSOLETE PACKAGE
Consider the M and T Packages for Alternate Source

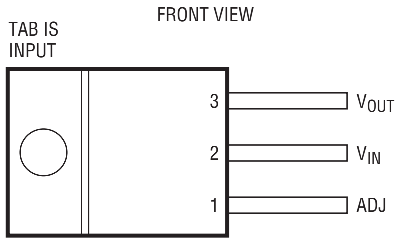


H PACKAGE
3-LEAD TO-39 METAL CAN
θ_{JA} = 150°C/W, θ_{JC} = 15°C/W

OBSOLETE PACKAGE
Consider the M and T Packages for Alternate Source



M PACKAGE
3-LEAD PLASTIC DD
θ_{JA} = 30°C/W, θ_{JC} = 3°C/W



T PACKAGE
3-LEAD PLASTIC TO-220
θ_{JA} = 50°C/W, θ_{JC} = 4°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LT337AM#PBF	LT337AM#TRPBF	LT337AM	3-Lead Plastic DD	0°C to 125°C
LT337AT#PBF	LT337AT#TRPBF	LT337AT	3-Lead Plastic TO-220	0°C to 125°C
LM337T#PBF	LM337T#TRPBF	LM337T	3-Lead Plastic TO-220	0°C to 125°C
LEAD BASED FINISH	**TAPE AND REEL**	**PART MARKING***	**PACKAGE DESCRIPTION**	**TEMPERATURE RANGE**
LT337AM	LT337AM#TR	LT337AM	3-Lead Plastic DD	0°C to 125°C
LT337AT	LT337AT#TR	LT337AT	3-Lead Plastic TO-220	0°C to 125°C

ORDER INFORMATION

LEAD BASED FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LM337T	LM337T#TR	LM337T	3-Lead Plastic TO-220	0°C to 125°C

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Notes 2, 3)

SYMBOL	PARAMETER	CONDITIONS		LT137A MIN	LT137A TYP	LT137A MAX	LM137 MIN	LM137 TYP	LM137 MAX	UNITS
V_{REF}	Reference Voltage	$\lvert V_{IN} - V_{OUT}\rvert = 5V$, $I_{OUT} = 10mA$, $T_j = 25°C$		–1.238	–1.250	–1.262	–1.225	–1.250	–1.275	V
		$3V \le \lvert V_{IN} - V_{OUT}\rvert \le 40V$ $10mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	●	–1.220	–1.250	–1.280	–1.200	–1.250	–1.300	V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$10mA \le I_{OUT} \le I_{MAX}$, (Note 4)								
		$T_j = 25°C$, $\lvert V_{OUT}\rvert \le 5V$			5	25		15	25	mV
		$T_j = 25°C$, $\lvert V_{OUT}\rvert \ge 5V$			0.1	0.5		0.3	0.5	%
		$\lvert V_{OUT}\rvert \le 5V$	●		10	50		20	50	mV
		$\lvert V_{OUT}\rvert \ge 5V$	●		0.2	1		0.3	1	%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$3V \le \lvert V_{IN} - V_{OUT}\rvert \le 40V$ (Note 4) $T_j = 25°C$			0.005	0.01		0.01	0.02	%/V
			●		0.01	0.03		0.02	0.05	%/V
	Ripple Rejection	$V_{OUT} = –10V$, f = 120Hz								
		$C_{ADJ} = 0$		60	66			60		dB
		$C_{ADJ} = 10µF$	●	70	80		66	77		dB
	Thermal Regulation	$T_j = 25°C$, 10ms Pulse			0.002	0.02		0.002	0.02	%/W
I_{ADJ}	Adjust Pin Current		●		65	100		65	100	µA
ΔI_{ADJ}	Adjust Pin Current Change	$10mA \le I_{OUT} \le I_{MAX}$	●		0.2	2		0.5	5	µA
		$3V \le \lvert V_{IN} - V_{OUT}\rvert \le 40V$	●		1	5		2	5	µA
	Minimum Load Current	$\lvert V_{IN} - V_{OUT}\rvert \le 40V$	●		2.5	5		2.5	5	mA
		$\lvert V_{IN} - V_{OUT}\rvert \le 10V$	●		1.2	3		1.2	3	mA
I_{SC}	Current Limit	$\lvert V_{IN} - V_{OUT}\rvert \le 15V$,								
		K and T Package (Note 7)	●	1.5	2.2		1.5	2.2		A
		H Package	●	0.5	0.8		0.5	0.8		A
		$\lvert V_{IN} - V_{OUT}\rvert = 40V$, K and T Package		0.24	0.4		0.24	0.4		A
		$T_j = 25°C$ H Package		0.15	0.25		0.15	0.25		A
$\frac{\Delta V_{OUT}}{\Delta Temp}$	Temperature Stability of Output Voltage (Note 6)	$T_{MIN} \le T \le T_{MAX}$	●		0.6	1.5		0.6		%
$\frac{\Delta V_{OUT}}{\Delta Time}$	Long Term Stability	$T_A = 125°C$, 1000 Hours			0.3	1		0.3	1	%
e_n	RMS Output Noise (% of V_{OUT})	$T_A = 25°C$, $10Hz \le f \le 10kHz$			0.003			0.003		%
θ_{JC}	Thermal Resistance Junction to Case	H Package			12	15		12	15	°C/W
		K Package			2.3	3		2.3	3	°C/W

