LM338-MIL 5A可変レギュレータ

1 特長

- 7Aのピーク出力電流を規定
- 5Aの出力電流を規定
- 可変出力電圧: 最小1.2V
- 熱レギュレーションを規定
- 温度に対して一定の電流制限
- P+ Product Enhancementテスト済み
- 出力の短絡保護

2 アプリケーション

- 可変電源
- 定電流レギュレータ
- バッテリ充電器

3 概要

LM338-MILシリーズは、可変の3端子正電圧レギュレータで、1.2V～32Vの出力電圧範囲で5A以上を供給可能です。非常に使い勝手がよく、2つの抵抗だけで出力電圧を設定できます。周到な回路設計により、負荷およびラインのレギュレーションが非常に優れており、多くの商用電源に匹敵します。LM338-MILファミリは、標準の3リードのトランジスタ・パッケージで供給されます。

LM338-MILファミリ独自の機能として、時間依存の電流制限が挙げられます。電流制限回路により、短い時間ならレギュレータから最高12Aのピーク電流を出力できます。このため、LM338-MILは全負荷の状況で大きな過渡負荷に対応でき、スタートアップを高速化できます。持続的な負荷状況では、レギュレータを保護するために電流制限が安全な値まで低下します。チップには熱過負荷保護と、電力トランジスタの安全領域保護も組み込まれています。過負荷保護は、調整(ADJ)ピンが誤って切断された場合でも動作し続けます。

デバイスが入力フィルタ・コンデンサから6インチ以上離れていない限り、通常はコンデンサ不要です。6インチ以上離れている場合には、入力バイパス・コンデンサが必要です。出力コンデンサを追加すると過渡応答を改善できます。また調整ピンをバイパスするとレギュレータのリップル除去率が改善されます。

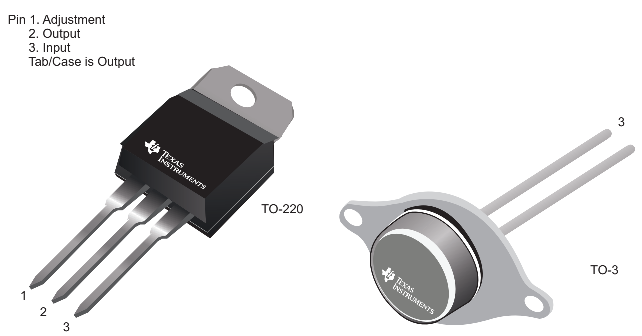
LM338-MILは、固定レギュレータやディスクリート設計の置き換え以外にも、広範な他の用途に有効です。レギュレータはフローティング状態で、入力から出力への差動電圧のみを受け取るため、入力から出力への差分の最大値を超過せず、出力からグランドへの短絡が発生しない限り、数百ボルトの電圧の電源でもレギュレート可能です。LM338-MILシリーズの部品番号で、接尾辞*K*があるものは標準のスチール製TO-CANパッケージで供給され、接尾辞*T*があるものはTO-220プラスチック・パッケージで供給されます。LM338-MILはT_J = 0℃～125℃が定格です。

製品情報(1)

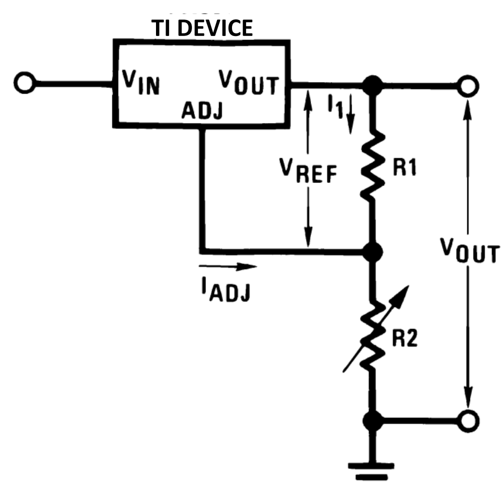
型番	パッケージ	本体サイズ(公称)
LM338-MIL	TO-220 (3)	10.16mm×14.986mm
	TO-CAN (2)	25.40mm×38.94mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。

利用可能なパッケージ



代表的なアプリケーション回路



目次

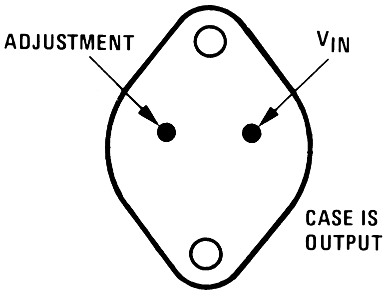
4 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

日付	改訂内容	注
2017年6月	*	初版

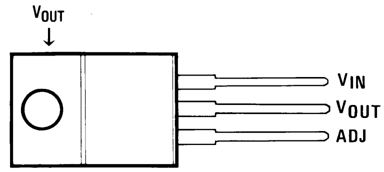
5 Pin Configuration and Functions

NDS Package
2-Pin TO-CAN
Bottom View



Package Number NDS0002A

NDE Package
3-Pin TO-220
Front View



Package Number NDE0003B

Pin Functions

PIN			I/O	DESCRIPTION
NAME	TO-220	TO-CAN		
ADJ	1	1	I	Output voltage adjustment pin. Connect to a resistor divider to set V_O
V_{IN}	3	2	I	Supply input pin
V_{OUT}	2	Case	O	Voltage output pin

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Input and output voltage differential		–0.3	40	V
Power dissipation		Internally limited		
Lead temperature	TO-3 package (soldering, 10 s)		300	°C
	TO-220 package (soldering, 4 s)		260	
Operating temperature, T_J		0	125	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

	MIN	MAX	UNIT
Input-to-output voltage differential	3	40	V
Output current		5	A

6.3 Thermal Information

THERMAL METRIC(1)		LM338		UNIT
		NDE (TO-220)	NDS (TO-CAN)	
		3 PINS	2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	22.9	35	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

Thermal Information (continued)

THERMAL METRIC(1)		LM338 NDE (TO-220) 3 PINS	LM338 NDS (TO-CAN) 2 PINS	UNIT
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	15.7	1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	4.1	—	°C/W
ψ_{JT}	Junction-to-top characterization parameter	2.1	—	°C/W
ψ_{JB}	Junction-to-board characterization parameter	4.1	—	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.7	—	°C/W

6.4 Electrical Characteristics

Values apply for T_J = 25°C; V_{IN} – V_{OUT} = 5 V; and I_{OUT} = 10 mA (unless otherwise noted).(1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{REF}	Reference voltage	3 V ≤ (V_{IN} – V_{OUT}) ≤ 35 V, 10 mA ≤ I_{OUT} ≤ 5 A, P ≤ 50 W, T_J = 0°C to 125°C		1.19	1.24	1.29	V
V_{RLINE}	Line regulation	3 V ≤ (V_{IN} – V_{OUT}) ≤ 35 V (2)	T_J = 25°C		0.005%	0.03%	V
			T_J = 0°C to 125°C		0.02%	0.06%	V
V_{RLOAD}	Load regulation	10 mA ≤ I_{OUT} ≤ 5 A (2)	T_J = 25°C		0.1	0.5	
			T_J = 0°C to 125°C		0.3	1	
	Thermal regulation	20-ms pulse			0.002%	0.02%	W
I_{ADJ}	Adjustment pin current	T_J = 0°C to 125°C			45	100	µA
ΔI_{ADJ}	Adjustment pin current change	10 mA ≤ I_{OUT} ≤ 5 A, 3 V ≤ (V_{IN} – V_{OUT}) ≤ 35 V, T_J = 0°C to 125°C			0.2	5	µA
$\Delta V_{R/T}$	Temperature stability	T_J = 0°C to 125°C			1		
$I_{LOAD(MIN)}$	Minimum load current	V_{IN} – V_{OUT} = 35 V, T_J = 0°C to 125°C			3.5	10	mA
I_{CL}	Current limit	V_{IN} – V_{OUT} ≤ 10 V					
		DC, T_J = 0°C to 125°C		5	8		A
		0.5-ms peak, T_J = 0°C to 125°C		7	12		A
		V_{IN} – V_{OUT} = 30 V				1	A
V_N	RMS output noise (percent of V_{OUT})	10 Hz ≤ f ≤ 10 kHz			0.003%		
$\Delta V_R/\Delta V_{IN}$	Ripple rejection ratio	V_{OUT} = 10 V, f = 120 Hz, C_{ADJ} = 0 µF, T_J = 0°C to 125°C			60		dB
		V_{OUT} = 10 V, f = 120 Hz, C_{ADJ} = 10 µF, T_J = 0°C to 125°C		60	75		dB
	Long-term stability	T_J = 125°C, 1000 Hrs			0.3%	1%	

(1) These specifications are applicable for power dissipations up to 50 W for the TO-3 (NDS) package and 25 W for the TO-220 (NDE) package. Power dissipation is specified at these values up to 15-V input-output differential. Above 15-V differential, power dissipation is limited by internal protection circuitry. All limits (that is, the numbers in the minimum and maximum columns) are specified to TI's AOQL (Average Outgoing Quality Level).

