LM150QML 3-Amp Adjustable Regulators

Check for Samples: LM150QML

FEATURES

- **Adjustable Output Down to 1.2V**
- **Ensured 3A Output Current**
- **Ensured Thermal Regulation**
- **Output is Short Circuit Protected**
- **Current Limit Constant with Temperature**
- **86 dB Ripple Rejection**

APPLICATIONS

- **Adjustable Power Supplies**
- **Constant Current Regulators**
- **Battery Chargers**

DESCRIPTION

The LM150 adjustable 3-terminal positive voltage regulator is capable of supplying in excess of 3A over a 1.2V to 33V output range. It is exceptionally easy to use and requires only 2 external resistors to set the output voltage. Further, both line and load regulation are comparable to discrete designs. Also, the LM150 is packaged in standard transistor package which is easily mounted and handled.

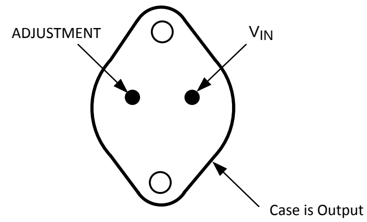
In addition to higher performance than fixed regulators, the LM150 offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is accidentally disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An output capacitor can be added to improve transient response, while bypassing the adjustment pin will increase the regulator's ripple rejection.

Besides replacing fixed regulators or discrete designs, the LM150 is useful in a wide variety of other applications. Since the regulator is “floating” and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

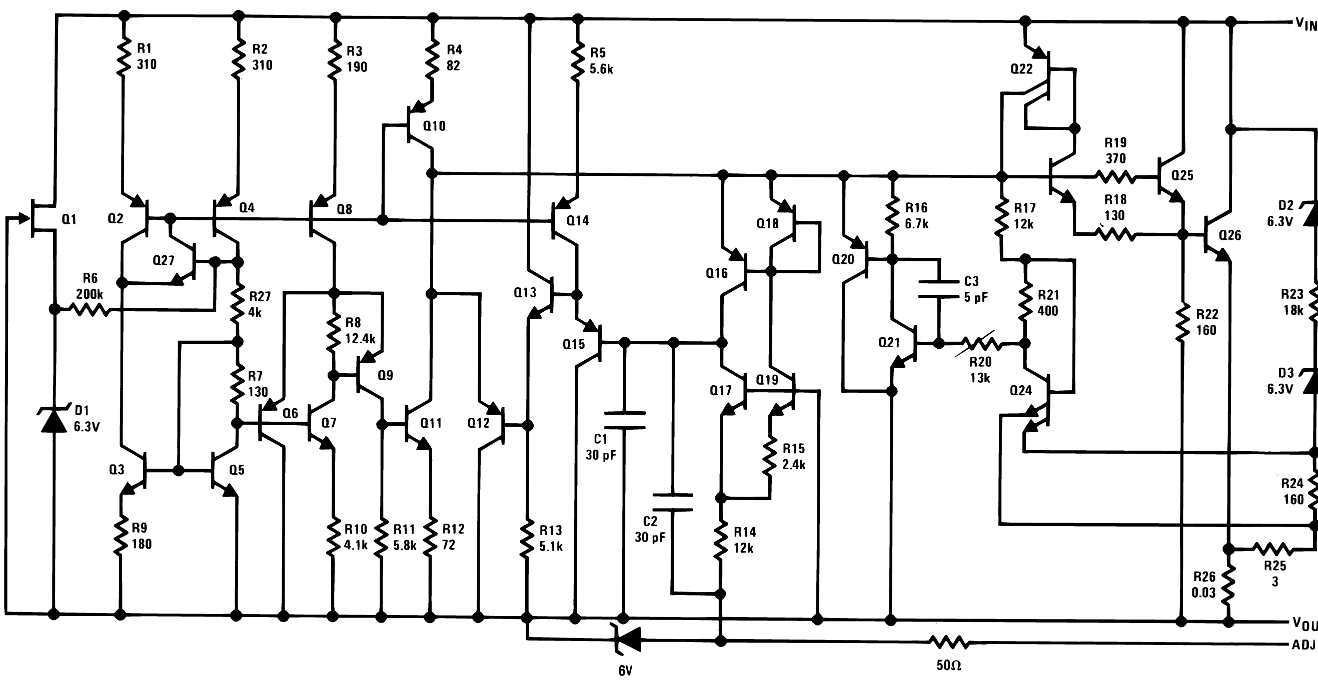
By connecting a fixed resistor between the adjustment pin and output, the LM150 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

Connection Diagram



Bottom View
TO-3 Metal Can Package
See Package Number K02C

Schematic Diagram



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]

Power Dissipation[2]	Internally Limited
Input-Output Voltage Differential	+35V
Storage Temperature	−65°C ≤ T_A ≤ +150°C
Lead Temperature (Soldering, 10 sec.)	300°C
ESD Tolerance	TBD
Operating Temperature Range	−55°C ≤ T_A ≤ +125°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The specified specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower.