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. (Notes 2, 3)

				LT337A			LM337			
SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	MIN	TYP	MAX	UNITS
V_{REF}	Reference Voltage	$\|V_{IN} - V_{OUT}\|$ = 5V, I_{OUT} = 10mA, T_j = 25°C		–1.238	–1.250	–1.262	–1.213	–1.250	–1.287	V
		3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V 10mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}	●	–1.220	–1.250	–1.280	–1.200	–1.250	–1.300	V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	10mA ≤ I_{OUT} ≤ I_{MAX}, (Notes 4 and 5)								
		T_j = 25°C, $\|V_{OUT}\|$ ≤ 5V			5	25		15	50	mV
		T_j = 25°C, $\|V_{OUT}\|$ ≥ 5V			0.1	0.5		0.3	1	%
		$\|V_{OUT}\|$ ≤ 5V	●		10	50		20	70	mV
		$\|V_{OUT}\|$ ≥ 5V	●		0.2	1		0.3	1.5	%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V (Note 4) T_j = 25°C			0.005	0.01		0.01	0.04	%/V
			●		0.01	0.03		0.02	0.07	%/V
	Ripple Rejection	V_{OUT} = –10V, f = 120Hz C_{ADJ} = 0		60	66			60		dB
		C_{ADJ} = 10µF	●	70	80		66	77		dB
	Thermal Regulation	T_j = 25°C, 10ms Pulse			0.002	0.02		0.003	0.04	%/W
I_{ADJ}	Adjust Pin Current		●		65	100		65	100	µA
ΔI_{ADJ}	Adjust Pin Current Change	10mA ≤ I_{OUT} ≤ I_{MAX}	●		0.2	2		0.5	5	µA
		3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V	●		1	5		2	5	µA
	Minimum Load Current	$\|V_{IN} - V_{OUT}\|$ ≤ 40V	●		2.5	5		2.5	10	mA
		$\|V_{IN} - V_{OUT}\|$ ≤ 10V	●		1.2	3		1	6	mA
I_{SC}	Current Limit	$\|V_{IN} - V_{OUT}\|$ ≤ 15V, K, M and T Package	●	1.5	2.2		1.5	2.2		A
		H Package	●	0.5	0.8		0.5	0.8		A
		$\|V_{IN} - V_{OUT}\|$ = 40V, K, M and T Package		0.24	0.5		0.15	0.4		A
		T_j = 25°C H Package		0.15	0.25		0.1	0.17		A
$\frac{\Delta V_{OUT}}{\Delta Temp}$	Temperature Stability of Output Voltage (Note 6)		●		0.6	1.5		0.6		%
$\frac{\Delta V_{OUT}}{\Delta Time}$	Long Term Stability	T_A = 125°C, 1000 Hours			0.3	1		0.3	1	%
e_n	RMS Output Noise (% of V_{OUT})	T_A = 25°C, 10Hz ≤ f ≤ 10kHz			0.003			0.003		%
θ_{JC}	Thermal Resistance Junction to Case	H Package			12	15		12	15	°C/W
		K Package			2.3	3		2.3	3	°C/W
		M and T Package			3	5		3	5	°C/W

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The shaded electrical specifications indicate those parameters which have been improved or guaranteed test limits provided for the first time.

Note 3: Unless otherwise indicated, these specifications apply: $|V_{IN} - V_{OUT}|$ = 5V; and I_{OUT} = 0.1A for the H package, I_{OUT} = 0.5A for the K, M, and T packages. Power dissipation is internally limited. However, these specifications apply for power dissipation up to 2W for the H package and 20W for the K and T packages. I_{MAX} = 1.5A for the K, M, and T packages, and 0.2A for the H package.

Note 4: Testing is done using a pulsed low duty cycle technique. See thermal regulation specifications for output changes due to heating effects. Load regulation is measured on the output pin at a point 1/8" below the base of the K and H package and at the junction of the wide and narrow portion of the lead on the M and T package.

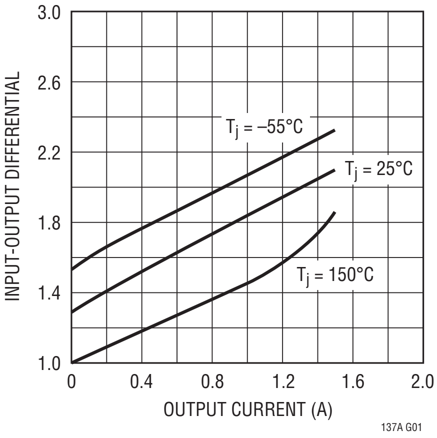
Note 5: Load regulation for the LT337AT is the same as for LM337T.

Note 6: Guaranteed on LT137A and LT337A, but not 100% tested in production.