(2) 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.

6.5 Typical Characteristics

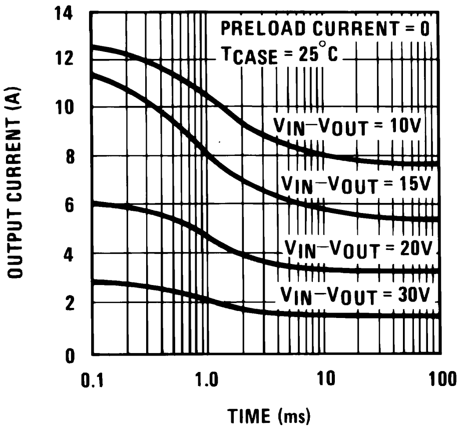


Figure 1. Current Limit

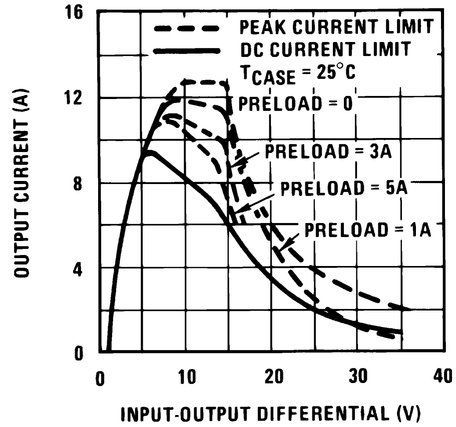


Figure 2. Current Limit

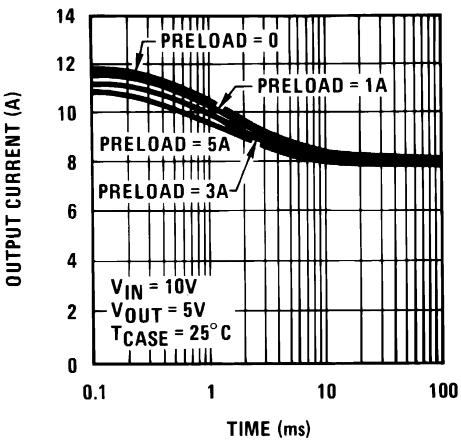


Figure 3. Current Limit

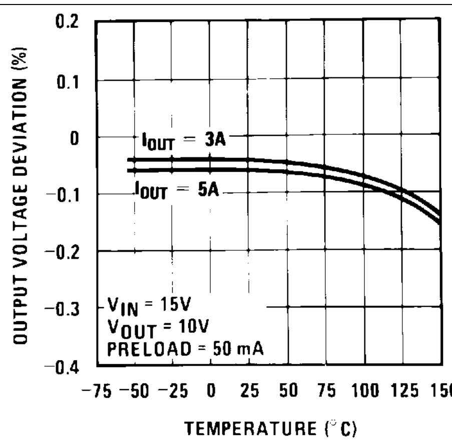


Figure 4. Load Regulation

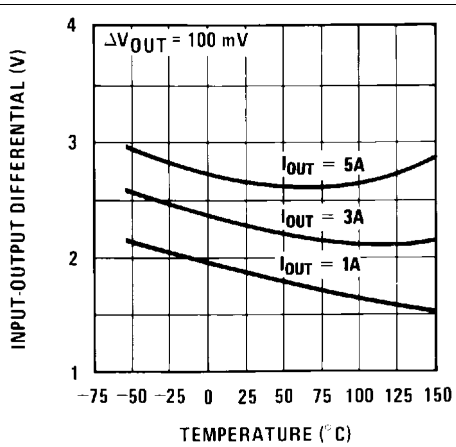


Figure 5. Dropout Voltage

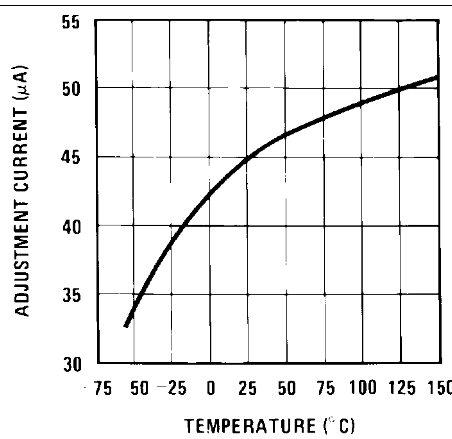


Figure 6. Adjustment Current

Typical Characteristics (continued)

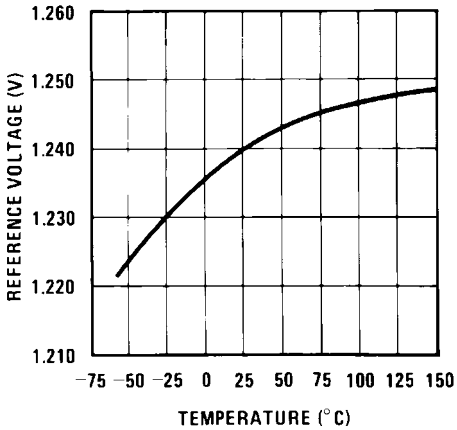


Figure 7. Temperature Stability

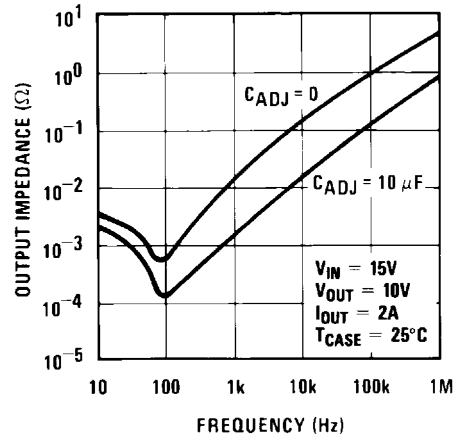


Figure 8. Output Impedance

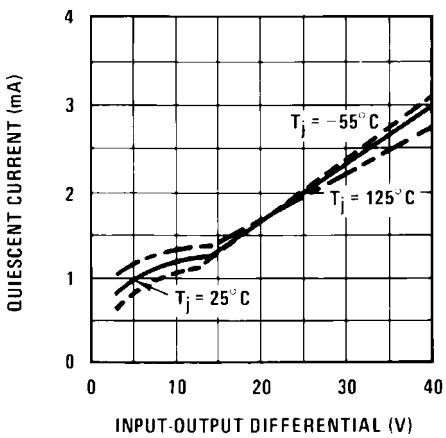


Figure 9. Minimum Operating Current

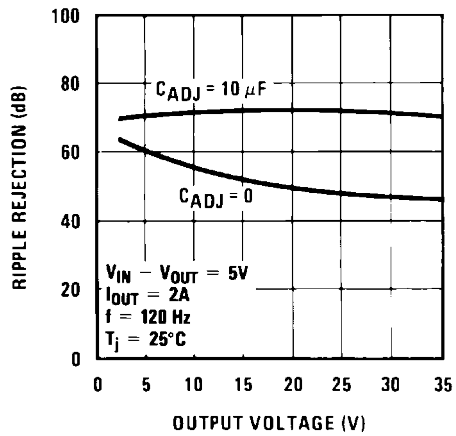


Figure 10. Ripple Rejection

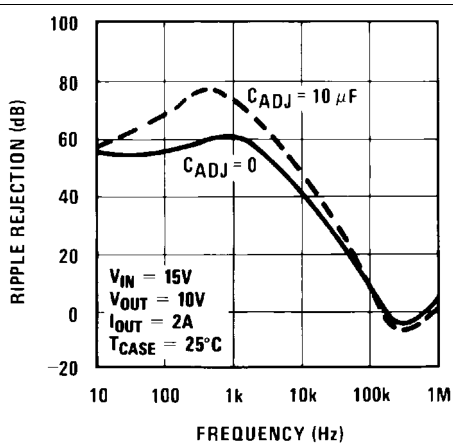


Figure 11. Ripple Rejection

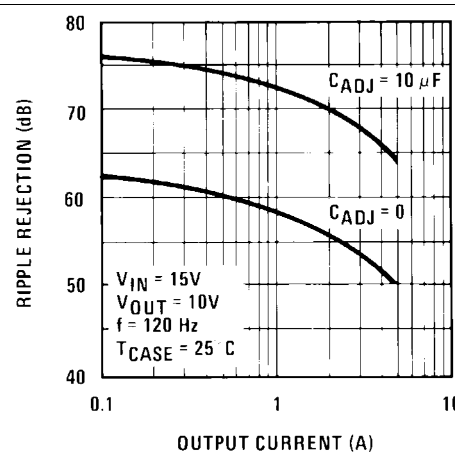


Figure 12. Ripple Rejection

Typical Characteristics (continued)