Quality Conformance Inspection

Mil-Std-883, Method 5005 - Group A

Subgroup	Description	Temp °C
1	Static tests at	25
2	Static tests at	125
3	Static tests at	-55
4	Dynamic tests at	25
5	Dynamic tests at	125
6	Dynamic tests at	-55
7	Functional tests at	25
8A	Functional tests at	125
8B	Functional tests at	-55
9	Switching tests at	25
10	Switching tests at	125
11	Switching tests at	-55
12	Settling time at	25
13	Settling time at	125
14	Settling time at	-55

LM150 Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified.
DC: V_{Diff} = 5V, V_O = V_{Ref}, I_O = 1.5A.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Ref}	Reference Voltage			1.2	1.3	V	1, 2, 3
		V_{Diff} = 3.0V, I_L = 10mA		1.2	1.3	V	1, 2, 3
		V_{Diff} = 3.0V, I_L = 3.0A		1.2	1.3	V	1, 2, 3
		V_{Diff} = 35V, I_L = 10mA		1.2	1.3	V	1, 2, 3
		V_{Diff} = 10V, I_L = 3.0A	See (1)	1.2	1.3	V	1, 2, 3
		V_{Diff} = 30V, I_L = 300mA		1.2	1.3	V	1, 2, 3
V_{Line}	Line Regulation	3V ≤ V_{Diff} ≤ 35V, I_{Load} = 10mA	See (2)(3)	-3.8	3.8	mV	1
			See (2)(3)	-19.0	19.0	mV	2, 3
V_{Load}	Load Regulation	10mA ≤ I_L ≤ 3A, V_O = V_{Ref}	See (3)(4)(5)	-3.6	3.6	mV	1
			See (3)(4)(5)	-12.0	12.0	mV	2, 3
		V_{Diff} = 30V, 10mA ≤ I_L ≤ 300mA	See (3)	-2.0	2.0	mV	1
			See (3)	-5.0	5.0	mV	2, 3
		10mA ≤ I_L ≤ 3A, V_O = 5.0V	See (3)(4)(6)	-15.0	15.0	mV	1
			See (3)(4)(6)	-50.0	50.0	mV	2, 3
T_{Reg}	Thermal Regulation	t = 20mS	See (7)	-9.75	9.75	mV	1
I_{Adj}	Adjust Pin Current				100	µA	1, 2, 3
		V_{Diff} = 35V, I_O = 10mA			100	µA	1, 2, 3
I_Q	Quiescent Current				5.0	mA	1, 2, 3
		V_{Diff} = 35V			5.0	mA	1, 2, 3
ΔI_{Adj}	Delta Adjustment Current	3V ≤ V_{Diff} ≤ 35V I_O = 10mA		-5.0	5.0	µA	1, 2, 3
		10mA ≤ I_L ≤ 3A		-5.0	5.0	µA	1, 2, 3
		V_{Diff} = 30V, 10mA ≤ I_L ≤ 300mA		-5.0	5.0	µA	1, 2, 3
	Current Limit	V_{Diff} = 10V		3.0		A	1, 2, 3
		V_{Diff} = 30V		0.3		A	1, 2, 3
$\Delta V_O / \Delta t$	Long Term Stability	T_A = +125°C, t = 1000 Hrs, V_{Diff} = 3.0V, I_L = 10mA	See (8)		1.0	%/V_O	2
V_{Drop}	Voltage Dropout	V_{Diff} = 2.9V, I_L = 3A		-100	100	mV	1, 2, 3

(1) Represents worst case power dissipation of 30W.
(2) Limits = 0.01% of V_O @ 25°C, 0.05% @ −55°C, +125°C per volt of V_{Diff} change at V_O = V_{Ref}.
(3) Regulation is measured at a constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specifications for thermal regulation.
(4) These V_O conditions are worst case
(5) Limits are equivalent to 15mV @ 25°C and 50mV @ −55°C, +125°C @ V_O = 5.0V.
(6) Limits = 0.3% of V_O @ 25°C, 1.0% @ −55°C, +125°C @ V_O = 5.0V.
(7) Limits = 0.01% of V_O @ 25°C per Watt of power dissipation at P_D = 7.5W.
(8) Periodic Group C testing.

LM150 Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	f = 120 Hz, e_I = $1V_{RMS}$, C_{Adj} = 10µF, V_O = 10V		66		dB	4, 5, 6

Typical Performance Characteristics

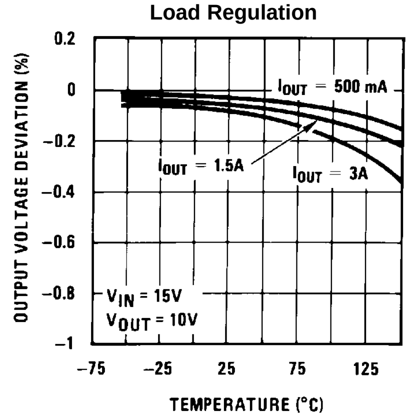


Figure 1.

