LINEAR TECHNOLOGY

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 LT137A/LT337A negative adjustable regulators will deliver up to 1.5Amps 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.

Negative Regulator
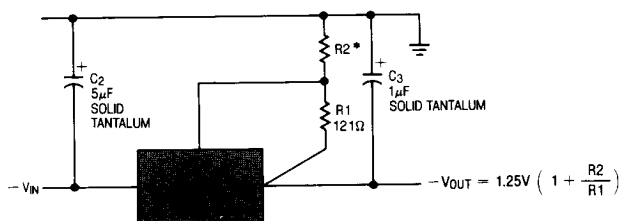
$$-V_{OUT} = 1.25V \left(1 + \frac{R2}{R1} \right)$$

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

Output Voltage Error

LT137A/LM137
LT337A/LM337
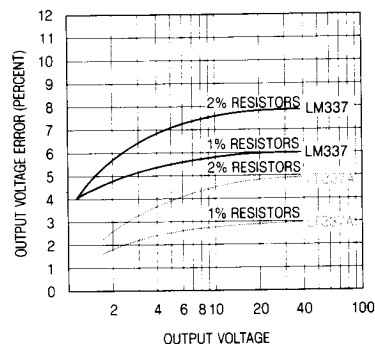
ABSOLUTE MAXIMUM RATINGS

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

PACKAGE/ORDER INFORMATION

	ORDER PART NO.
BOTTOM VIEW (K PACKAGE)	LT137AK / LM137K / LT337AK / LM337K
BOTTOM VIEW (H PACKAGE)	LT137AH / LM137H / LT337AH / LM337H
FRONT VIEW (T PACKAGE)	LT337AT / LM337T

ELECTRICAL CHARACTERISTICS (See Note 1)

SYMBOL	PARAMETER	CONDITIONS	LT137A MIN	LT137A TYP	LT137A MAX	LM137 MIN	LM137 TYP	LM137 MAX	UNITS
V_{REF}	Reference Voltage	$\|V_{IN} - V_{OUT}\| = 5V$, $I_{OUT} = 10mA$, $T_j = 25°C$				−1.225	−1.250	−1.275	V
		$3V \le \|V_{IN} - V_{OUT}\| \le 40V$ $10mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$ ●				−1.200	−1.250	−1.300	V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$10mA \le I_{OUT} \le I_{MAX}$, (See Note 2)							
		$T_j = 25°C$, $\|V_{OUT}\| \le 5V$		5	25		15	25	mV
		$T_j = 25°C$, $\|V_{OUT}\| \ge 5V$		0.1	0.5		0.3	0.5	%
		$\|V_{OUT}\| \le 5V$ ●		10	50		20	50	mV
		$\|V_{OUT}\| \ge 5V$ ●		0.2	1.0		0.3	1.0	%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$3V \le \|V_{IN} - V_{OUT}\| \le 40V$, (See Note 2) $T_j = 25°C$					0.01	0.02	%/V
		●					0.02	0.05	%/V
	Ripple Rejection	$V_{OUT} = -10V$, $f = 120Hz$ $C_{ADJ} = 0$					60		dB
		$C_{ADJ} = 10\mu F$ ●				66	77		dB
	Thermal Regulation	$T_j = 25°C$, 10msec Pulse		0.002	0.02		0.002	0.02	%/W
I_{ADJ}	Adjust Pin Current	●					65	100	μA
ΔI_{ADJ}	Adjust Pin Current Change	$10mA \le I_{OUT} \le I_{MAX}$ ●					0.5	5	μA
		$3V \le V_{IN}$ $V_{OUT} \le 40V$ ●					2	5	μA
	Minimum Load Current	$\|V_{IN} - V_{OUT}\| \le 40V$ ●		2.5	5.0		2.5	5.0	mA
		$\|V_{IN} - V_{OUT}\| \le 10V$ ●		1.2	3.0		1.2	3.0	mA
I_{SC}	Current Limit	$\|V_{IN} - V_{OUT}\| \le 15V$, K and T Package ●	1.5	2.2	3.2	1.5	2.2		A
		H Package ●	0.5	0.8	1.5	0.5	0.8		A
		$\|V_{IN} - V_{OUT}\| = 40V$, K and T Package	0.24	0.4	1.0	0.24	0.4		A
		$T_j = 25°C$ H Package	0.15	0.25	0.5	0.15	0.25		A
$\frac{\Delta V_{OUT}}{\Delta Temp}$	Temperature Stability of Output Voltage (Note 4)	$T_{MIN} \le T \le T_{MAX}$ ●		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		0.3	1.0	%
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	3.0		2.3	3.0	°C/W