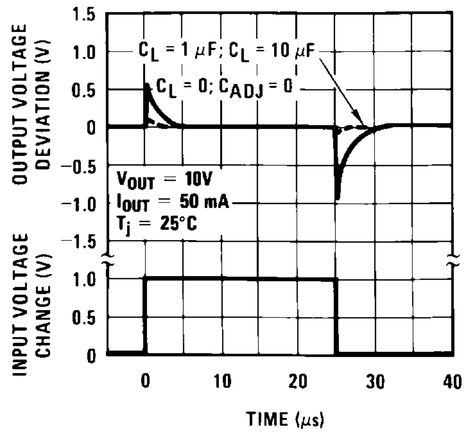


Figure 13. Line Transient Response

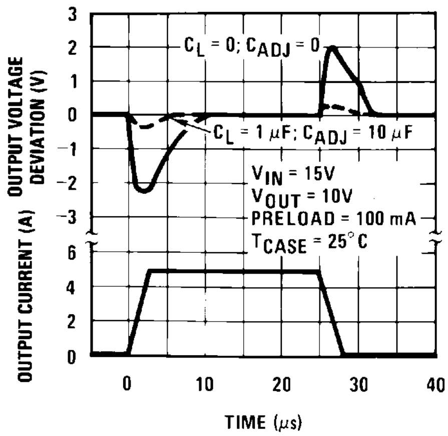


Figure 14. Load Transient Response

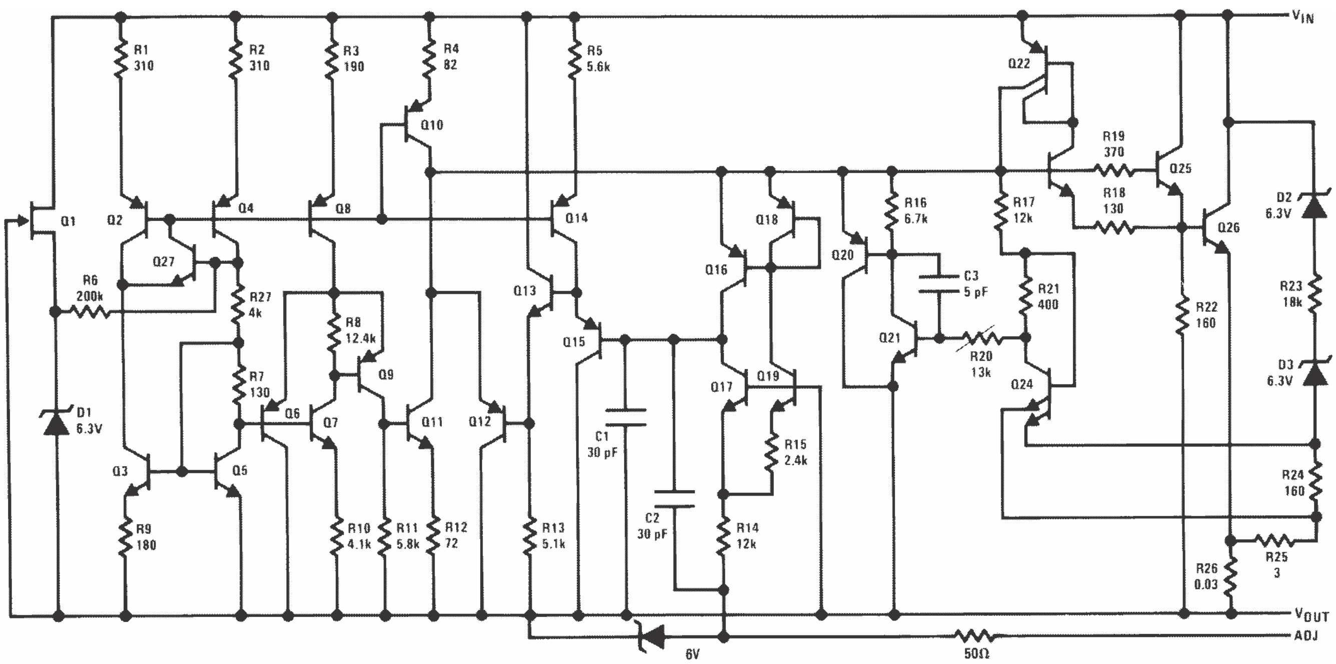
7 Detailed Description

7.1 Overview

The LM338 device is an adjustable, three-terminal, positive-voltage regulator capable of supplying more than 5 A over an output-voltage range of 1.2 V to 32 V. It requires only two external resistors to set the output voltage. The device feature a typical line regulation of 0.005% and typical load regulation of 0.1%. It includes time-dependent current limiting, thermal overload protection, and safe operating area protection. Overload protection remains functional even if the ADJUST terminal is disconnected.

The LM338 device is versatile in its applications, including uses in programmable output regulation and local on-card regulation. Or, by connecting a fixed resistor between the ADJUST and OUTPUT terminals, the LM338 device can function as a precision current regulators. An optional output capacitor can be added to improve transient response. The ADJUST terminal can be bypassed to achieve very high ripple-rejection ratios, which are difficult to achieve with standard three-terminal regulators.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 NPN Darlington Output Drive

NPN Darlington output topology provides naturally low output impedance and an output capacitor is optional. To support maximum current and lowest temperature, 3-V headroom is recommended (V_I – V_O).

7.3.2 Overload Block

Overcurrent and overtemperature shutdown protects the device against overload or damage from operating in excessive heat.

7.3.3 Programmable Feedback

Op amp with 1.25-V offset input at the ADJUST terminal provides easy output voltage or current (not both) programming. For current regulation applications, a single resistor whose resistance value is 1.25 V/IO and power rating is greater than 1.25 V^2/R must be used. For voltage regulation applications, two resistors set the output voltage.

7.4 Device Functional Modes

7.4.1 Normal Operation

The device OUTPUT pin sources current necessary to make OUTPUT pin 1.25 V greater than ADJUST terminal to provide output regulation.

7.4.2 Operation With Low Input Voltage

The device requires up to 3-V headroom (V_I – V_O) to operate in regulation. With less headroom, the device may drop out and OUTPUT voltage is INPUT voltage minus drop out voltage.

7.4.3 Operation at Light Loads

The device passes its bias current to the OUTPUT pin. The load or feedback must consume this minimum current for regulation or the output may be too high. A 250-Ω feedback resistor between OUTPUT and ADJUST consumes the worst case minimum load current of 5 mA.

7.4.4 Operation in Self Protection

When an overload occurs, the device shuts down Darlington NPN output stage or reduces the output current to prevent device damage. The device automatically resets from the overload. The output may be reduced or alternate between on and off until the overload is removed.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

In operation, the LM338-MIL develops a nominal 1.25-V 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 calculated with Equation 1.

