The LT®1038 is a three terminal regulator which is capable of providing in excess of 10A output current over 1.2V to 32V range. The device is packaged in a standard T0-3 power package and is plug-in compatible with industry standard adjustable regulators, such as the LM117 and LM138. Also, the LT1038 is a functional replacement for the LM396.

In addition to excellent load and line regulations, the LT1038 is fully protected by current limiting, safe area protection and thermal shutdown. New current limiting circuitry allows transient load currents up to 24A to be supplied for 500μs without causing the regulator to current limit and drop out of regulation during the transient. On-chip trimming of initial reference voltage to ±0.8% combined with 0.4% load regulation minimize errors in all high current applications. Further, the LT1038 is manufactured with standard bipolar processing and has Linear Technology’s high reliability.

**APPLICATIONS**
- System Power Supplies
- High Power Linear Regulator
- Battery Chargers
- Power Driver
- Constant Current Regulator

**FEATURES**
- Guaranteed 0.8% Initial Tolerance
- Guaranteed 0.4% Load Regulation
- Guaranteed 10A Output Current
- 100% Thermal Limit Burn-In
- 24A Transient Output Current
- Standard Adjustable Pinout
- Operates to 35V

**DESCRIPTION**

The LT®1038 is a three terminal regulator which is capable of providing in excess of 10A output current over 1.2V to 32V range. The device is packaged in a standard TO-3 power package and is plug-in compatible with industry standard adjustable regulators, such as the LM117 and LM138. Also, the LT1038 is a functional replacement for the LM396.

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### ABSOLUTE MAXIMUM RATINGS

*Note 1*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LT1038M</th>
<th>LT1038C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Dissipation</td>
<td>Internally Limited</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Input to Output Voltage Differential</td>
<td>35V</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Operating Junction Temperature Range</td>
<td>LT1038M Control Circuitry: –55°C to 150°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>LT1038M Power Transistor: –55°C to 200°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>LT1038C Control Circuitry: 0°C to 125°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>LT1038C Power Transistor: 0°C to 175°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>–65°C to 150°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lead Temperature (Soldering, 10 sec)</td>
<td>300°C</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{REF}} )</td>
<td>Reference Voltage</td>
<td>( I_{\text{OUT}} = 20 \text{mA}, T_j = 25°C )</td>
<td>1.24</td>
<td>1.25</td>
<td>1.26</td>
<td>1.23</td>
<td>1.25</td>
<td>1.275</td>
<td>V</td>
</tr>
<tr>
<td>( \Delta V_{\text{OUT}} )</td>
<td>Line Regulation</td>
<td>( 3V \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 35V, I_{\text{OUT}} = 20 \text{mA} ) (Note 3)</td>
<td>0.005</td>
<td>0.01</td>
<td></td>
<td>0.005</td>
<td>0.02</td>
<td>0.03</td>
<td>%/V</td>
</tr>
<tr>
<td>( \Delta V_{\text{IN}} )</td>
<td>Load Regulation</td>
<td>( 20 \text{mA} \leq I_{\text{OUT}} \leq 10 \text{A} ) (Note 3)</td>
<td>0.1</td>
<td>0.4</td>
<td></td>
<td>0.1</td>
<td>0.6</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Thermal Regulation</td>
<td>20ms Pulse</td>
<td>0.002</td>
<td>0.005</td>
<td></td>
<td>0.002</td>
<td>0.01</td>
<td></td>
<td>%/W</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{ADJ}} )</td>
<td>Adjust Pin Current</td>
<td>●</td>
<td>50</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td></td>
<td></td>
<td>( \mu \text{A} )</td>
</tr>
<tr>
<td>( \Delta I_{\text{ADJ}} )</td>
<td>Adjust Pin Current Change</td>
<td>( 20 \text{mA} \leq I_{\text{OUT}} \leq 10 \text{A} ) (Note 3)</td>
<td>0.2</td>
<td>3</td>
<td></td>
<td>0.2</td>
<td>3</td>
<td></td>
<td>( \mu \text{A} )</td>
</tr>
<tr>
<td>Minimum Load Current</td>
<td>( (V_{\text{IN}} - V_{\text{OUT}}) = 35V ) ( (V_{\text{IN}} - V_{\text{OUT}}) \leq 20V )</td>
<td>7</td>
<td>20</td>
<td></td>
<td>7</td>
<td>20</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>( I_{\text{SC}} )</td>
<td>Current Limit</td>
<td>( (V_{\text{IN}} - V_{\text{OUT}}) \leq 10V ) ( \text{DC} ) ( \text{Trans} 0.5\text{ms} )</td>
<td>10</td>
<td>14</td>
<td></td>
<td>14</td>
<td>14</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>( (V_{\text{IN}} - V_{\text{OUT}}) = 30V, T_j = 25°C )</td>
<td>1</td>
<td>2</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>( \Delta V_{\text{OUT}} )</td>
<td>Temperature Stability</td>
<td>●</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>( \Delta V_{\text{Temp}} )</td>
<td>Long Term Stability</td>
<td>( T_A = 125°C, 1000 \text{ Hours} )</td>
<td>0.3</td>
<td>1</td>
<td>0.3</td>
<td>1</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>( \theta_{\text{JA}} )</td>
<td>RMS Output Noise</td>
<td>( 10Hz \leq f \leq 10kHz )</td>
<td>0.001</td>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>( \theta_{\text{JC}} )</td>
<td>Thermal Resistance Junction to Case</td>
<td>Power Transistor Control Circuitry</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
</tbody>
</table>