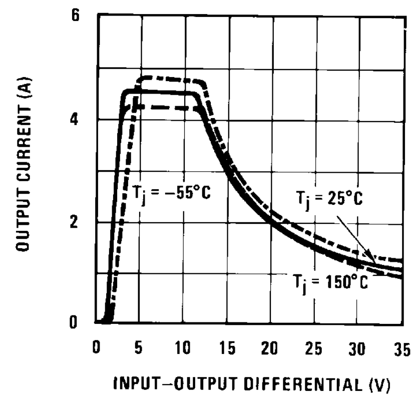


Figure 2.

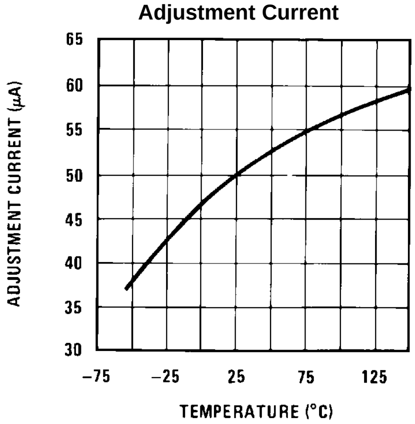


Figure 3.

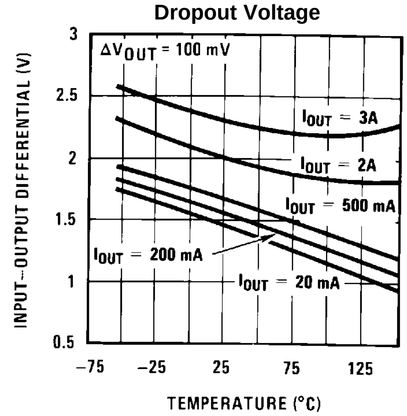


Figure 4.

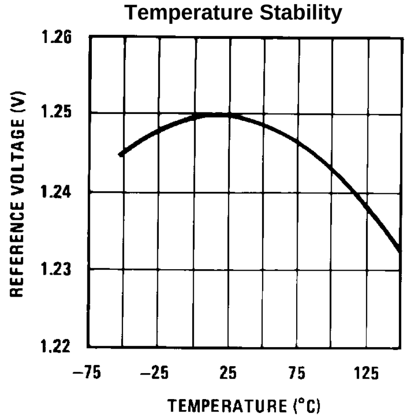


Figure 5.

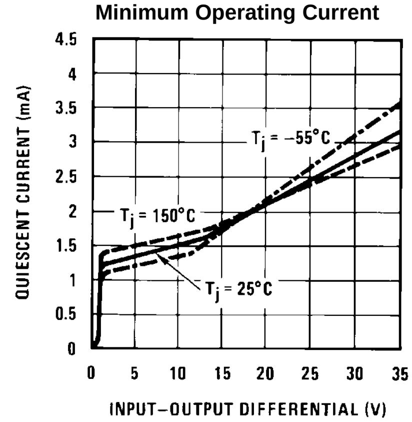


Figure 6.

Typical Performance Characteristics (continued)

Ripple Rejection

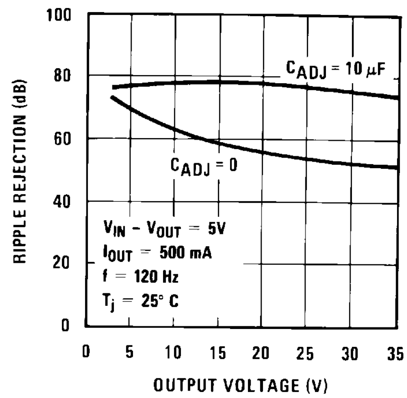


Figure 7.

Ripple Rejection

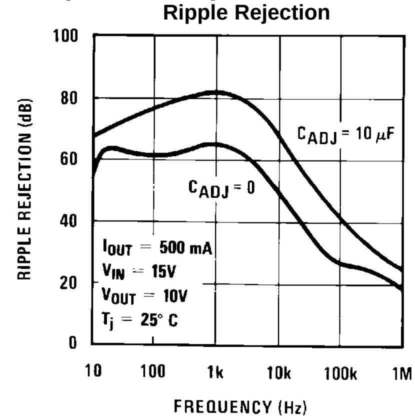


Figure 8.

Ripple Rejection

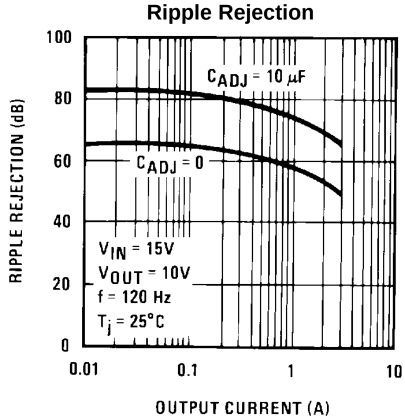


Figure 9.

