

## LM138QML 軍用グレードの5A可変出力リニア・レギュレータ

### 1 特長

- テキサス・インスツルメンツの軍用グレード・フローで製造およびテスト済み
- 7Aのピーク出力電流を規定
- 5Aの出力電流を規定
- 広い温度範囲: -55°C~150°C
- 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
- バッテリー充電器

### 3 概要

LM138QML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。このデバイスは非常に簡単に使用でき、2つの外付け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。

LM138QMLデバイス独自の機能として、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、LM138QMLデバイス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。過渡応答を改善するため出力コンデンサを追加できます。また、調整ピンをバイパスすると、レギュレータのリプル除去が強化されます。

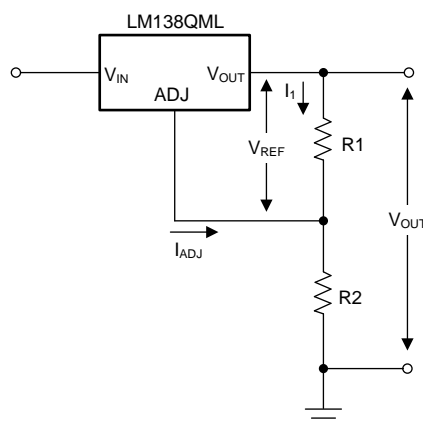
LM138QMLは、固定レギュレータやディスクリート設計の置き換え以外にも、広範な他の用途に有効です。レギュレータは「フローティング」状態で、入力から出力への差動電圧のみを検出するため、入力から出力への差分の最大値を超過せず、出力からグランドへの短絡が発生しない限り、数百ボルトの電圧の電源でもレギュレート可能です。

#### 製品情報<sup>(1)</sup>

型番	グレード	パッケージ
LM138K-MIL	軍用	TO-3 (2)
LM138KG-MD8	軍用	ダイ
LM138KG-MW8	軍用	ウェハー

(1) 提供されているすべてのパッケージについては、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。

#### 代表的なアプリケーション回路



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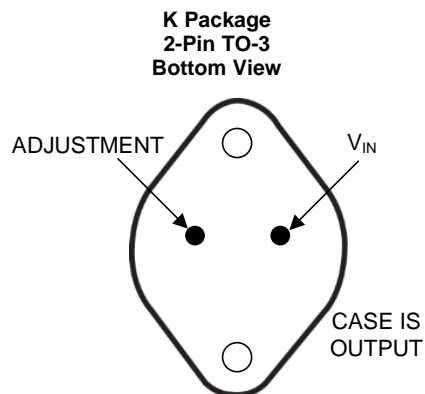
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## 4 改訂履歴

日付	改訂内容	注
2017年10月	*	初版

## 5 Pin Configuration and Functions



Package Number K0002C

### Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
ADJ	1	I	Output voltage adjustment pin. Connect to a resistor divider to set $V_O$ .
$V_{IN}$	2	I	Supply input pin.
$V_{OUT}$	Case	O	Voltage output pin.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

	MIN	MAX	UNIT
Power dissipation	Internally limited		
Input and output voltage differential	-0.3	40	V
Storage temperature, $T_{stg}$	-65	150	°C
Lead temperature (soldering, 10 seconds)		300	°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
Operating temperature, $T_J$	-55	150	°C
Input-to-output voltage differential	3	40	V
Output current		5	A

### 6.3 Thermal Information

THERMAL METRIC <sup>(1)</sup>		LM138QML	UNIT
		K (TO-3)	
		2 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	42.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	3.3	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	2.5	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	37.4	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

### 6.4 Electrical Characteristics

Values apply for  $V_{IN} - V_{OUT} = 5\text{ V}$ ; and  $I_{OUT} = 10\text{ mA}$  (unless otherwise noted)<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	SUB-GROUPS	MIN	TYP <sup>(2)</sup>	MAX	UNIT
$V_{REF}$ Reference voltage	$V_{IN} - V_{OUT} = 3\text{ V}$ <sup>(3)</sup>	[1, 2, 3]	1.19		1.29	V
	$V_{IN} - V_{OUT} = 3\text{ V}$ , $I_{OUT} = 5\text{ A}$	[1, 2, 3]	1.19		1.29	
	$V_{IN} - V_{OUT} = 5\text{ V}$ , $I_{OUT} = 7\text{ A}$	[1, 2, 3]	1.19		1.29	
	$V_{IN} - V_{OUT} = 35\text{ V}$	[1, 2, 3]	1.19		1.29	
	$V_{IN} - V_{OUT} = 35\text{ V}$ , $I_{OUT} = 150\text{ mA}$	[1, 2, 3]	1.19		1.29	
$V_{RLINE}$ Line regulation <sup>(4)</sup>	$3\text{ V} \leq (V_{IN} - V_{OUT}) \leq 35\text{ V}$	[1]	-3.5		3.5	mV
	$3.3\text{ V} \leq (V_{IN} - V_{OUT}) \leq 35\text{ V}$	[2, 3]	-14		14	
$V_{RLOAD}$ Load regulation <sup>(4)</sup>	$V_{IN} - V_{OUT} = 3\text{ V}$ , $10\text{ mA} \leq I_{OUT} \leq 5\text{ A}$ , $V_{OUT} = V_{REF}$	[1]	-3.8		3.8	mV
	$V_{IN} - V_{OUT} = 3.3\text{ V}$ , $10\text{ mA} \leq I_{OUT} \leq 5\text{ A}$ , $V_{OUT} = V_{REF}$	[2, 3]	-8		8	
	$V_{IN} - V_{OUT} = 35\text{ V}$ , $10\text{ mA} \leq I_{OUT} \leq 150\text{ mA}$ , $V_{OUT} = V_{REF}$	[1] [2, 3]	-3.8 -8		3.8 8	
$V_{RTH}$ Thermal regulation	$V_{IN} - V_{OUT} = 10\text{ V}$ , pulse = 20 ms, $I_{OUT} = 1\text{ A}$ <sup>(5)</sup>	[1]		0.002	0.01	%/W
$I_{ADJ}$ Adjustment pin current	$V_{IN} - V_{OUT} = 3\text{ V}$ <sup>(3)</sup>	[1, 2, 3]	2	45	100	$\mu\text{A}$
	$V_{IN} - V_{OUT} = 35\text{ V}$	[1, 2, 3]	2		100	
$\Delta I_{ADJ}$ Adjustment pin current change	$3\text{ V} \leq (V_{IN} - V_{OUT}) \leq 35\text{ V}$ <sup>(3)</sup>	[1, 2, 3]	-5	0.2	5	$\mu\text{A}$
	$10\text{ mA} \leq I_{OUT} \leq 5\text{ A}$	[1, 2, 3]	-5		5	
$I_{LOAD(MIN)}$ Minimum load current	$V_{IN} - V_{OUT} = 3\text{ V}$ , $V_{OUT} = 1.4\text{ V}$ <sup>(3)</sup>	[1, 2, 3]	0.5		5	mA
	$V_{IN} - V_{OUT} = 35\text{ V}$ , $V_{OUT} = 1.4\text{ V}$	[1, 2, 3]	0.5	3.5	5	
$I_{CL}$ Current limit	$V_{IN} - V_{OUT} = 10\text{ V}$ , $T = 0.5\text{ ms}$ , $V_{OUT} = 0\text{ V}$	[1, 2, 3]	7		16	A
	$T = 5\text{ ms}$ , $V_{OUT} = 0\text{ V}$	[1, 2, 3]	5		15	
$\Delta V_R/\Delta V_{IN}$ Ripple rejection ratio	$V_{OUT} = V_{REF}$ , $e_{IN} = 1\text{ V}_{RMS}$ , $f = 120\text{ Hz}$ , $I_{OUT} = 500\text{ mA}$ <sup>(6)</sup>	[4]	60			dB

- (1) These specifications are applicable for power dissipations up to 50W. Power dissipation is specified at these values up to 15-V input-output differential. Above 15-V differential, power dissipation will be 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) Typical figures are at  $T_A = 25^\circ\text{C}$ , and represent most likely parametric norms. Test limits are ensured to Texas Instruments' average outgoing quality level (AOQL).
- (3)  $V_{IN} - V_{OUT} = 3.3\text{ V}$  at  $-55^\circ\text{C}$  and  $125^\circ\text{C}$ .
- (4) 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.
- (5) Datalog reading in mV, 0.01% = 1.19 mV.
- (6) Family board not required for this device.

