FEATURES
- 3-Terminal Adjustable or Fixed
  2.85V, 3.3V, 3.6V, 5V, 12V
- Output Current of 1.5A, (0.5A for LT1086H)
- Operates Down to 1V Dropout
- Guaranteed Dropout Voltage at Multiple Current Levels
- Line Regulation: 0.015%
- Load Regulation: 0.1%
- 100% Thermal Limit Functional Test

APPLICATIONS
- SCSI-2 Active Terminator
- High Efficiency Linear Regulators
- Post Regulators for Switching Supplies
- Constant Current Regulators
- Battery Chargers
- Microprocessor Supply

DESCRIPTION
The LT®1086 is designed to provide 1.5A with higher efficiency than currently available devices. All internal circuitry is designed to operate down to 1V input-to-output differential and the dropout voltage is fully specified as a function of load current. Dropout is guaranteed at a maximum of 1.5V at maximum output current, decreasing at lower load currents. On-chip trimming adjusts the reference/output voltage to 1%. Current limit is also trimmed, minimizing the stress on both the regulator and power source circuitry under overload conditions.

The LT1086 is pin compatible with older 3-terminal adjustable regulators. A 10µF output capacitor is required on these new devices; however, this is usually included in most regulator designs.

A 2.85V output version is offered for SCSI-2 active termination. For surface mount applications see the LT1117-2.85 data sheet. For high current or lower dropout requirements see the LT1123-2.85 data sheet.

Unlike PNP regulators, where up to 10% of the output current is wasted as quiescent current, the LT1086 quiescent current flows into the load, increasing efficiency.

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TYPICAL APPLICATION

5V to 3.3V Regulator

$V_{IN} \geq 4.75V$

$10\mu F$ TANTALUM

* MAY BE OMITTED IF INPUT SUPPLY IS WELL BYPASSED WITHIN 2" OF THE LT1086

LT1086 Dropout Voltage

- $-55^\circ C \leq T_J \leq 150^\circ C$
- $0^\circ C \leq T_J \leq 125^\circ C$
- $T_J = -55^\circ C$
- $T_J = 25^\circ C$
- $T_J = 150^\circ C$

$V_{MIN} = 3.3V$ AT 1.5A
**ABSOLUTE MAXIMUM RATINGS**

Power Dissipation ................................. Internally Limited
Input Voltage (Note 1) ............................... 30V

Operating Input Voltage
  Adjustable Devices ................................. 25V
  2.85V Devices ................................. 18V
  3.3V, 3.6V, and 5V Devices .................. 20V
  12V Devices ................................. 25V

Operating Junction Temperature Range
  “C” Grades
    Control Section ............................... 0°C to 125°C
    Power Transistor .......................... –40°C to 125°C

  “I” Grades
    Control Section .......................... –40°C to 125°C
    Power Transistor .......................... –40°C to 150°C

  “M” Grades
    Control Section .......................... –55°C to 150°C
    Power Transistor ........................ –55°C to 200°C

Storage Temperature Range .................. –65°C to 150°C

Lead Temperature (Soldering, 10 sec) .............. 300°C

**Note 1:** Although the device’s maximum operating voltage is limited, (18V for a 2.85V device, 20V for a 5V device, and 25V for adjustable and 12V devices) the devices are guaranteed to withstand transient input voltages up to 30V. For input voltages greater than the maximum operating input voltage some degradation of specifications will occur. For fixed voltage devices operating at input/output voltage differentials greater than 15V, a minimum external load of 5mA is required to maintain regulation.

**PRECONDITIONING**

100% Thermal Shutdown Functional Test.

