LM138QML 軍事用グレードの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事用グレード・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℃～150℃
- 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

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、レギュレータのリップル除去が強化されます。

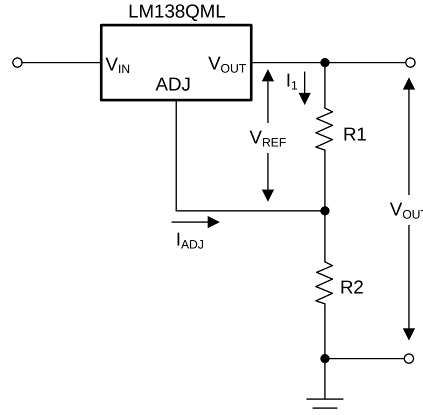
LM138QMLは、固定レギュレータやディスクリート設計の置き換え以外にも、広範な他の用途に有効です。レギュレータは「フローティング」状態で、入力から出力への差動電圧のみを検出するため、入力から出力への差分の最大値を超過せず、出力からグランドへの短絡が発生しない限り、数百ボルトの電圧の電源でもレギュレート可能です。

製品情報(1)

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



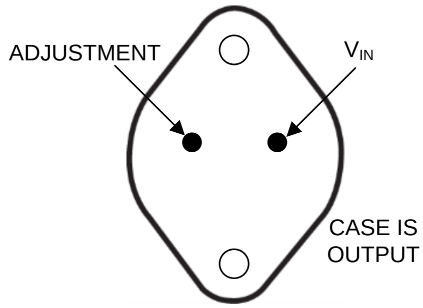
目次

4 改訂履歴

日付	改訂内容	注
2017年10月	*	初版

5 Pin Configuration and Functions

K Package
2-Pin TO-3
Bottom View



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)[(1)]

	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(1)		LM138QML K (TO-3) 2 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	42.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	3.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	2.5	°C/W
ψ_{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 V; and I_{OUT} = 10 mA (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS	SUB-GROUPS	MIN	TYP(2)	MAX	UNIT
V_{REF}	Reference voltage	$V_{IN} – V_{OUT}$ = 3 V(3)	[1, 2, 3]	1.19		1.29	V
		$V_{IN} – V_{OUT}$ = 3 V, I_{OUT} = 5 A	[1, 2, 3]	1.19		1.29	
		$V_{IN} – V_{OUT}$ = 5 V, I_{OUT} = 7 A	[1, 2, 3]	1.19		1.29	
		$V_{IN} – V_{OUT}$ = 35 V	[1, 2, 3]	1.19		1.29	
		$V_{IN} – V_{OUT}$ = 35 V, I_{OUT} = 150 mA	[1, 2, 3]	1.19		1.29	
V_{RLINE}	Line regulation(4)	3 V ≤ ($V_{IN} – V_{OUT}$) ≤ 35 V	[1]	–3.5		3.5	mV
		3.3 V ≤ ($V_{IN} – V_{OUT}$) ≤ 35 V	[2, 3]	–14		14	
V_{RLOAD}	Load regulation(4)	$V_{IN} – V_{OUT}$ = 3 V, 10 mA ≤ I_{OUT} ≤ 5 A, V_{OUT} = V_{REF}	[1]	–3.8		3.8	mV
		$V_{IN} – V_{OUT}$ = 3.3 V, 10 mA ≤ I_{OUT} ≤ 5 A, V_{OUT} = V_{REF}	[2, 3]	–8		8	
		$V_{IN} – V_{OUT}$ = 35 V, 10 mA ≤ I_{OUT} ≤ 150 mA, V_{OUT} = V_{REF}	[1]	–3.8		3.8	
			[2, 3]	–8		8	
V_{RTH}	Thermal regulation	$V_{IN} – V_{OUT}$ = 10 V, pulse = 20 ms, I_{OUT} = 1 A(5)	[1]		0.002	0.01	%/W
I_{ADJ}	Adjustment pin current	$V_{IN} – V_{OUT}$ = 3 V(3)	[1, 2, 3]	2	45	100	µA
		$V_{IN} – V_{OUT}$ = 35 V	[1, 2, 3]	2		100	
ΔI_{ADJ}	Adjustment pin current change	3 V ≤ ($V_{IN} – V_{OUT}$) ≤ 35 V(3)	[1, 2, 3]	–5	0.2	5	µA
		10 mA ≤ I_{OUT} ≤ 5 A	[1, 2, 3]	–5		5	
$I_{LOAD(MIN)}$	Minimum load current	$V_{IN} – V_{OUT}$ = 3 V, V_{OUT} = 1.4 V(3)	[1, 2, 3]	0.5		5	mA
		$V_{IN} – V_{OUT}$ = 35 V, V_{OUT} = 1.4 V	[1, 2, 3]	0.5	3.5	5	
I_{CL}	Current limit	$V_{IN} – V_{OUT}$ = 10 V, T = 0.5 ms, V_{OUT} = 0 V	[1, 2, 3]	7		16	A
		T = 5 ms, V_{OUT} = 0 V	[1, 2, 3]	5		15	
$\Delta V_R/\Delta V_{IN}$	Ripple rejection ratio	V_{OUT} = V_{REF}, e_{IN} = 1 V_{RMS}, f = 120 Hz, I_{OUT} = 500 mA(6)	[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°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 V at –55°C and 125°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

