

LM138,LM338

LM138/LM338 5-Amp Adjustable Regulators

Datasheet.Directory



Literature Number: SNVS771A

LM138/LM338

5-Amp Adjustable Regulators

General Description

The LM138 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 5A over a 1.2V to 32V output range. They are exceptionally easy to use and require only 2 resistors to set the output voltage. Careful circuit design has resulted in outstanding load and line regulation—comparable to many commercial power supplies. The LM138 family is supplied in a standard 3-lead transistor package.

A unique feature of the LM138 family is time-dependent current limiting. The current limit circuitry allows peak currents of up to 12A to be drawn from the regulator for short periods of time. This allows the LM138 to be used with heavy transient loads and speeds start-up under full-load conditions. Under sustained loading conditions, the current limit decreases to a safe value protecting the regulator. Also included on the chip are thermal overload protection and safe area protection for the power transistor. Overload protection remains functional even if the adjustment pin 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 LM138 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., do not short-circuit output to ground. The part numbers in the LM138 series which have a K suffix are packaged in a standard Steel TO-3 package, while those with a T suffix are packaged in a TO-220 plastic package. The LM138 is rated for $-55^{\circ}\text{C} \leq T_J \leq +150^{\circ}\text{C}$, and the LM338 is rated for $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$.

Features

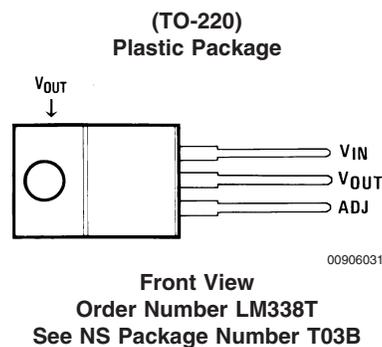
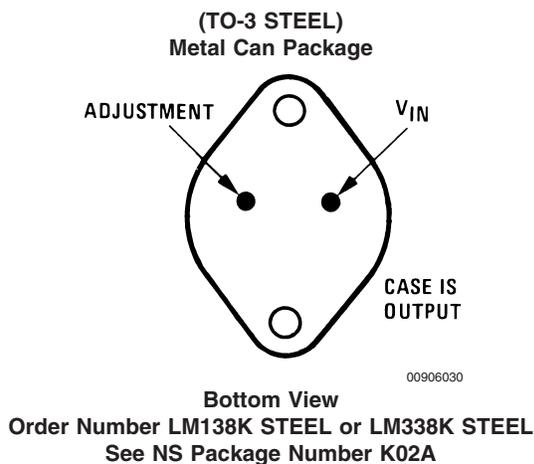
- Guaranteed 7A peak output current
- Guaranteed 5A output current
- Adjustable output down to 1.2V
- Guaranteed thermal regulation
- Current limit constant with temperature
- P+ Product Enhancement tested
- Output is short-circuit protected

Applications

- Adjustable power supplies
- Constant current regulators
- Battery chargers

Connection Diagrams (See Physical Dimension section for further information)

Connection Diagrams



Absolute Maximum Ratings (Note 1)

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

(Note 4)

Power Dissipation	Internally limited	Storage Temperature	-65°C to +150°C
Input/Output Voltage Differential	+40V, -0.3V	Lead Temperature	
		Metal Package (Soldering, 10 seconds)	
		Plastic Package (Soldering, 4 seconds)	300°C
		ESD Tolerance	260°C
			TBD

Operating Temperature Range

LM138

 $-55^{\circ}\text{C} \leq T_J \leq +150^{\circ}\text{C}$

LM338

 $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ **Electrical Characteristics**

Specifications with standard type face are for $T_J = 25^{\circ}\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN} - V_{OUT} = 5\text{V}$; and $I_{OUT} = 10\text{mA}$. (Note 2)

Symbol	Parameter	Conditions	LM138			Units
			Min	Typ	Max	
V_{REF}	Reference Voltage	$3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$, $10\text{mA} \leq I_{OUT} \leq 5\text{A}$, $P \leq 50\text{W}$	1.19	1.24	1.29	V
V_{RLINE}	Line Regulation	$3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$ (Note 3)		0.005	0.01	%/V
V_{RLOAD}	Load Regulation	$10\text{mA} \leq I_{OUT} \leq 5\text{A}$ (Note 3)		0.02	0.04	%/V
	Thermal Regulation	20 ms Pulse		0.1	0.3	%
				0.3	0.6	%
I_{ADJ}	Adjustment Pin Current			0.002	0.01	%/W
ΔI_{ADJ}	Adjustment Pin Current Change	$10\text{mA} \leq I_{OUT} \leq 5\text{A}$, $3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$		45	100	μA
$\Delta V_{R/T}$	Temperature Stability	$T_{MIN} \leq T_J \leq T_{MAX}$		0.2	5	μA
$I_{LOAD(Min)}$	Minimum Load Current	$V_{IN} - V_{OUT} = 35\text{V}$		1		%
I_{CL}	Current Limit	$V_{IN} - V_{OUT} \leq 10\text{V}$		3.5	5	mA
		DC	5	8		A
		0.5 ms Peak	7	12		A
		$V_{IN} - V_{OUT} = 30\text{V}$		1	1	A
V_N	RMS Output Noise, % of V_{OUT}	$10\text{Hz} \leq f \leq 10\text{kHz}$		0.003		%
$\frac{\Delta V_R}{\Delta V_{IN}}$	Ripple Rejection Ratio	$V_{OUT} = 10\text{V}$, $f = 120\text{Hz}$, $C_{ADJ} = 0\mu\text{F}$		60		dB
		$V_{OUT} = 10\text{V}$, $f = 120\text{Hz}$, $C_{ADJ} = 10\mu\text{F}$	60	75		dB
	Long-Term Stability	$T_J = 125^{\circ}\text{C}$, 1000 Hrs		0.3	1	%
θ_{JC}	Thermal Resistance, Junction to Case	K Package			1	$^{\circ}\text{C/W}$
θ_{JA}	Thermal Resistance, Junction to Ambient (No Heat Sink)	K Package		35		$^{\circ}\text{C/W}$

Electrical Characteristics

Symbol	Parameter	Conditions	LM338			Units
			Min	Typ	Max	
V_{REF}	Reference Voltage	$3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$, $10\text{mA} \leq I_{OUT} \leq 5\text{A}$, $P \leq 50\text{W}$	1.19	1.24	1.29	V
V_{RLINE}	Line Regulation	$3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$ (Note 3)		0.005	0.03	%/V
V_{RLOAD}	Load Regulation	$10\text{mA} \leq I_{OUT} \leq 5\text{A}$ (Note 3)		0.02	0.06	%/V
				0.1	0.5	%
				0.3	1	%

Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	LM338			Units
			Min	Typ	Max	
	Thermal Regulation	20 ms Pulse		0.002	0.02	%/W
I_{ADJ}	Adjustment Pin Current			45	100	μ A
ΔI_{ADJ}	Adjustment Pin Current Change	$10 \text{ mA} \leq I_{OUT} \leq 5\text{A}$, $3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$		0.2	5	μ A
$\Delta V_{R/T}$	Temperature Stability	$T_{MIN} \leq T_J \leq T_{MAX}$		1		%
$I_{LOAD(Min)}$	Minimum Load Current	$V_{IN} - V_{OUT} = 35\text{V}$		3.5	10	mA
I_{CL}	Current Limit	$V_{IN} - V_{OUT} \leq 10\text{V}$				
		DC	5	8	A	
		0.5 ms Peak	7	12	A	
		$V_{IN} - V_{OUT} = 30\text{V}$			1	A
V_N	RMS Output Noise, % of V_{OUT}	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$		0.003		%
$\frac{\Delta V_R}{\Delta V_{IN}}$	Ripple Rejection Ratio	$V_{OUT} = 10\text{V}$, $f = 120 \text{ Hz}$, $C_{ADJ} = 0 \mu\text{F}$		60		dB
		$V_{OUT} = 10\text{V}$, $f = 120 \text{ Hz}$, $C_{ADJ} = 10 \mu\text{F}$	60	75		dB
	Long-Term Stability	$T_J = 125^\circ\text{C}$, 1000 hrs		0.3	1	%
θ_{JC}	Thermal Resistance	K Package			1	$^\circ\text{C/W}$
	Junction to Case	T Package			4	$^\circ\text{C/W}$
θ_{JA}	Thermal Resistance, Junction to	K Package		35		$^\circ\text{C/W}$
	Ambient (No Heat Sink)	T Package		50		$^\circ\text{C/W}$

Note 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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

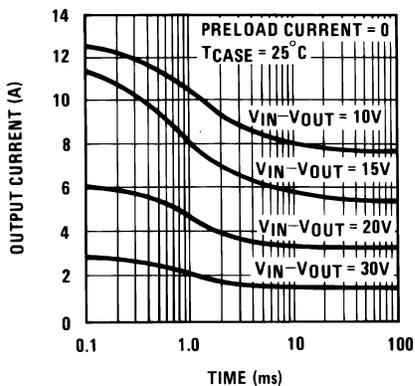
Note 2: These specifications are applicable for power dissipations up to 50W for the TO-3 (K) package and 25W for the TO-220 (T) package. Power dissipation is guaranteed at these values up to 15V input-output differential. Above 15V differential, power dissipation will be limited by internal protection circuitry. All limits (i.e., the numbers in the Min. and Max. columns) are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 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.

Note 4: Refer to RETS138K drawing for military specifications of LM138K.

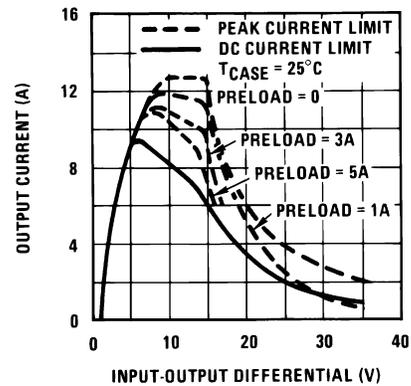
Typical Performance Characteristics

Current Limit



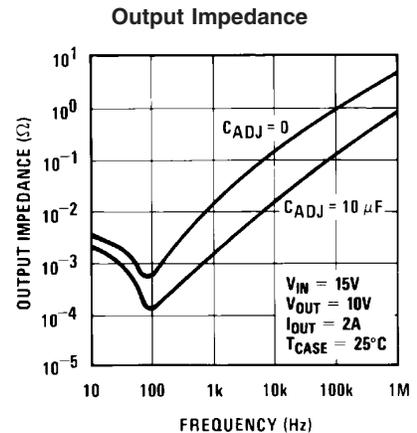
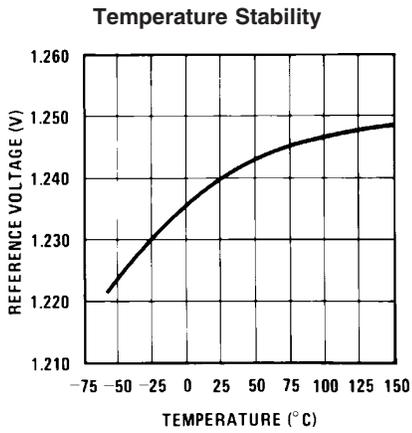
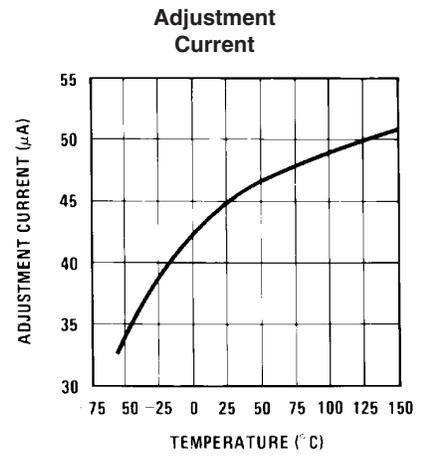
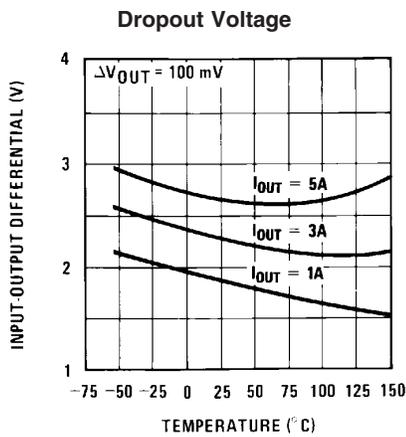
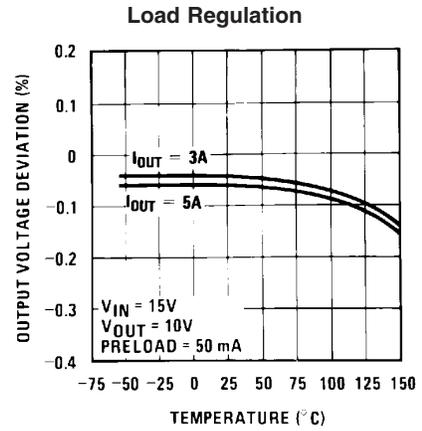
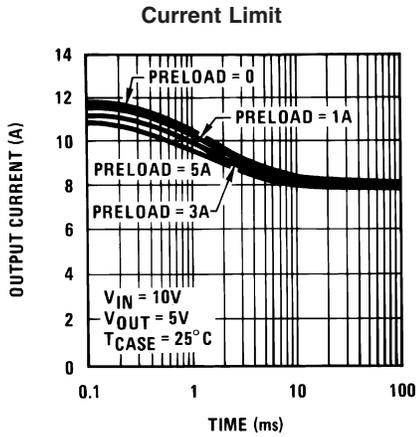
00906032