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

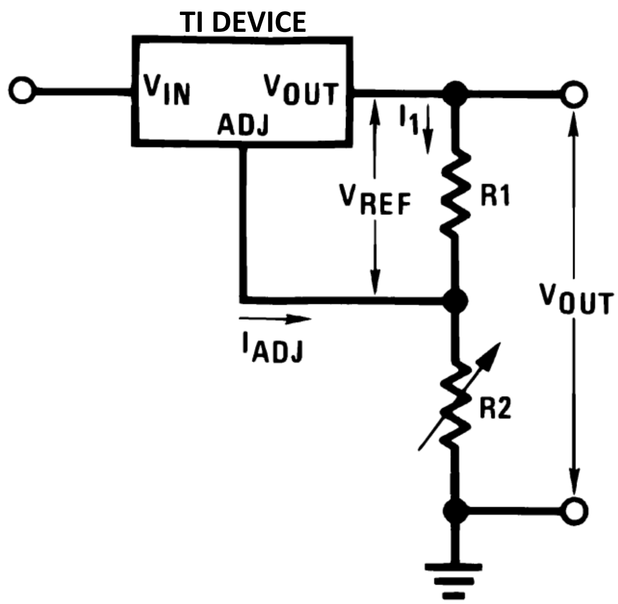
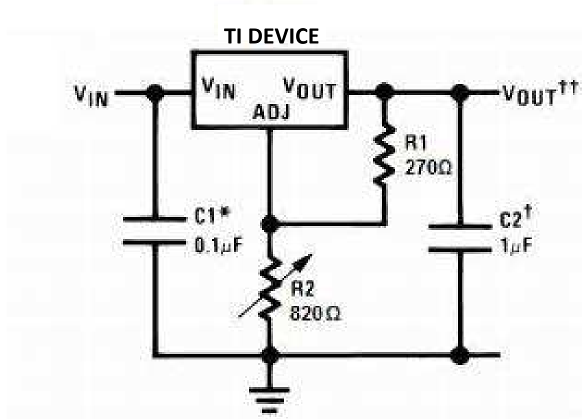


Figure 15. Typical Application Circuit

Because the 50-µA current from the adjustment terminal represents an error term, the LM338-MIL 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 rises.

8.2 Typical Applications

8.2.1 Constant 5-V Regulator



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

†Optional—improves transient response

†† $V_{OUT} = 1.25\ V\left(1+\frac{R2}{R1}\right)+I_{ADJ}\left(R_2\right)$

Figure 16. Constant 5-V Regulator

8.2.1.1 Design Requirements

R1: Because the LM338-MIL produces a typical 1.24 V potential between the OUTPUT and ADJUST pins, placing a 270-Ω resistor between them causes 4.6 mA to flow through R1 and R2.

R2: To achieve a 5-V output, the sum of the voltages across R1 and R2 must equal 5 V. Therefore, Vr2 must equal 3.76 V when 4.6 mA is flowing through it. R2 = Vr2 / I = 3.76 V / 4.6 mA = ~820 Ω.

C_{IN}: 0.1 µF of input capacitance helps filter out unwanted noise, especially if the regulator is located far from the power supply filter capacitors.

C_{OUT}: The regulator is stable without any output capacitance, but adding a 1-µF capacitor improves the transient response.

C_{ADJ}: A 10-µF capacitor bypassing the ADJUST pin to ground improves the regulators ripple rejection.

D1: Protection diode D1 is recommended if C_{OUT} is used. The diode provides a low-impedance discharge path to prevent the capacitor from discharging into the output of the regulator (see *Protection Diodes*).

D2: Protection diode D2 is recommended if C_{ADJ} is used. The diode provides a low-impedance discharge path to prevent the capacitor from discharging into the output of the regulator (see *Protection Diodes*).

Table 1 lists the design parameters for this typical application.

Table 1. Design Parameters

PARAMETER	VALUE
Feedback resistor 1 (R1)	270 Ω
Feedback resistor 2 (R2)	820 Ω
Input capacitor (C_{IN})	0.1 µF
Output capacitor (C_{OUT})	1 µF
Adjust capacitor(C_{ADJ})	10 µF

8.2.1.2 Detailed Design Procedure

8.2.1.2.1 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 eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM338-MIL to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10-µF bypass capacitor, 75-dB ripple rejection is obtainable at any output level. Increases over 20 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 are 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 LM338-MIL 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.

8.2.1.2.2 Load Regulation

The LM338-MIL 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 240 Ω) must 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 15-V regulator with 0.05-Ω resistance between the regulator and load has a load regulation due to line resistance of 0.05 Ω × I_L. If the set resistor is connected near the load, the effective line resistance is 0.05 Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 17 shows the effect of resistance between the regulator and 240-Ω set resistor.

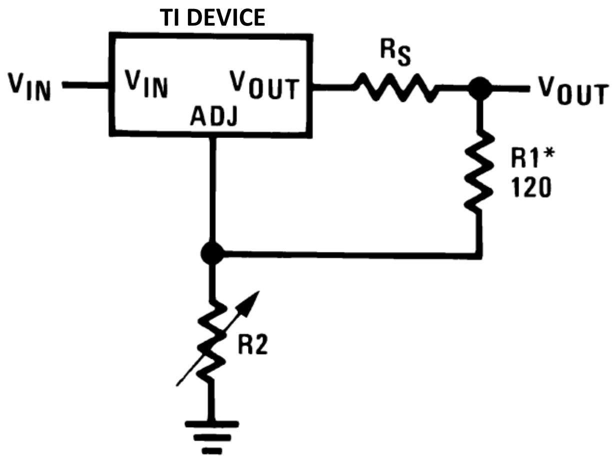


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Figure 17. Regulator With Line Resistance in Output Lead

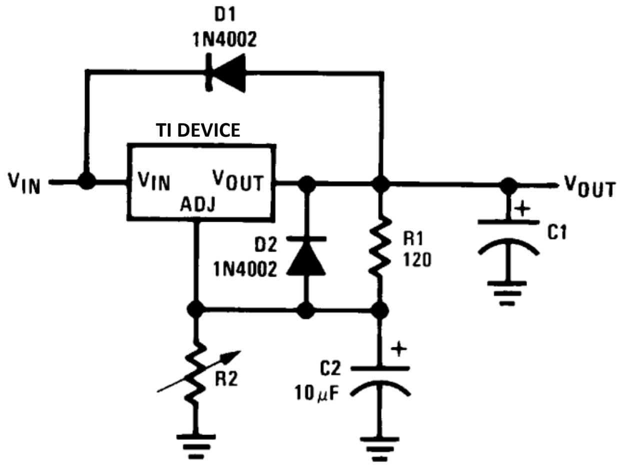
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using 2 separate leads to the case. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

8.2.1.2.3 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-µF capacitors have low enough internal series resistance to deliver 20-A 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 discharges 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 LM338-MIL this discharge path is through a large junction that is able to sustain 25-A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 100 µF or less at output of 15 V 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 LM338-MIL is a 50-Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25-V or less and 10-µF capacitance. Figure 18 shows an LM338-MIL with protection diodes included for use with outputs greater than 25 V and high values of output capacitance.