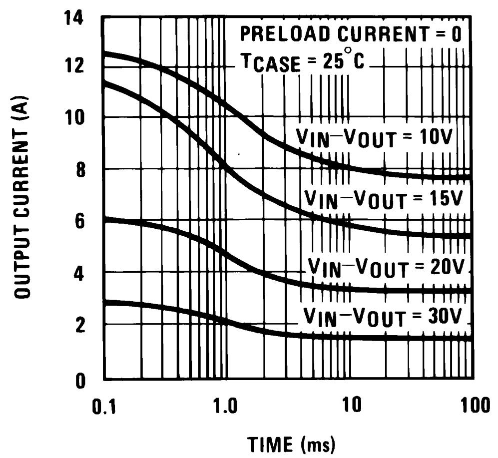


図 1. Current Limit

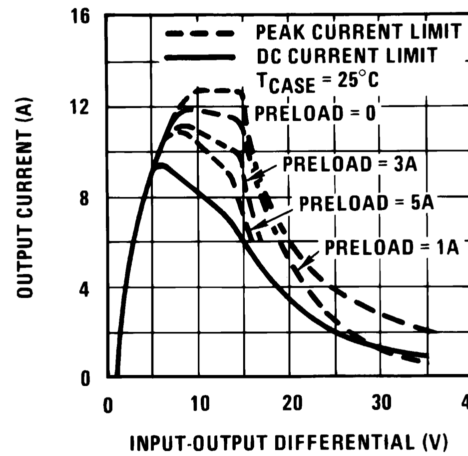


図 2. Current Limit

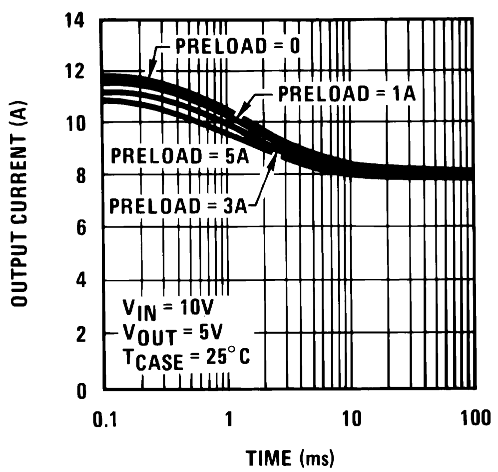


図 3. Current Limit

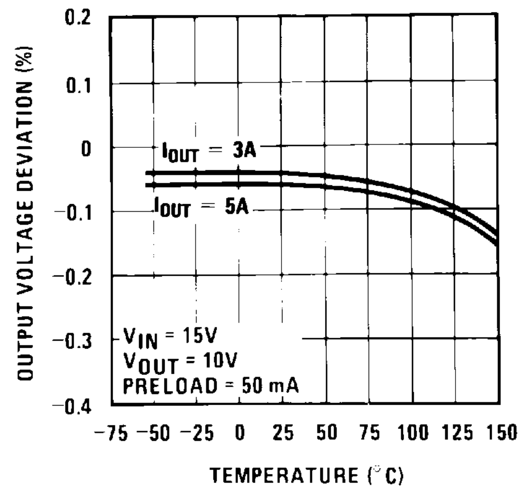


図 4. Load Regulation

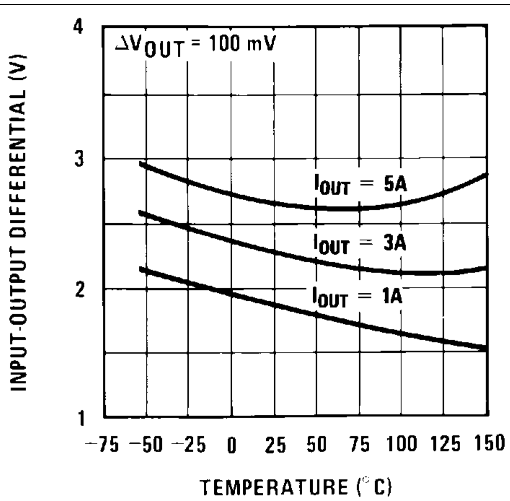


図 5. Dropout Voltage

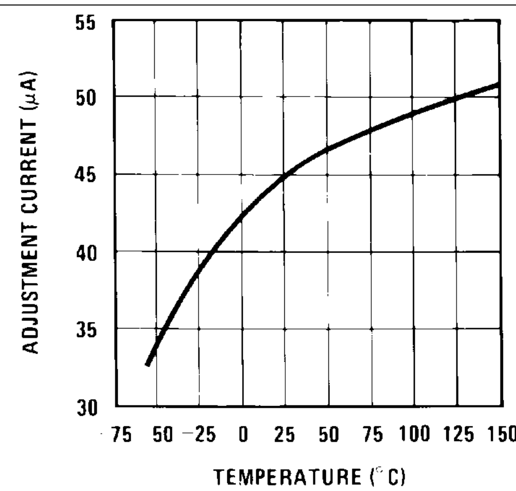


図 6. Adjustment Current

Typical Performance Characteristics (continued)

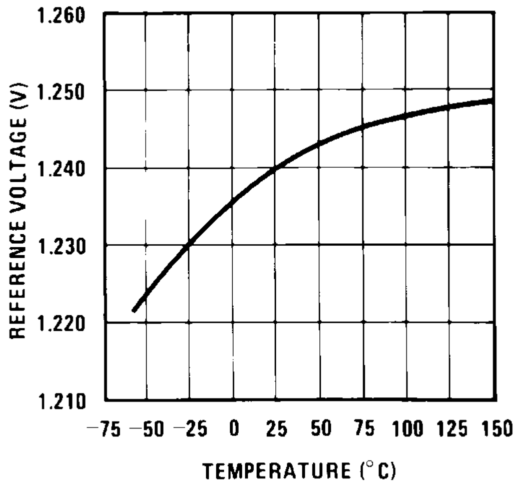


図 7. Temperature Stability

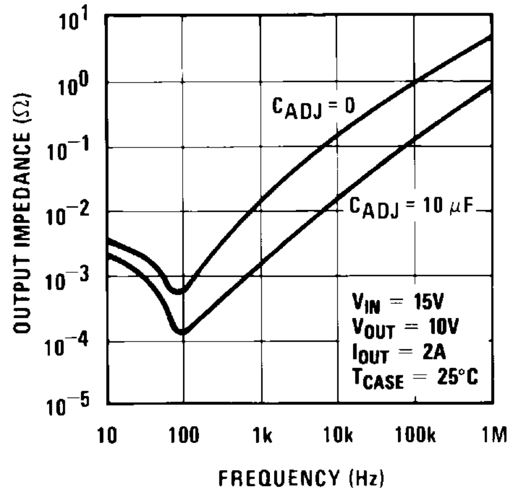


図 8. Output Impedance

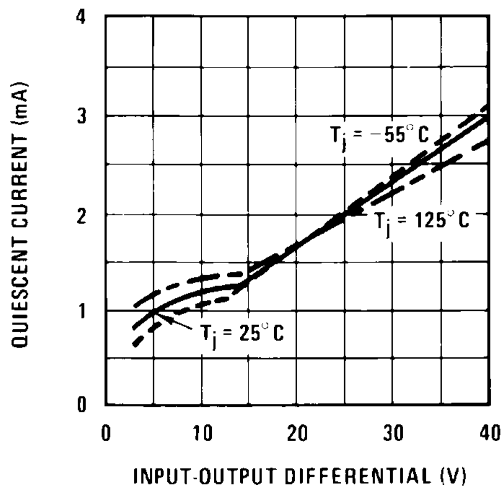


図 9. Minimum Operating Current

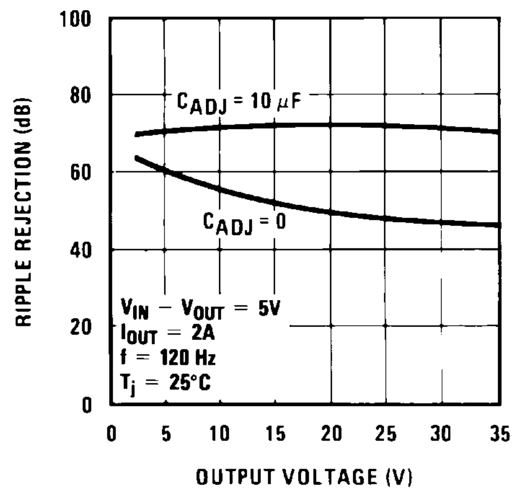


図 10. Ripple Rejection

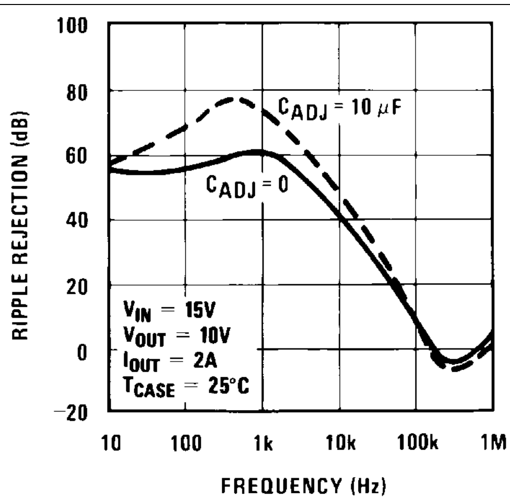


図 11. Ripple Rejection

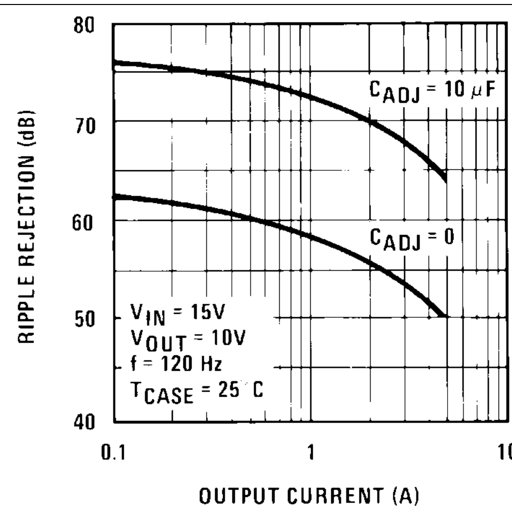


図 12. Ripple Rejection

Typical Performance Characteristics (continued)