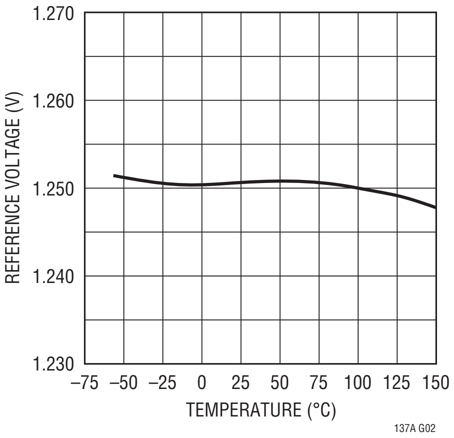
Note 7: I_{SC} is tested at the ambient temperatures of 25°C and –55°C. I_{SC} cannot be tested at the maximum ambient temperature of 150°C due to the high power level required. I_{SC} specification at 150°C ambient is guaranteed by characterization and correlation to 25°C testing.

TYPICAL PERFORMANCE CHARACTERISTICS

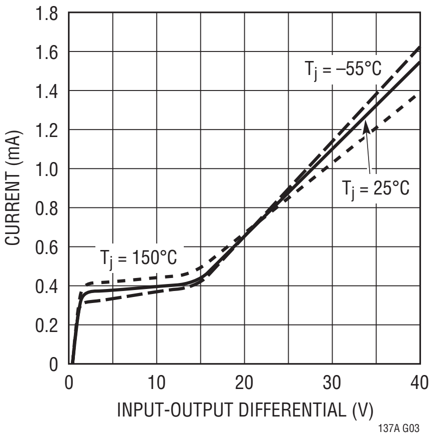
Dropout Voltage



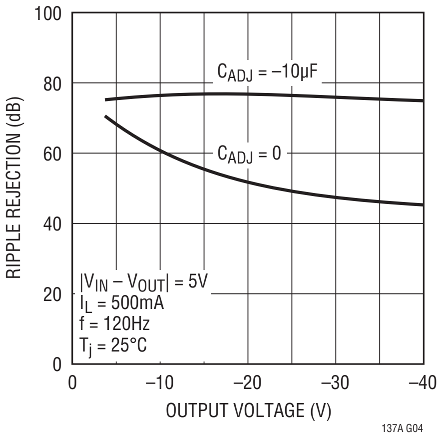
Temperature Stability



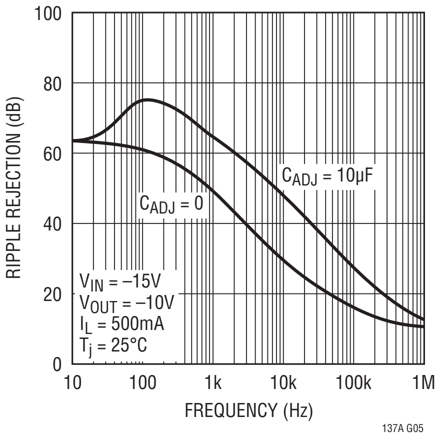
Minimum Load Current



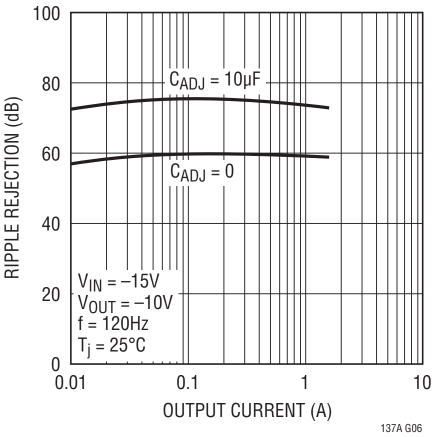
Ripple Rejection



Ripple Rejection

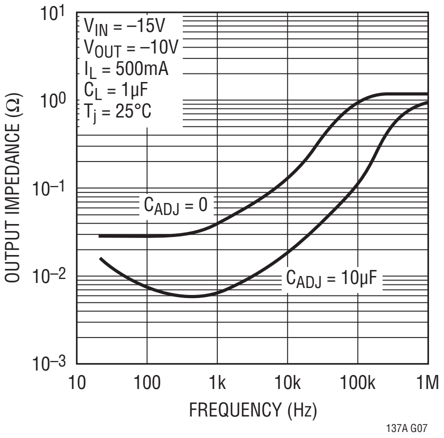


Ripple Rejection

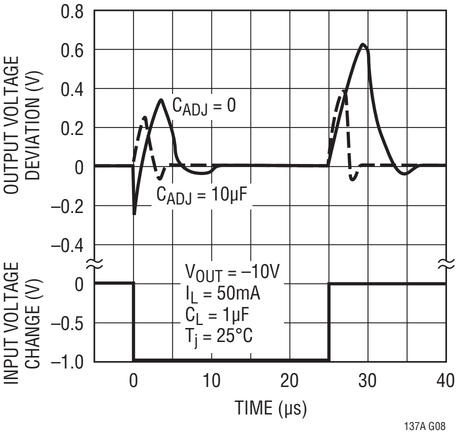


TYPICAL PERFORMANCE CHARACTERISTICS

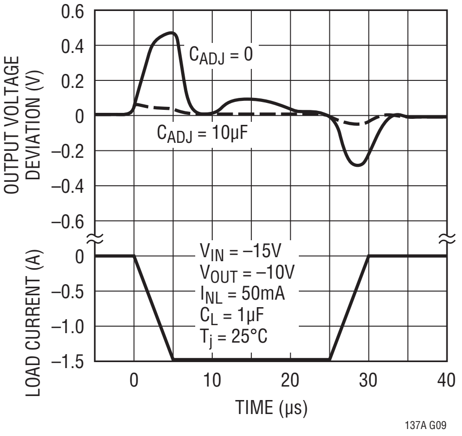
Output Impedance



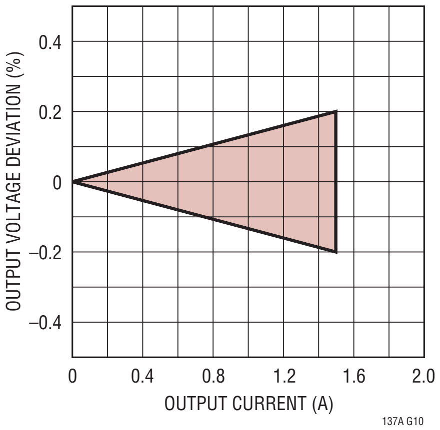
Line Transient Response



Load Transient Response

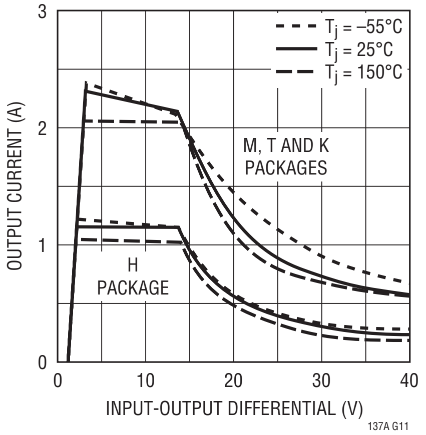


Load Regulation*

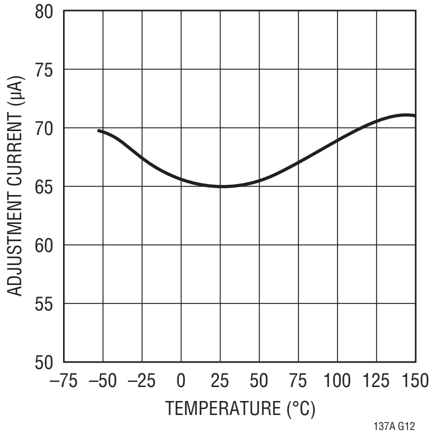


*THE LT137A/LT337A HAS LOAD REGULATION COMPENSATION WHICH MAKES THE TYPICAL UNIT READ CLOSE TO ZERO. THIS BAND REPRESENTS THE TYPICAL PRODUCTION SPREAD.

Current Limit



Adjustment Current



APPLICATIONS INFORMATION

Output Voltage

The output voltage is determined by two external resistors, R1 and R2 (see Figure 1). The exact formula for the output voltage is:

$$V_{OUT} = V_{REF}\left(1+\frac{R2}{R1}\right)+I_{ADJ}(R2)$$

Where: V_{REF} = Reference Voltage, I_{ADJ} = Adjustment Pin Current. In most applications, the second term is small enough to be ignored, typically about 0.5% of V_{OUT}. In more critical applications, the exact formula should be used, with I_{ADJ} equal to 65µA. Solving for R2 yields:

$$R2=\frac{V_{OUT}-V_{REF}}{\dfrac{V_{REF}}{R1}+I_{ADJ}}$$

Smaller values of R1 and R2 will reduce the influence of I_{ADJ} on the output voltage, but the no-load current drain on the regulator will be increased. Typical values for R1 are between 100Ω and 300Ω, giving 12.5mA and 4.2mA no-load current respectively. There is an additional consideration in selecting R1, the minimum load current specification of the regulator. The operating current of the LT137A flows from input to output. If this current is not absorbed by the load, the output of the regulator will rise above the regulated value. The current drawn by R1 and R2 is normally high enough to absorb the current, but care must be taken in no-load situations where R1 and R2 have high values.

The maximum value for the operating current, which must be absorbed, is 5mA for the LT137A. If input-output voltage differential is less than 10V, the operating current that must be absorbed drops to 3mA.

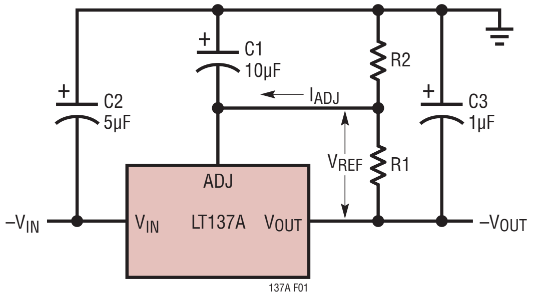


Figure 1

EXAMPLES:

1. A precision 10V regulator to supply up to 1A load current.

   a. Select R1 = 100Ω to minimize effect of I_{ADJ}

   b. Calculate R2 =

$$\frac{V_{OUT}-V_{REF}}{\dfrac{V_{REF}}{R1}+I_{ADJ}}=\frac{10V-1.25V}{\dfrac{1.25V}{100\Omega}+65\mu A}=696.4\Omega$$

   Use R2 = 698Ω

2. A 15V regulator to run off batteries and supply 50mA. $V_{IN\ MAX}$ = 25V

   a. To minimize battery drain, select R1 as high as possible

$$R1=\frac{1.25V}{3mA}=417\Omega\text{, use }402\Omega\text{, }1\%$$

   b. The high value for R1 will exaggerate the error due to I_{ADJ}, so the exact formula to calculate R2 should be used.