Current Limit

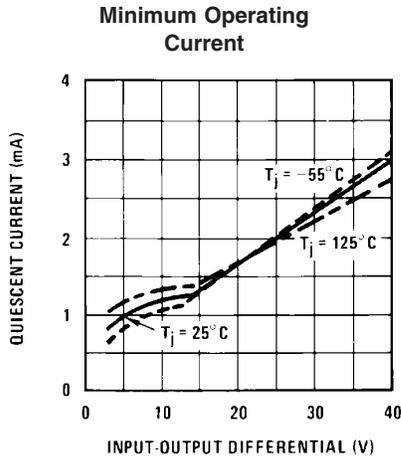


00906033

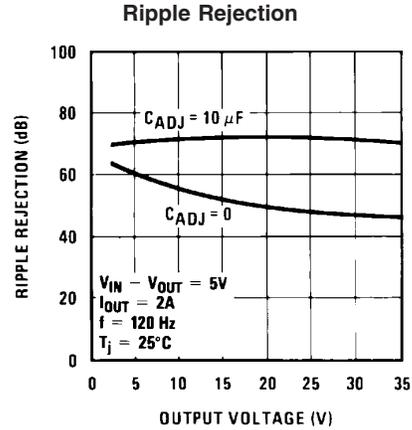
Typical Performance Characteristics (Continued)



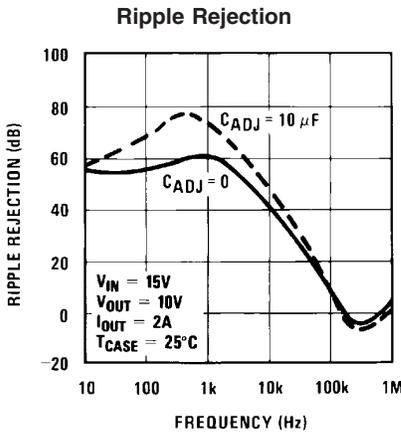
Typical Performance Characteristics (Continued)



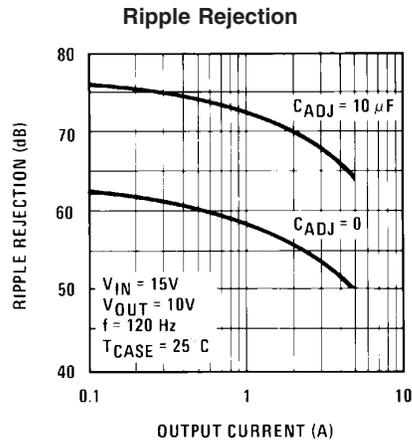
00906040



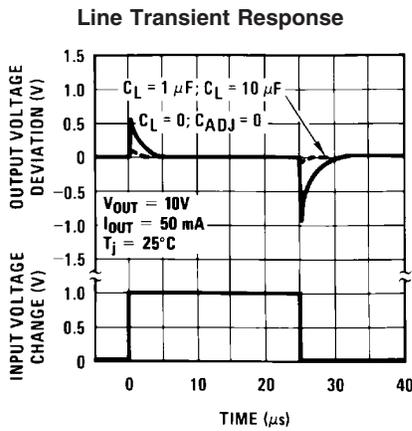
00906041



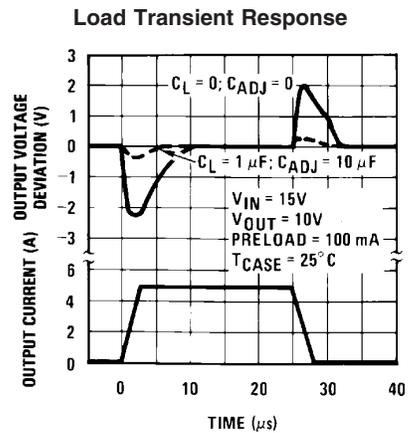
00906042



00906043



00906044



00906045

Application Hints

In operation, the LM138 develops a nominal 1.25V reference voltage, V_{REF} , between the output and adjustment terminal. The reference voltage is impressed across program resistor R_1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R_2 , giving an output voltage of

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

Application Hints (Continued)

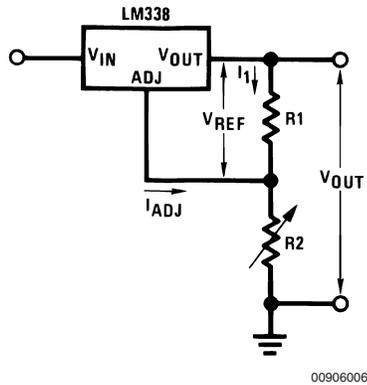


FIGURE 1.

Since the 50 μ A current from the adjustment terminal represents an error term, the LM138 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 μ F disc or 1 μ F 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 LM138 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 μ F bypass capacitor 75 dB ripple rejection is obtainable at any output level. Increases over 20 μ F 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 are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 μ F in aluminum electrolytic to equal 1 μ F 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 μ F disc may seem to work better than a 0.1 μ F disc as a bypass.

Although the LM138 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 μ F solid tantalum (or 25 μ F aluminum electrolytic) on the output swamps this effect and insures stability.

LOAD REGULATION

The LM138 is capable of providing extremely good load regulation but a few precautions are needed to obtain maxi-

imum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240 Ω) should be tied directly to the output of the regulator (case) 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 0.05 Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05 Ω \times I_L . If the set resistor is connected near the load the effective line resistance will be 0.05 Ω (1 + R_2/R_1) or in this case, 11.5 times worse.

Figure 2 shows the effect of resistance between the regulator and 240 Ω set resistor.

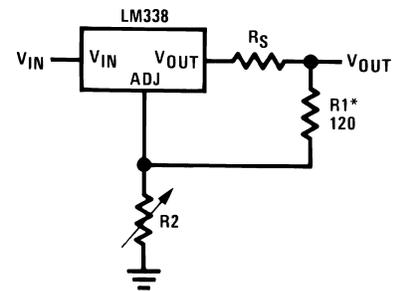


FIGURE 2. Regulator with Line Resistance in Output Lead

With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using 2 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.