## 6.5 Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

SUBGROUP	DESCRIPTION	TEMPERATURE (°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	Setting time at	25
13	Setting time at	125
14	Setting time at	-55

### 6.6 Typical Performance Characteristics

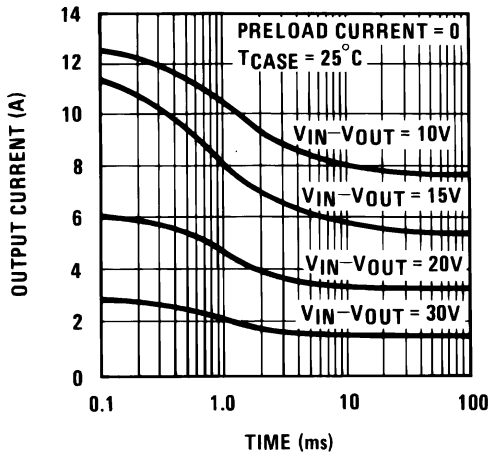


图 1. Current Limit

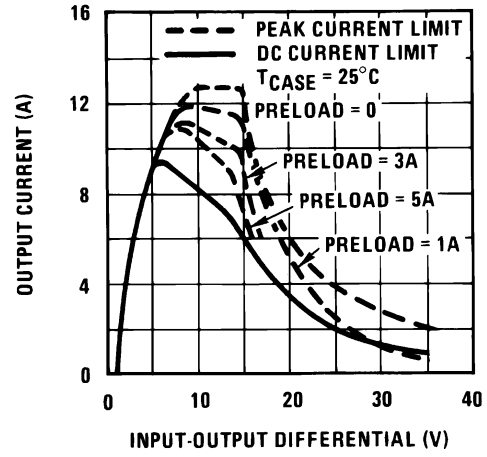


图 2. Current Limit

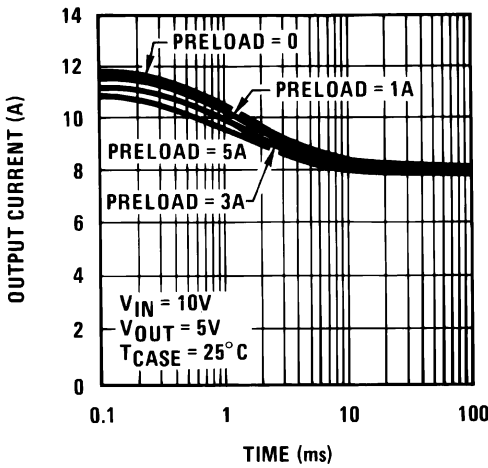


图 3. Current Limit

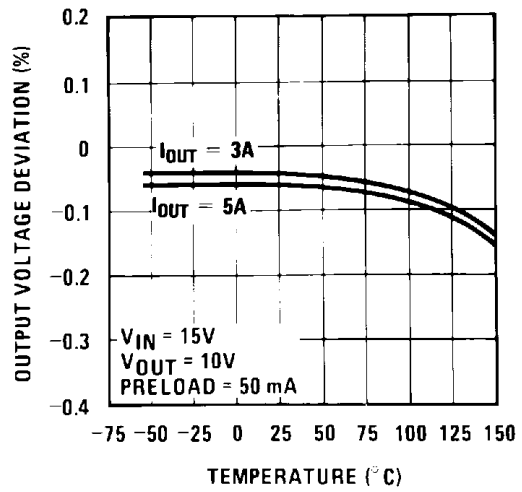


图 4. Load Regulation

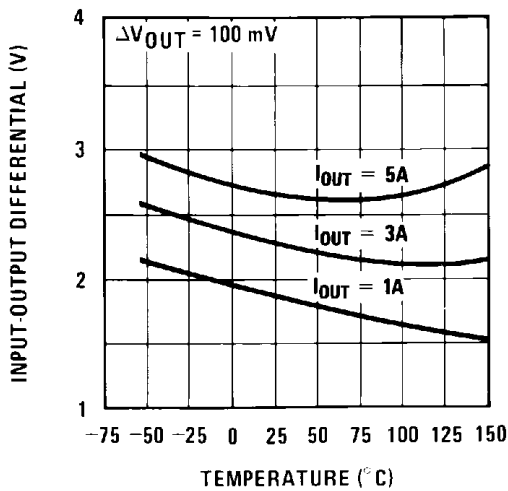


图 5. Dropout Voltage

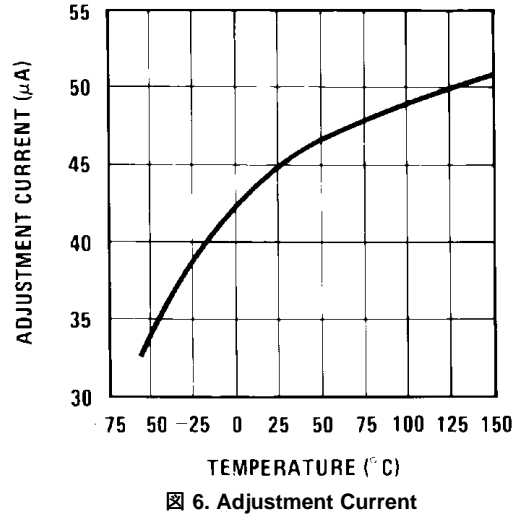
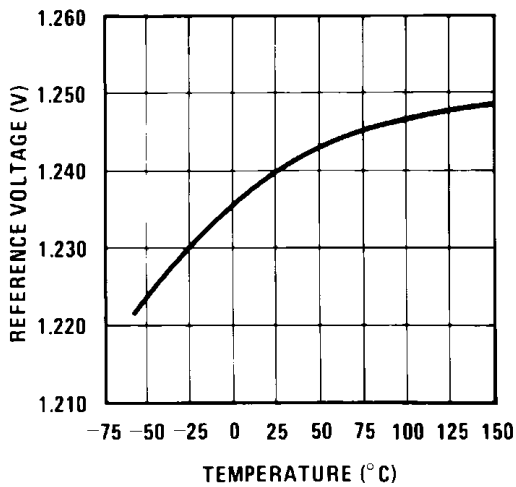
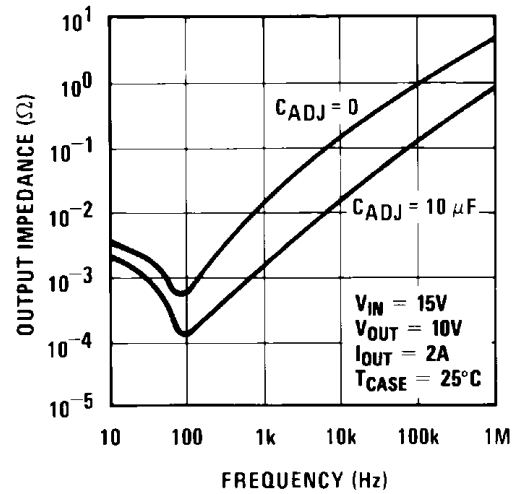


图 6. Adjustment Current

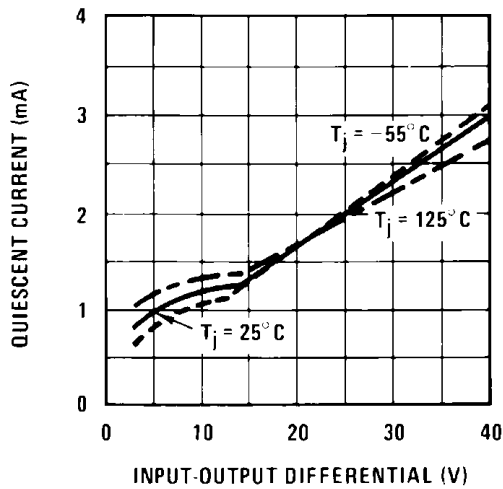
**Typical Performance Characteristics (continued)**