### ORDER PART NUMBER

- LT1038MK
- LT1038CK

**PRECONDITIONING**

100% Thermal Limit Burn-in
**ELECTRICAL CHARACTERISTICS**

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Unless otherwise specified, these specifications apply:

- $V_{IN} - V_{OUT} = 5V$ and $I_{OUT} = 5A$. These specifications are applicable for power dissipations up to 75W. At input-output voltage differentials greater than 10V, achievable output current and power dissipation decrease due to protection circuitry.

**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**

![Dropout Voltage Graph](image1)

- Dropout Voltage
- $\Delta V_{OUT} = 100\text{mV}$
- $I_{OUT} = 10A$
- $I_{OUT} = 6A$
- $I_{OUT} = 2A$

![Adjustment Current Graph](image2)

- Adjustment Current
- $I_{ADJ} = 65\mu A$
- $I_{ADJ} = 60\mu A$
- $I_{ADJ} = 55\mu A$
- $I_{ADJ} = 50\mu A$

![Temperature Stability Graph](image3)

- Temperature Stability
- $T_j = 150\degree C$
- $T_j = 125\degree C$
- $T_j = 100\degree C$
- $T_j = 75\degree C$
- $T_j = 50\degree C$
- $T_j = 25\degree C$
- $T_j = 0\degree C$
- $T_j = -5\degree C$
- $T_j = -25\degree C$
- $T_j = -50\degree C$

![Output Impedance Graph](image4)

- Output Impedance
- $V_{IN} = 15V$
- $V_{OUT} = 10V$
- $I_{OUT} = 1A$

![Minimum Operating Current Graph](image5)

- Minimum Operating Current
- $I_{MIN} = 10\text{mA}$
- $I_{MIN} = 8\text{mA}$
- $I_{MIN} = 6\text{mA}$
- $I_{MIN} = 4\text{mA}$
- $I_{MIN} = 2\text{mA}$

![Ripple Rejection Graph](image6)

- Ripple Rejection
- $V_{IN} - V_{OUT} = 5V$
- $I_{OUT} = 1A$
- $f = 120Hz$
- $T_j = 25\degree C$
- $T_j = 55\degree C$
- $T_j = 150\degree C$
TYPICAL PERFORMANCE CHARACTERISTICS

Ripple Rejection

FREQUENCY (Hz)

LOAD TRANSIENT RESPONSE

INPUT-OUTPUT DIFFERENTIAL (V)

OUTPUT CURRENT (A)

OUTPUT VOLTAGE DEVIATION (V)

LOAD CURRENT (A)

INPUT VOLTAGE CHANGE (V)

PRELOAD CURRENT = 0A

PEAK CURRENT LIMIT

PEAK CURRENT LIMIT

DC CURRENT LIMIT

TCASE = 25°C

TCASE = 25°C

PRELOAD = 10A

PRELOAD = 2A

PRELOAD = 0A

VIN = 15V

VOUT = 10V

VOUT = 10V

VOUT = 10V

IOUT = 1A

Vin – VOUT = 15V

Vin – VOUT = 20V

VIN = 10V

VOUT = 5V

CASE = 25°C

IOUT = 100mA

Tj = 25°C

CL = 1µF; CADJ = 10µF

CL = 0µF; CADJ = 0µF

CL = 0µF; CADJ = 0µF
**APPLICATIONS INFORMATION**

**General**

The LT1038 develops a 1.25V reference voltage between the output and the adjustment 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 10mA or 20mA. 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.