ELECTRICAL CHARACTERISTICS (See Note 1)

SYMBOL	PARAMETER	CONDITIONS	LT337A MIN	TYP	MAX	LM337 MIN	TYP	MAX	UNITS
V_{REF}	Reference Voltage	$\|V_{IN} - V_{OUT}\| = 5V, I_{OUT} = 10mA, T_j = 25°C$				−1.213	−1.250	−1.287	V
		$3V \leqslant \|V_{IN} - V_{OUT}\| \leqslant 40V$ $10mA \leqslant I_{OUT} \leqslant I_{MAX}, P \leqslant P_{MAX}$ ●				−1.200	−1.250	−1.300	V
$\dfrac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$10mA \leqslant I_{OUT} \leqslant I_{MAX}$, (See Note 2 & 3)							
		$T_j = 25°C, \|V_{OUT}\| \leqslant 5V$	5		25	15		50	mV
		$T_j = 25°C, \|V_{OUT}\| \geqslant 5V$	0.1		0.5	0.3		1.0	%
		$\|V_{OUT}\| \leqslant 5V$ ●	10		50	20		70	mV
		$\|V_{OUT}\| \geqslant 5V$ ●	0.2		1.0	0.3		1.5	%
$\dfrac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$3V \leqslant \|V_{IN} - V_{OUT}\| \leqslant 40V$, (See Note 2)							
		$T_j = 25°C$					0.01	0.04	%/V
		●					0.02	0.07	%/V
	Ripple Rejection	$V_{OUT} = -10V, f = 120Hz$ $C_{ADJ} = 0$					60		dB
		$C_{ADJ} = 10\mu F$ ●				66	77		dB
	Thermal Regulation	$T_j = 25°C$, 10msec Pulse					0.003	0.04	%/W
I_{ADJ}	Adjust Pin Current	●					65	100	μA
ΔI_{ADJ}	Adjust Pin Current Change	$10mA \leqslant I_{OUT} \leqslant I_{MAX}$ ●					0.5	5	μA
		$3V \leqslant \|V_{IN} - V_{OUT}\| \leqslant 40V$ ●					2	5	μA
	Minimum Load Current	$\|V_{IN} - V_{OUT}\| \leqslant 40V$ ●					2.5	10	mA
		$\|V_{IN} - V_{OUT}\| \leqslant 10V$ ●					1	6	mA
I_{SC}	Current Limit	$\|V_{IN} - V_{OUT}\| \leqslant 15V$, K and T Package ●				1.5	2.2		A
		H Package ●				0.5	0.8		A
		$\|V_{IN} - V_{OUT}\| = 40V$, K and T Package				0.15	0.4		A
		$T_j = 25°C$ H Package				0.10	0.17		A
$\dfrac{\Delta V_{OUT}}{\Delta Temp}$	Temperature Stability of Output Voltage (Note 4)	●					0.6		%
$\dfrac{\Delta V_{OUT}}{\Delta Time}$	Long Term Stability	$T_A = 125°C$, 1000 Hours	0.3		1.0	0.3		1.0	%
e_n	RMS Output Noise (% of V_{OUT})	$T_A = 25°C$, $10Hz \leqslant f \leqslant 10kHz$		0.003			0.003		%
Θ_{JC}	Thermal Resistance Junction to Case	H Package					12	15	°C/W
		K Package					2.3	3.0	°C/W
		T Package					3	5	°C/W

The ● denotes the specifications which apply over the full operating temperature range.

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

Note 1: 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 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 and T packages, and 0.2A for the H package.