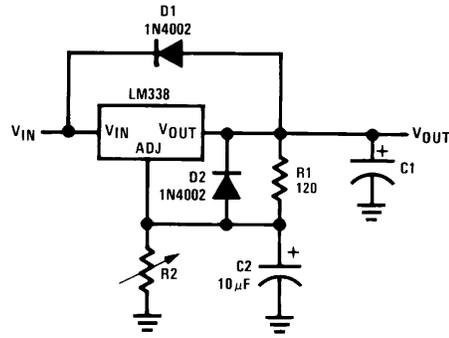
PROTECTION DIODES

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 20 μ F 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 LM138 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 100 μ F or less at output of 15V 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 LM138 is a 50 Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10 μ F capacitance. Figure 3 shows an LM138 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.

Application Hints (Continued)



00906008

D1 protects against C1

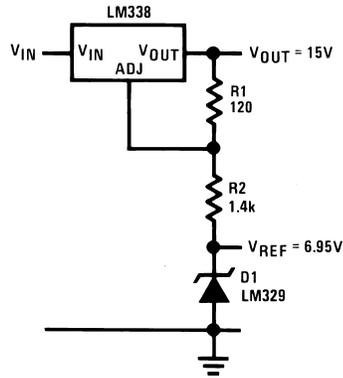
D2 protects against C2

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

FIGURE 3. Regulator with Protection Diodes

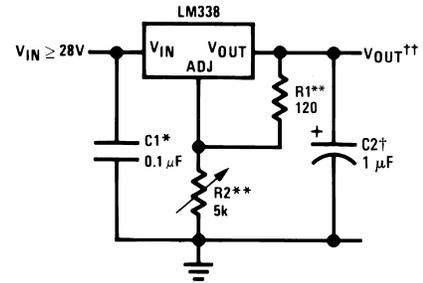
Typical Applications

Regulator and Voltage Reference



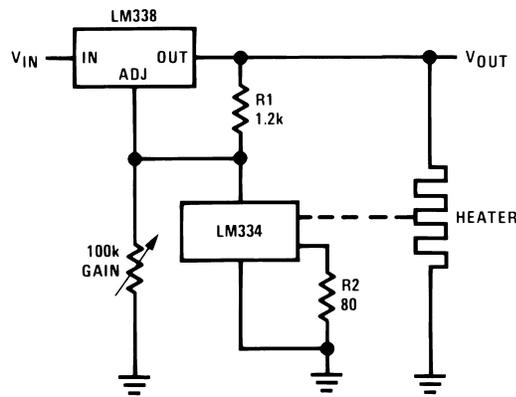
00906003

1.2V–25V Adjustable Regulator



00906001

Temperature Controller



00906010

Full output current not available
at high input-output voltages

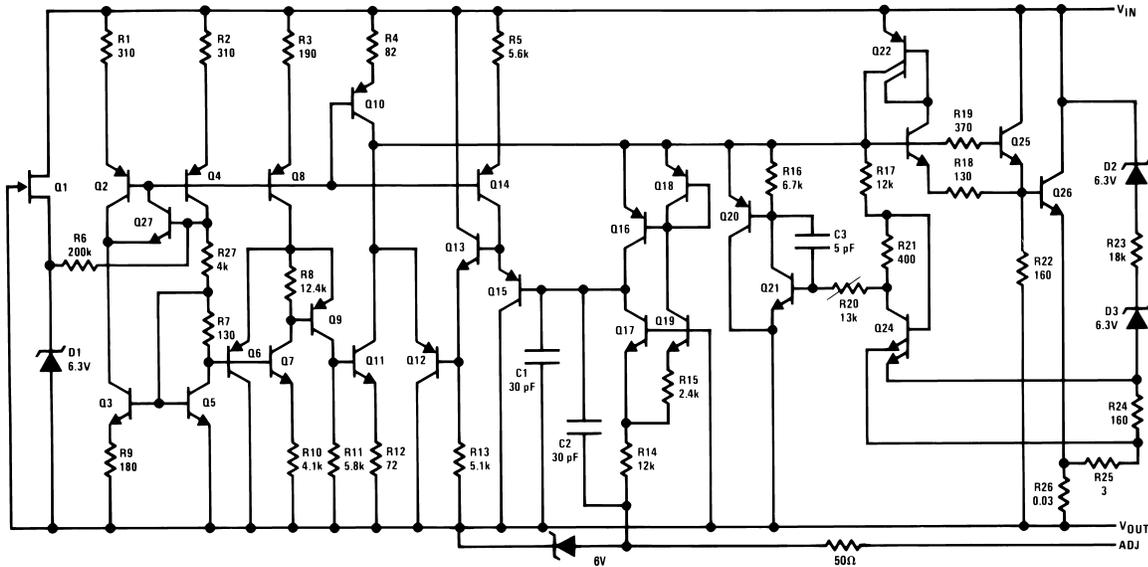
†Optional — improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

*Needed if device is more than 6 inches from filter capacitors.

$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ} (R_2)$$

**R1 = 240Ω for LM138. R1, R2 as an assembly can be ordered from Bourns:
MIL part no. 7105A-AT2-502
COMM part no. 7105A-AT7-502