Output Impedance

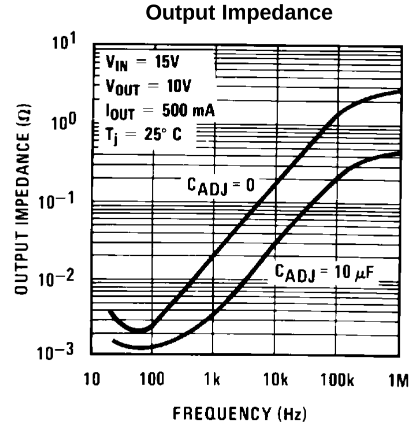


Figure 10.

Line Transient Response

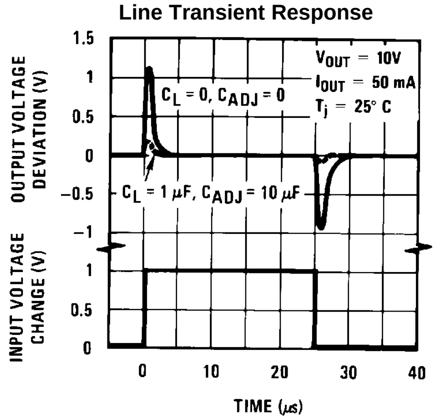


Figure 11.

Load Transient Response

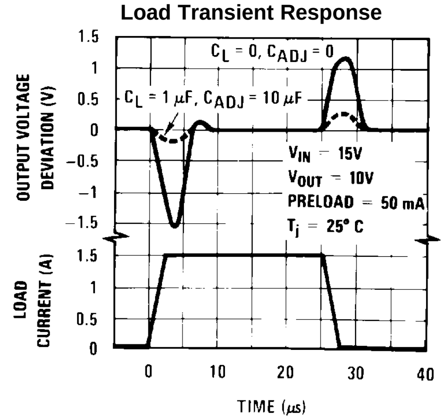
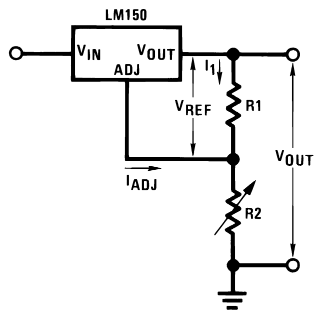


Figure 12.

APPLICATION HINTS

In operation, the LM150 develops a nominal 1.25V reference voltage, V_{Ref}, between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

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



Since the 50 µA current from the adjustment terminal represents an error term, the LM150 was designed to minimize I_{Adj} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

EXTERNAL CAPACITORS

An input bypass capacitor is recommended. A 0.1 µF disc or 1 µF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM150 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 µF bypass capacitor 86 dB ripple rejection is obtainable at any output level. Increases over 10 µF do not appreciably improve the ripple rejection at frequencies above 120 Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use is solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 µF in aluminum electrolytic to equal 1 µF solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies, but some types have a large decrease in capacitance at frequencies around 0.5 MHz. For this reason, 0.01 µF disc may seem to work better than a 0.1 µF disc as a bypass.

Although the LM150 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1 µF solid tantalum (or 25 µF aluminum electrolytic) on the output swamps this effect and insures stability.

LOAD REGULATION

The LM150 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240Ω) should be tied directly to the output (case) of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of $0.05\Omega \times I_{OUT}$. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 13 shows the effect of resistance between the regulator and 240Ω set resistor.

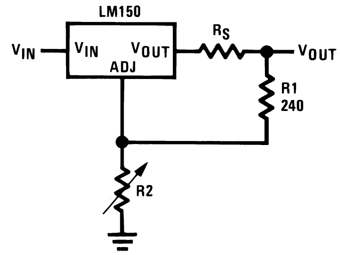


Figure 13. Regulator with Line Resistance in Output Lead

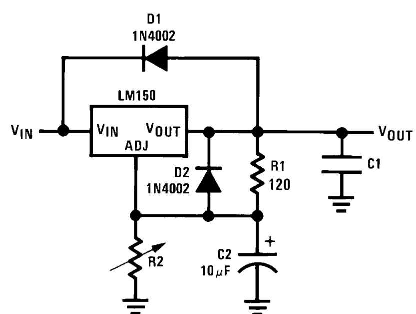
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

PROTECTION DIODES

When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10 μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN}. In the LM150, this discharge path is through a large junction that is able to sustain 25A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25 μF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when *either* the input or output is shorted. Internal to the LM150 is a 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10 μF capacitance. Figure 14 shows an LM150 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