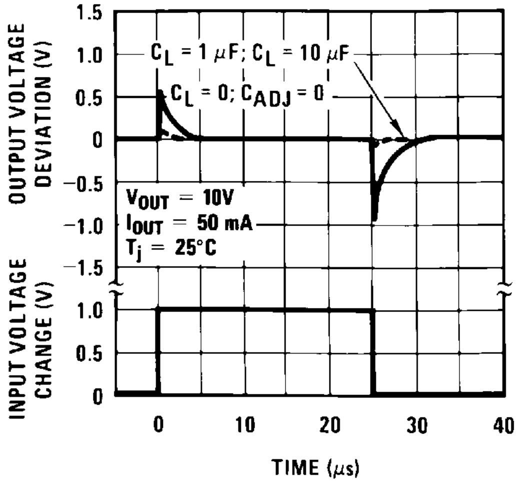


図 13. Line Transient Response

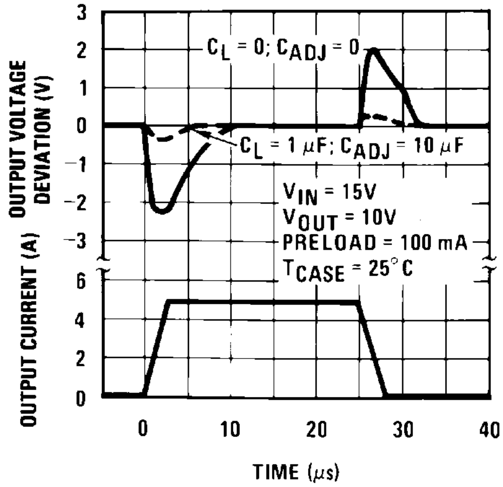


図 14. Load Transient Response

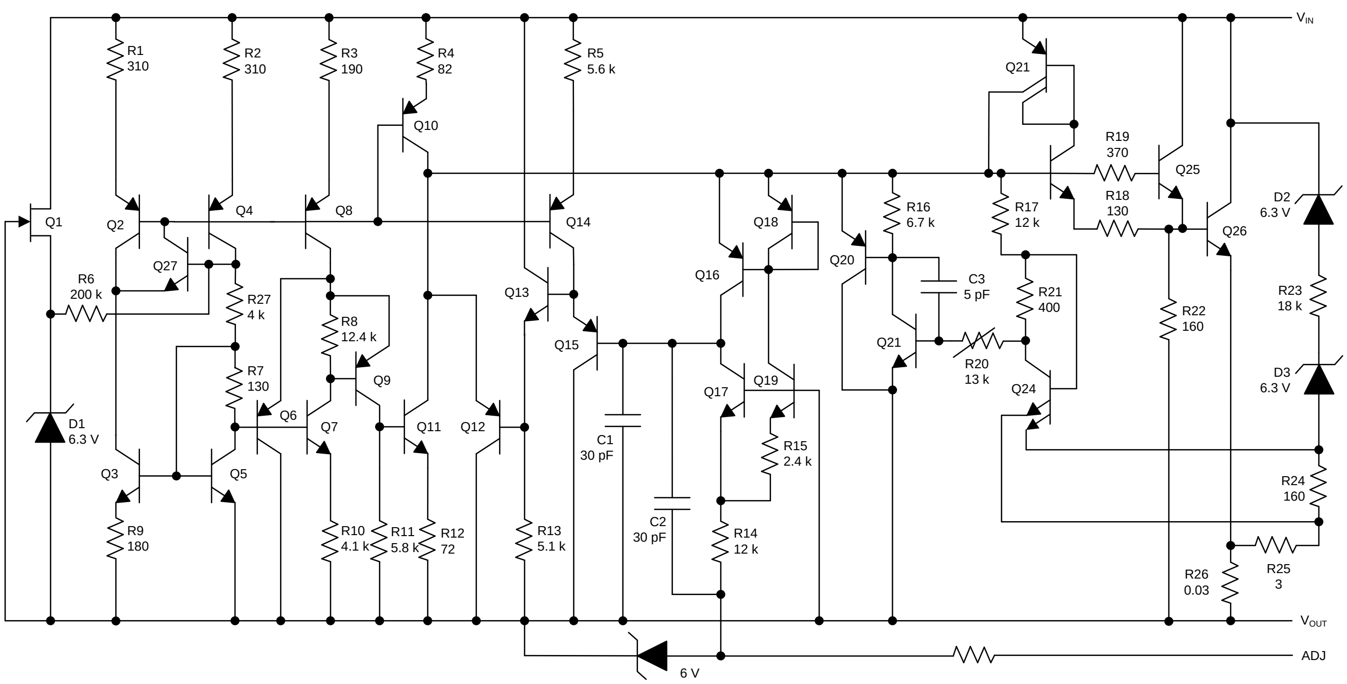
7 Detailed Description

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



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-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 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

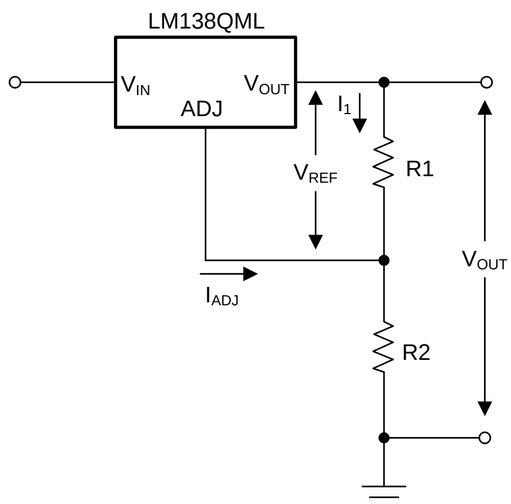
注

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:

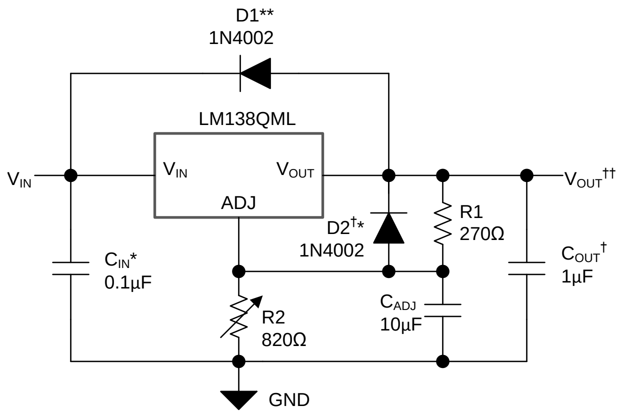
$$V_{OUT} = V_{REF}\left(1+\frac{R2}{R1}\right)+I_{ADJ}R2 \tag{1}$$



Because the 50-µA 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_{OUT} is used

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

†*Recommended if C_{ADJ} is used

図 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_{R2} must equal 3.76 V when 4.6 mA is flowing through it. R2 = V_{R2} / I = 3.76 V / 4.6 mA = ~820 Ω.
Input capacitor (C_{IN})	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_{OUT})	1 µF	The regulator is stable without any output capacitance, but adding a 1-µF capacitor improves the transient response.
Adjust capacitor (C_{ADJ})	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_{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).
Protection diode 2 (D2)	1N4002	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).

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 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-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; however, some types have a large decrease in capacitance at frequencies around 0.5 MHz. For this reason, a 0.01-µF disc may seem to work better than a 0.1-µF 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-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 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 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 15-V regulator with 0.05-Ω resistance between the regulator and load will have 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 will be 0.05 Ω (1 + R2/R1) or in this case, 11.5 times worse.

図 16 shows the effect of resistance between the regulator and 240-Ω set resistor.

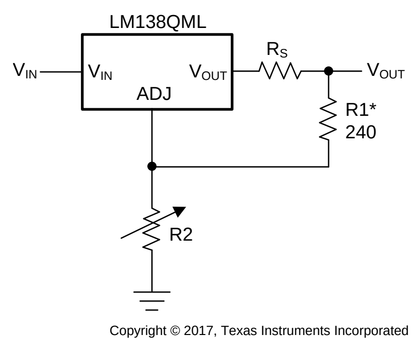


図 16. Regulator With Line Resistance in Output Lead

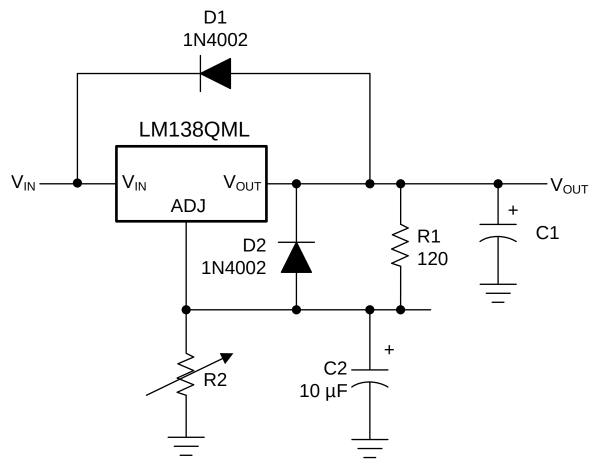
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor by using two separate leads to the case. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

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 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 μF 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-Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25-V or less and 10-μF capacitance. 図 17 shows an LM138QML with protection diodes included for use with outputs greater than 25 V and high values of output capacitance.