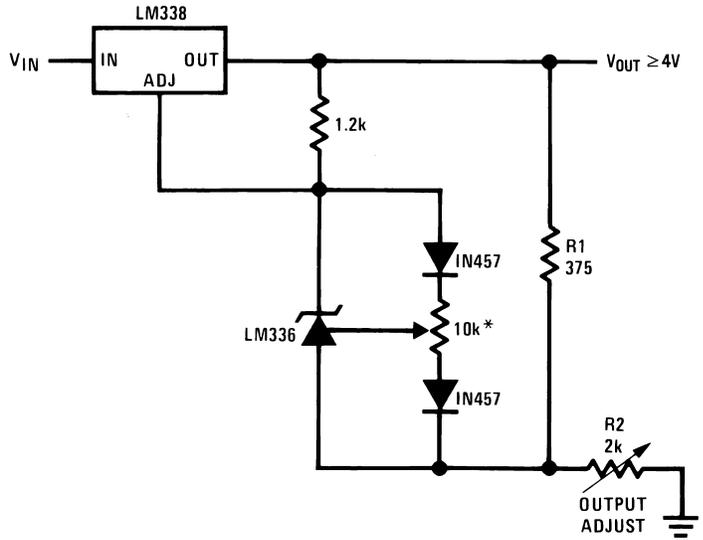
Schematic Diagram



00906009

Typical Applications

Precision Power Regulator with Low Temperature Coefficient

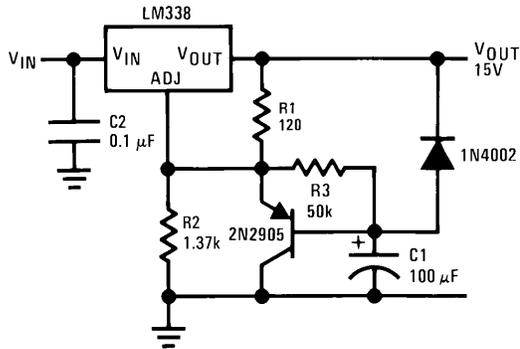


00906012

* Adjust for 3.75 across R1

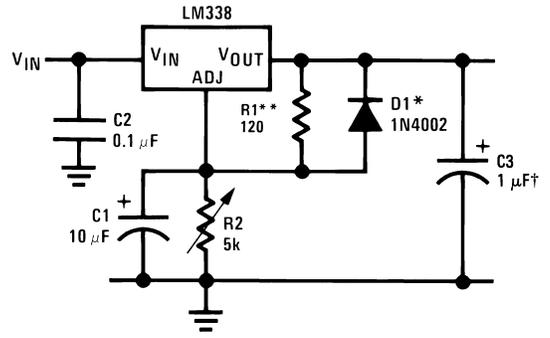
Typical Applications (Continued)

Slow Turn-On 15V Regulator



00906013

Adjustable Regulator with Improved Ripple Rejection



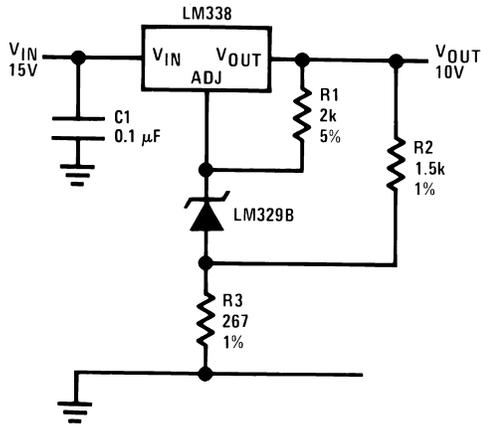
00906014

†Solid tantalum

*Discharges C1 if output is shorted to ground

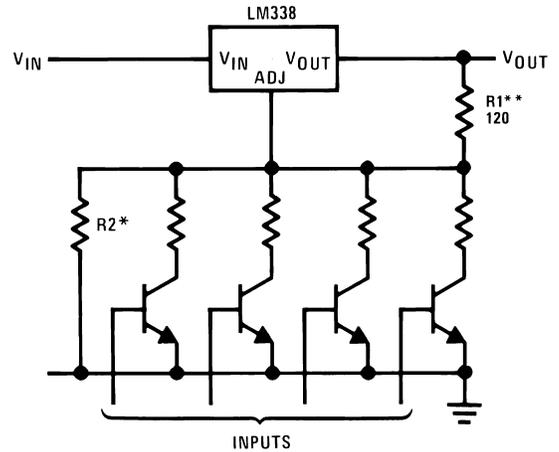
**R1 = 240Ω for LM138

High Stability 10V Regulator



00906015

Digitally Selected Outputs

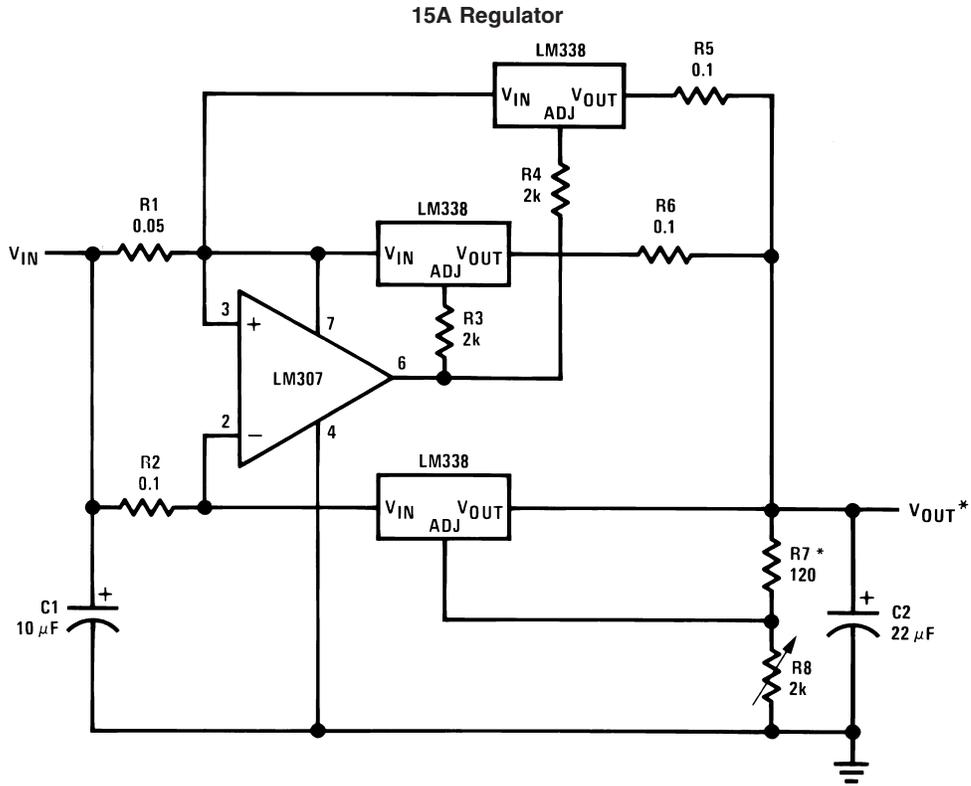


00906016

*Sets maximum V_{OUT}

**R1 = 240Ω for LM138

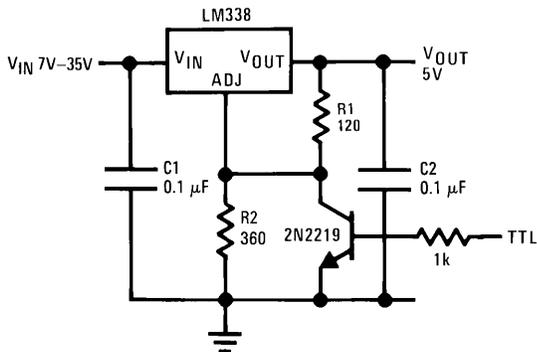
Typical Applications (Continued)