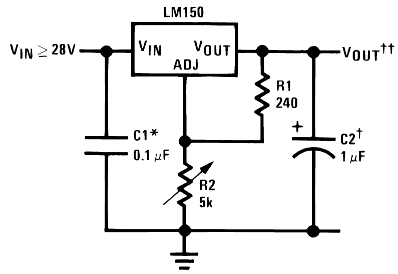
D1 protects against C1

D2 protects against C2

$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

Figure 14. Regulator with Protection Diodes

Typical Applications

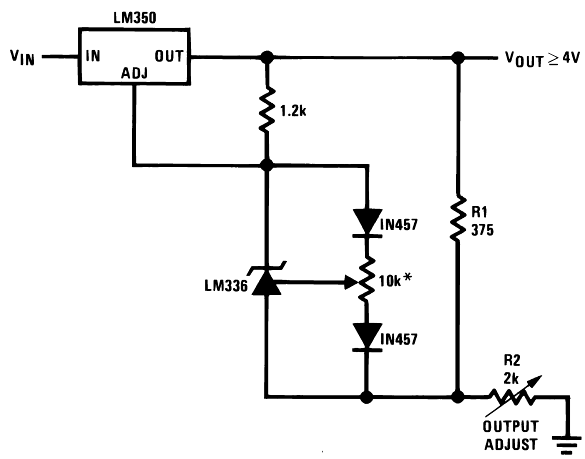


Full output current not available
at high input-output voltages.
†Optional—improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.
*Needed if device is more than 6 inches from filter capacitors.

$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R2}{R1}\right) + I_{ADJ}\,(R2)$$

Note: Usually R1 = 240Ω for LM150 and R1 = 120Ω.

Figure 15. 1.2V–25V Adjustable Regulator



*Adjust for 3.75V across R1

Figure 16. Precision Power Regulator with Low Temperature Coefficient

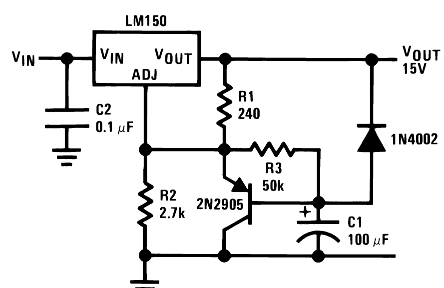
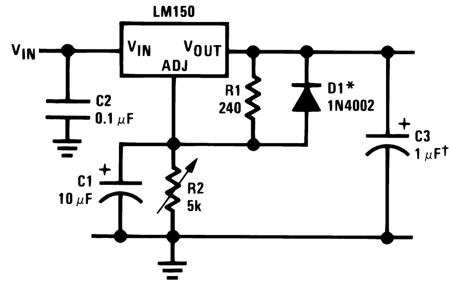


Figure 17. Slow Turn-ON 15V Regulator



†Solid tantalum
*Discharges C1 if output is shorted to ground

Figure 18. Adjustable Regulator with Improved Ripple Rejection

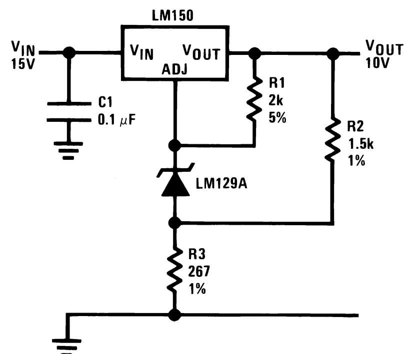
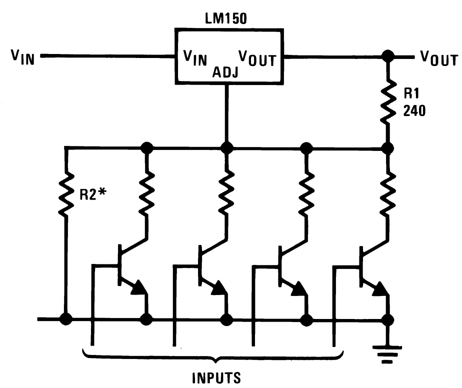