D1 protects against C1
D2 protects against C2

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

図 17. Regulator With Protection Diodes

8.2.1.3 Application Curves

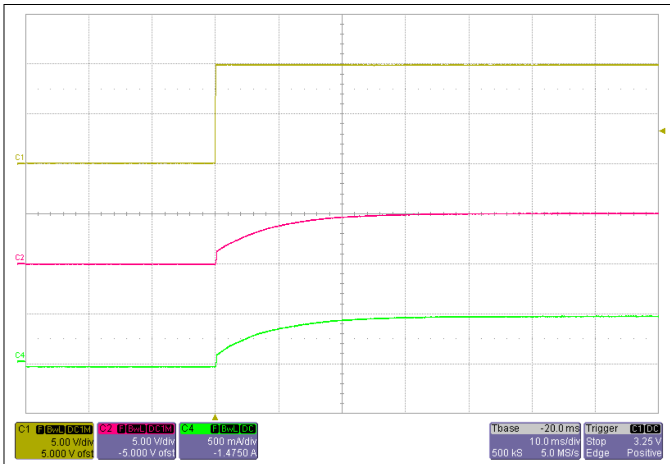


図 18. Regulator Start-Up

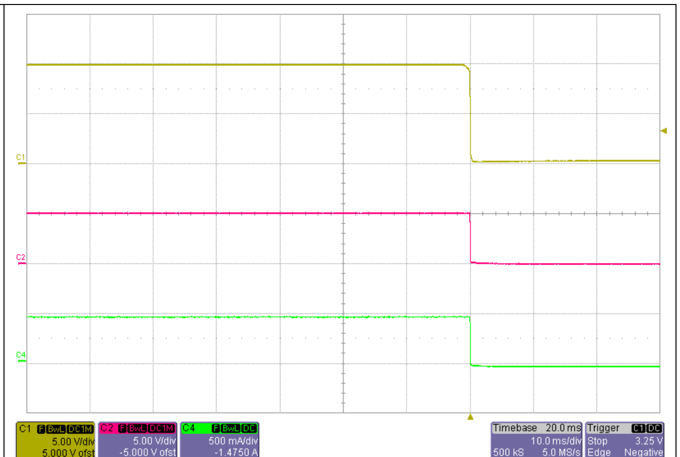


図 19. Regulator Shutdown

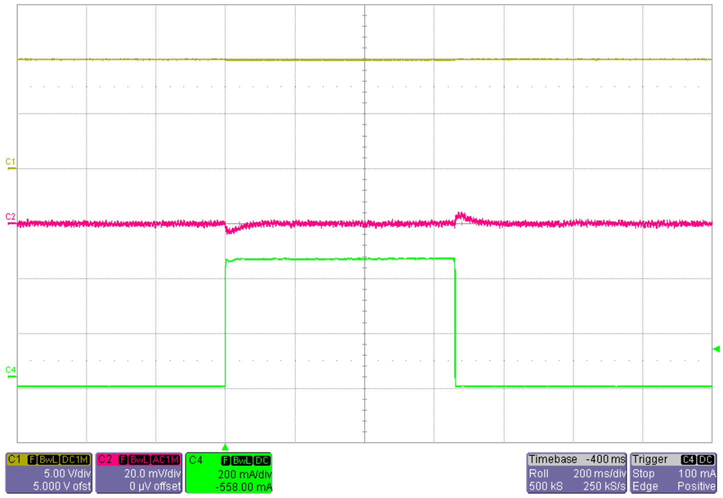


図 20. Regulator Response to Load Stop

8.3 System Examples

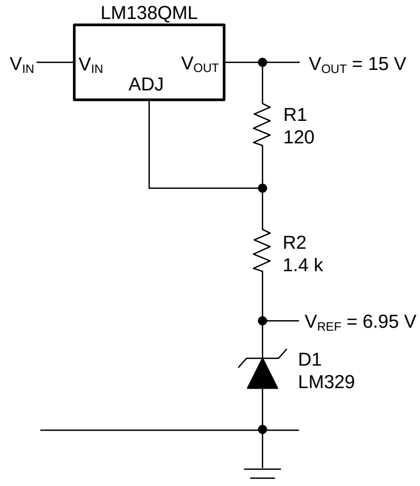
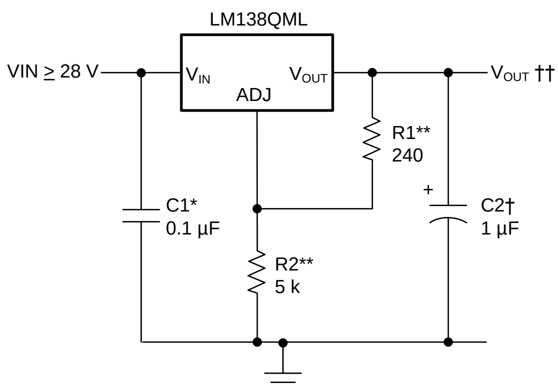


図 21. Regulator and Voltage Reference



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

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

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

System Examples (continued)

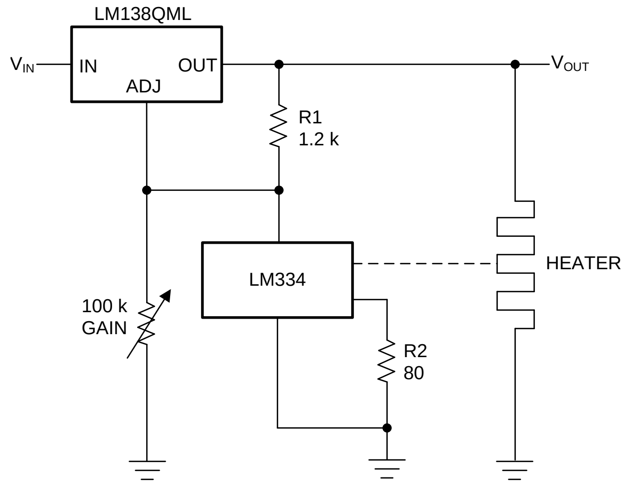
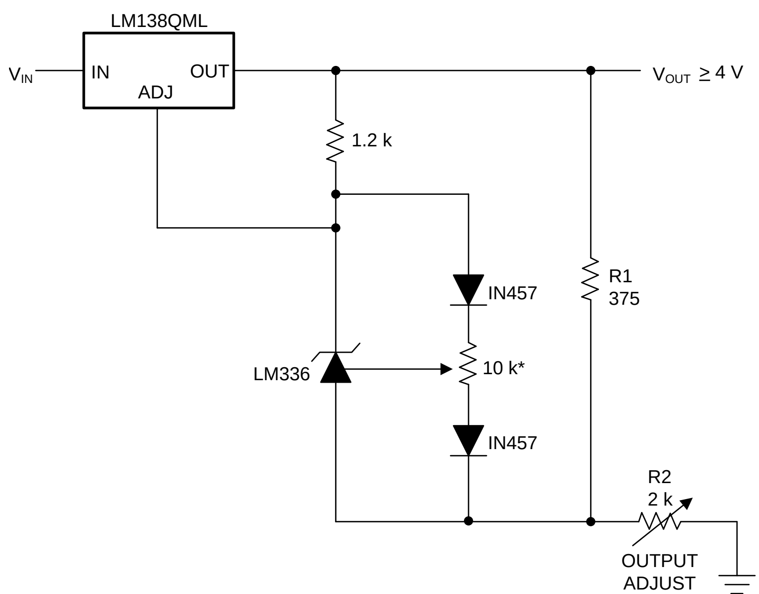


図 23. Temperature Controller



* Adjust for 3.75 V across R1

図 24. Precision Power Regulator With Low Temperature Coefficient

System Examples (continued)

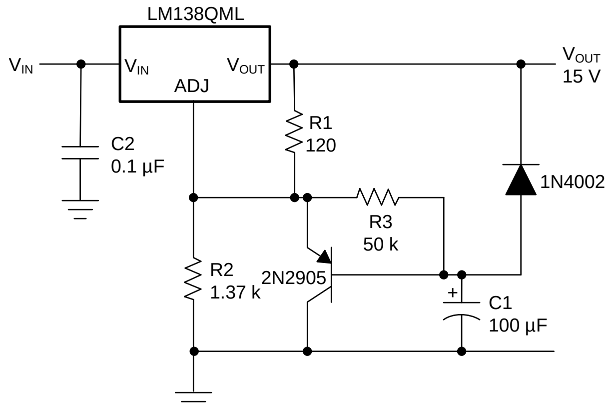
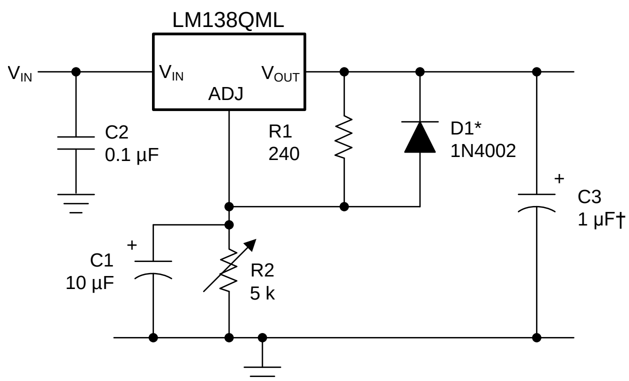