00906017

* Minimum load—100 mA

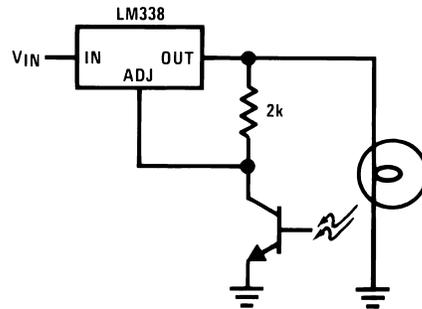
5V Logic Regulator with Electronic Shutdown**



00906018

** Minimum output = 1.2V

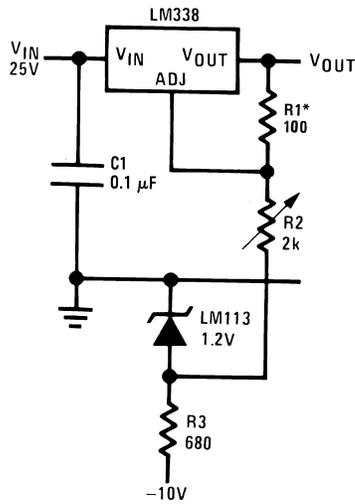
Light Controller



00906011

Typical Applications (Continued)

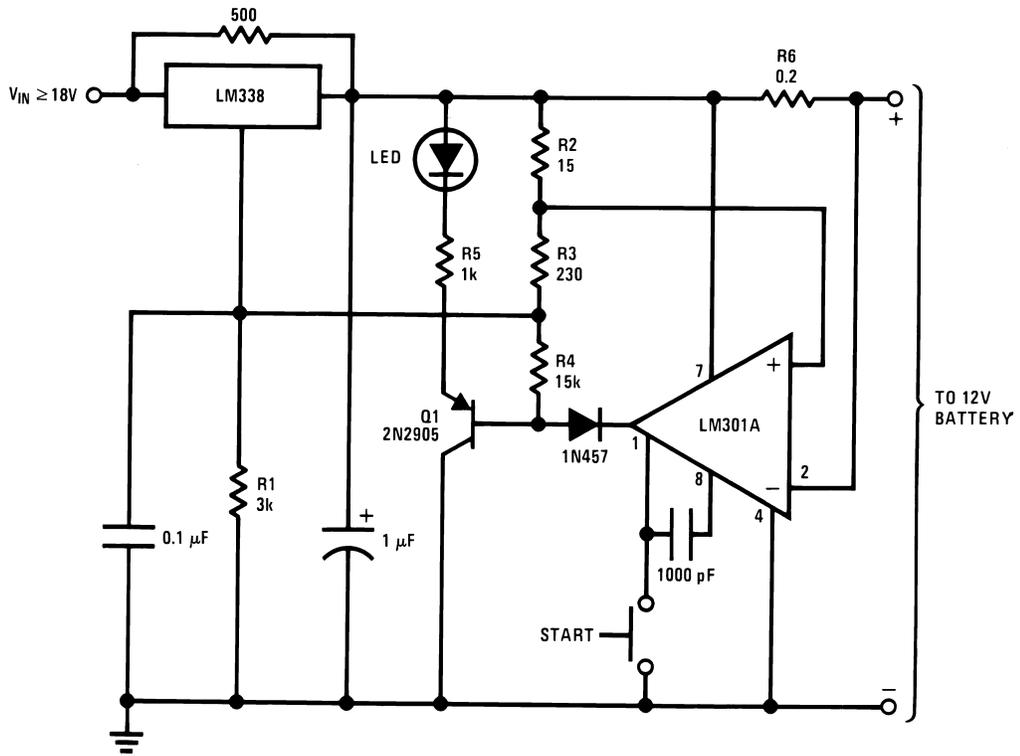
0 to 22V Regulator



00906019

* R1 = 240Ω, R2 = 5k for LM138
Full output current not available
at high input-output voltages

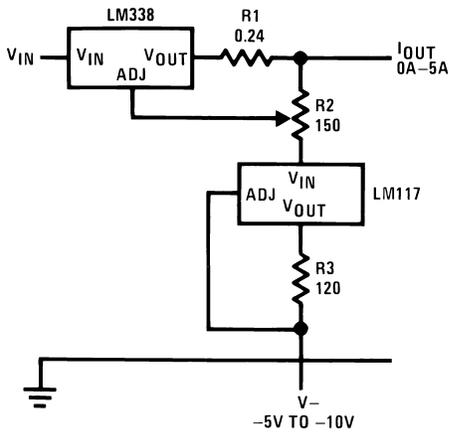
12V Battery Charger



00906020

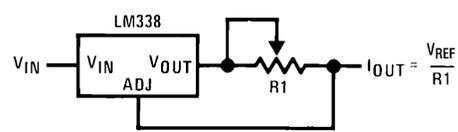
Typical Applications (Continued)