Figure 19. High Stability 10V Regulator



*Sets maximum V_O

Figure 20. Digitally Selected Outputs

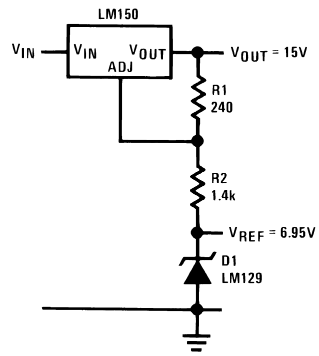
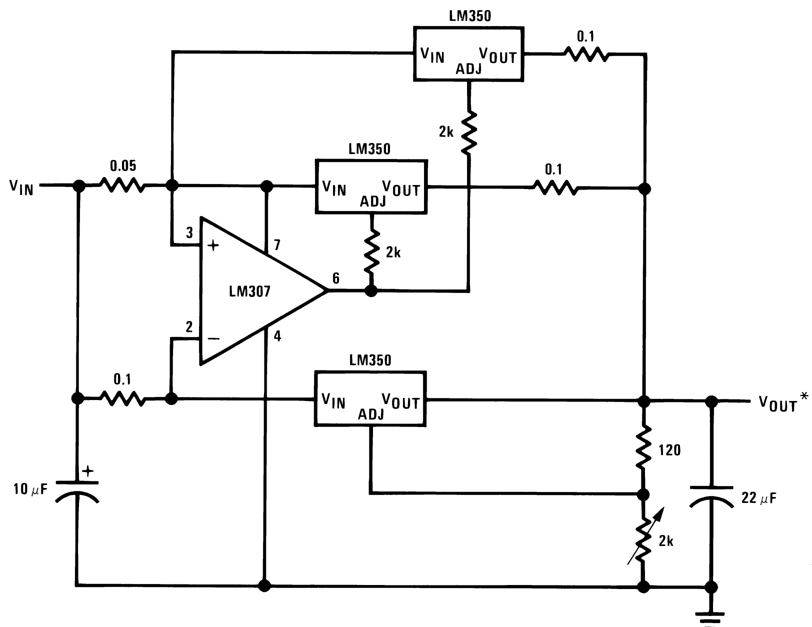
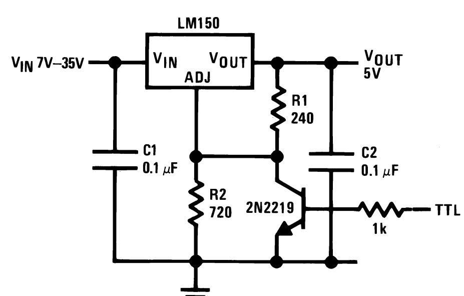