図 25. Slow Turnon 15-V Regulator



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

図 26. Adjustable Regulator With Improved Ripple Rejection

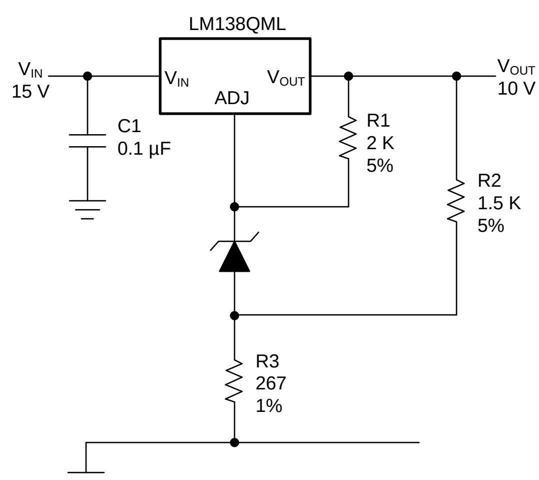
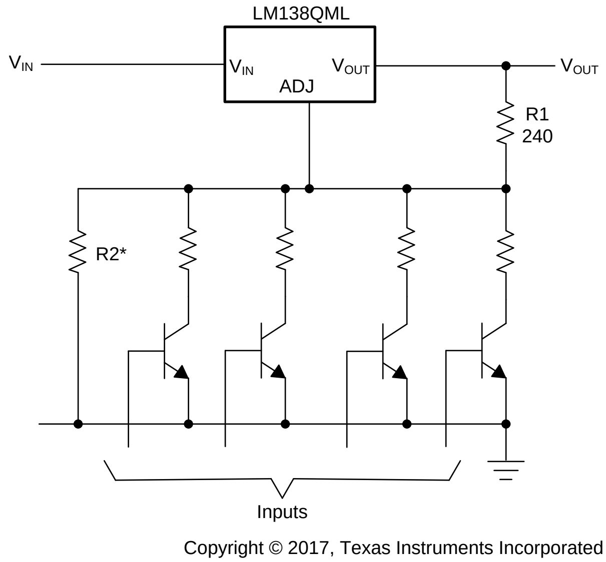


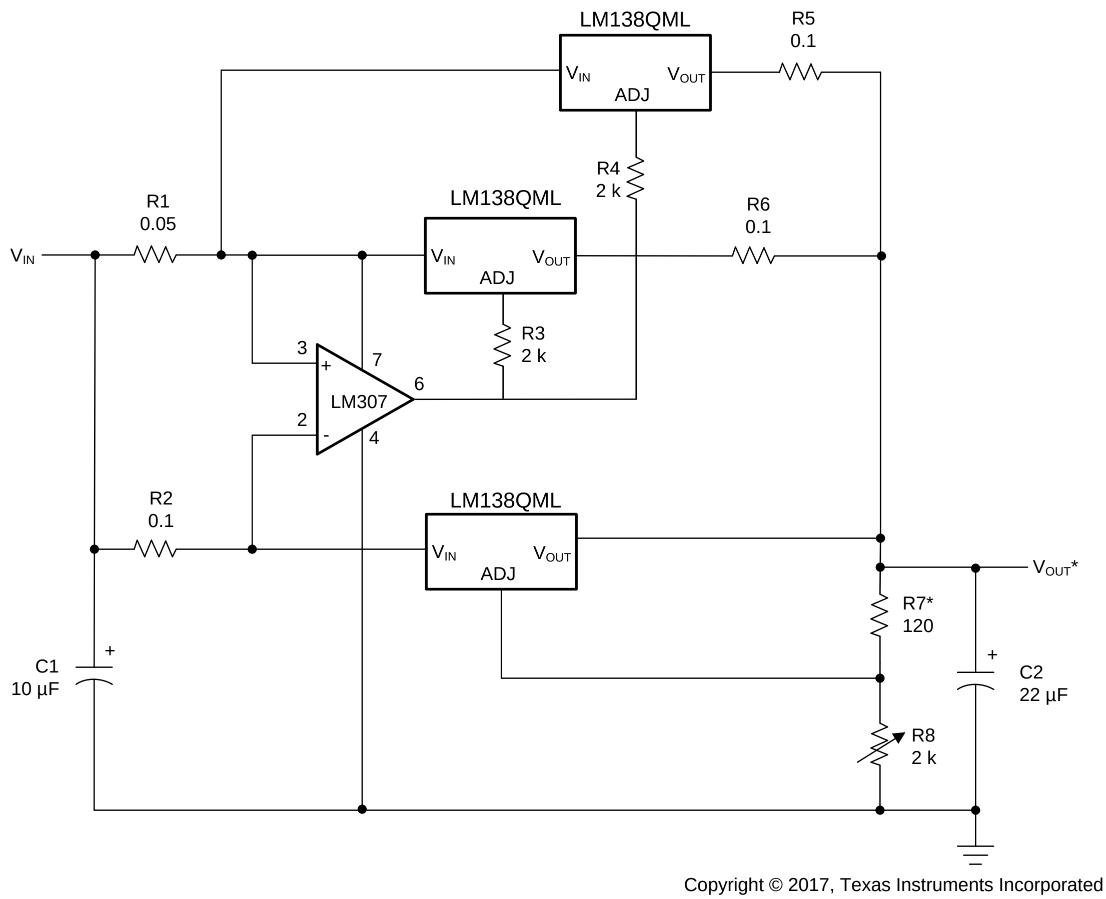
図 27. High Stability 10-V Regulator

System Examples (continued)



* Sets maximum V_{OUT}

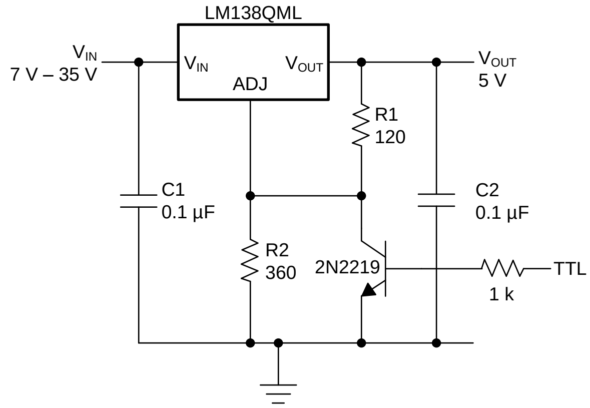
図 28. Digitally Selected Outputs



* Minimum load—100 mA

図 29. 15-A Regulator

System Examples (continued)



** Minimum output ≈ 1.2 V

図 30. 5-V Logic Regulator With Electronic Shutdown**

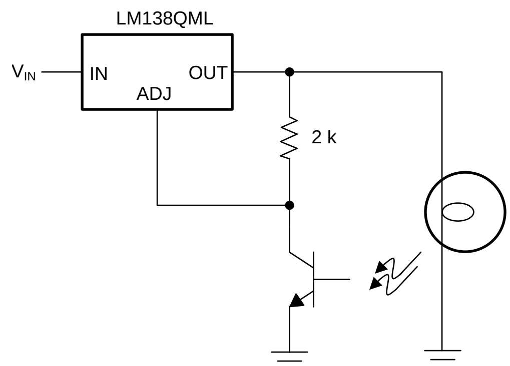
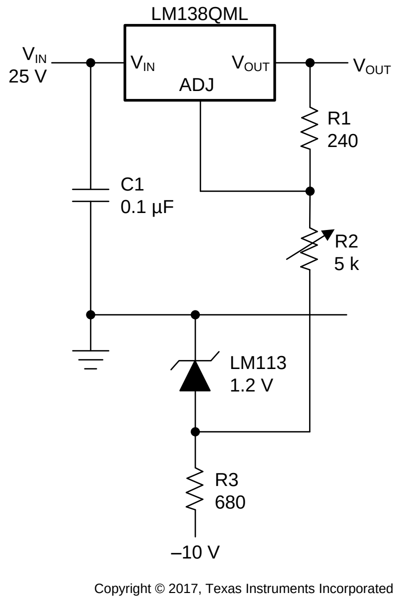