---

**PACKAGE/ORDER INFORMATION**

<table>
<thead>
<tr>
<th>ORDER PART NUMBER</th>
<th>FRONT VIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1086CH</td>
<td>M PACKAGE</td>
</tr>
<tr>
<td>LT1086MH</td>
<td>3-LEAD PLASTIC DIP</td>
</tr>
<tr>
<td></td>
<td>( \theta_{JA} = 30°C/W ) **</td>
</tr>
<tr>
<td></td>
<td>** WITH PACKAGE SOLDERED TO 0.5IN² COPPER AREA OVER BACKSIDE GROUND PLANE OR INTERNAL POWER PLANE. ( \theta_{JA} ) CAN VARY FROM 20°C/W TO &gt;40°C/W DEPENDING ON MOUNTING TECHNIQUE.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORDER PART NUMBER</th>
<th>FRONT VIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1086CK</td>
<td>T PACKAGE</td>
</tr>
<tr>
<td>LT1086CK-5</td>
<td>3-LEAD PLASTIC TO-220</td>
</tr>
<tr>
<td>LT1086CK-12</td>
<td>( \theta_{JA} = 50°C/W )</td>
</tr>
</tbody>
</table>

*For fixed versions.*
# ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Voltage</td>
<td>$I_{OUT} = 10mA, T_J = 25^\circ C, (V_{IN} – V_{OUT}) = 3V$</td>
<td>1.238</td>
<td>1.250</td>
<td>1.262</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$10mA \leq I_{OUT} \leq 1.5A, (0.5A for LT1086H), 1.5V \leq (V_{IN} – V_{OUT}) \leq 15V$</td>
<td>1.225</td>
<td>1.250</td>
<td>1.270</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>$I_{OUT} = 0mA, T_J = 25^\circ C, V_{IN} = 5V$</td>
<td>2.82</td>
<td>2.85</td>
<td>2.88</td>
<td>V</td>
</tr>
<tr>
<td>(Note 2)</td>
<td>$0V \leq I_{OUT} \leq 1.5A, 4.75V \leq V_{IN} \leq 18V$</td>
<td>2.79</td>
<td>2.85</td>
<td>2.91</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5V, I_{OUT} = 0mA, T_J = 25^\circ C$</td>
<td>3.267</td>
<td>3.300</td>
<td>3.333</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$0V \leq I_{OUT} \leq 1.5A, 4.75V \leq V_{IN} \leq 18V$</td>
<td>3.235</td>
<td>3.300</td>
<td>3.365</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5V, I_{OUT} = 0mA, T_J = 25^\circ C$</td>
<td>3.564</td>
<td>3.600</td>
<td>3.636</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$5V \leq V_{IN} \leq 18V, 0 \leq I_{OUT} \leq 1.5A$</td>
<td>3.500</td>
<td>3.672</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$4.75V \leq V_{IN} \leq 18V, 0 \leq I_{OUT} \leq 1A, T_J \geq 0^\circ C$</td>
<td>3.500</td>
<td>3.672</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 4.75V, I_{OUT} = 1.5A, T_J \geq 0^\circ C$</td>
<td>3.300</td>
<td>3.672</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Line Regulation</td>
<td>$I_{LOAD} = 10mA, 1.5V \leq (V_{IN} – V_{OUT}) \leq 15V, T_J = 25^\circ C$</td>
<td>0.015</td>
<td>0.2</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{LOAD} = 0mA, T_J = 25^\circ C, 4.35V \leq V_{IN} \leq 18V$</td>
<td>0.3</td>
<td>6</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{LOAD} = 0mA, T_J = 25^\circ C$</td>
<td>0.6</td>
<td>6</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$4.5V \leq V_{IN} \leq 18V, I_{OUT} = 0mA, T_J = 25^\circ C$</td>
<td>0.5</td>
<td>10</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$4.75V \leq V_{IN} \leq 18V, I_{OUT} = 0mA, T_J = 25^\circ C$</td>
<td>0.5</td>
<td>10</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$6.5V \leq V_{IN} \leq 20V$</td>
<td>0.5</td>
<td>10</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{OUT} = 0mA, T_J = 25^\circ C, 13.5V \leq V_{IN} \leq 25V$</td>
<td>1.0</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td>$I_{OUT} = 0mA, T_J = 25^\circ C, 13.5V \leq V_{IN} \leq 25V$</td>
<td>1.0</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>$(V_{IN} – V_{OUT}) = 3V, 10mA \leq I_{OUT} \leq 1.5A, (0.5A for LT1086H)$</td>
<td>0.1</td>
<td>0.3</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>(Note 2)</td>
<td>$T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>0.2</td>
<td>0.4</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5V, 0 \leq I_{OUT} \leq 1.5A, T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>3</td>
<td>12</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5V, 0 \leq I_{OUT} \leq 1.5A, T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>3</td>
<td>15</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5.25V, 0 \leq I_{OUT} \leq 1.5A, T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>3</td>
<td>15</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 5V, 0 \leq I_{OUT} \leq 1A, T_J = 25^\circ C$</td>
<td>6</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 8V, 0 \leq I_{OUT} \leq 1.5A, T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>2</td>
<td>15</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 15V, 0 \leq I_{OUT} \leq 1.5A, T_J = 25^\circ C$ (Notes 1, 2)</td>
<td>4</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>$(V_{IN} – V_{OUT}) = 3V, 10mA \leq I_{OUT} \leq 1.5A, (0.5A for LT1086H)$</td>
<td>1.3</td>
<td>1.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(Note 3)</td>
<td>$V_{IN} = 0.5A$</td>
<td>0.95</td>
<td>1.25</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Specifications are valid for ambient temperature range. 
2. Measurements done with DC conditions.
3. Dropout voltage for LT1086H is measured at $I_{OUT} = 0.5A$.
## Electrical Characteristics

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Limit</strong></td>
<td>LT1086/-2.85/-3.3/-3.6/-5/-12 (VIN – VOUT) = 5V</td>
<td>1.50</td>
<td>2.00</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>(VIN – VOUT) = 25V</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>LT1086H (VIN – VOUT) = 5V</td>
<td>0.50</td>
<td>0.700</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>(VIN – VOUT) = 25V</td>
<td>0.02</td>
<td>0.075</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td><strong>Minimum Load Current</strong></td>
<td>LT1086/LT1086H (VIN – VOUT) = 25V (Note 4)</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td><strong>Quiescent Current</strong></td>
<td>LT1086-2.85 VIN ≤ 18V</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>LT1086-3.3 VIN ≤ 18V</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>LT1086-3.6 VIN ≤ 18V</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>LT1086-5 VIN ≤ 20V</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>LT1086-12 VIN ≤ 25V</td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td><strong>Thermal Regulation</strong></td>
<td>T_A = 25°C, 30ms pulse</td>
<td>0.008</td>
<td>0.04</td>
<td></td>
<td>%/W</td>
</tr>
<tr>
<td><strong>Ripple Rejection</strong></td>
<td>f = 120Hz, C_OUT = 25µF Tantalum, I_OUT = 1.5A, (I_OUT = 0.5A for LT1086H)</td>
<td>60</td>
<td>75</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1086, LT1086H C_ADJ = 25µF, (VIN – VOUT) = 9V</td>
<td>60</td>
<td>72</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1086-2.85 VIN = 6V</td>
<td>60</td>
<td>72</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1086-3.3 VIN = 6.3V</td>
<td>60</td>
<td>72</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1086-3.6 VIN = 6.6V</td>
<td>60</td>
<td>72</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1086-5 VIN = 8V</td>
<td>60</td>
<td>68</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LT1083-12 VIN = 15V</td>
<td>54</td>
<td>60</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td><strong>Adjust Pin Current</strong></td>
<td>LT1086, LT1086H T_J = 25°C</td>
<td>55</td>
<td></td>
<td>120</td>
<td>µA</td>
</tr>
<tr>
<td><strong>Adjust Pin Current Change</strong></td>
<td>LT1086, LT1086H 10mA ≤ I_OUT ≤ 1.5A, (0.5A for LT1086H)</td>
<td>0.2</td>
<td>5</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td><strong>Temperature Stability</strong></td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td><strong>Long Term Stability</strong></td>
<td>T_A = 125°C, 1000 Hrs.</td>
<td>0.3</td>
<td>1</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td><strong>RMS Output Noise (% of V_OUT)</strong></td>
<td>T_A = 25°C, 10Hz = f ≤ 10kHz</td>
<td>0.003</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td><strong>Thermal Resistance</strong></td>
<td>H Package: Control Circuitry/Power Transistor</td>
<td>15/20</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td>K Package: Control Circuitry/Power Transistor</td>
<td>1.7/4.0</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td>M Package: Control Circuitry/Power Transistor</td>
<td>1.5/4.0</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td>T Package: Control Circuitry/Power Transistor</td>
<td>1.5/4.0</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
</tbody>
</table>

Note 1: See thermal regulation specifications for changes in output voltage due to heating effects. Line and load regulation are measured at a constant junction temperature by low duty cycle pulse testing. Load regulation is measured at the output lead = 1/8” from the package.

Note 2: Line and load regulation are guaranteed up to the maximum power dissipation of 15W (3W for the LT1086H). Power dissipation is determined by the input/output differential and the output current. Guaranteed maximum power dissipation will not be available over the full input/output range. See Short-Circuit Current curve for available output current.

Note 3: Dropout voltage is specified over the full output current range of the device. Test points and limits are shown on the Dropout Voltage curve.

Note 4: Minimum load current is defined as the minimum output current required to maintain regulation. At 25V input/output differential the device is guaranteed to regulate if the output current is greater than 10mA.
LT1086 Series

TYPICAL PERFORMANCE CHARACTERISTICS

LT1086H Ripple Rejection

<table>
<thead>
<tr>
<th>FREQUENCY (Hz)</th>
<th>RIPPLE REJECTION (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>1k</td>
<td>80</td>
</tr>
<tr>
<td>10k</td>
<td>70</td>
</tr>
<tr>
<td>100k</td>
<td>60</td>
</tr>
</tbody>
</table>

- \( V_{ripples} \leq 3V_{pp} \)
- \( V_{ripples} = 0.5V_{pp} \)

- \( (V_{IN} - V_{OUT}) \geq 3V \)
- \( (V_{IN} - V_{OUT}) \geq V_{DROP} \)

- \( C_{ADJ} = 200\mu F \) AT FREQUENCIES < 60Hz
- \( C_{ADJ} = 25\mu F \) AT FREQUENCIES > 60Hz
- \( V_{OUT} = 0.5A \)

LT1086H Maximum Power Dissipation*

<table>
<thead>
<tr>
<th>CASE TEMPERATURE (°C)</th>
<th>POWER (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>120</td>
<td>5</td>
</tr>
<tr>
<td>140</td>
<td>LT1086MH</td>
</tr>
<tr>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

*AS LIMITED BY MAXIMUM JUNCTION TEMPERATURE

BLOCK DIAGRAM

[Block Diagram]

CADJ = 200\mu F AT FREQUENCIES < 60Hz
CADJ = 25\mu F AT FREQUENCIES > 60Hz
I_{OUT} = 0.5A
The LT1086 family of 3-terminal regulators is easy to use and has all the protection features that are expected in high performance voltage regulators. They are short-circuit protected, have safe area protection as well as thermal shutdown to turn off the regulator should the temperature exceed about 165°C at the sense point.

These regulators are pin compatible with older 3-terminal adjustable devices, offer lower dropout voltage and more precise reference tolerance. Further, the reference stability with temperature is improved over older types of regulators. The only circuit difference between using the LT1086 family and older regulators is that they require an output capacitor for stability.

Stability

The circuit design used in the LT1086 family requires the use of an output capacitor as part of the device frequency compensation. For all operating conditions, the addition of 150µF aluminum electrolytic or a 22µF solid tantalum on the output will ensure stability. Normally capacitors much smaller than this can be used with the LT1086. Many different types of capacitors with widely varying characteristics are available. These capacitors differ in capacitor tolerance (sometimes ranging up to ±100%), equivalent series resistance, and capacitance temperature coefficient. The 150µF or 22µF values given will ensure stability.

When using the LT1086 the adjustment terminal can be bypassed to improve ripple rejection. When the adjustment terminal is bypassed the requirement for an output capacitor increases. The values of 22µF tantalum or 150µF aluminum cover all cases of bypassing the adjustment terminal. For fixed voltage devices or adjustable devices without an adjust pin bypass capacitor, smaller output capacitors can be used with equally good results and the table below shows approximately what size capacitors are needed to ensure stability.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10µF</td>
<td>10µF Tantalum, 50µF Aluminum</td>
<td>None</td>
</tr>
<tr>
<td>10µF</td>
<td>22µF Tantalum, 150µF Aluminum</td>
<td>20µF</td>
</tr>
</tbody>
</table>

Normally, capacitor values on the order of 100µF are used in the output of many regulators to ensure good transient response with heavy load current changes. Output capacitance can be increased without limit and larger values of output capacitor further improve stability and transient response of the LT1086 regulators.

Another possible stability problem that can occur in monolithic IC regulators is current limit oscillations. These can occur because in current limit, the safe area protection exhibits a negative impedance. The safe area protection decreases the current limit as the input-to-output voltage increases. That is the equivalent of having a negative resistance since increasing voltage causes current to decrease. Negative resistance during current limit is not unique to the LT1086 series and has been present on all power IC regulators. The value of negative resistance is a function of how fast the current limit is folded back as input-to-output voltage increases. This negative resistance can react with capacitors or inductors on the input to cause oscillation during current limiting. Depending on the value of series resistance, the overall circuitry may end up unstable. Since this is a system problem, it is not necessarily easy to solve; however it does not cause any problems with the IC regulator and can usually be ignored.

Protection Diodes

In normal operation the LT1086 family does not need any protection diodes. Older adjustable regulators required protection diodes between the adjustment pin and the output and from the output to the input to prevent over-stressing the die. The internal current paths on the LT1086 adjustment pin are limited by internal resistors. Therefore, even with capacitors on the adjustment pin, no protection diode is needed to ensure device safety under short-circuit conditions.

Diodes between input and output are usually not needed. The internal diode between the input and the output pins of the LT1086 family can handle microsecond surge currents of 10A to 20A. Even with large output capacities, it is very difficult to get those values of surge currents in normal operation. Only with high value output capacitors such as 1000µF to 5000µF, and with the input pin instantaneously shorted to ground, can damage occur. A crowbar circuit at the input of the LT1086 can generate those kinds of currents and a diode from output to input is then recommended. Normal power supply cycling or even
plugging and unplugging in the system will not generate current large enough to do any damage.

The adjustment pin can be driven on a transient basis ±25V, with respect to the output without any device degradation. Of course as with any IC regulator, exceeding the maximum input-to-output voltage differential causes the internal transistors to break down and none of the protection circuitry is functional.

Ripple Rejection
For the LT1086 the typical curves for ripple rejection reflect values for a bypassed adjust pin. This curve will be true for all values of output voltage. For proper bypassing and ripple rejection approaching the values shown, the impedance of the adjust pin capacitor at the ripple frequency should equal the value of R1, (normally 100Ω to 120Ω). The size of the required adjust pin capacitor is a function of the input ripple frequency. At 120Hz the adjust pin capacitor should be 13µF if R1 = 100Ω. At 10kHz only 0.16µF is needed.