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

D1 protects against C1
D2 protects against C2

Figure 18. Regulator With Protection Diodes

8.2.1.3 Application Curves

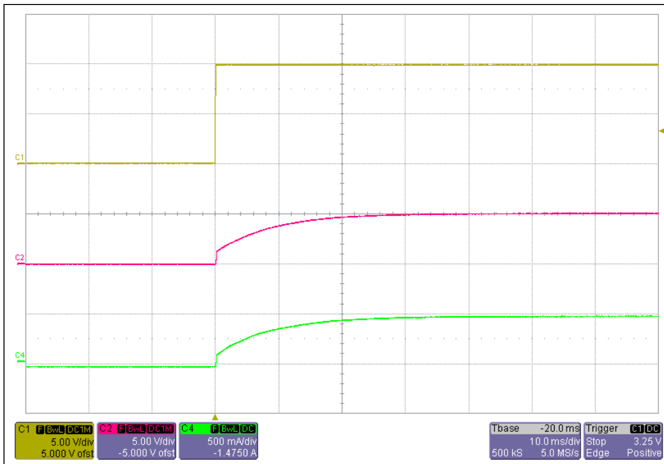


Figure 19. Regulator Start-Up

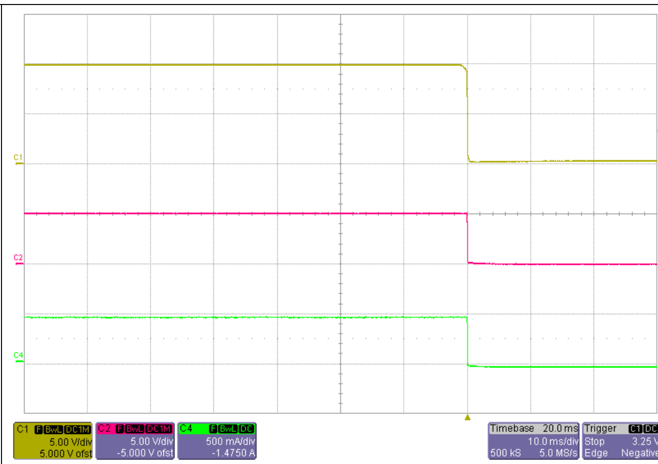


Figure 20. Regulator Shutdown

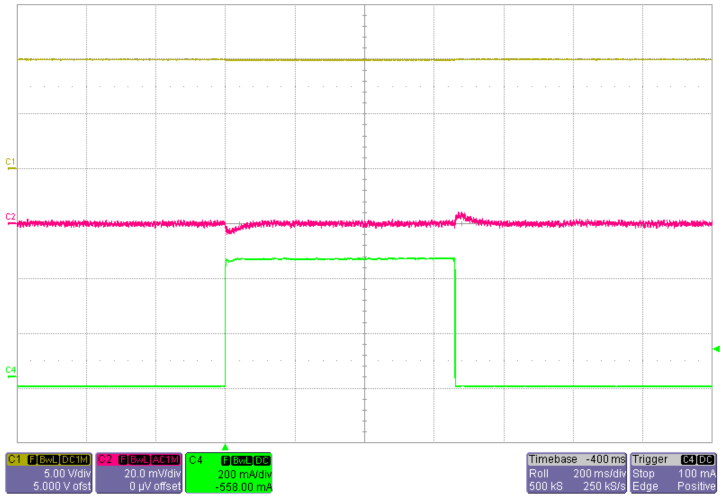


Figure 21. Regulator Response to Load Step

8.3 System Examples

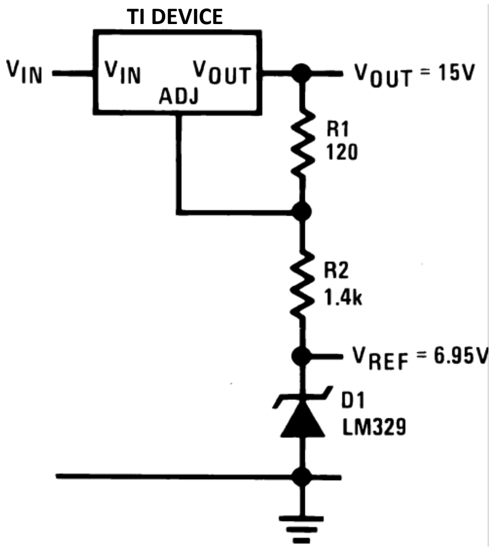


Figure 22. Regulator and Voltage Reference

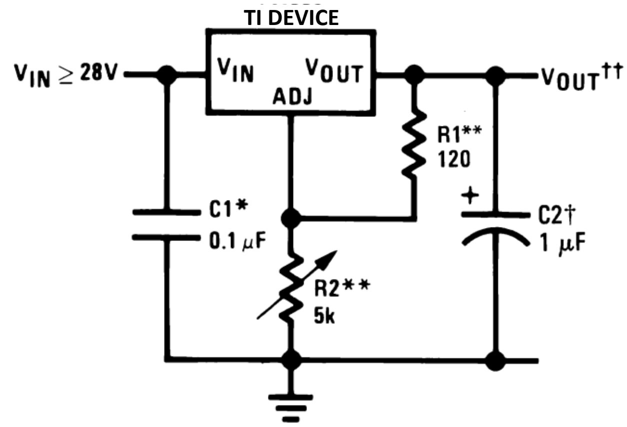
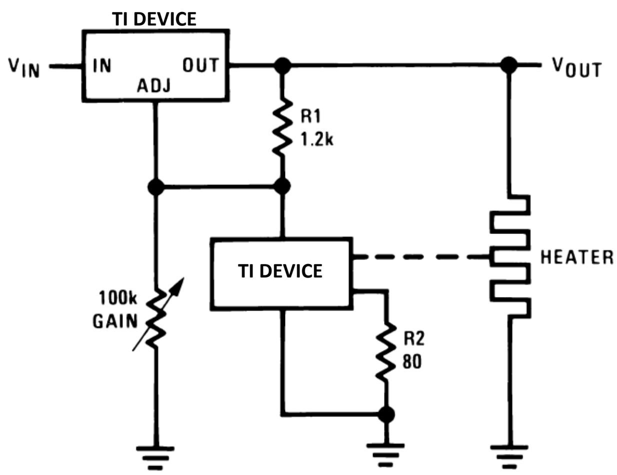


Figure 23. 1.2-V to 25-V Adjustable Regulator



Full output current not available at high input-output voltages

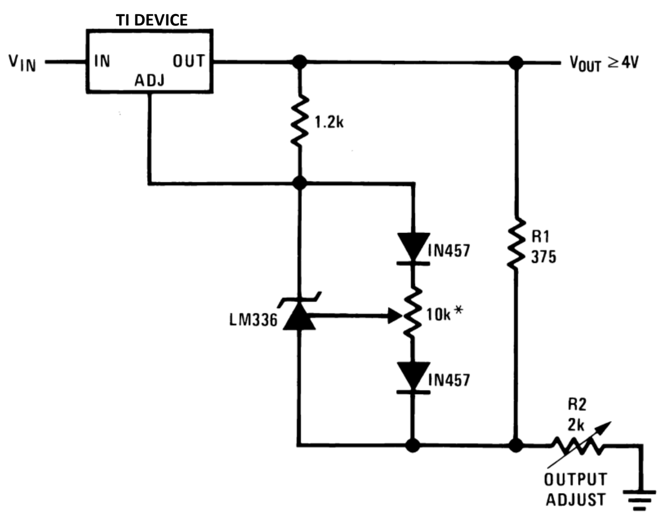
†Optional—improves transient response. Output capacitors in the range of 1 µF to 1000 µF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

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

$$^{\dagger\dagger}V_{OUT} = 1.25V\left(1+\frac{R2}{R1}\right)+I_{ADJ}\,(R_2)$$

R1, R2 as an assembly can be ordered from Bourns:
MIL part no. 7105A-AT2-502
COMM part no. 7105A-AT7-502

Figure 24. Temperature Controller



* Adjust for 3.75 across R1

Figure 25. Precision Power Regulator With Low Temperature Coefficient

System Examples (continued)

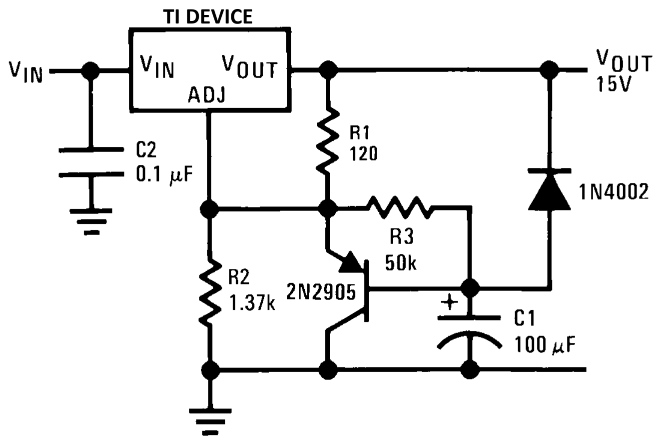
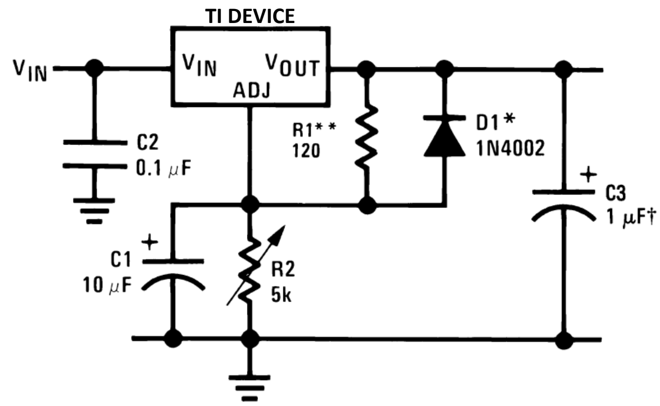