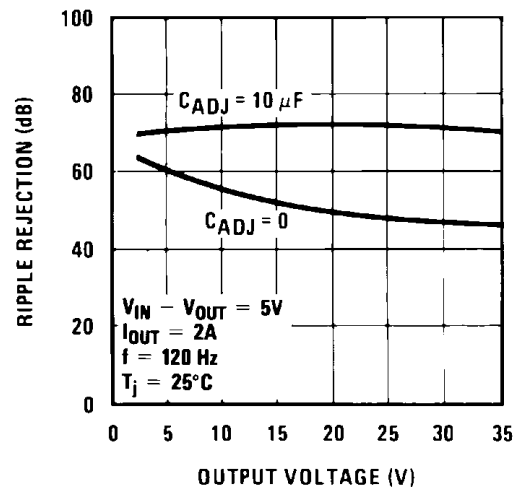
7. Temperature Stability



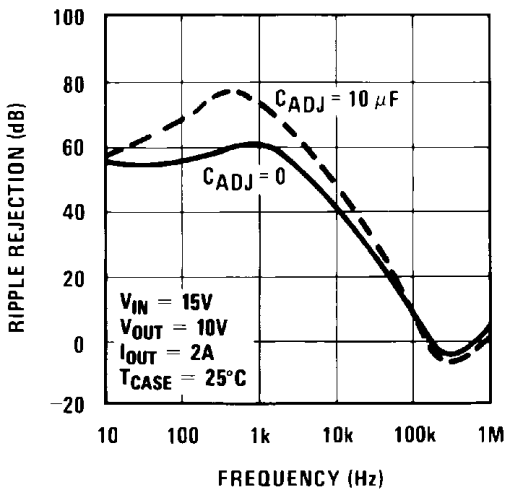
8. Output Impedance



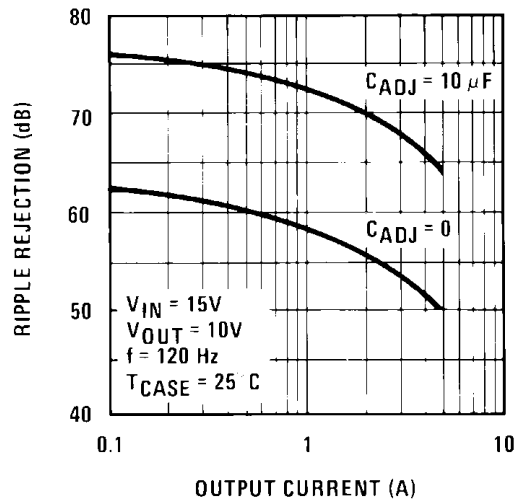
9. Minimum Operating Current



10. Ripple Rejection



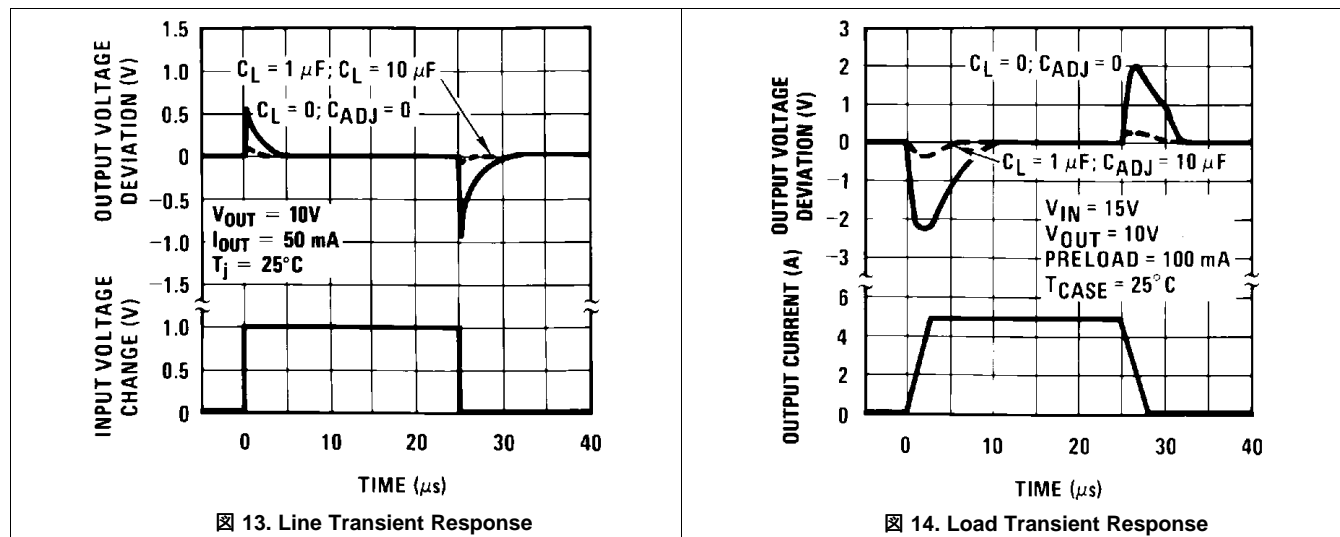
11. Ripple Rejection



12. Ripple Rejection



Typical Performance Characteristics (continued)



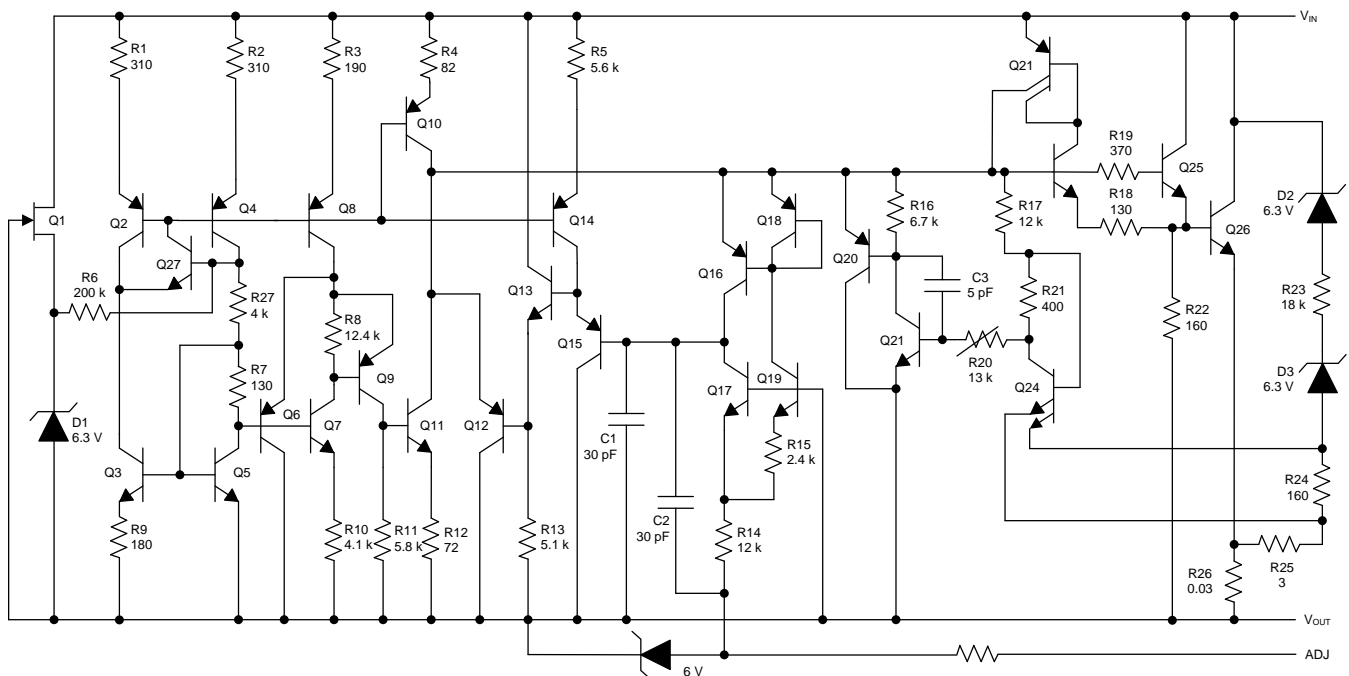
## 7 Detailed Description

### 7.1 Overview

The LM138QML 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 LM138QML device features 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 LM138QML devices are versatile in their 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 LM138QML device can function as a precision current regulator. 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



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### 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

An op amp with 1.25-V offset input at the ADJUST terminal provides easy output voltage or current, but not both, programming. For current regulation applications, a single resistor whose resistance value is  $1.25 V/I_O$  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 the OUTPUT pin 1.25-V greater than the 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 the OUTPUT voltage is then the INPUT voltage minus the 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- $\Omega$  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 the 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

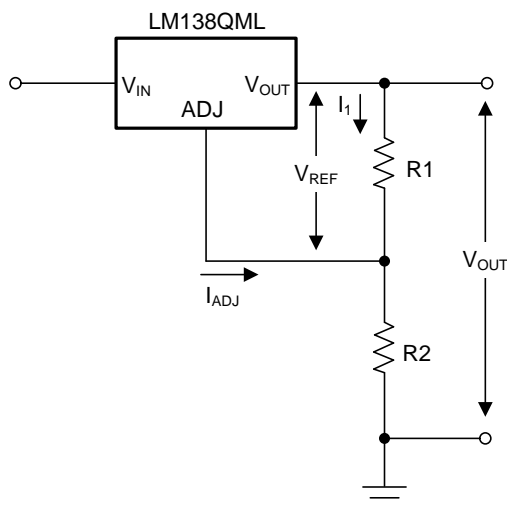
### 注

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 LM138QML device 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 of:

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

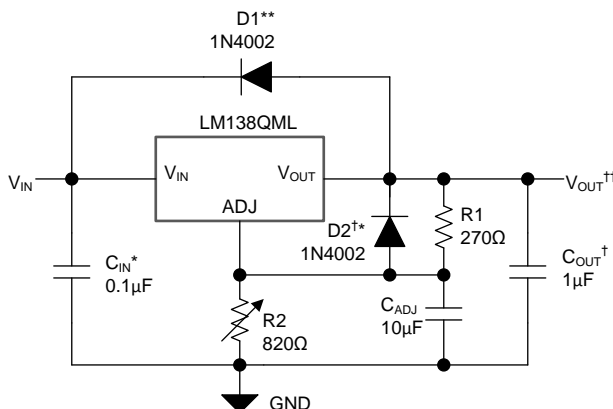


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Because the 50- $\mu$ A current from the adjustment terminal represents an error term, the LM138QML was designed to minimize  $I_{ADJ}$  and make it very constant with line and load changes. To do this, all quiescent operating current is returned to 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

\*\*Recommended if C<sub>OUT</sub> is used

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

††Recommended if C<sub>ADJ</sub> is used

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#### 15. Constant 5-V Regulator