$$R2=\frac{V_{OUT}-V_{REF}}{\dfrac{V_{REF}}{R1}+I_{ADJ}}=\frac{15V-1.25V}{\dfrac{1.25V}{402\Omega}+65\mu A}=4331\Omega$$

   Use R2 = 4320Ω

Capacitors and Protection Diodes

An output capacitor, C3, is required to provide proper frequency compensation of the regulator feedback loop. A 1µF or larger solid tantalum capacitor is generally sufficient for this purpose if the 1MHz impedance of the capacitor is 2Ω or less. High Q capacitors, such as Mylar, are not recommended because they tend to reduce the phase margin at light load currents. Aluminum electrolytic capacitors may also be used, but the minimum value should be 10µF to ensure a low impedance at 1MHz. The output capacitor should be located within a few inches of the regulator to keep lead impedance to a minimum. The following caution should be noted: if the output voltage is greater than 6V and an output capacitor greater than 20µF has been used, it is possible to damage the regulator if the input voltage

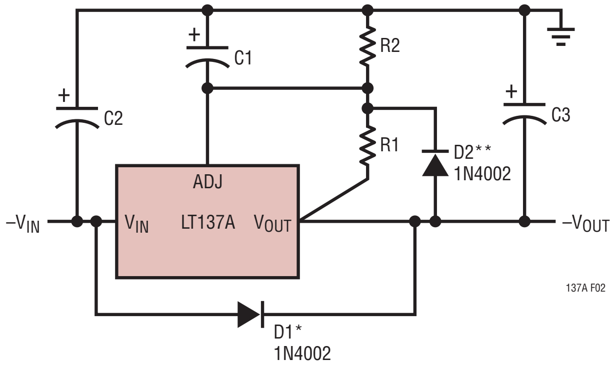
APPLICATIONS INFORMATION

becomes shorted, due to the output capacitor discharging into the regulator. This can be prevented by using the diode D1 (see Figure 2) between the input and the output.

The input capacitor, C2, is only required if the regulator is more than 4 inches from the raw supply filter capacitor.

Bypassing the Adjustment Pin

The adjustment pin of the LT137A may be bypassed with a capacitor to ground, C1, to reduce output ripple, noise, and impedance. These parameters scale directly with output voltage if the adjustment pin is not bypassed. A bypass capacitor reduces ripple, noise, and impedance to that of a 1.25V regulator. In a 15V regulator, for example, these parameters are improved by 15V/1.25V = 12 to 1. This improvement holds only for those frequencies where the impedance of the bypass capacitor is less than R1. Ten microfarads is generally sufficient for 60Hz power line applications where the ripple frequency is 120Hz since $X_C = 130\Omega$. The capacitor should have a voltage rating at least as high as the output voltage of the regulator. Values larger than 10µF may be used, but if the output is larger than 25V, a diode, D2, should be added between the output and adjustment pins (see Figure 2).



*D1 PROTECTS THE REGULATOR FROM INPUT SHORTS TO GROUND. IT IS REQUIRED ONLY WHEN C3 IS LARGER THAN 20µF AND V_{OUT} IS LARGER THAN 6V.

**D2 PROTECTS THE ADJUST PIN OF THE REGULATOR FROM OUTPUT SHORTS IF C2 IS LARGER THAN 10µF AND V_{OUT} IS LARGER THAN –25V.

Figure 2

Proper Connection of Divider Resistors

The LT137A has an excellent load regulation specification of 0.5% and is measured at a point 1/8" from the bottom of the package. To prevent degradation of load regulation, the resistors which set output voltage, R1 and R2, must be connected as shown in Figure 3. Note that the positive side of the load has a true force and sense (Kelvin) connection, but the negative side of the load does not.

R1 should be connected directly to the output lead of the regulator, as close as possible to the specified point 1/8" from the case. R2 should be connected to the positive side of the load separately from the positive (ground) connection to the raw supply. With this arrangement, load regulation is degraded only by the resistance between the regulator output pin and the load. If R1 is connected to the load, regulation will be degraded.