Figure 21. Regulator and Voltage Reference



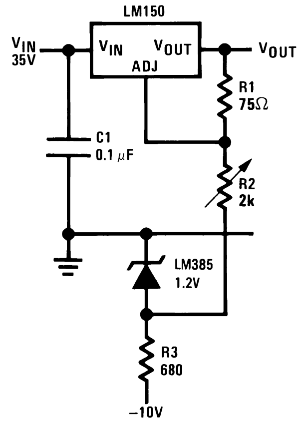
*Minimum load current 50 mA

Figure 22. 10A Regulator



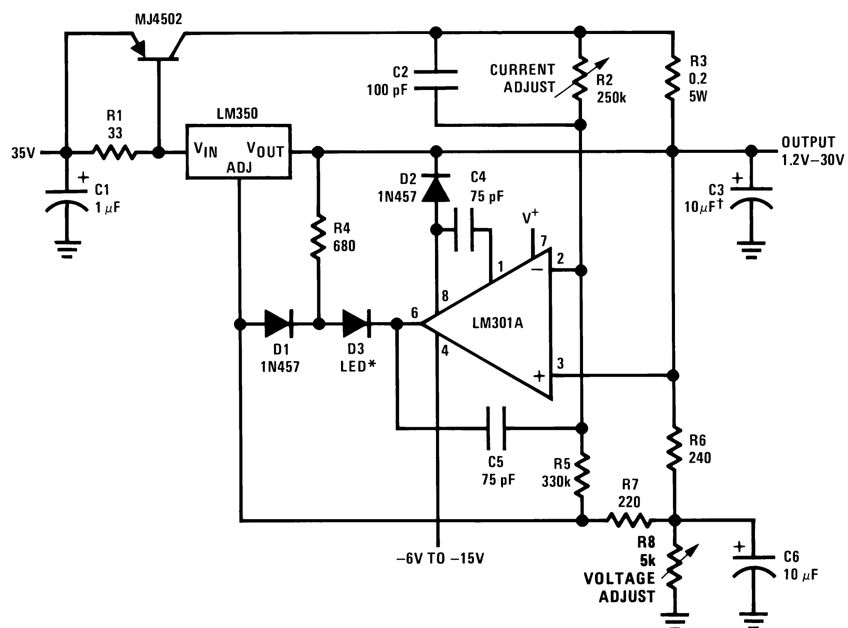
*Minimum output ≈ 1.2V

Figure 23. 5V Logic Regulator with Electronic Shutdown*



Full output current not available at high input-output voltages

Figure 24. 0 to 30V Regulator



†Solid tantalum

*Lights in constant current mode

Figure 25. 5A Constant Voltage/Constant Current Regulator

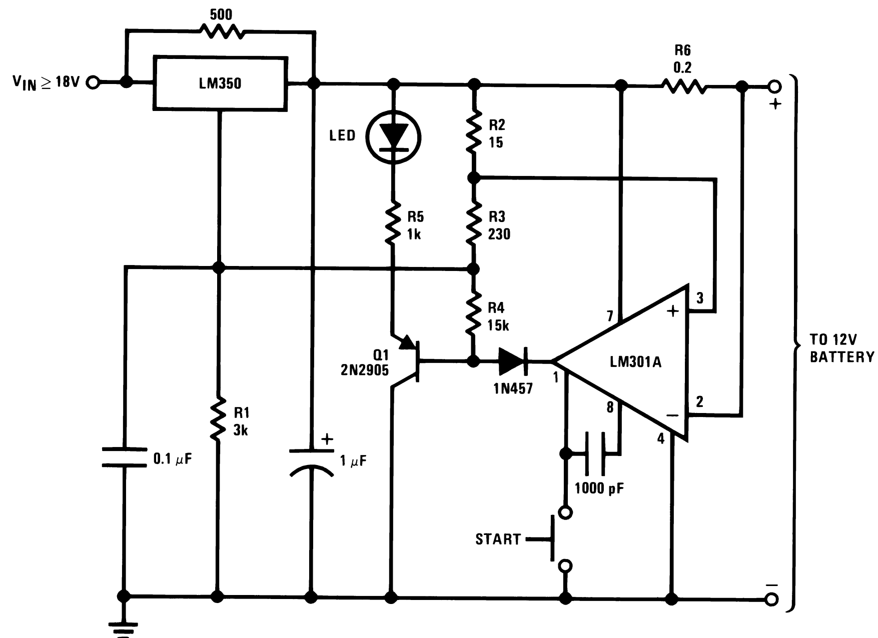


Figure 26. 12V Battery Charger

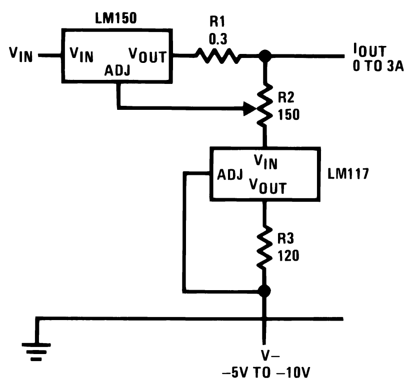
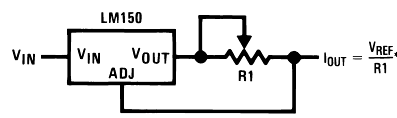
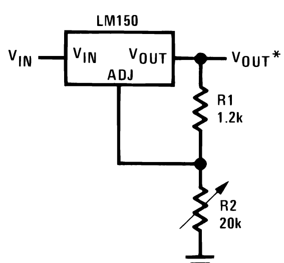


Figure 27. Adjustable Current Regulator



*0.4 ≤ R_1 ≤ 120Ω

Figure 28. Precision Current Limiter



*Minimum output current ≈ 4 mA

Figure 29. .2V–20V Regulator with Minimum Program Current

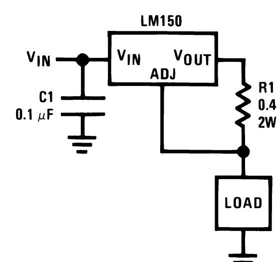


Figure 30. 3A Current Regulator

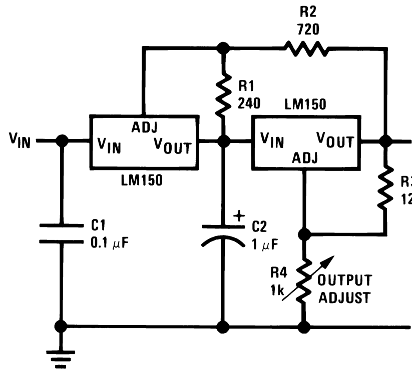
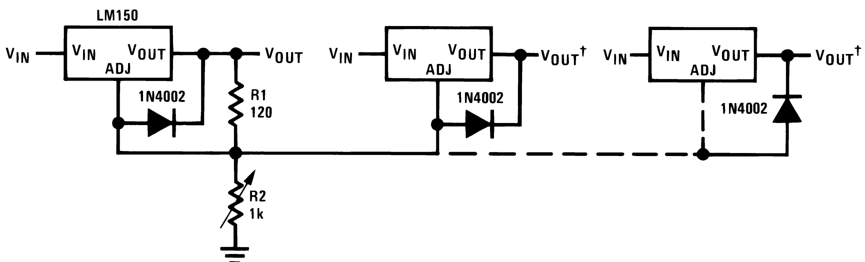


Figure 31. Tracking Preregulator



†Minimum load—10 mA
*All outputs within ±100 mV

Figure 32. Adjusting Multiple On-Card Regulators with Single Control*

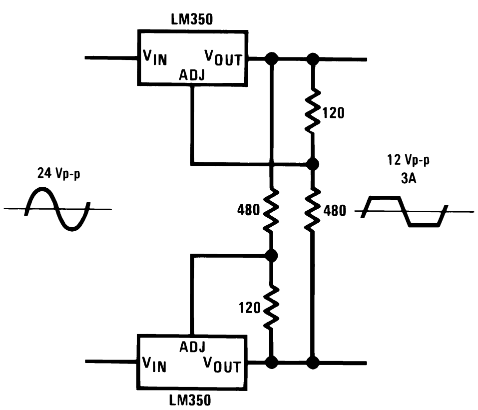
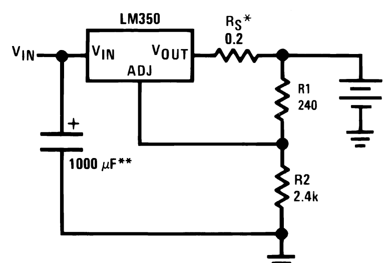