#### 8.2.1.1 Design Requirements

表 1. Design Parameters

PARAMETER	PART NUMBER/VALUE	DESCRIPTION
Feedback resistor 1 (R1)	270 Ω	The LM138QML produces a typical 1.24-V potential between the OUTPUT and ADJUST pins; therefore, placing a 270-Ω resistor between the OUTPUT and ADJUST pins causes 4.6 mA to flow through R1 and R2
Feedback resistor 2 (R2)	820 Ω	To achieve a 5-V output, the sum of the voltages across R1 and R2 must equal 5 V. Therefore, V <sub>R2</sub> must equal 3.76 V when 4.6 mA is flowing through it. R2 = V <sub>R2</sub> / I = 3.76 V / 4.6 mA = ~820 Ω.
Input capacitor (C <sub>IN</sub> )	0.1 μF	0.1 μF of input capacitance helps filter out unwanted noise, especially if the regulator is located far from the power supply filter capacitors.
Output capacitor (C <sub>OUT</sub> )	1 μF	The regulator is stable without any output capacitance, but adding a 1-μF capacitor improves the transient response.
Adjust capacitor (C <sub>ADJ</sub> )	10 μF	A 10-μF capacitor bypassing the ADJUST pin to ground improves the regulators ripple rejection.
Protection diode 1 (D1)	1N4002	Protection diode D1 is recommended if C <sub>OUT</sub> is used. The diode provides a low-impedance discharge path to prevent the capacitor from discharging into the output of the regulator (see <a href="#">Protection Diodes</a> ).
Protection diode 2 (D2)	1N4002	Protection diode D2 is recommended if C <sub>ADJ</sub> is used. The diode provides a low-impedance discharge path to prevent the capacitor from discharging into the output of the regulator (see <a href="#">Protection Diodes</a> ).

### 8.2.1.2 Detailed Design Procedure

#### 8.2.1.2.1 External Capacitors

An input bypass capacitor is recommended. A 0.1- $\mu\text{F}$  disc or 1- $\mu\text{F}$  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 LM138QML to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10- $\mu\text{F}$  bypass capacitor, 75-dB ripple rejection is obtainable at any output level. Increases over 20  $\mu\text{F}$  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.

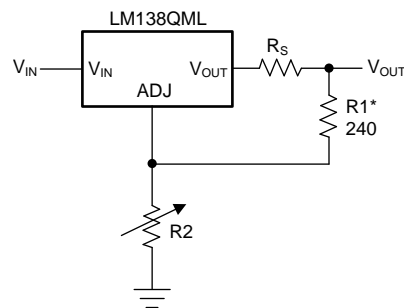
In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25  $\mu\text{F}$  in aluminum electrolytic to equal 1- $\mu\text{F}$  solid tantalum at high frequencies. Ceramic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

Although the LM138QML 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- $\mu\text{F}$  solid tantalum (or 25- $\mu\text{F}$  aluminum electrolytic) on the output swamps this effect and insures stability.

#### 8.2.1.2.2 Load Regulation

The LM138QML device 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  $\Omega$ ) 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 15-V regulator with 0.05- $\Omega$  resistance between the regulator and load will have a load regulation due to line resistance of  $0.05 \Omega \times I_L$ . If the set resistor is connected near the load the effective line resistance will be  $0.05 \Omega (1 + R_2/R_1)$  or in this case, 11.5 times worse.

Figure 16 shows the effect of resistance between the regulator and 240- $\Omega$  set resistor.



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Figure 16. Regulator With Line Resistance in Output Lead

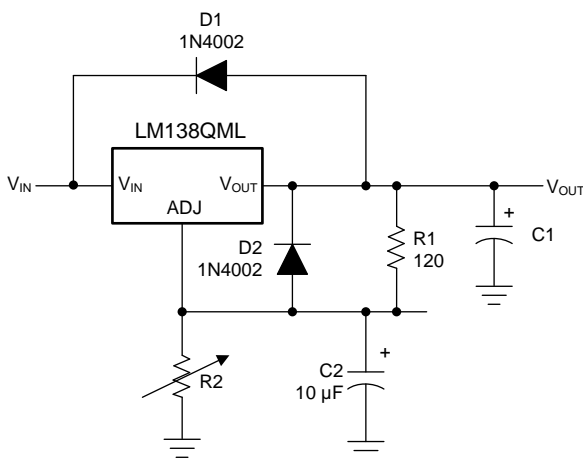
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor by using two separate leads to the case. The ground of R<sub>2</sub> can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

#### 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- $\mu\text{F}$  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 LM138QML, 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  $\mu\text{F}$  or less at an 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 LM138QML is a 50- $\Omega$  resistor which limits the peak discharge current. No protection is needed for output voltages of 25-V or less and 10- $\mu\text{F}$  capacitance. [17](#) shows an LM138QML with protection diodes included for use with outputs greater than 25 V and high values of output capacitance.



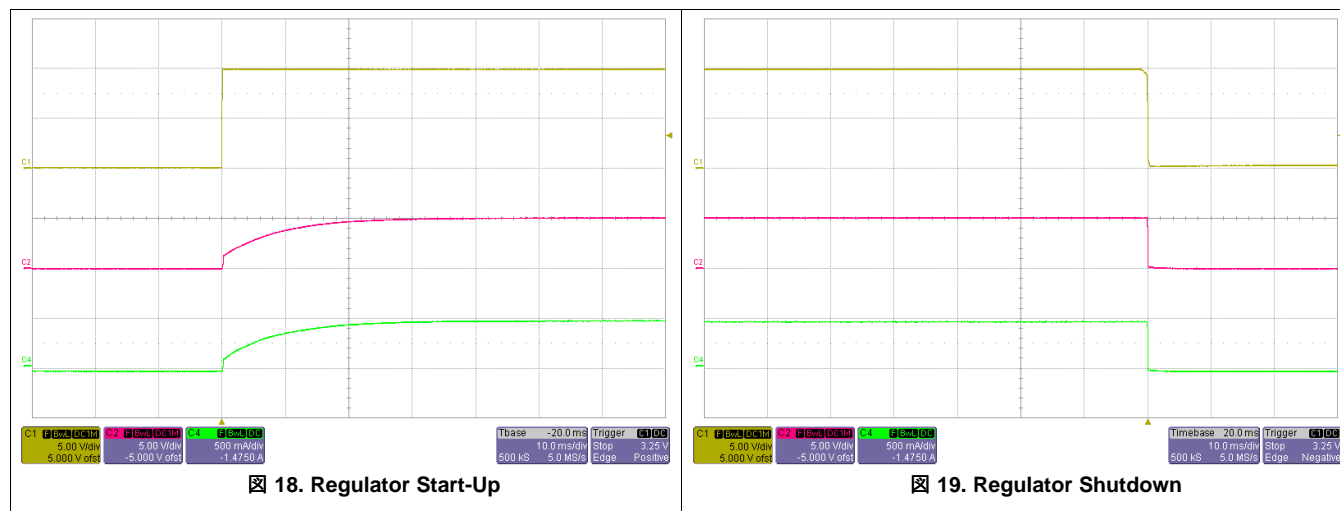
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D1 protects against C1  
D2 protects against C2

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

**17. Regulator With Protection Diodes**

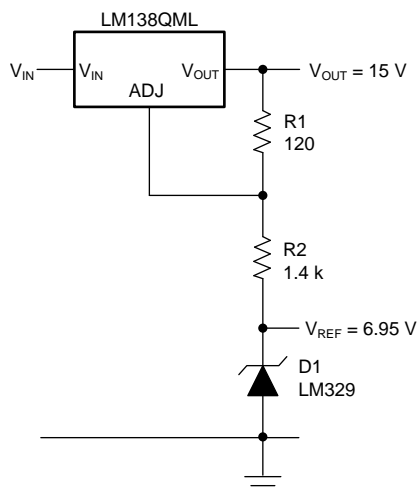
**8.2.1.3 Application Curves**





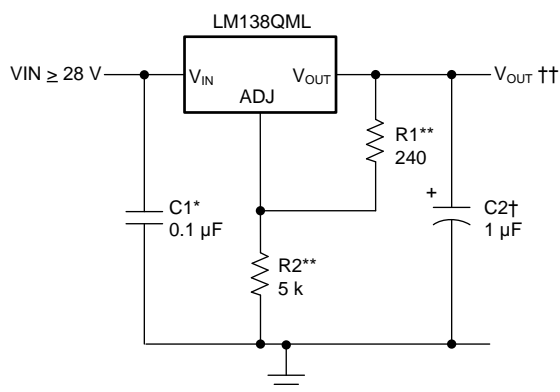


### 8.3 System Examples



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☒ 21. Regulator and Voltage Reference



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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.