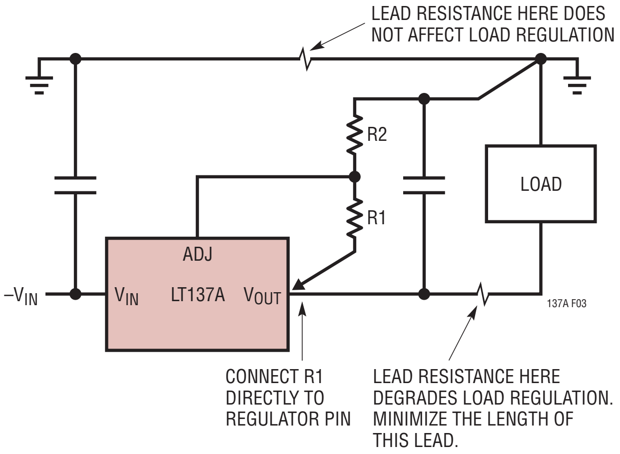


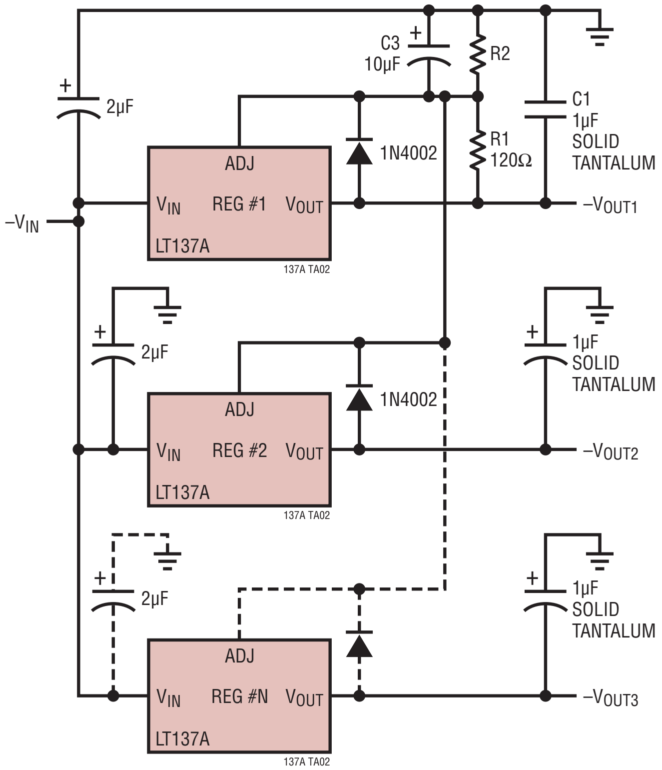
Figure 3

TYPICAL APPLICATIONS

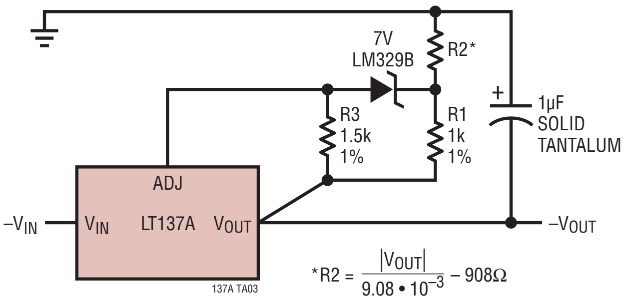
A high stability regulator is illustrated in the application circuit shown to the right. The output stability, load regulation, line regulation, thermal regulation, temperature drift, long term drift, and noise can be improved by a factor of 6.6 over the standard regulator configuration. This assumes a zener whose drift and noise is considerably better than the regulator itself. The LM329B has 20ppm/°C maximum drift and about 10 times lower noise than the regulator.

In the application shown below, regulators #2 to "N" will track regulator #1 to within ±24mV initially, and to ±60mV over all load, line, and temperature conditions. If any regulator output is shorted to ground, all other outputs will drop to approximately ≈ –2V. Load regulation of regulators 2 to "N" will be improved by V_{OUT}/1.25V compared to a standard regulator, so regulator #1 should be the one which has the lowest load current.

Multiple Tracking Regulators

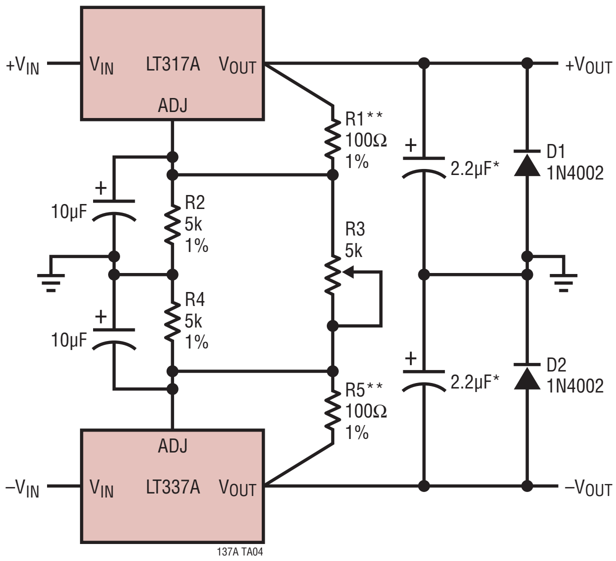


High Stability Regulator



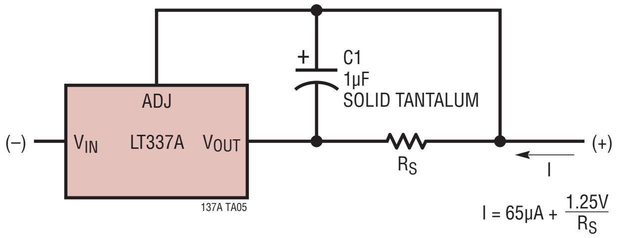
$$*R2 = \frac{|V_{OUT}|}{9.08 \bullet 10^{-3}} - 908\Omega$$