図 31. Light Controller

System Examples (continued)



Full output current not available at high input-output voltages

図 32. 0-V to 22-V Regulator

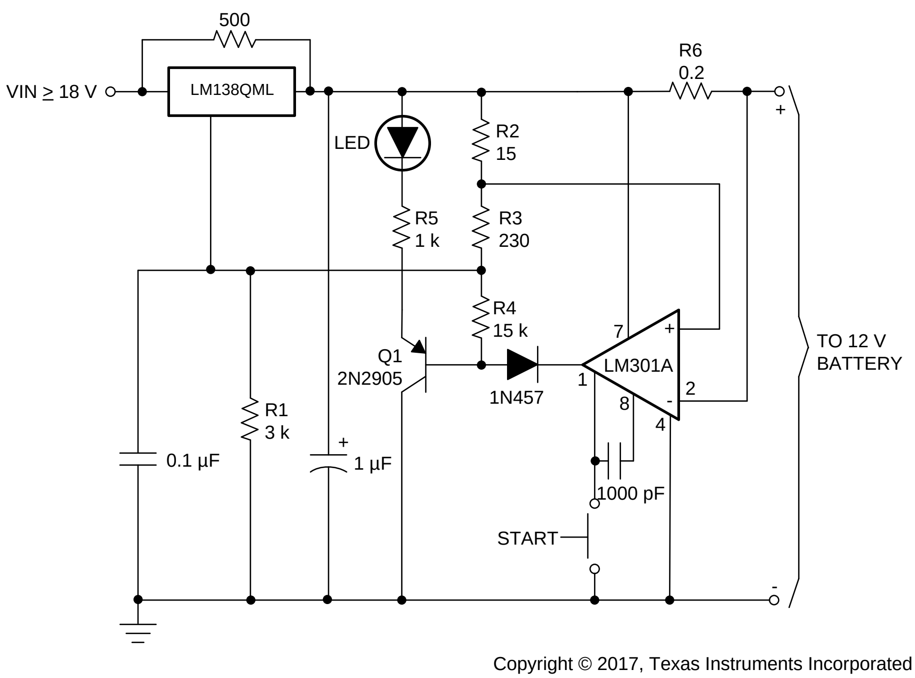


図 33. 12-V Battery Charger

System Examples (continued)

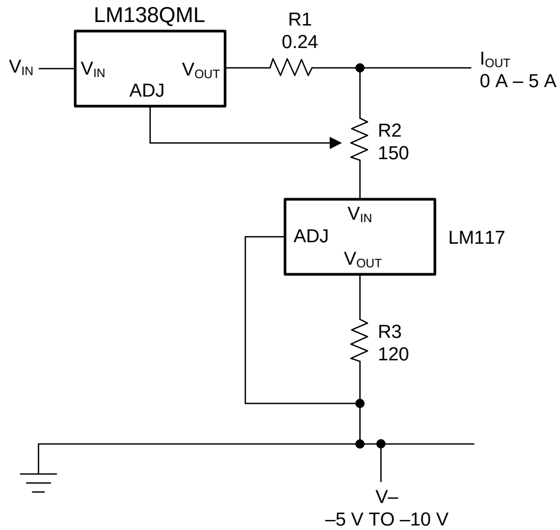


図 34. Adjustable Current Regulator

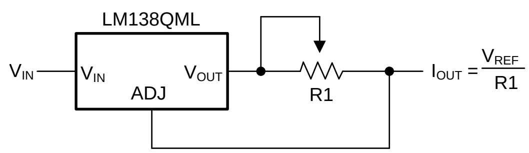


図 35. Precision Current Limiter

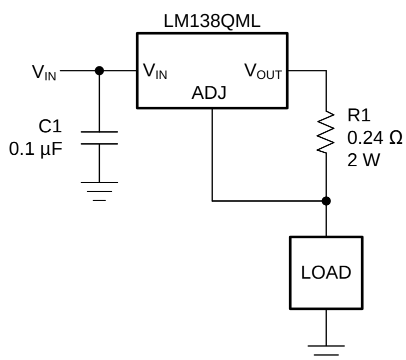


図 36. 5-A Current Regulator

System Examples (continued)

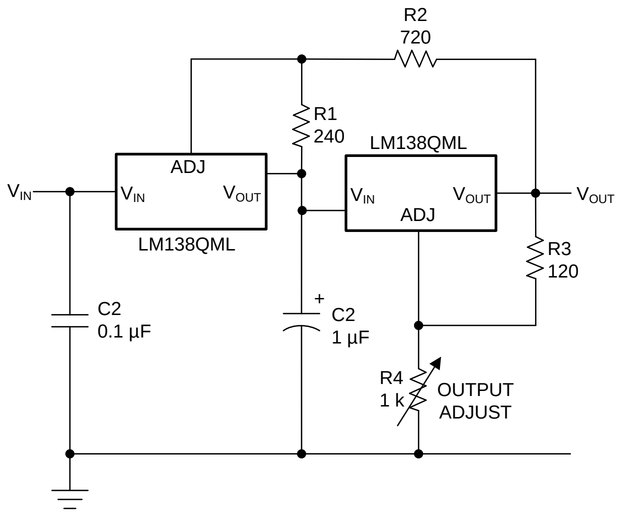
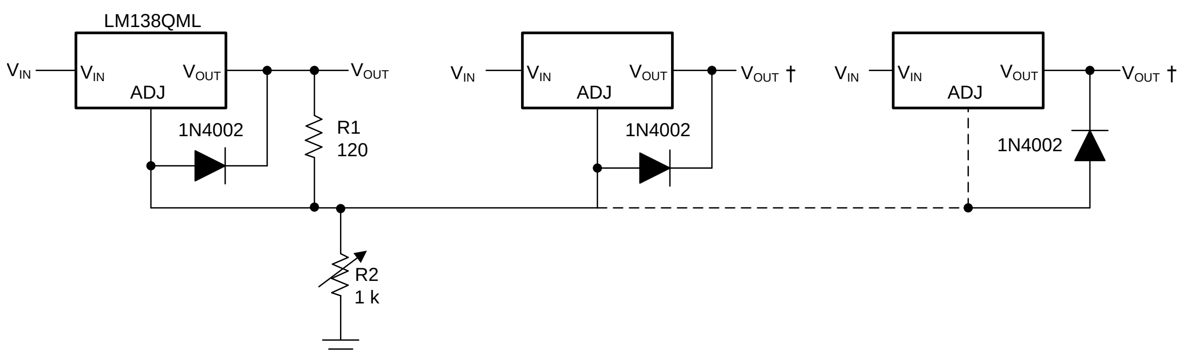