Adjustable Current Regulator



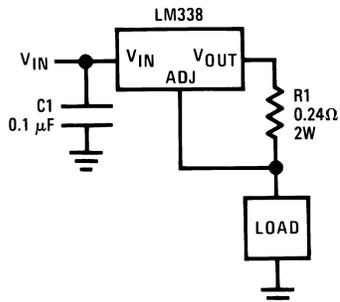
00906021

Precision Current Limiter



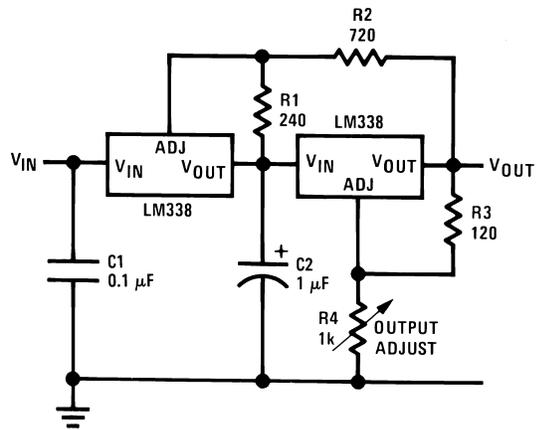
00906022

5A Current Regulator



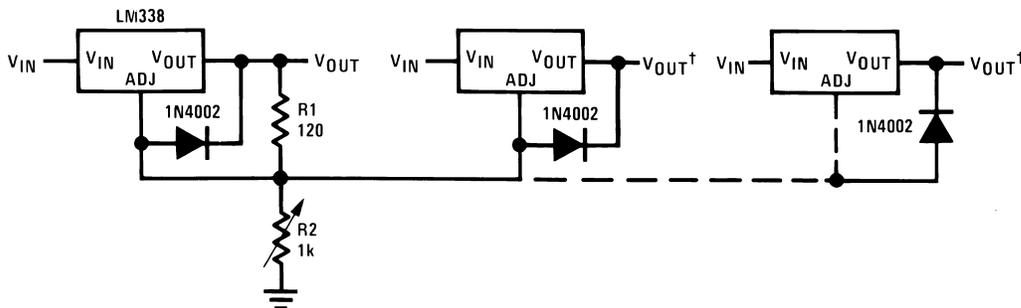
00906023

Tracking Preregulator



00906024

Adjusting Multiple On-Card Regulators with Single Control*



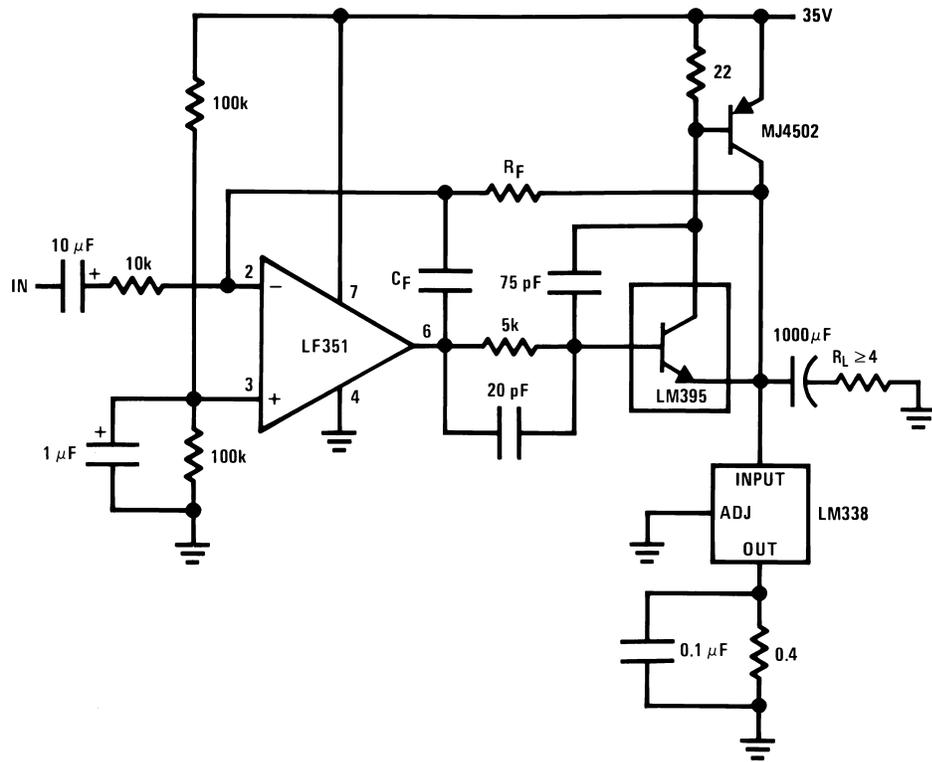
00906025

† Minimum load—10 mA

* All outputs within ±100 mV

Typical Applications (Continued)

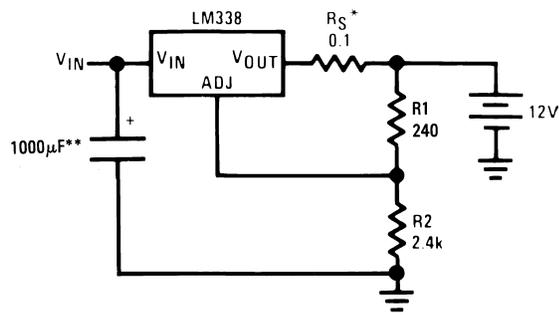
Power Amplifier



$A_V = 1$, $R_F = 10k$, $C_F = 100 \text{ pF}$
 $A_V = 10$, $R_F = 100k$, $C_F = 10 \text{ pF}$
 Bandwidth $\geq 100 \text{ kHz}$
 Distortion $\leq 0.1\%$

00906027

Simple 12V Battery Charger



00906028

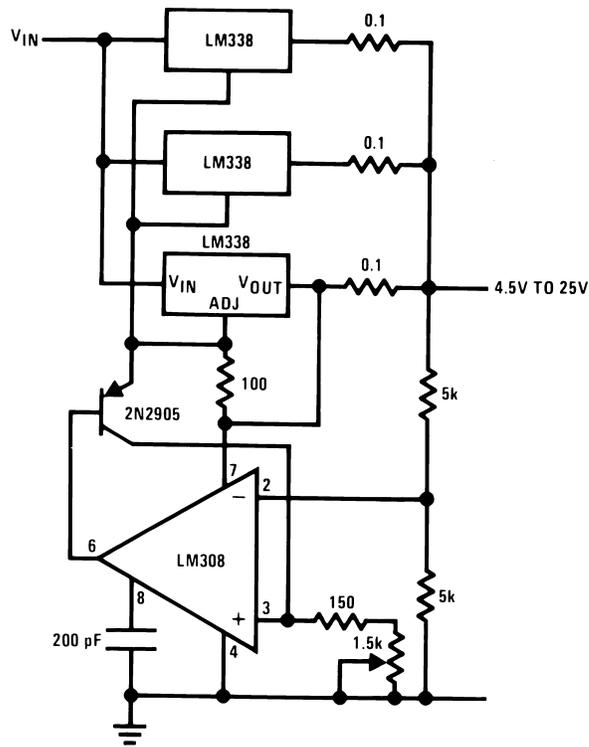
* R_S —sets output impedance of charger $Z_{OUT} = R_S \left(1 + \frac{R_2}{R_1} \right)$

Use of R_S allows low charging rates with fully charged battery.

**The 1000 μF is recommended to filter out input transients

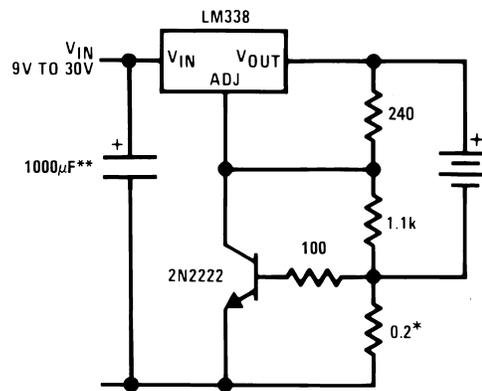
Typical Applications (Continued)