Figure 33. AC Voltage Regulator



*R_S—sets output impedance of charger: $Z_{OUT} = R_S\left(1 + \frac{R2}{R1}\right)$

Use of R_S allows low charging rates with fully charged battery.
**1000 μF is recommended to filter out any input transients

Figure 34. Simple 12V Battery Charger

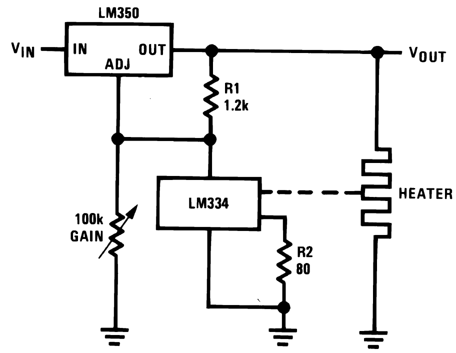


Figure 35. Simple 12V Battery Charger

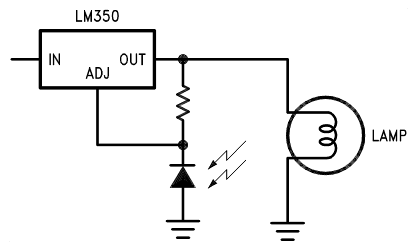


Figure 36. Light Controller

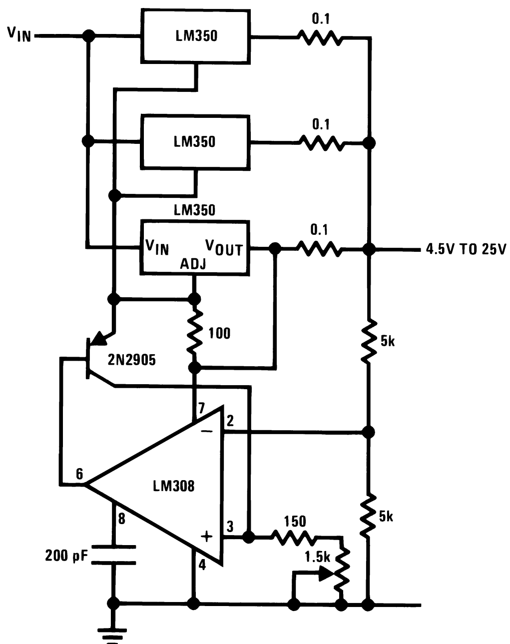
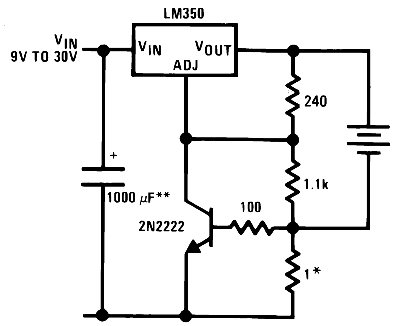


Figure 37. Adjustable 10A Regulator



*Sets peak current (2A for 0.3Ω)

**1000 μF is recommended to filter out any input transients.

Figure 38. Current Limited 6V Charger

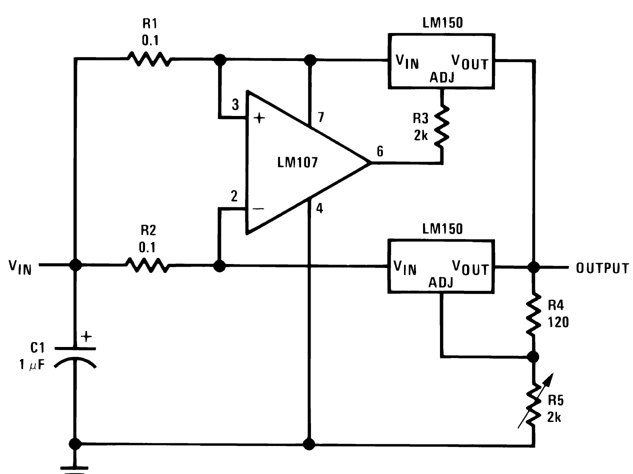


Figure 39. 6A Regulator

REVISION HISTORY

Released	Revision	Section	Changes
03/10/06	A	New Release, Corporate format	1 MDS data sheet converted into one Corp. data sheet format. MNLM150-X Rev. 0BL will be archived.
09/27/2010	B	Obsolete Data Sheet	End Of Life on Product/NSID Dec. 2009

Changes from Revision A (April 2013) to Revision B **Page**

- Changed layout of National Data Sheet to TI format 15

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