Note 2: 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 T package.

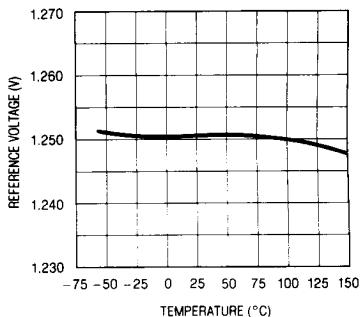**Note 3:** Load Regulation for the LT337AT is the same as for LM337T.

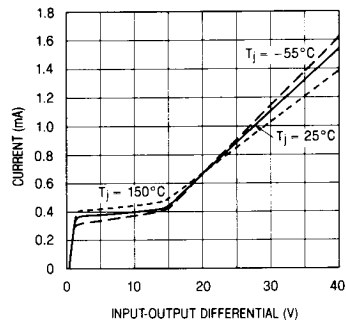**Note 4:** Guaranteed on LT137A and LT337A, but not 100% tested in production.

VOLTAGE REGULATORS

3

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TYPICAL PERFORMANCE CHARACTERISTICS

Dropout Voltage
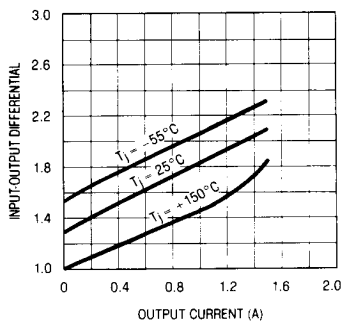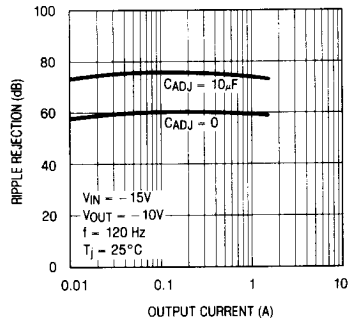

Temperature Stability

Minimum Load Current
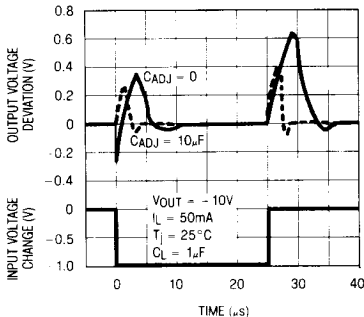

Ripple Rejection
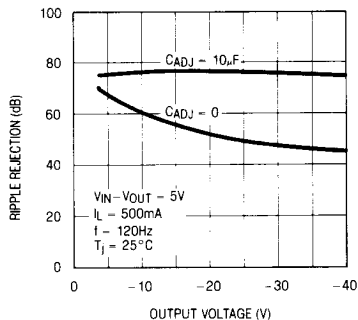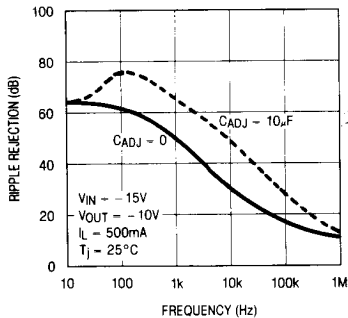
Ripple Rejection

Ripple Rejection

Output Impedance
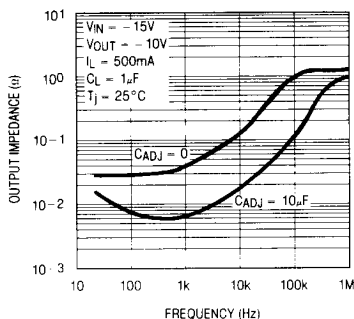
Line Transient Response

Load Transient Response

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TYPICAL PERFORMANCE CHARACTERISTICS