Adjustable 15A Regulator



00906026

Current Limited 6V Charger



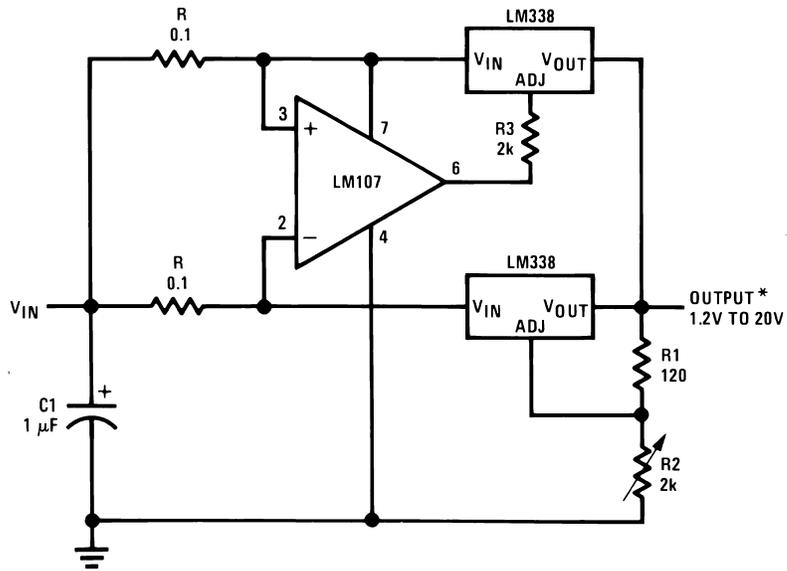
00906029

* Set max charge current to 3A

** THE 1000 μ F is recommended to filter out input transients.

Typical Applications (Continued)

10A Regulator

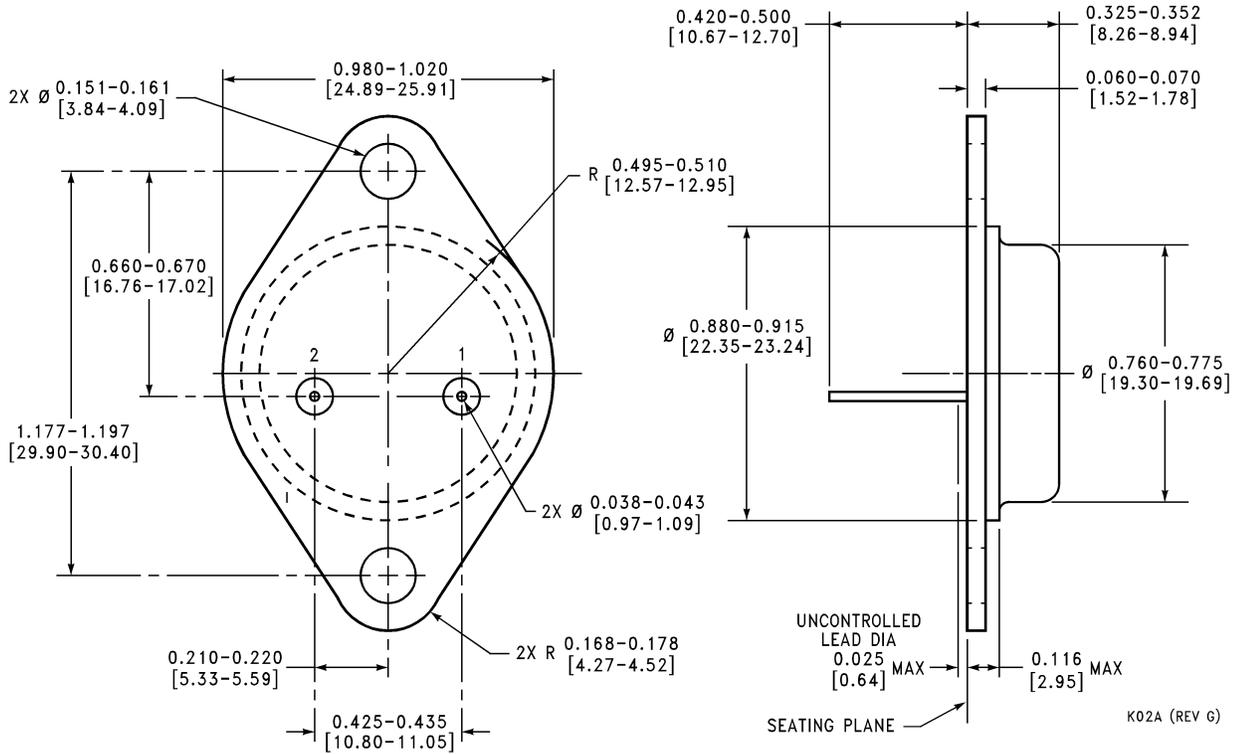


* Minimum load—100 mA

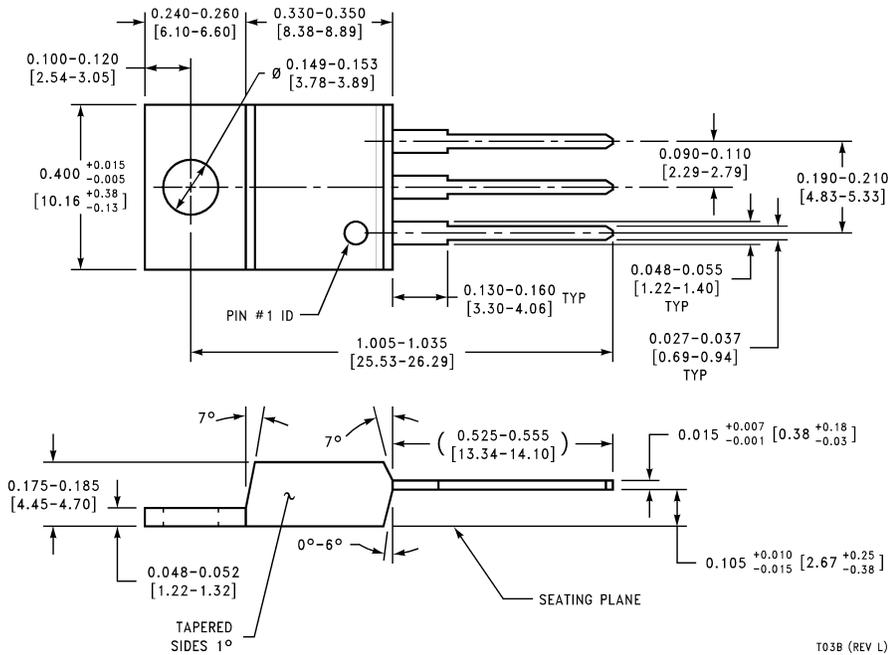
00906002

Physical Dimensions inches (millimeters)

unless otherwise noted



2 Lead TO-3 Metal Can Package (K)
Order Number LM138K or LM338K STEEL
NS Package Number K02A



3 Lead Molded TO-220 (T)
Order Number LM338T
NS Package Number T03B

Notes

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at www.national.com.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated