**DESCRIPTION**

The LT®138A series of adjustable regulators provide 5A output current over an output voltage range of 1.2V to 32V. The internal voltage reference is trimmed to less than 1%, enabling a very tight output voltage. In addition to excellent line and load regulation, with full overload protection, the LT138A incorporates new current limiting circuitry allowing large transient load currents to be handled for short periods. Transient load currents of up to 12A can be supplied without limiting, eliminating the need for a large output capacitor.

The LT138A is an improved version of the popular LM138 with improved circuit design and advanced process techniques to provide superior performance and reliability.

The graph below shows the significant improvement in output voltage tolerance achieved by using the LT138A or LT338A.

---

**FEATURES**

- Guaranteed 1% Initial Tolerance
- Guaranteed 0.3% Load Regulation
- Guaranteed 5A Output Current
- 100% Thermal Limit Burn-In
- 12A Transient Output Current

**APPLICATIONS**

- High Power Linear Regulator
- Battery Chargers
- Power Driver
- Constant-Current Regulator

---

**TYPICAL APPLICATION**

**Parallel Regulators for Higher Current**

- LT338A
- LT350A

**Output Voltage Error**

*THIS CIRCUIT WILL NOT WORK WITH LM VERSION DEVICES
**CURRENT SHARING RESISTORS DEGRADE REGULATION TO 1%*
LT138A/LT339A
LM138/LM338

ABSOLUTE MAXIMUM RATINGS (Note 1)

Power Dissipation ......................... Internally Limited
Input-to-Output Voltage Differential .......... 35V
Operating Junction Temperature Range
  LT138A/LM138 ................................ –55°C to 150°C
  LT338A/LM338 ................................ 0°C to 125°C

Storage Temperature Range ........ –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ........ 300°C

PRECONDITIONING
100% Thermal Limit Burn-In

PIN CONFIGURATION

<table>
<thead>
<tr>
<th>BOTTOM VIEW</th>
<th>FRONT VIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_IN</td>
<td>V_IN</td>
</tr>
<tr>
<td>CASE IS OUTPUT</td>
<td>V_OUT</td>
</tr>
<tr>
<td>ADJ (GND*)</td>
<td>ADJ</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

K PACKAGE
2-LEAD TO-3 METAL CAN
T_JMAX = 150°C, r_JA = 35°C/W, θ_JA = 1°C/W (LT138A/LT138)
T_JMAX = 125°C, r_JA = 35°C/W, θ_JA = 1°C/W (LT338A/LT338)

OBSOLETE PACKAGE

P PACKAGE
3-LEAD PLASTIC TO-3P
T_JMAX = 125°C, r_JA = 45°C/W

OBSOLETE PACKAGE

For more information www.linear.com/LT138A
## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$. (Note 2)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT138A</th>
<th>LM138</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIN</td>
<td>TYP</td>
</tr>
<tr>
<td>VREF</td>
<td>Reference Voltage</td>
<td>$I_{OUT} = 10mA, T_J = 25^\circ C$</td>
<td>1.238</td>
<td>1.250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$3V \leq (V_{IN} - V_{OUT}) \leq 35V, 10mA \leq I_{OUT} \leq 5A, P \leq 50W$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta V_{OUT}$</td>
<td>Line Regulation</td>
<td>$3V \leq (V_{IN} - V_{OUT}) \leq 35V, (Note 3)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\Delta V_{IN}$</td>
<td>$0.005 0.01$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\Delta V_{OUT}$</td>
<td>$0.02 0.04$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta V_{OUT}$</td>
<td>Load Regulation</td>
<td>$10mA \leq I_{OUT} \leq 5A, (Note 3)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{OUT} \leq 5V$</td>
<td>$5 15$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{OUT} \geq 5V$</td>
<td>$0.1 0.3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{OUT} \leq 5V$</td>
<td>$20 30$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{OUT} \geq 5V$</td>
<td>$0.3 0.6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal Regulation</td>
<td>$20ms Pulse$</td>
<td>$0.002$</td>
<td>0.02</td>
</tr>
</tbody>
</table>

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$.
ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ C$.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>LT138A</th>
<th>LM138</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ripple Rejection</td>
<td>$V_{OUT} = 10V, f = 120Hz$</td>
<td>● 60</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{ADJ} = 0\mu F$</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{ADJ} = 10\mu F$</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>$I_{ADJ}$</td>
<td>Adjust Pin Current</td>
<td>● 45</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>$\Delta I_{ADJ}$</td>
<td>Adjust Pin Current Change</td>
<td>10mA ≤ $I_{OUT}$ ≤ 5A, 3V ≤ ($V_{IN}$ − $V_{OUT}$) ≤ 35V</td>
<td>● 0.2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Minimum Load Current</td>
<td>($V_{IN}$ − $V_{OUT}$) = 35V</td>
<td>● 3.5</td>
<td>10</td>
</tr>
<tr>
<td>$I_{SC}$</td>
<td>Current Limit</td>
<td>($V_{IN}$ − $V_{OUT}$) ≤ 10V</td>
<td>● 5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC</td>
<td>8</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5ms Peak</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>($V_{IN}$ − $V_{OUT}$) = 30V, $T_J = 25^\circ C$</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>$\Delta V_{OUT}$</td>
<td>Temperature Stability</td>
<td>●</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>$\Delta V_{OUT}$</td>
<td>Long-Term Stability</td>
<td>$T_A = 125^\circ C$, 1000 Hours</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>$e_n$</td>
<td>RMS Output Noise (% of $V_{OUT}$)</td>
<td>10Hz ≤ f ≤ 10kHz</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td>$\theta_{JC}$</td>
<td>Thermal Resistance</td>
<td>Junction-to-Case</td>
<td>K Package</td>
<td>1</td>
</tr>
</tbody>
</table>

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: Unless otherwise specified, these specifications apply: $V_{IN} − V_{OUT} = 5V$ and $I_{OUT} = 2.5A$. These specifications are applicable for power dissipations up to 50W.

Note 3: See thermal regulation specifications for changes in output voltage due to heating effects. Load and line regulation are measured at a constant junction temperature by low duty cycle pulse testing.

Typical Performance Characteristics

- **Load Regulation**
- **Dropout Voltage**
- **Adjustment Current**
**Typical Performance Characteristics**

**Temperature Stability**

![Temperature Stability Graph](138a/138m-504)

**Output Impedance**

![Output Impedance Graph](138a/138m-505)

**Minimum Operating Current**

![Minimum Operating Current Graph](138a/138m-506)

**Ripple Rejection**

![Ripple Rejection Graph 1](138a/138m-507)

![Ripple Rejection Graph 2](138a/138m-508)

**Current Limit**

![Current Limit Graph 1](138a/138m-510)

![Current Limit Graph 2](138a/138m-511)

For more information, visit www.linear.com/LT138A
**APPLICATIONS INFORMATION**

**General**

The LT138A develops a 1.25V reference voltage between the output and the adjustable terminal (see Figure 1). By placing a resistor, R1, between these two terminals, a constant current is caused to flow through R1 and down through R2 to set the overall output voltage. Normally this current is the specified minimum load current of 5mA or 10mA. Because I_{ADJ} is very small and constant when compared with the current through R1, it represents a small error and can usually be ignored. It is easily seen from the output voltage equation, that even if the resistors were of exact value, the accuracy of the output is limited by the accuracy of V_{REF}. Earlier adjustable regulators had a reference tolerance of ±4% which is dangerously close to the ±5% supply tolerance required in many logic and analog systems. Further, even 1% resistors can drift 0.01%/°C, adding additional error to the output voltage tolerance.

For example, using 2% resistors and ±4% tolerance for V_{REF}, calculations will show that the expected range of a 5V regulator design would be 4.66V ≤ V_{OUT} ≤ 5.36V or approximately ±7%. If the same example were used for a 15V regulator, the expected tolerance would be ±8%. With these results most applications required some method of trimming, usually a trim pot. This solution is both expensive and not conductive to volume production.

One of the enhancements of Linear Technology’s adjustable regulators over existing devices is the tightened initial tolerance of V_{REF}. This allows relatively inexpensive 1% or 2% film resistors to be used for R1 and R2 to set the output voltage within an acceptable tolerance.

With a guaranteed 1% reference, a 5V power supply design, using ±2% resistors, would have a worst-case manufacturing tolerance of ±4%. If 1% resistors are used, the tolerance will drop to ±2.5%. A plot of the worst-case output voltage tolerance as a function of resistor tolerance is shown on the front page of this data sheet.

For convenience, a table of standard 1% resistor values is shown in Table 1.

---

**Figure 1. Basic Adjustable Regulator**

---
Table 1. 0.5% and 1% Standard Resistance Values

<table>
<thead>
<tr>
<th>Value</th>
<th>0.5% Resistance</th>
<th>1% Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.47</td>
<td>2.15</td>
</tr>
<tr>
<td>1.02</td>
<td>1.50</td>
<td>2.21</td>
</tr>
<tr>
<td>1.05</td>
<td>1.54</td>
<td>2.26</td>
</tr>
<tr>
<td>1.07</td>
<td>1.58</td>
<td>2.32</td>
</tr>
<tr>
<td>1.10</td>
<td>1.62</td>
<td>2.37</td>
</tr>
<tr>
<td>1.13</td>
<td>1.65</td>
<td>2.43</td>
</tr>
<tr>
<td>1.15</td>
<td>1.69</td>
<td>2.49</td>
</tr>
<tr>
<td>1.18</td>
<td>1.74</td>
<td>2.55</td>
</tr>
<tr>
<td>1.21</td>
<td>1.78</td>
<td>2.61</td>
</tr>
<tr>
<td>1.24</td>
<td>1.82</td>
<td>2.67</td>
</tr>
<tr>
<td>1.27</td>
<td>1.87</td>
<td>2.74</td>
</tr>
<tr>
<td>1.30</td>
<td>1.91</td>
<td>2.80</td>
</tr>
<tr>
<td>1.33</td>
<td>1.96</td>
<td>2.87</td>
</tr>
<tr>
<td>1.37</td>
<td>2.00</td>
<td>2.94</td>
</tr>
<tr>
<td>1.40</td>
<td>2.05</td>
<td>3.01</td>
</tr>
<tr>
<td>1.43</td>
<td>2.10</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Standard resistance values are obtained from the Decade Table by multiplying by multiples of 10. As an example, 1.21 can represent 1.21 Ω, 12.1 Ω, 121 Ω, 1.21k etc.

Bypass Capacitors

Input bypassing using a 1μF tantalum or 25μF electrolytic is recommended when the input filter capacitors are more than 5 inches from the device. Improved ripple rejection (80dB) can be accomplished by adding a 10μF capacitor from the ADJ pin to ground. Increasing the size of the capacitor to 20μF will help ripple rejection at low output voltage since the reactance of this capacitor should be small compared to the voltage setting resistor, R2. For improved AC transient response and to prevent the possibility of oscillation due to unknown reactive load, a 1μF capacitor is also recommended at the output. Because of their low impedance at high frequencies, the best type of capacitor to use is solid tantalum.

Protection Diodes

The LT138A/LT338A do not require a protection diode from the adjustment terminal to the output (see Figure 2). Improved internal circuitry eliminates the need for this diode when the adjustment pin is bypassed with a capacitor to improve ripple rejection.

If a very large output capacitor is used, such as a 100μF shown in Figure 2, the regulator could be damaged or destroyed if the input is accidentally shorted to ground or crowbarred, due to the output capacitor discharging into the output terminal of the regulator. To prevent this, a diode D1 as shown, is recommended to safely discharge the capacitor.

Load Regulation

Because the LT138A is a three-terminal device, it is not possible to provide true remote load sensing. Load regulation will be limited by the resistance of the wire connecting the regulator to the load. The data sheet specification for load regulation is measured at the bottom of the package. Negative side sensing is a true Kelvin connection, with the bottom of the output divider returned to the negative side of the load. Although it may not be immediately obvious, best load regulation is obtained when the top of the resistor divider, R1, is connected directly to the case not to the load. This is illustrated in Figure 3. If R1 were connected to the load, the effective resistance between the regulator and the load would be:

\[ R_p = \frac{(R_2 + R_1)}{R_1} \]

where \( R_p \) is the Parasitic Line Resistance.

Connected as shown, \( R_p \) is not multiplied by the divider ratio. \( R_p \) is about 0.004Ω per foot using 16 gauge wire. This translates to 4mV/ft at 1A load current, so it is important to keep the positive lead between regulator and load as short as possible, and use large wire or PC board traces.
For more information www.linear.com/LT138A
TYPICAL APPLICATIONS

5V Regulator with Shutdown

Temperature Compensated Lead Acid Battery Charger

Remote Sensing
PACKAGE DESCRIPTION


**K Package**

2-Lead TO-3 Metal Can

(Reference LTC DWG # 05-08-1310)

![Diagram of K Package 2-Lead TO-3 Metal Can](image)

**OBSOLETE PACKAGE**

For more information [www.linear.com/LT138A](http://www.linear.com/LT138A)
LT138A/LT339A
LM138/LM338

PACKAGE DESCRIPTION
Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

P Package
3-Lead Plastic TO-3P (Similar to TO-247)
(Reference LTC DWG # 05-08-1450)

BOTTOM VIEW OF TO-3P
HATCHED AREA IS SOLDER PLATED COPPER HEAT SINK

EJECTOR PIN MARKS

MOUNTING HOLE

3-7

18 – 22

107 – 129
(2.71 – 3.25)

113 – 123
(2.87 – 3.13)

.074 – .084
(.19 – .213)

.020 – .040
(.51 – 1.02)

.097 – .102
(2.46 – 2.56)

.215
(5.46)

BSC

.060 – .080
(1.52 – 2.03)

.020 – .040
(.51 – 1.02)

P 2001

For more information www.linear.com/LT138A
# Revision History

(Revision history begins at Rev D)

<table>
<thead>
<tr>
<th>REV</th>
<th>DATE</th>
<th>DESCRIPTION</th>
<th>PAGE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>05/15</td>
<td>Obsolete packaged parts.</td>
<td>1, 2, 12</td>
</tr>
</tbody>
</table>


TYPICAL APPLICATION

Lamp Flasher

Automatic Light Control

Protected High Current Lamp Driver

RELATED PARTS

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1083/LT1084/ LT1085</td>
<td>3A/5A/7.5A Low Dropout Regulators Fixed Outputs, $V_{IN}$ Up to 30V</td>
<td></td>
</tr>
<tr>
<td>LT1580</td>
<td>7A Fast Transient Response Regulator with 0.7V Dropout For 3.3V to 2.xxV Applications</td>
<td></td>
</tr>
<tr>
<td>LT1581</td>
<td>10A Fast Transient Response Regulator For 3.3V to 2.xxV Applications</td>
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</tr>
<tr>
<td>LT1584/LT1585/ LT1587</td>
<td>7A/4.6A/3A Low Dropout Fast Transient Response Regulator For 1.2V to 3.3V Outputs from 5V</td>
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</tr>
<tr>
<td>LT1764</td>
<td>3A Fast Transient Response Regulator Dropout Voltage 340mV, Low Noise: 40µV_{RMS}</td>
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