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

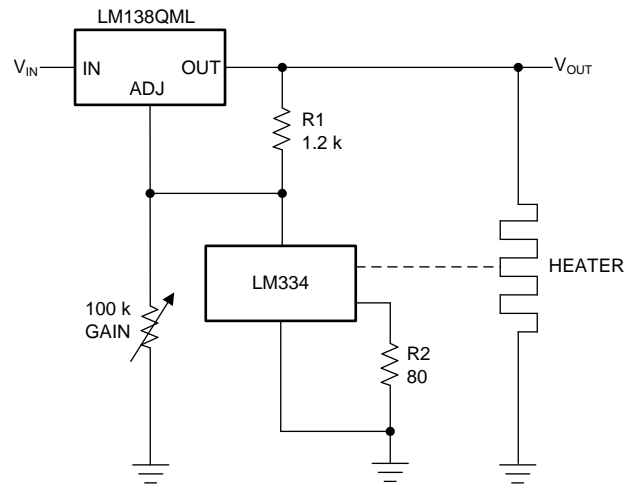
\*\* R1, R2 as an assembly can be ordered from Bourns:

MIL part no. 7105A-AT2-502

COMM part no. 7105A-AT7-502

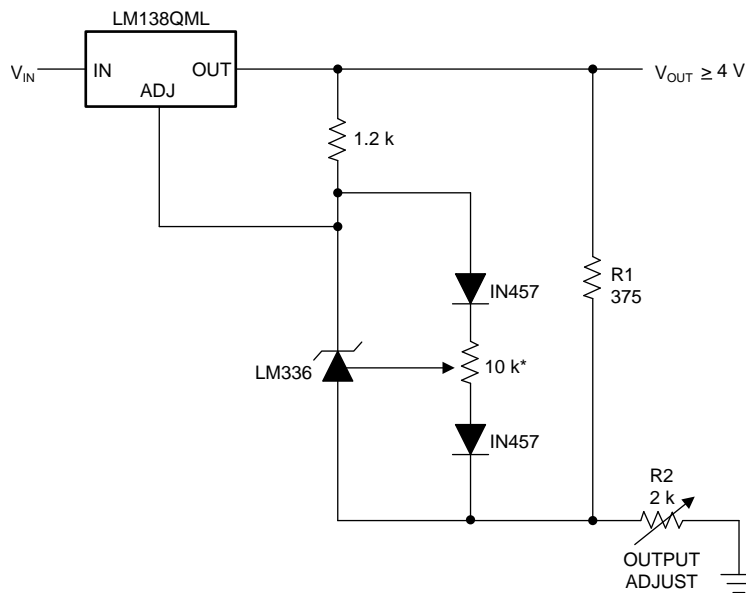
☒ 22. 1.2-V to 25-V Adjustable Regulator

System Examples (continued)



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23. Temperature Controller

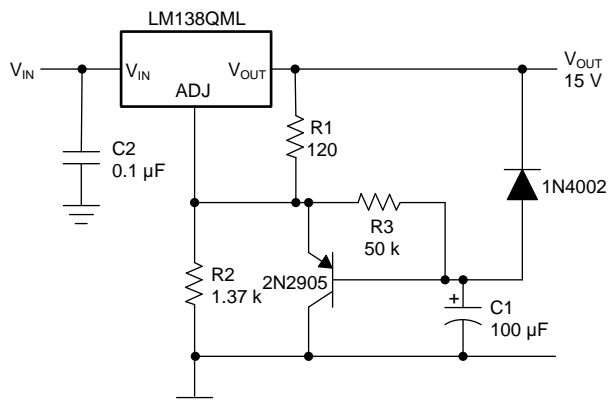


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\* Adjust for 3.75 V across R1

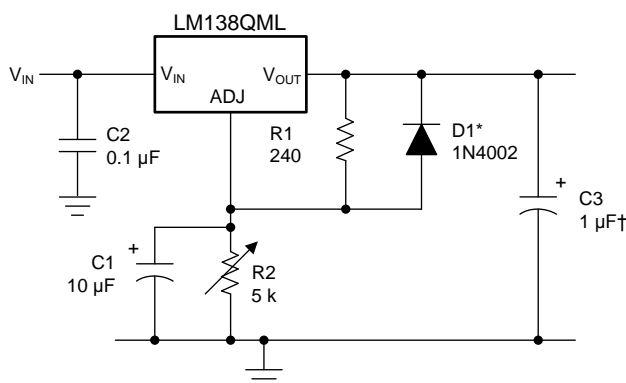
24. Precision Power Regulator With Low Temperature Coefficient

System Examples (continued)



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Figure 25. Slow Turnon 15-V Regulator

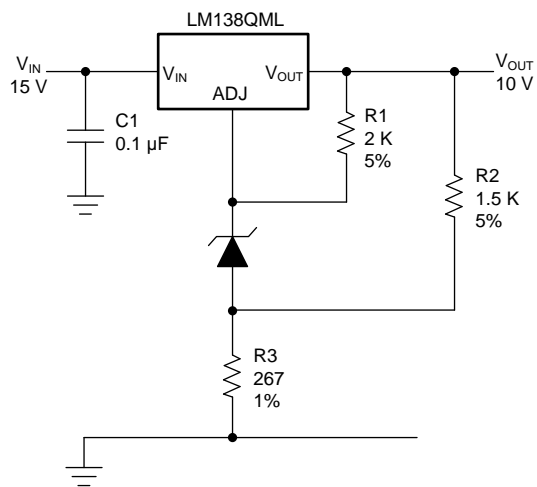


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† Solid tantalum

\* Discharges C1 if output is shorted to ground

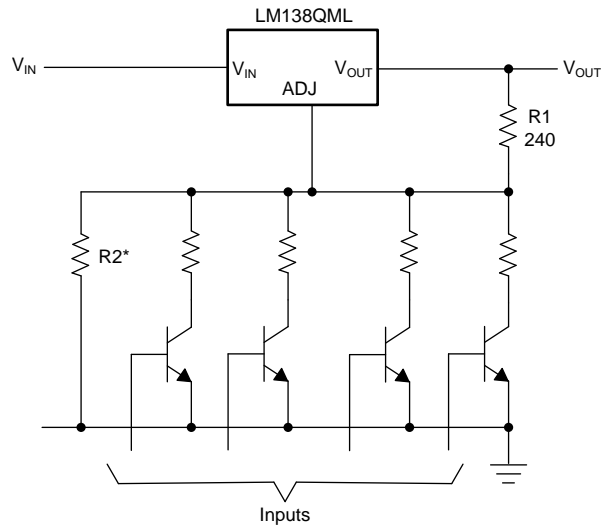
Figure 26. Adjustable Regulator With Improved Ripple Rejection



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Figure 27. High Stability 10-V Regulator

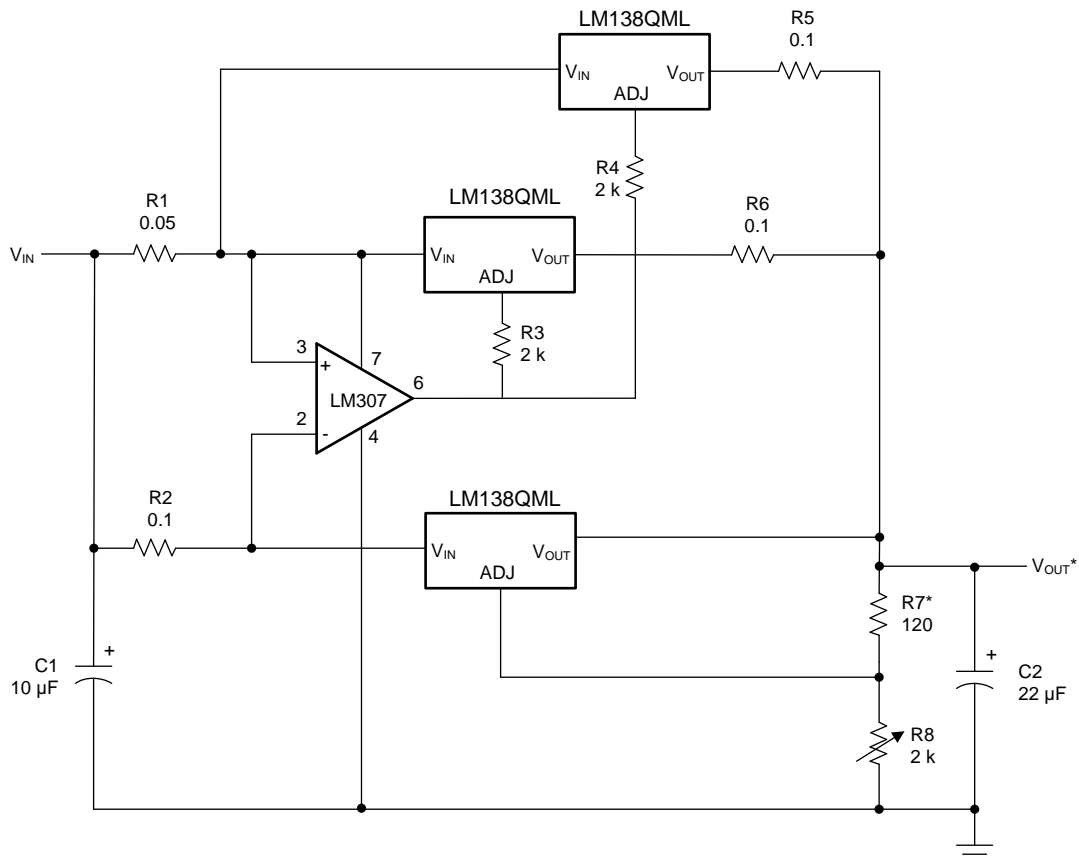
System Examples (continued)