Dual Tracking Supply ±1.25V to ±20V



*SOLID TANTALUM
**R1 OR R5 MAY BE TRIMMED SLIGHTLY TO IMPROVE TRACKING

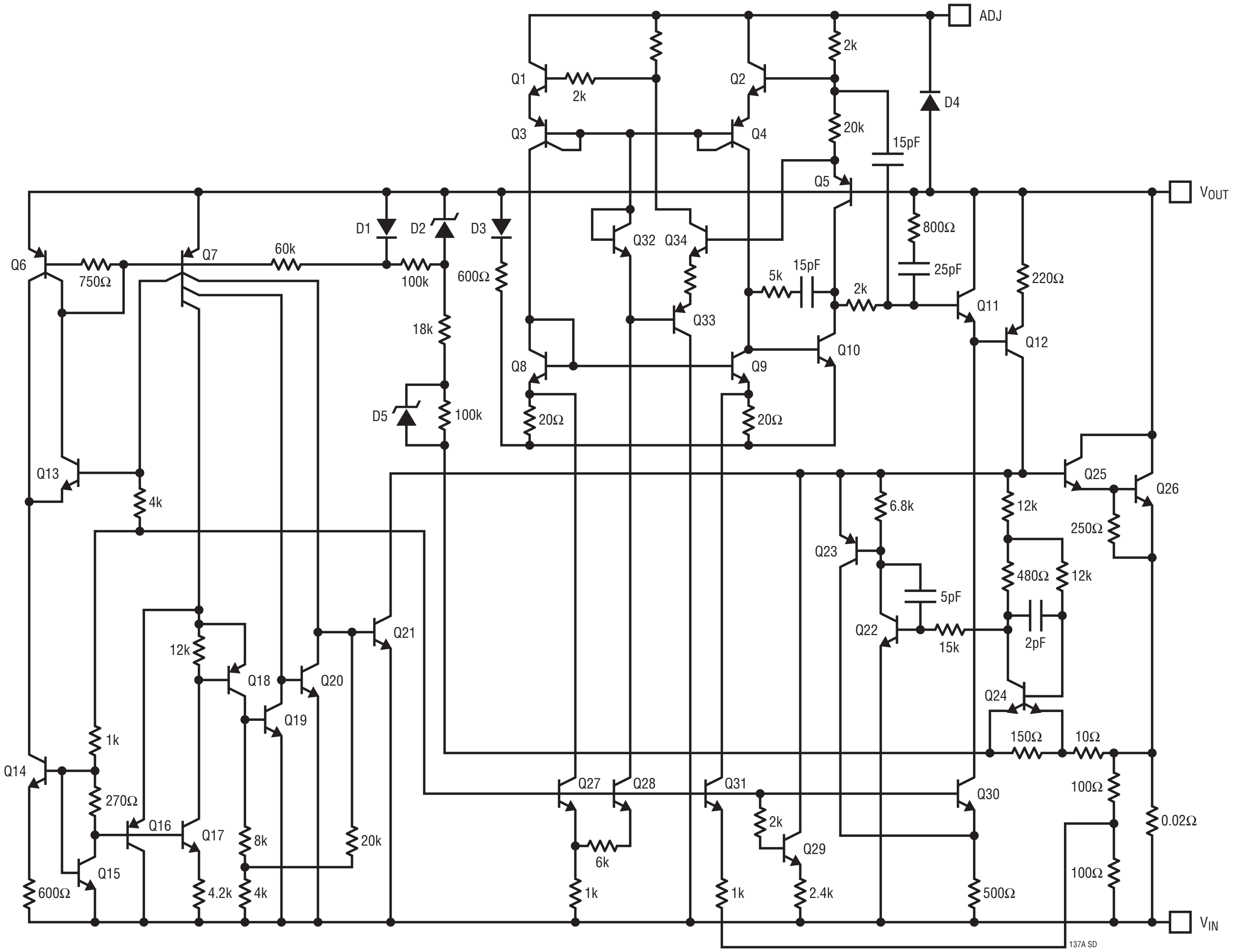
Current Regulator



$$I = 65\mu A + \frac{1.25V}{R_S}$$

$(0.8\Omega < R_S < 250\Omega)$

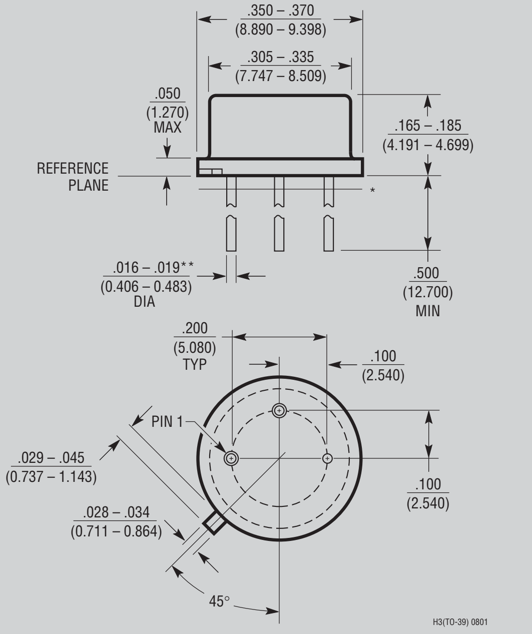
SCHEMATIC DIAGRAM



PACKAGE DESCRIPTION

OBSOLETE PACKAGES

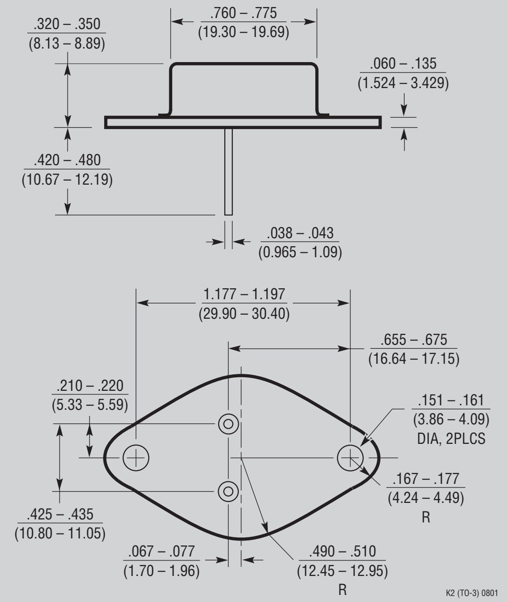
H Package
3-Lead TO-39 Metal Can
(Reference LTC DWG # 05-08-1330)



*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND .050" BELOW THE REFERENCE PLANE

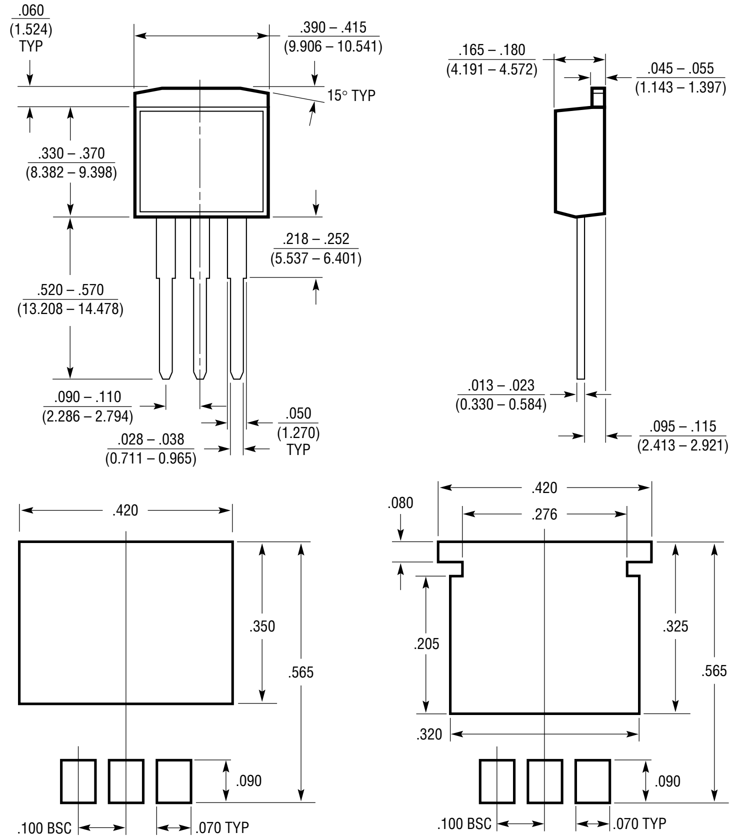