Figure 26. Slow Turnon 15-V Regulator



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

Figure 27. Adjustable Regulator With Improved Ripple Rejection

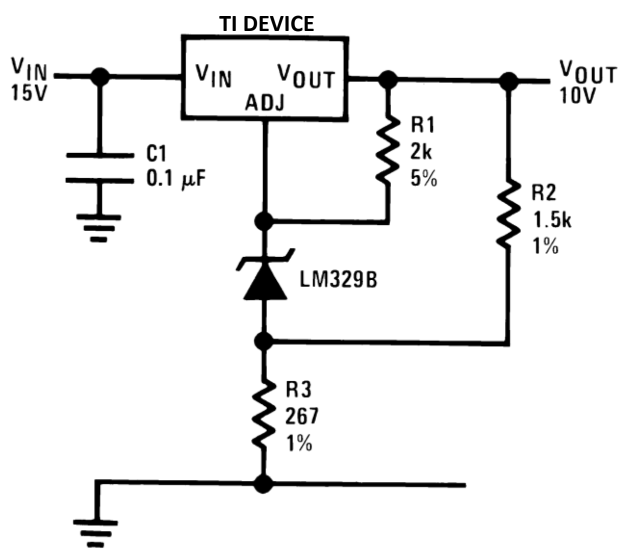
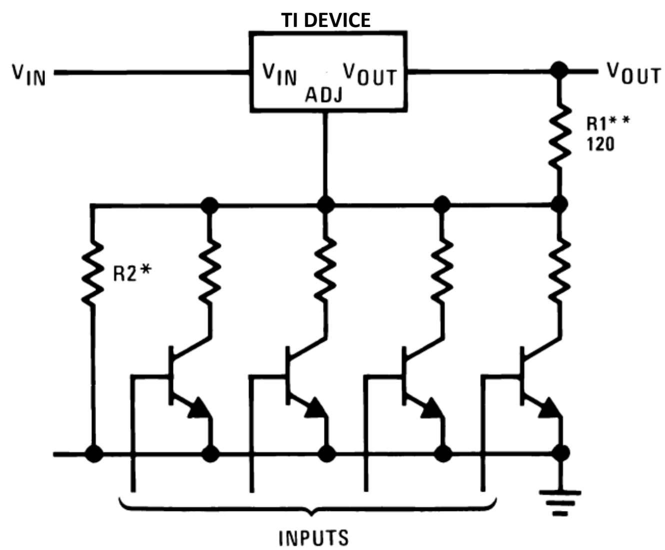


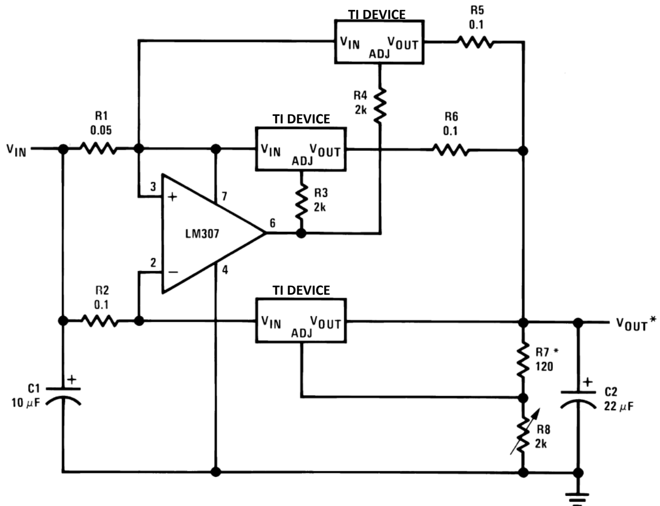
Figure 28. High Stability 10-V Regulator



*Sets maximum V_{OUT}

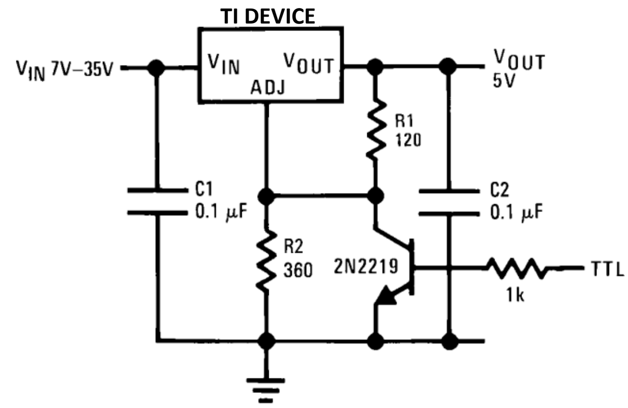
Figure 29. Digitally Selected Outputs

System Examples (continued)



* Minimum load—100 mA

Figure 30. 15-A Regulator



** Minimum output ≈ 1.2 V

Figure 31. 5-V Logic Regulator With Electronic Shutdown**

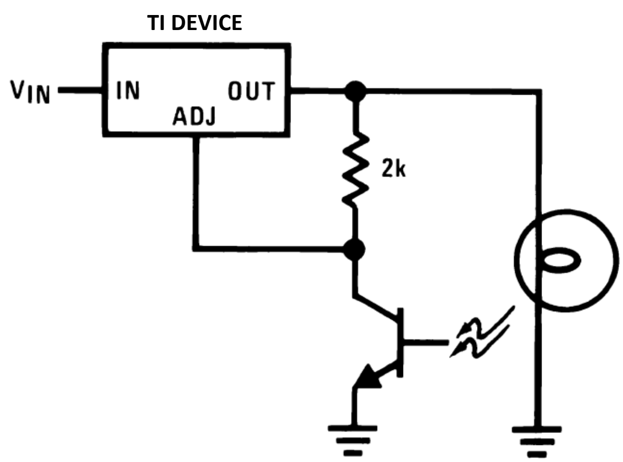
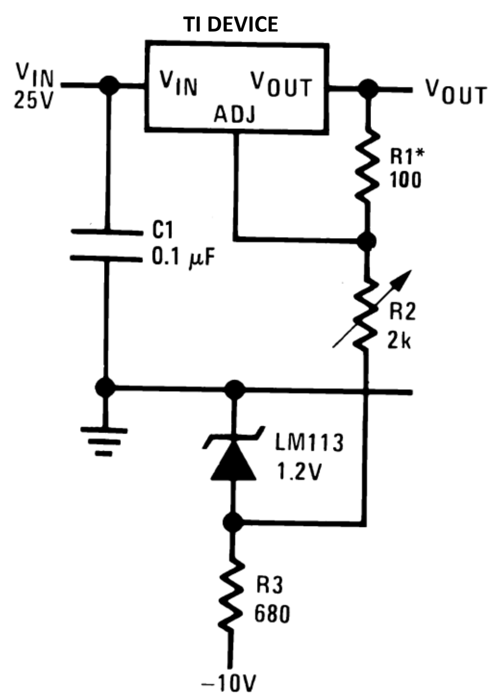


Figure 32. Light Controller



Full output current not available at high input-output voltages

Figure 33. 0 to 22-V Regulator

System Examples (continued)