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\* Sets maximum  $V_{OUT}$

28. Digitally Selected Outputs

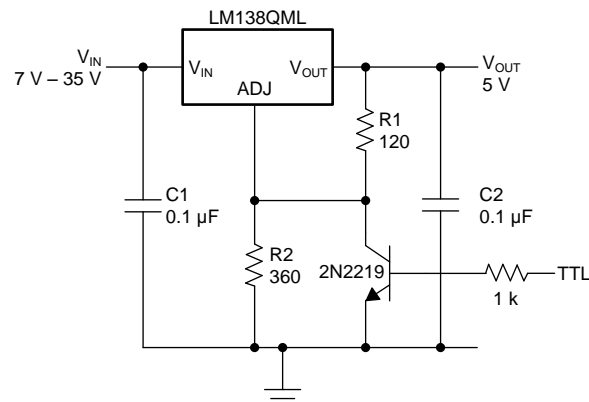


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\* Minimum load—100 mA

29. 15-A Regulator

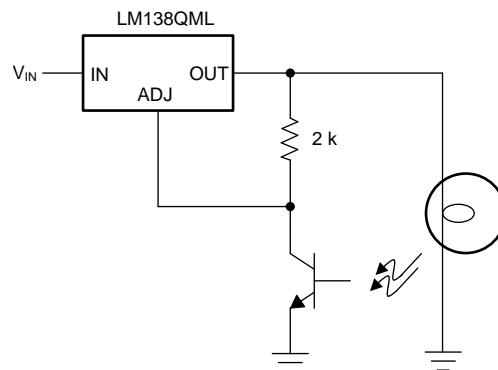
System Examples (continued)



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\*\* Minimum output  $\approx$  1.2 V

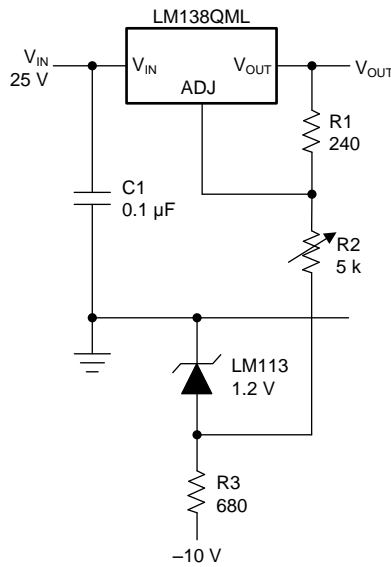
☒ 30. 5-V Logic Regulator With Electronic Shutdown\*\*



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☒ 31. Light Controller

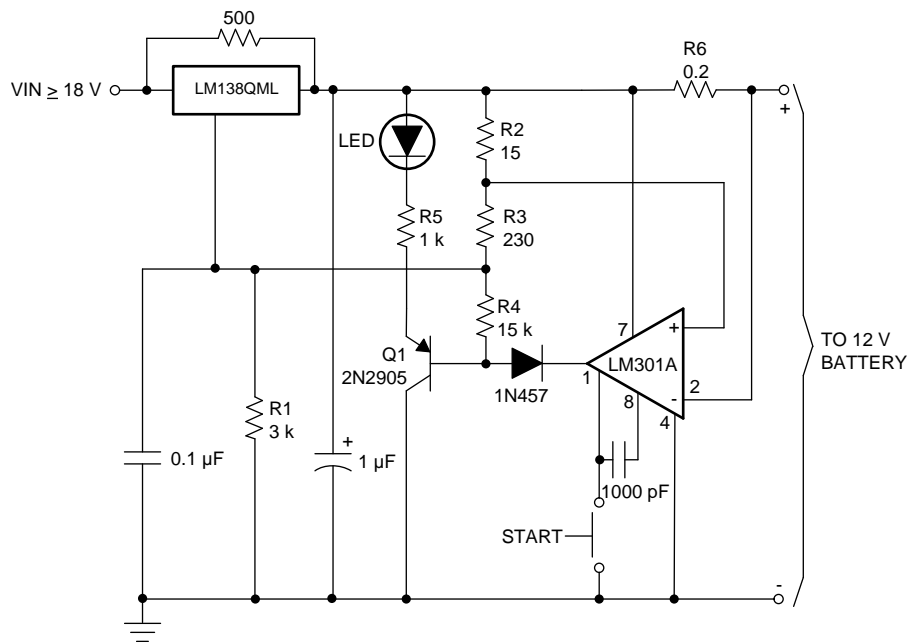
**System Examples (continued)**



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Full output current not available at high input-output voltages

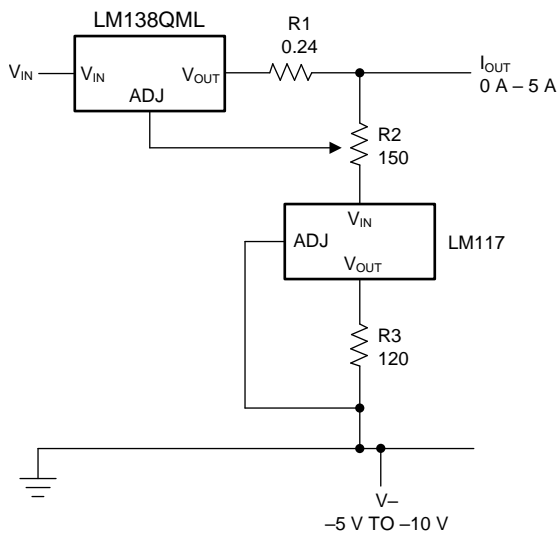
**32. 0-V to 22-V Regulator**



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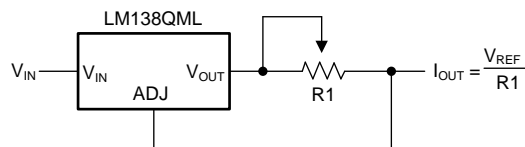
**33. 12-V Battery Charger**

System Examples (continued)



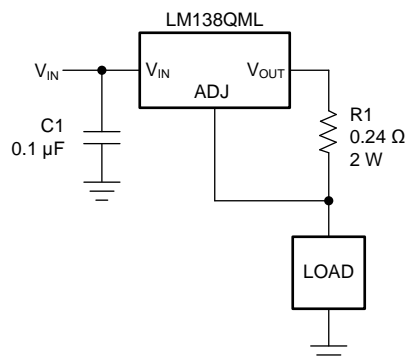
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34. Adjustable Current Regulator



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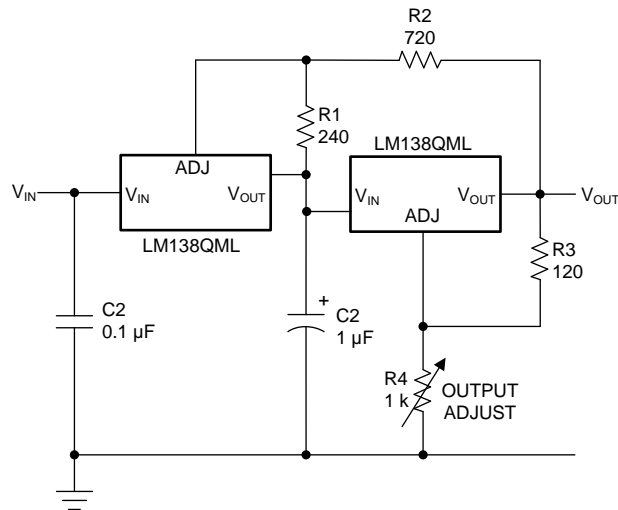
35. Precision Current Limiter



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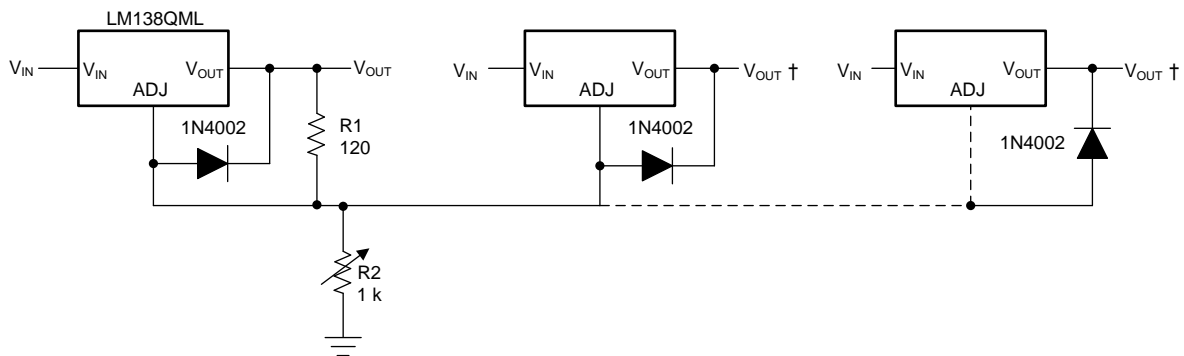
36. 5-A Current Regulator

**System Examples (continued)**



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**37. Tracking Preregulator**



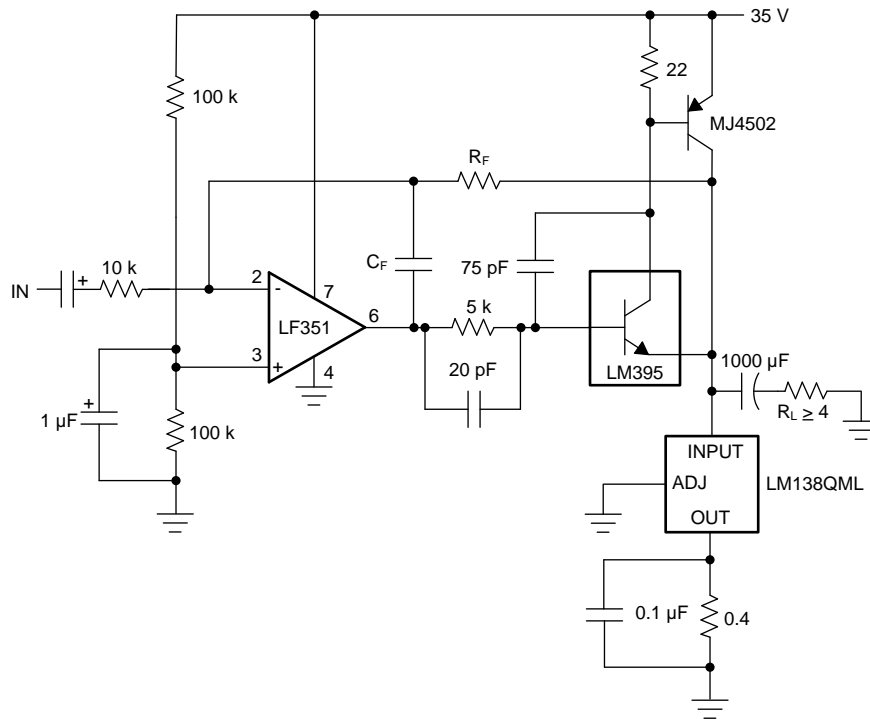
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† Minimum load—10 mA  
 \* All outputs within ±100 mV

**38. Adjusting Multiple On-Card Regulators With Single Control\***



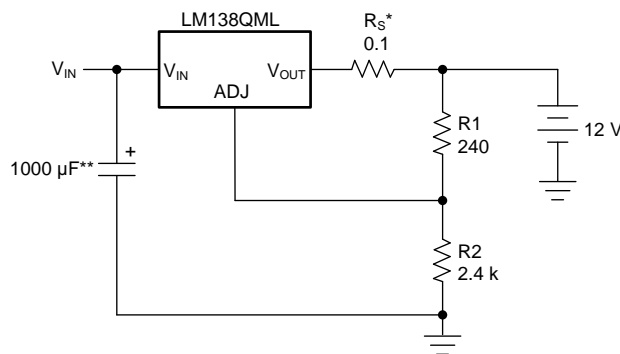
System Examples (continued)



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

39. Power Amplifier

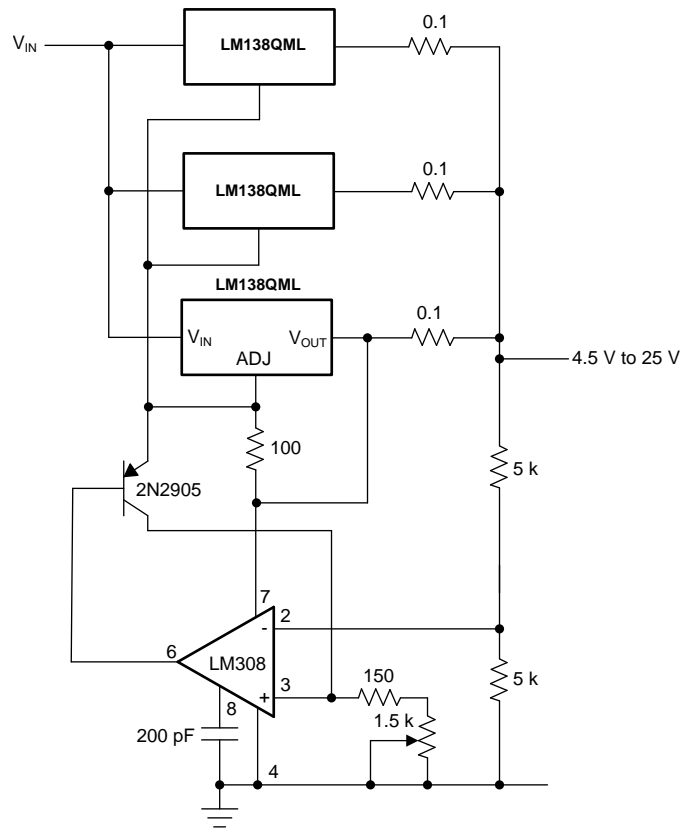


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$Z_{OUT} = R_S \left( 1 + \frac{R_2}{R_1} \right)$   
 \*  $R_S$  sets output impedance of charger  
 Use of  $R_S$  allows low charging rates with fully charged battery.  
 \*\* The 1000  $\mu$ F is recommended to filter out input transients

40. Simple 12-V Battery Charger

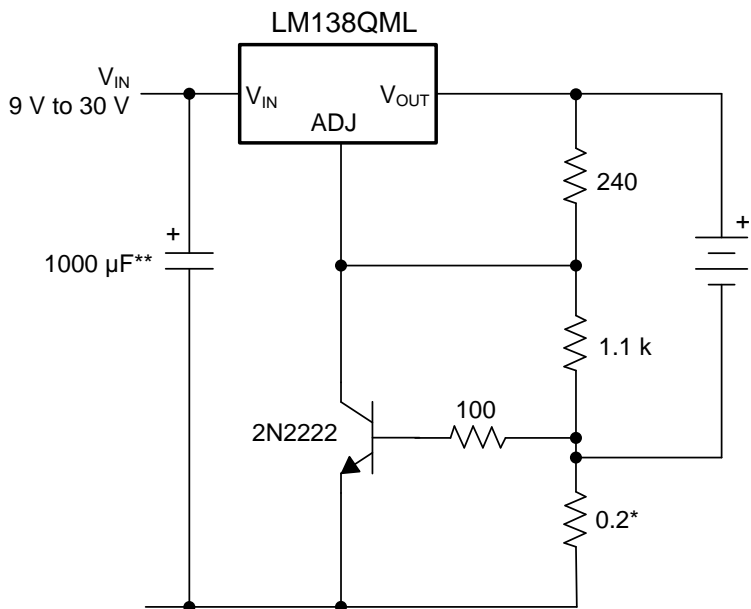
**System Examples (continued)**



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**图 41. Adjustable 15-A Regulator**

**System Examples (continued)**



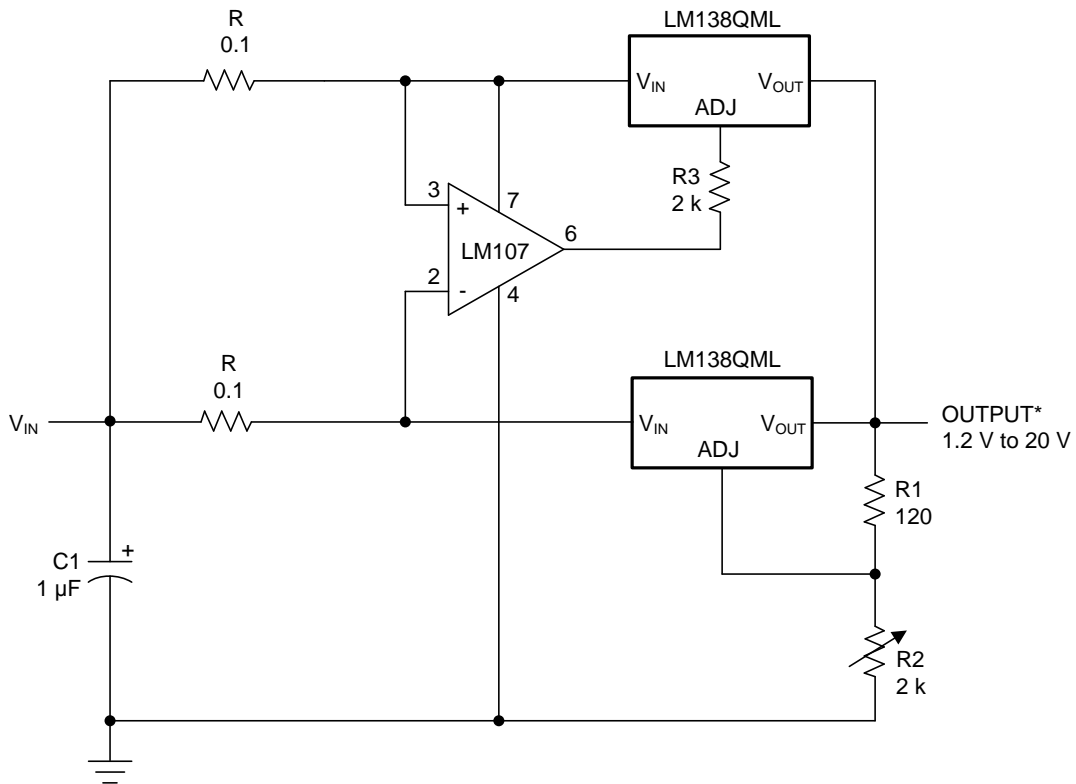
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\* Set max charge current to 3 A

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

**☒ 42. Current Limited 6-V Charger**

**System Examples (continued)**



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\* Minimum load—100 mA

**43. 10-A Regulator**

## 9 Power Supply Recommendations

The input supply to LM138QML 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 LM138QML 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 device. 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 device. Similarly, in cases when a large bypass capacitor is placed at the ADJ pin and  $V_{OUT}$  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 device pins to increase their effectiveness.