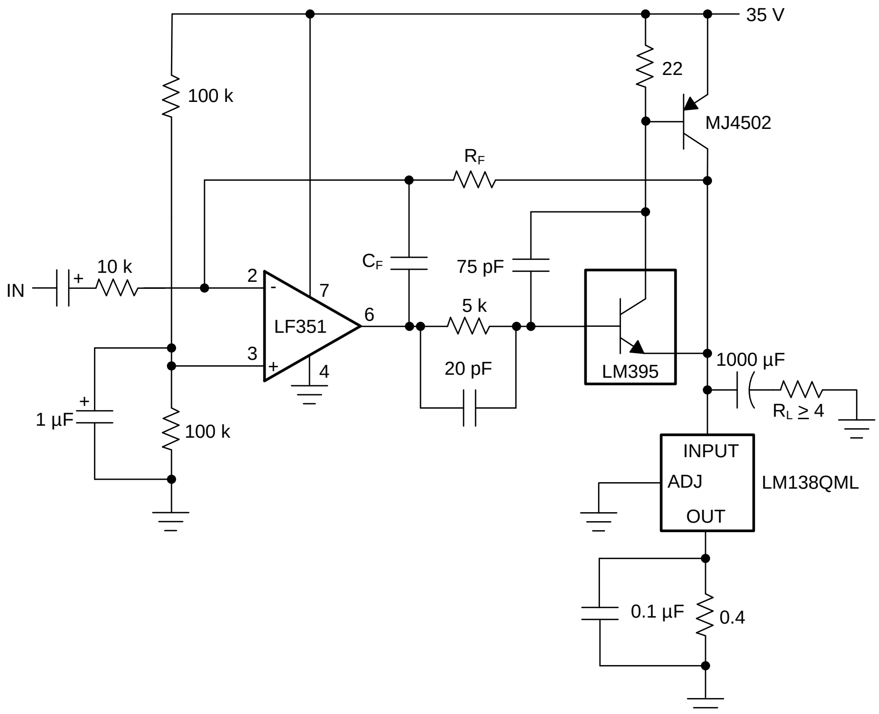
図 37. Tracking Preregulator



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

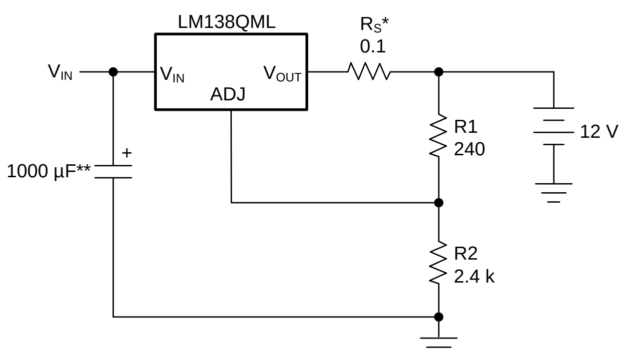
図 38. Adjusting Multiple On-Card Regulators With Single Control*

System Examples (continued)



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%

図 39. 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

図 40. Simple 12-V Battery Charger

System Examples (continued)

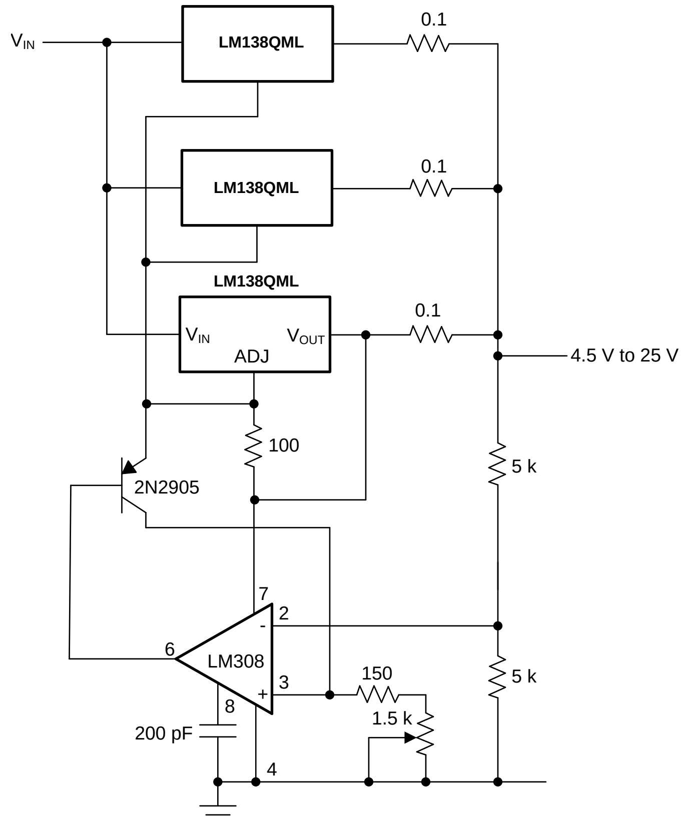
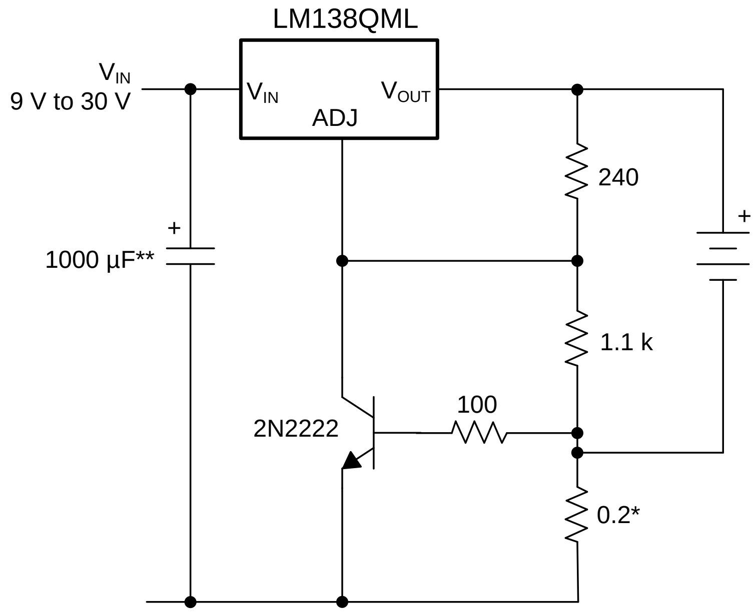


図 41. Adjustable 15-A Regulator

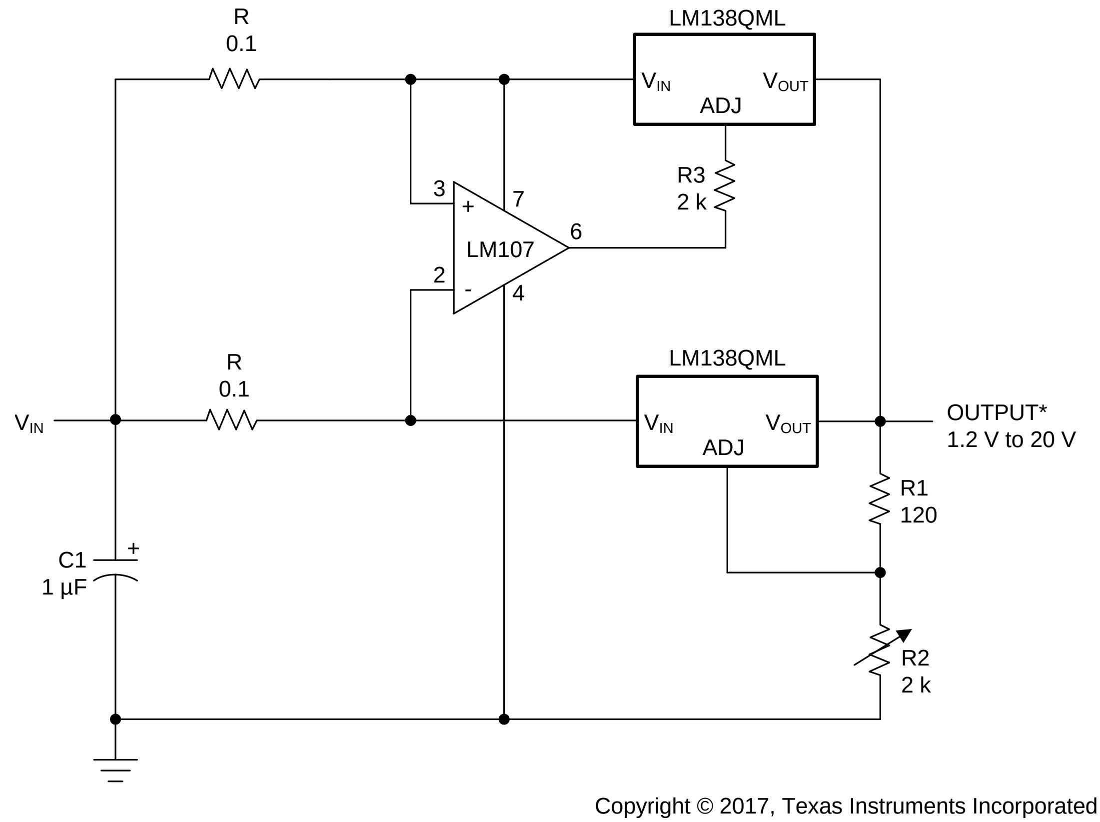
System Examples (continued)



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

図 42. Current Limited 6-V Charger

System Examples (continued)



* Minimum load—100 mA

図 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 deice. 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