**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 LT1038 does 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 LT1038 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 can be a true Kelvin connection if the bottom of resistor R2 is 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:

\[
R_p \cdot \left( \frac{R_2 + R_1}{R_1} \right) = \text{Parasitic Line Resistance}
\]

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 lead between the regulator and the load as short as possible, and use large wire or PC board traces.
**TYPICAL APPLICATIONS**

**Paralleling Regulators**

- **LT1038**
  - **VIN**
  - **VOUT (ADJ)**
  - **R1 120Ω**
  - **R2**
  - **2 FEET #18 WIRE***
  - **VOUT = 1.25 \(1 + \frac{R2}{R1}\)**
  - **IOUT = 0A TO 20A**
  - **THE #18 WIRE ACTS AS BALLAST RESISTANCE INSURING CURRENT SHARING BETWEEN BOTH DEVICES**

---

**10A Variable Regulator***

- **LT1038**
  - **VIN**
  - **VOUT (ADJ)**
  - **T1 TRIAD F-269U**
  - **C30B**
  - **1N4003**
  - **20Ω**
  - **C1 50,000µF**
  - **L 1MHz**
  - **L1**
  - **110V AC**
  - **NC**
  - **10k**
  - **15k**
  - **1N403**
  - **1N403**
  - **2N3904**
  - **0.1µF**
  - **LM301A**
  - **NC**
  - **120Ω**
  - **10k**
  - **15k**

*1% FILM RESISTOR L-DALE TO-5 TYPE T2-STANCOR 11Z-2003

GENERAL PURPOSE REGULATOR WITH SCR PREREGULATOR TO LOWER POWER DISSIPATION. ABOUT 4V DIFFERENTIAL IS MAINTAINED ACROSS THE LT1038 INDEPENDENT OF OUTPUT VOLTAGE AND LOAD CURRENT.

---

* THIS INFORMATION IS SUBJECT TO CHANGE WITHOUT NOTICE. FOR THE LATEST SPECIFICATIONS, PLEASE CONTACT LINEAR TECHNOLOGY.
**TYPICAL APPLICATIONS**

**Improving Ripple Rejection**

![Diagram of Improving Ripple Rejection](image)

*C1 IMPROVES RIPPLE REJECTION. C2 SHOULD BE SMALL COMPARED TO R2.*

**1.2V to 25V Adjustable Regulator**

![Diagram of 1.2V to 25V Adjustable Regulator](image)

*NEEDED IF DEVICE IS FAR FROM FILTER CAPACITORS
†OPTIONAL—IMPROVES TRANSIENT RESPONSE
†† VOUT = 1.25V (1 + R2/R1)

**5V Regulator with Shutdown**

![Diagram of 5V Regulator with Shutdown](image)

**Remote Sensing**

![Diagram of Remote Sensing](image)

**Temperature Compensated Lead Acid Battery Charger**

![Diagram of Temperature Compensated Lead Acid Battery Charger](image)

*LOAD ON BATTERY = 200µA WHEN NOT CHARGING*

**SCHEMATIC DIAGRAM**

![Schematic Diagram](image)
**TYPICAL APPLICATIONS**

**Lamp Flasher**

**Automatic Light Control**

**Protected High Current Lamp Driver**

**PACKAGE DESCRIPTION**
Dimensions in inches (millimeters) unless otherwise noted.

**RELATED PARTS**

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1084</td>
<td>Low Dropout, 0.01% Load Regulation</td>
<td>7.5A Max Current Output</td>
</tr>
<tr>
<td>LT1581</td>
<td>Low Dropout, 430mV at 10A</td>
<td>Best Replacement</td>
</tr>
<tr>
<td>LT1584</td>
<td>Low Dropout, 0.05% Load Regulation</td>
<td>7A Max Current Output</td>
</tr>
<tr>
<td>LT1585</td>
<td>Low Dropout, 0.05% Load Regulation</td>
<td>5A Max Current Output</td>
</tr>
</tbody>
</table>