### 10.2 Layout Example

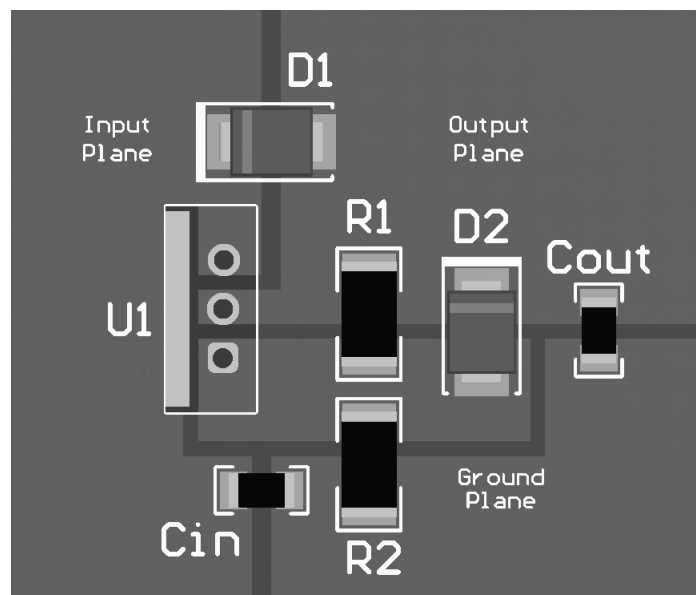


图 44. LM138QML Layout

## 11 デバイスおよびドキュメントのサポート

### 11.1 ドキュメントの更新通知を受け取る方法

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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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM138K-MIL	ACTIVE	TO	K	2	50	RoHS & Green	Call TI	Level-1-NA-UNLIM		LM138K-MIL ACO >T	<a href="#">Samples</a>
LM138KG-MD8	ACTIVE	DIESALE	Y	0	100	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

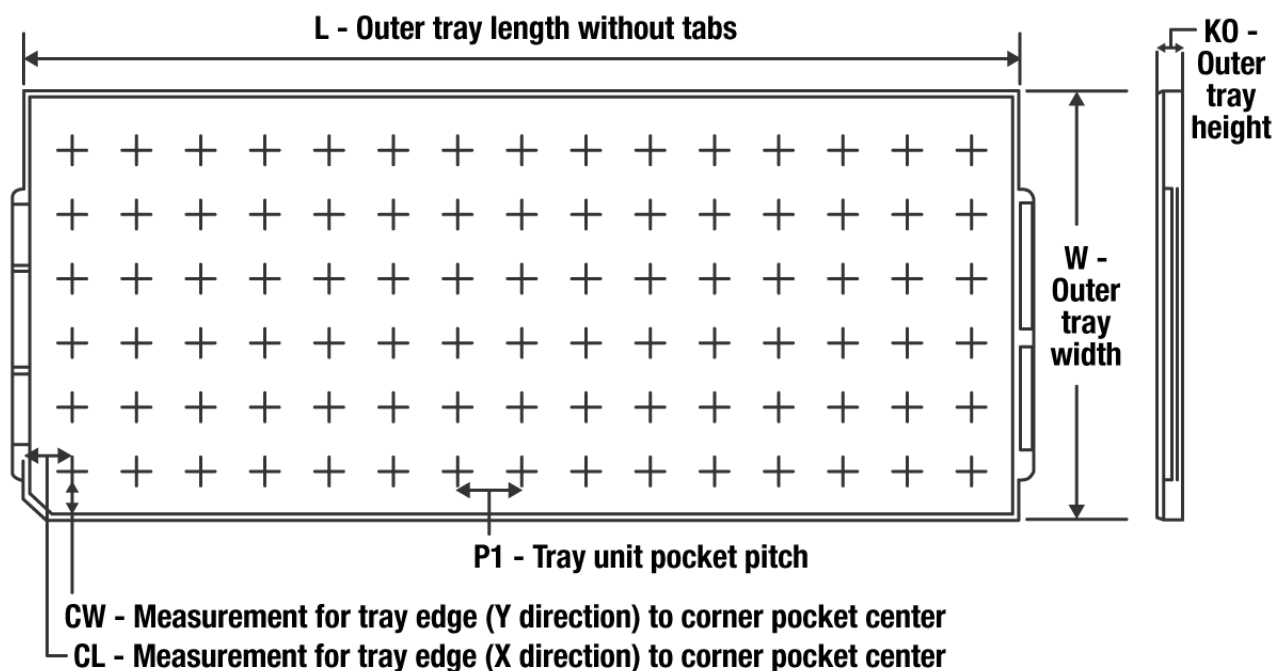
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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**TRAY**


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
LM138K-MIL	K	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4

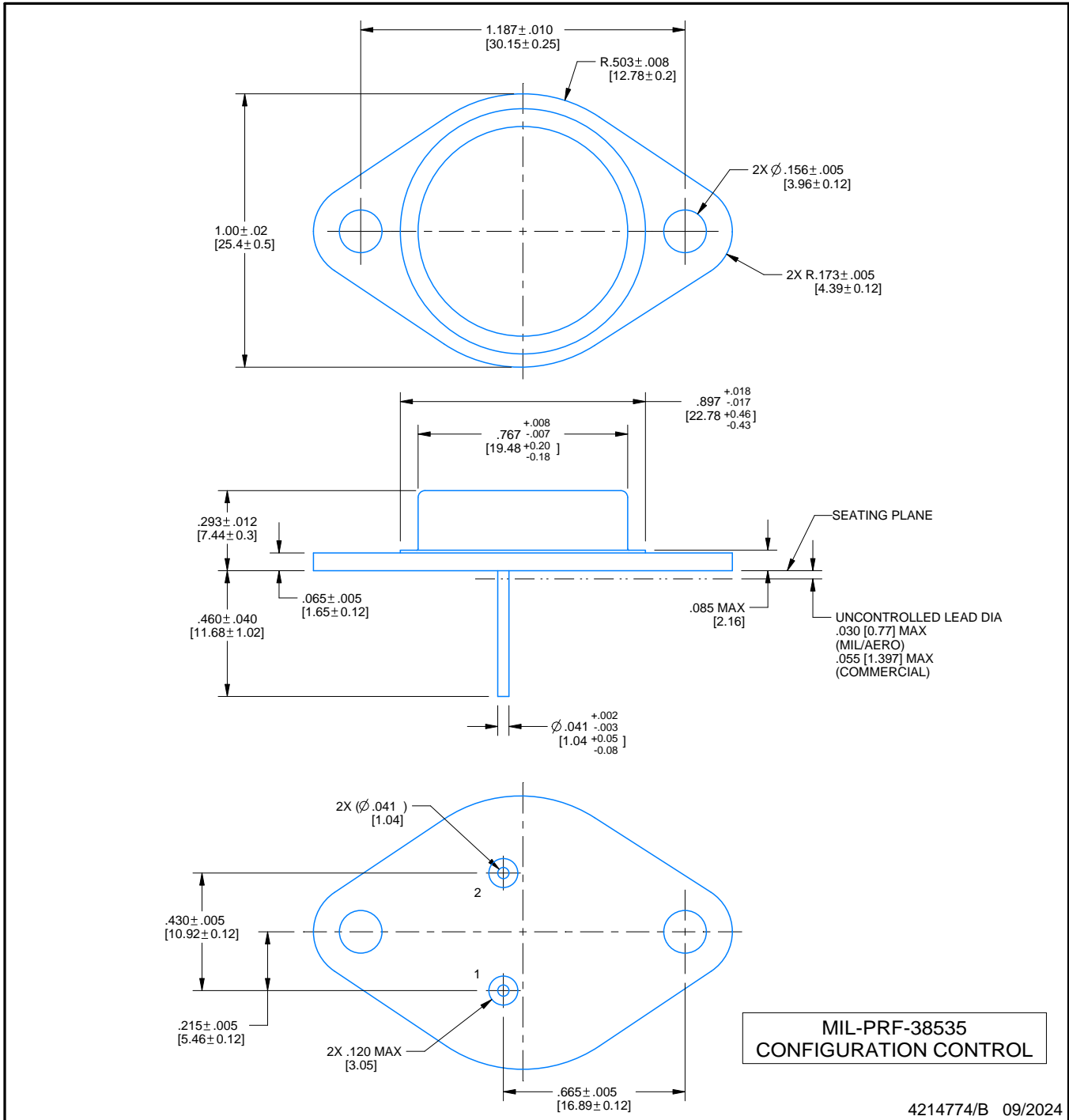
K0002A



# PACKAGE OUTLINE

TO-CAN - 7.747 mm max height

TRANSISTOR OUTLINE



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.
3. Leads not to be bent greater than  $15^\circ$ .

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