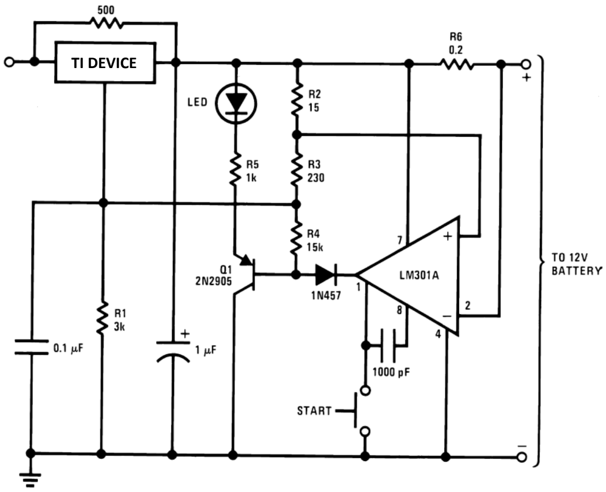


Figure 34. 12-V Battery Charger

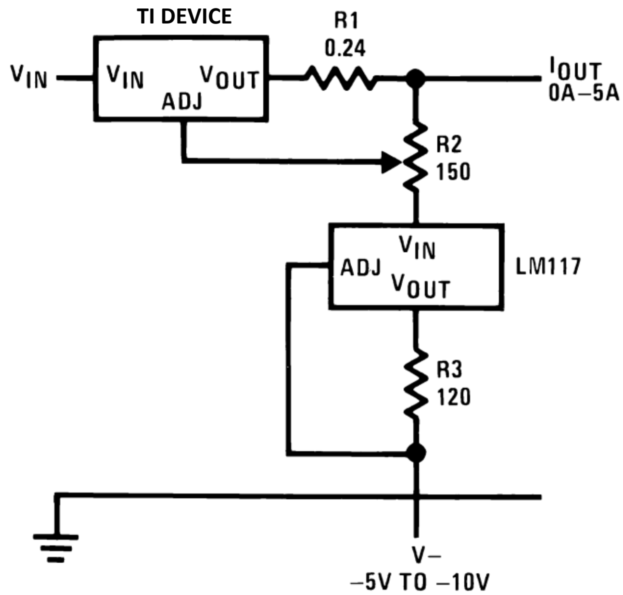


Figure 35. Adjustable Current Regulator

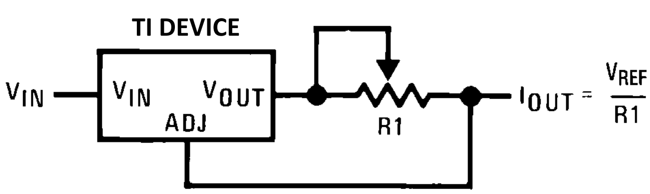


Figure 36. Precision Current Limiter

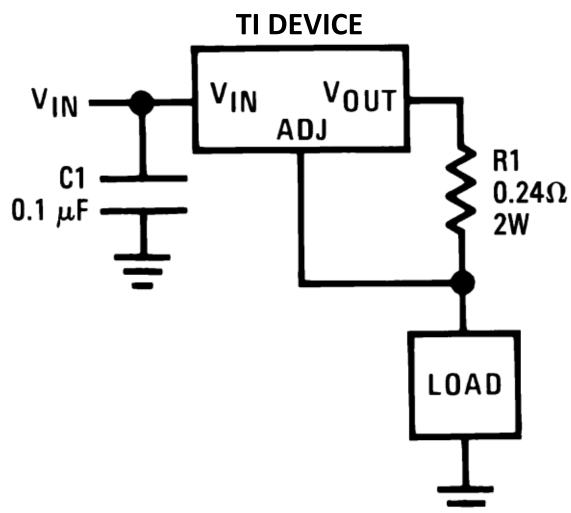


Figure 37. 5-A Current Regulator

System Examples (continued)

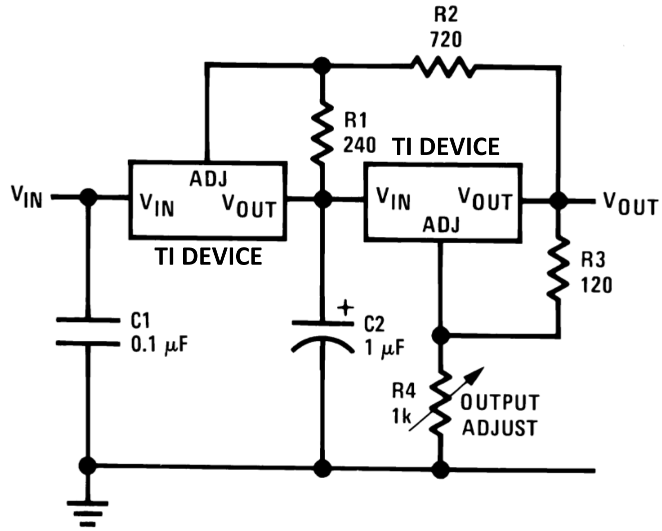
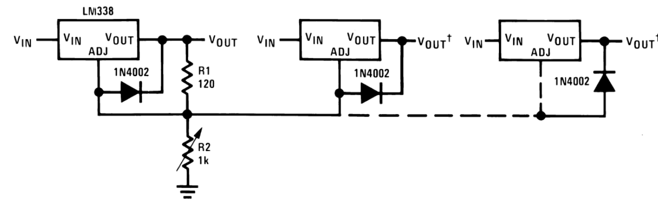
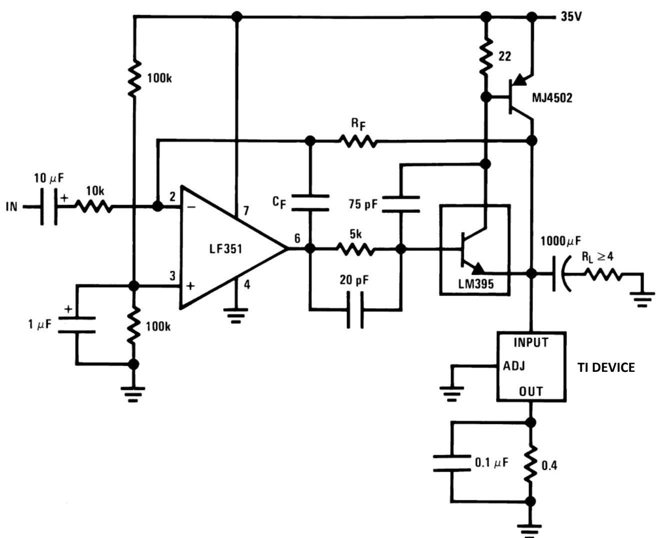


Figure 38. Tracking Preregulator



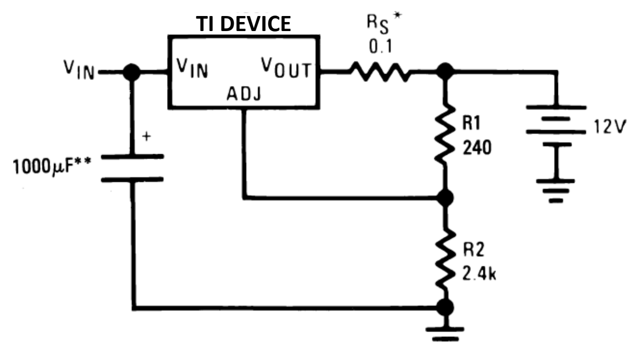
† Minimum load—10 mA
* All outputs within ±100 mV

Figure 39. Adjusting Multiple On-Card Regulators With Single Control*



A_V = 1, R_F = 10k, C_F = 100 pF
A_V = 10, R_F = 100k, C_F = 10 pF
Bandwidth ≥ 100 kHz
Distortion ≤ 0.1%

Figure 40. Power Amplifier



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

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

Figure 41. Simple 12-V Battery Charger

System Examples (continued)

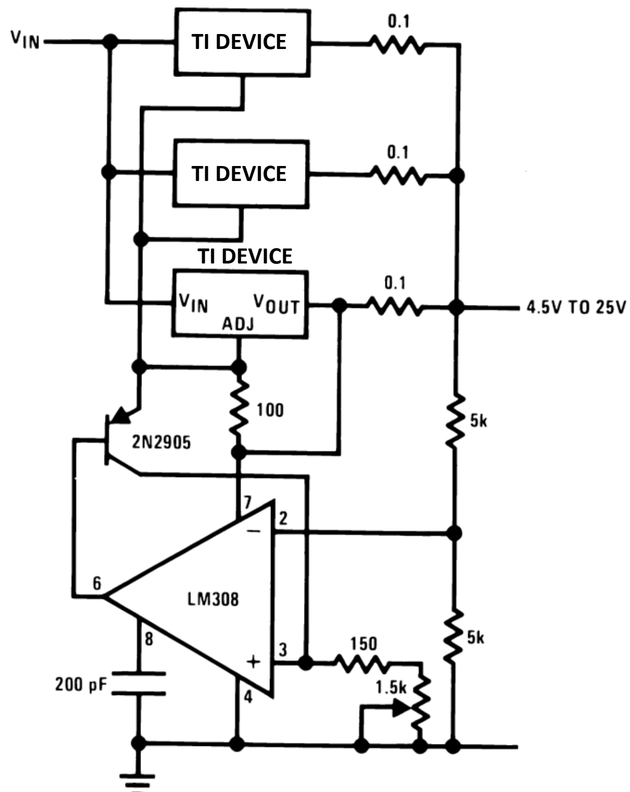
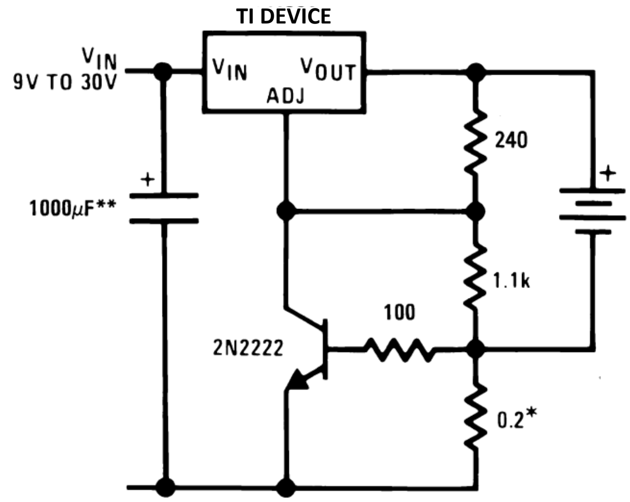
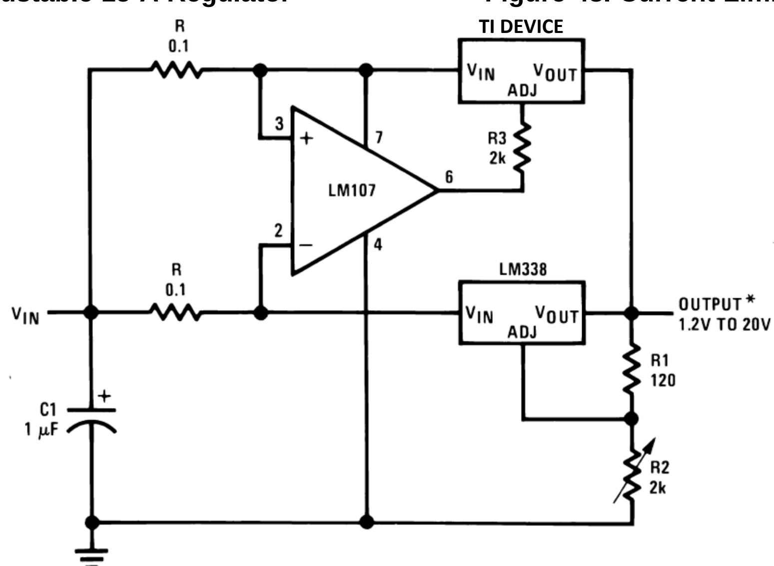


Figure 42. Adjustable 15-A Regulator



* Set max charge current to 3 A
** THE 1000 µF is recommended to filter out input transients.

Figure 43. Current Limited 6-V Charger



* Minimum load—100 mA

Figure 44. 10-A Regulator

9 Power Supply Recommendations

The input supply to LM338 must be kept at a voltage level such that its maximum input to output differential voltage rating is not exceeded. The minimum dropout voltage must also be met with extra headroom when possible to keep the LM338 in regulation. TI recommends a capacitor be placed at the input to bypass noise.

10 Layout

10.1 Layout Guidelines

Some layout guidelines must be followed to ensure proper regulation of the output voltage with minimum noise. Traces carrying the load current must be wide to reduce the amount of parasitic trace inductance and the feedback loop from V_{OUT} to ADJ must be kept as short as possible. To improve PSRR, a bypass capacitor can be placed at the ADJ pin and must be placed as close as possible to the IC. In cases when V_{IN} shorts to ground, an external diode must be placed from V_{OUT} to V_{IN} to divert the surge current from the output capacitor and protect the IC. Similarly, in cases when a large bypass capacitor is placed at the ADJ pin and VOUT shorts to ground, an external diode must be placed from ADJ to V_{OUT} to provide a path for the bypass capacitor to discharge. These diodes must be placed close to the corresponding IC pins to increase their effectiveness.

10.2 Layout Example

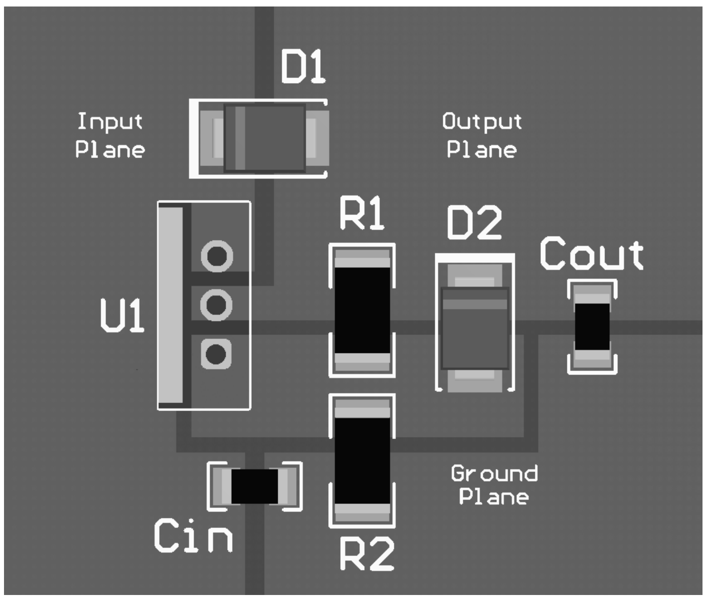


Figure 45. LMx38 Layout

11 デバイスおよびドキュメントのサポート

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11.2 コミュニティ・リソース

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11.5 Glossary

SLYZ022 — *TI Glossary*.
This glossary lists and explains terms, acronyms, and definitions.

12 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM338K STEEL	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	No	Call TI	Call TI	0 to 0	LM338K STEELP+
LM338K STEEL/NOPB	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	Yes	Call TI	Level-1-NA-UNLIM	0 to 0	LM338K STEELP+

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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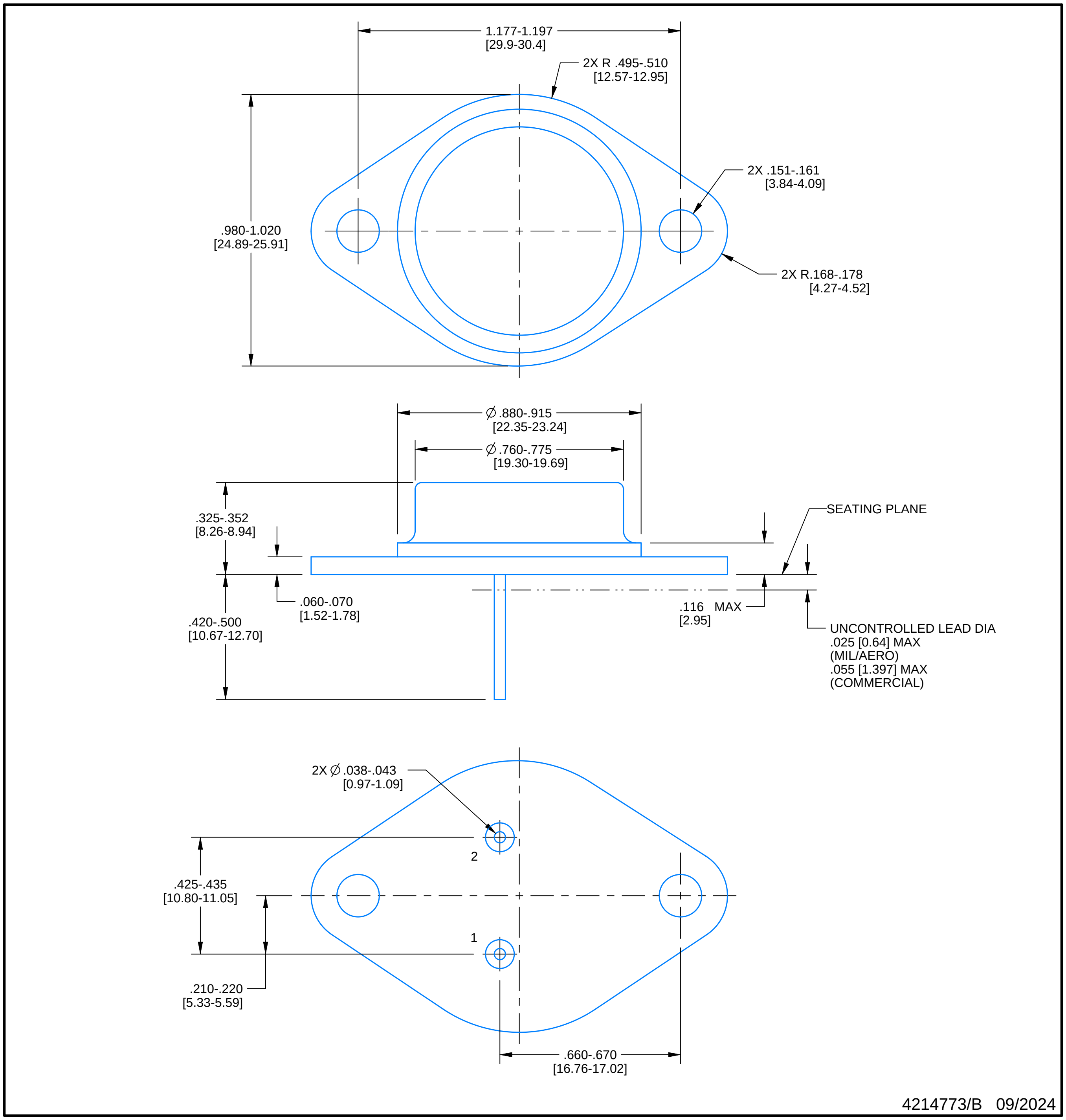

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

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最終更新日：2025 年 10 月