Load Regulation*

Current Limit

Adjustment Current
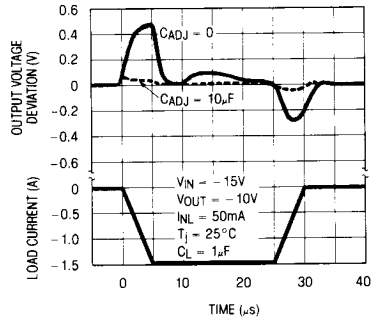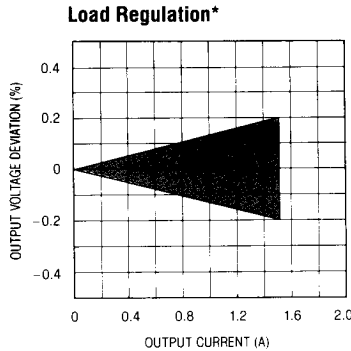
*The LT137A/337A has load regulation compensation which makes the typical unit read close to zero. This band represents the typical production spread.

3
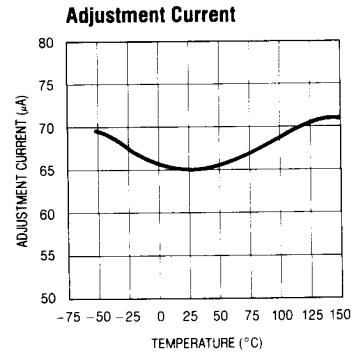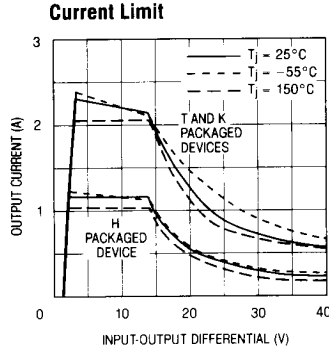
APPLICATION INFORMATION

Output Voltage: The output voltage is determined by two external resistors, R_1 & R_2 (see Figure 1). The exact formula for the output voltage is:

$$V_{OUT} = V_{Ref}\left(1 + \frac{R_2}{R_1}\right) + I_{ADJ}(R_2)$$

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 R_2 yields:

$$R_2 = \frac{V_{OUT} - V_{Ref}}{\frac{V_{Ref}}{R_1} + I_{ADJ}}$$

Smaller values of R_1 and R_2 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 R_1 are between 100Ω and 300Ω, giving 12.5mA and 4.2mA no-load current respectively. There is an additional consideration in selecting R_1, 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 R_1 and R_2 is normally high enough to

absorb the current, but care must be taken in no-load situations where R_1 and R_2 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.
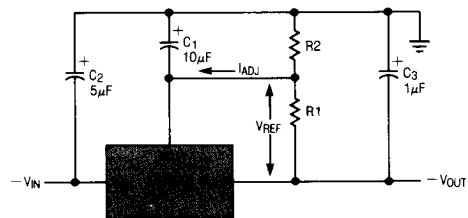
Figure 1

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

   a. Select R_1 = 100Ω to minimize effect of I_{ADJ}

   b. Calculate $R_2 = \dfrac{V_{OUT} - V_{Ref}}{\dfrac{V_{Ref}}{R_1} - I_{ADJ}} = \dfrac{10V - 1.25V}{\dfrac{1.25V}{100\Omega} - 65\mu A} = 704\Omega$

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

   a. To minimize battery drain, select R_1 as high as possible

   $$R_1 = \frac{1.25V}{3mA} = 417\Omega, \text{ use } 404\Omega, 1\%$$

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b. The high value for R_1 will exaggerate the error due to I_{ADJ}, so the exact formula to calculate R_2 should be used.

$$R_2 = \frac{V_{OUT} - V_{Ref}}{\frac{V_{Ref}}{R_1} - I_{ADJ}} = \frac{15V - 1.25V}{\frac{1.25V}{404\Omega} - 65 \times 10^{-6}} = 4539\Omega$$

Use $R_2 = 4530\Omega$

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 becomes shorted, due to the output capacitor discharging into the regulator. This can be prevented by using diode DI (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 R_1. 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).
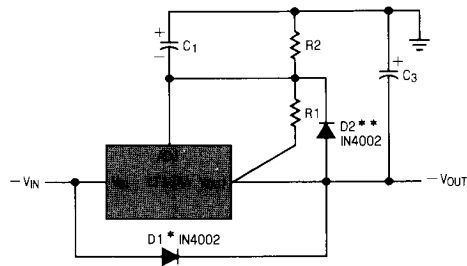
* D1 protects the regulator from input shorts to ground. It is required only when C3 is larger than 20μF and V_{OUT} is larger than 6V.