**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS $\frac{.016 – .024}{(0.406 – 0.610)}$

K Package
2-Lead TO-3 Metal Can
(Reference LTC DWG # 05-08-1310)



PACKAGE DESCRIPTION

M Package
3-Lead Plastic DD Pak
(Reference LTC DWG # 05-08-1460)



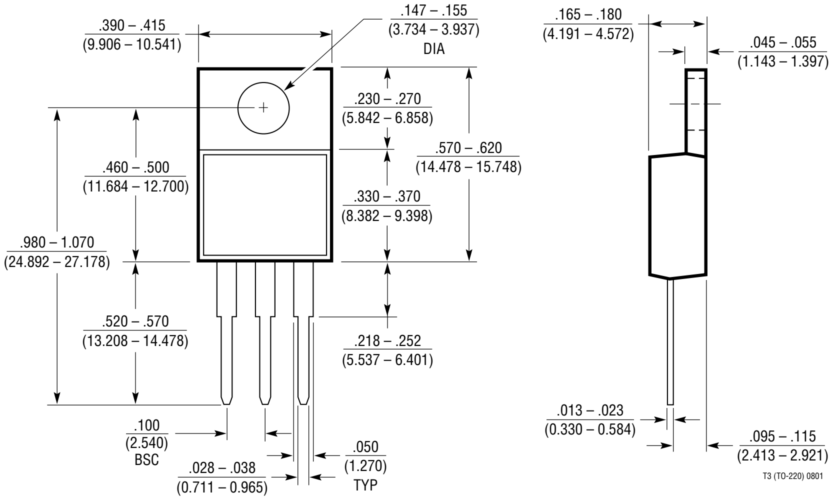
RECOMMENDED SOLDER PAD LAYOUT

RECOMMENDED SOLDER PAD LAYOUT
FOR THICKER SOLDER PASTE APPLICATIONS

NOTE:
1. DIMENSIONS IN INCH/(MILLIMETER)
2. DRAWING NOT TO SCALE

M(DD3) (STRAIGHT) 0801

T Package
3-Lead Plastic TO-220
(Reference LTC DWG # 05-08-1420)



Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

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