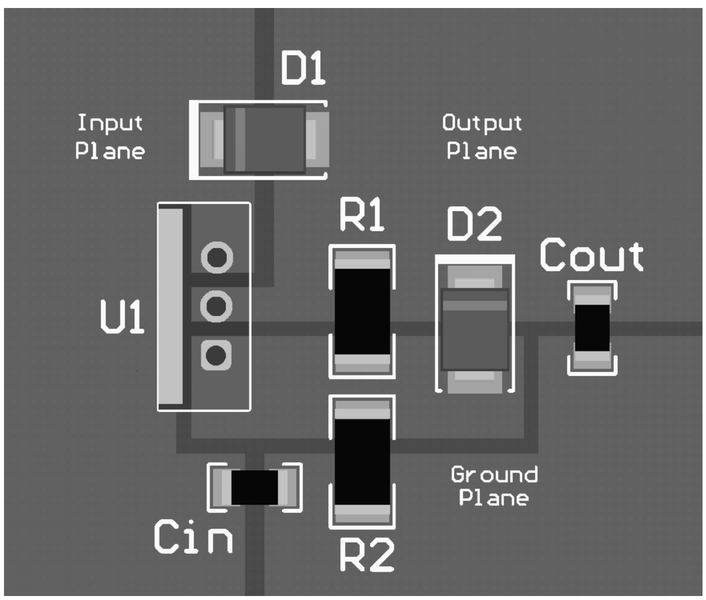


図 44. LM138QML Layout

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

ドキュメントの更新についての通知を受け取るには、ti.comのデバイス製品フォルダを開いてください。右上の隅にある「*通知を受け取る*」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

11.2 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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設計サポート ***TIの設計サポート*** 役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

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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)
LM138K-MIL	Active	Production	TO (K) | 2	50 | TRAY NON-STD	Yes	Call TI	Level-1-NA-UNLIM	-	LM138K-MIL ACO >T
LM138KG-MD8	Active	Production	DIESALE (Y) | 0	100 | JEDEC TRAY (5+1)	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	

(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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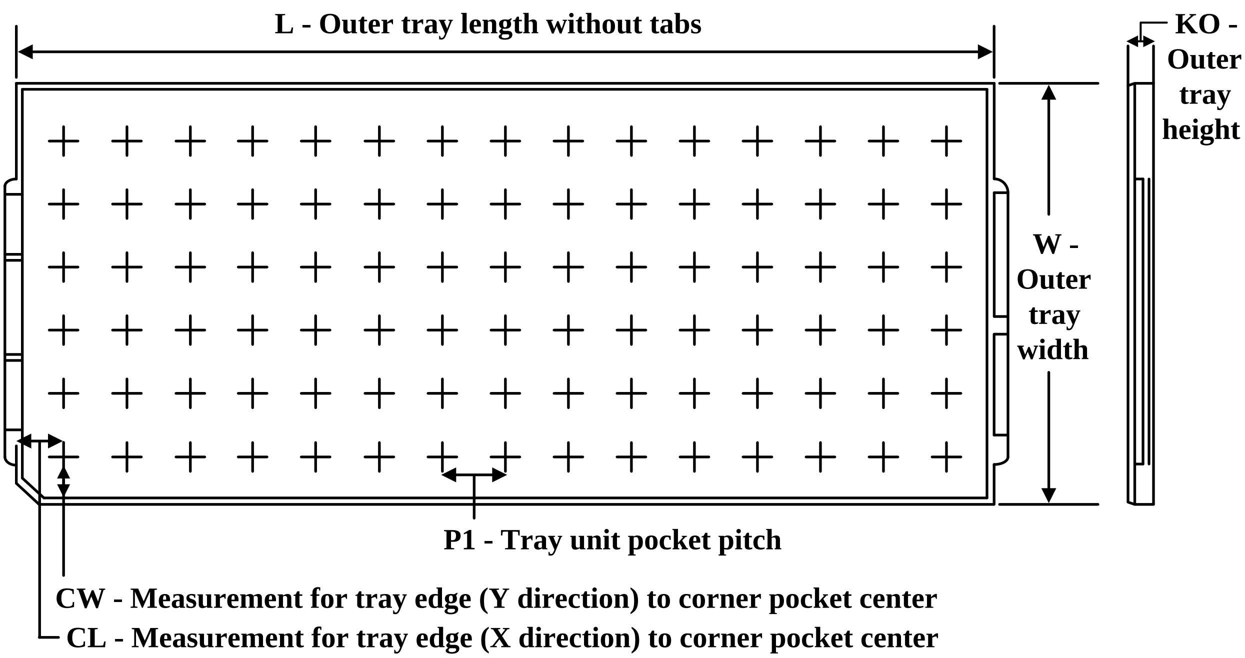
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

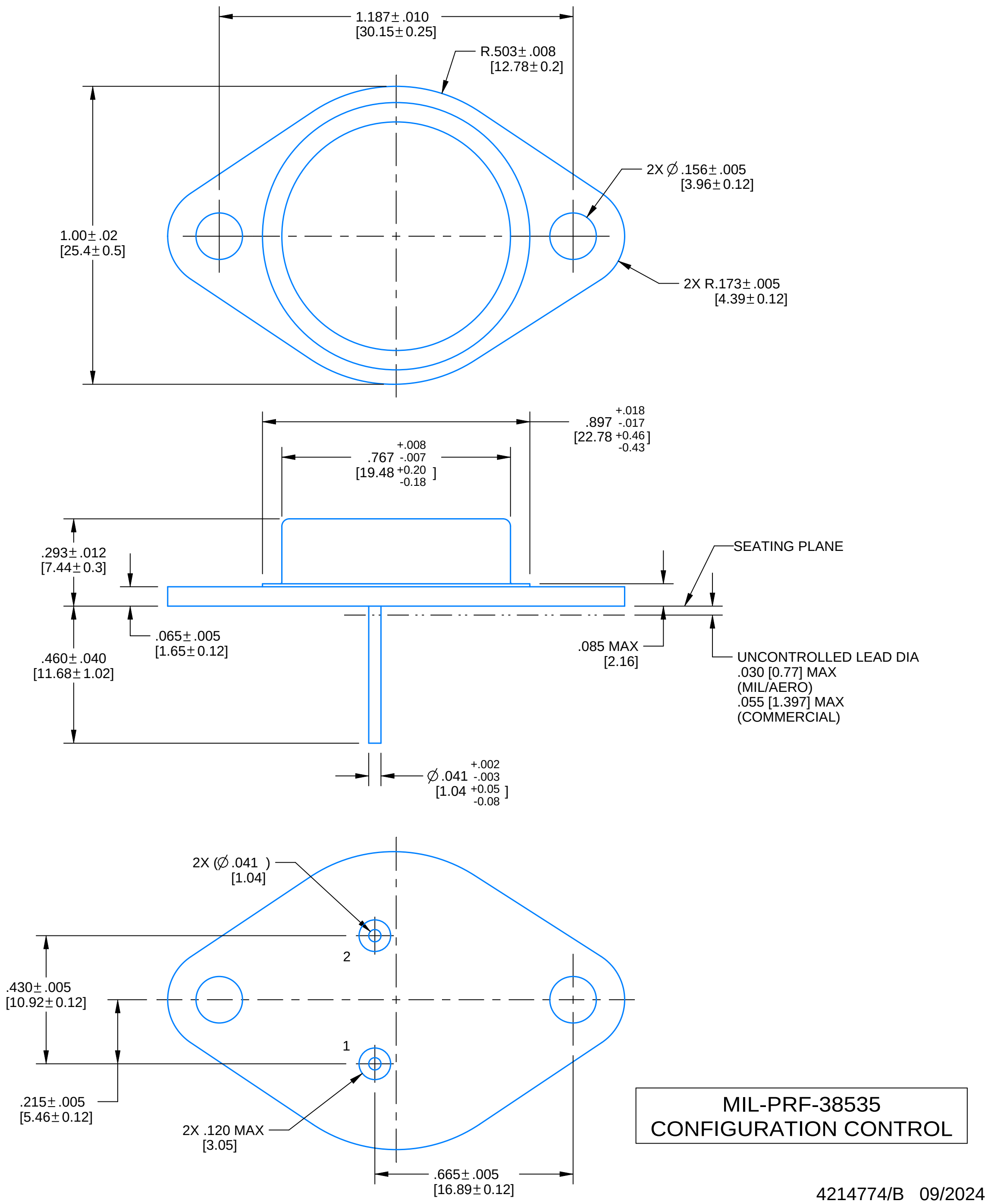
TRAY



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



4214774/B 09/2024

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°.