** 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.
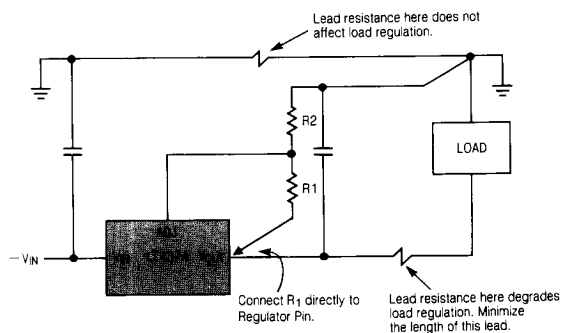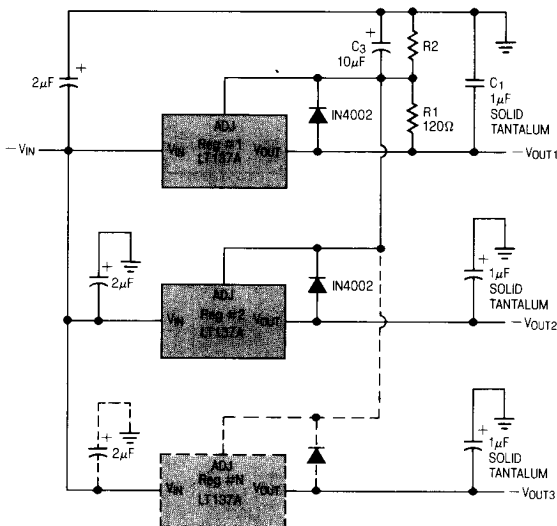

Figure 3

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.
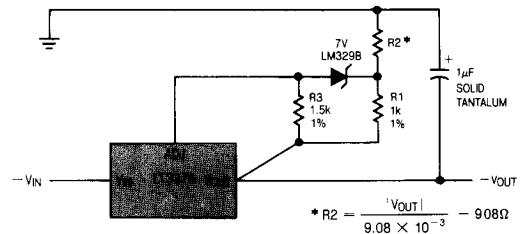
TYPICAL APPLICATIONS

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 ≈ −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.
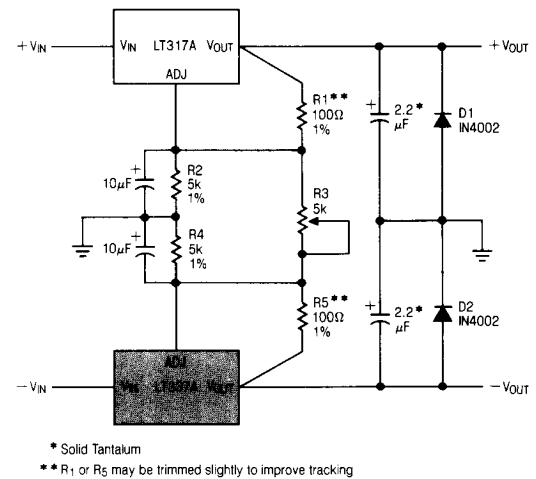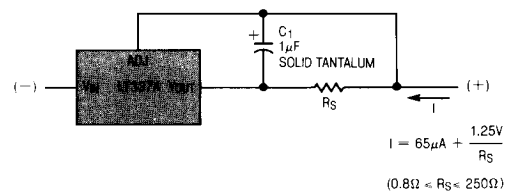
Multiple Tracking Regulators
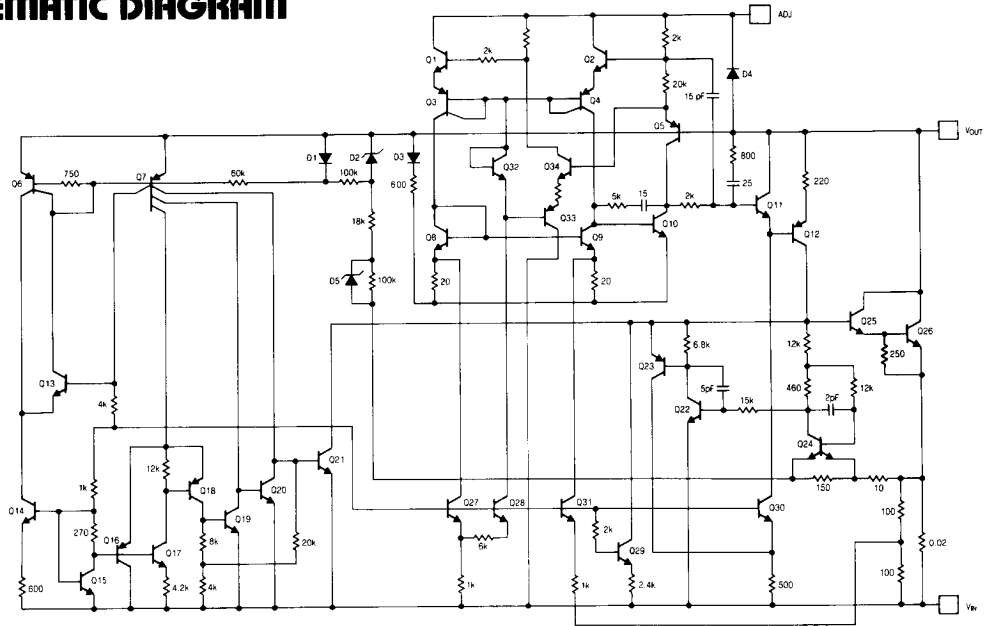
High Stability Regulator

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

Dual Tracking Supply ±1.25V to ±20V

* Solid Tantalum
** R_1 or R_5 may be trimmed slightly to improve tracking

Current Regulator

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

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

VOLTAGE REGULATORS

3

LT137A/LM137
LT337A/LM337

SCHEMATIC DIAGRAM

PACKAGE DESCRIPTION

K Package TO-3 STEEL Metal Can
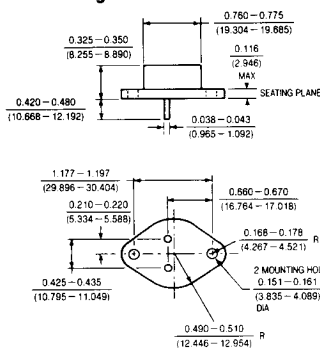
	TJ MAX	ΘJC
137A 137	150°C	3°C/W
337A 337	125°C	3°C/W

T Package TO-220 Plastic
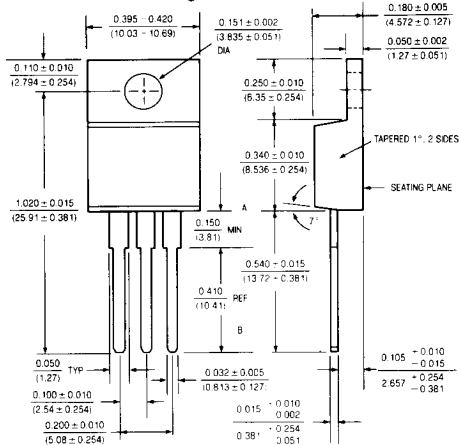
	TJ MAX	ΘJC
337A	125°C	4°C/W
337	125°C	4°C/W

3-Lead Metal Can Package (H)
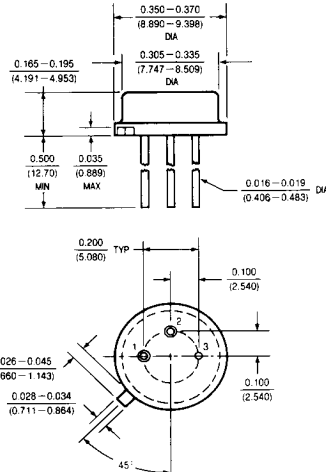
	TJ MAX	ΘJC
137A 137	150°C	15°C/W
337A 337	125°C	15°C/W

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