For circuits without an adjust pin bypass capacitor the ripple rejection will be a function of output voltage. The output ripple will increase directly as a ratio of the output voltage to the reference voltage (VOUT/VREF). For example, with the output voltage equal to 5V and no adjust pin capacitor, the output ripple will be higher by the ratio of 5V/1.25V or four times larger. Ripple rejection will be degraded by 12dB from the value shown on the LT1086 curve. Typical curves are provided for the 5V and 12V devices since the adjust pin is not available.

Output Voltage
The LT1086 develops a 1.25V reference voltage between the output and the adjust 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 chosen to be the specified minimum load current of 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. For fixed voltage devices R1 and R2 are included in the device.
Load Regulation

Because the LT1086 is a 3-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 2. If R1 were connected to the load, the effective resistance between the regulator and the load would be:

\[ R_P \left( \frac{R_2 + R_1}{R_1} \right), \quad R_P = \text{Parasitic Line Resistance} \]

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 positive lead between regulator and load as short as possible and use large wire or PC board traces.

Note that the resistance of the package leads for the H package = 0.06Ω/inch. While it is usually not possible to connect the load directly to the package, it is possible to connect larger wire or PC traces close to the case to avoid voltage drops that will degrade load regulation.

For fixed voltage devices the top of R1 is internally Kelvin connected and the ground pin can be used for negative side sensing.

Thermal Considerations

The LT1086 series of regulators have internal power and thermal limiting circuitry designed to protect the device under overload conditions. For continuous normal load conditions however, maximum junction temperature ratings must not be exceeded. It is important to give careful consideration to all sources of thermal resistance from junction to ambient. This includes junction-to-case, case-to-heat sink interface and heat sink resistance itself. New thermal resistance specifications have been developed to more accurately reflect device temperature and ensure safe operating temperatures. The data section for these new regulators provides a separate thermal resistance and maximum junction temperature for both the Control Section and the Power Transistor. Previous regulators, with a single junction-to-case thermal resistance specification, used an average of the two values provided here and therefore could allow excessive junction temperatures under certain conditions of ambient temperature and heat sink resistance. To avoid this possibility, calculations should be made for both sections to ensure that both thermal limits are met.

For example, using a LT1086CK (TO-3, Commercial) and assuming:

- \( V_{IN}(\text{max continuous}) = 9V, \quad V_{OUT} = 5V, \quad I_{OUT} = 1A, \quad T_A = 75^\circ C, \quad \theta_{\text{HEAT SINK}} = 3^\circ C/W, \quad \theta_{\text{CASE-TO-HEAT SINK}} = 0.2^\circ C/W \) for K package with thermal compound.

Power dissipation under these conditions is equal to:

\[ P_D = (V_{IN} - V_{OUT})(I_{OUT}) = 4W \]

Junction temperature will be equal to:

\[ T_J = T_A + P_D (\theta_{\text{HEAT SINK}} + \theta_{\text{CASE-TO-HEAT SINK}} + \theta_{JC}) \]

For the Control Section:

\[ T_J = 75^\circ C + 4W(3^\circ C/W + 0.2^\circ C/W + 0.7^\circ C/W) = 95^\circ C \]

95°C < 125°C = \( T_{J\text{MAX}} \) (Control Section Commercial Range)

For the Power Transistor:

\[ T_J = 75^\circ C + 4W(3^\circ C/W + 0.2^\circ C/W + 4^\circ C/W) = 103.8^\circ C \]

103.8°C < 150°C = \( T_{J\text{MAX}} \) (Power Transistor Commercial Range)
**APPLICATIONS INFORMATION**

In both cases the junction temperature is below the maximum rating for the respective sections, ensuring reliable operation.

Junction-to-case thermal resistance for the K and T packages is specified from the IC junction to the bottom of the case directly below the die. This is the lowest resistance path for heat flow. While this is also the lowest resistance path for the H package, most available heat sinks for this package are of the clip-on type that attach to the cap of the package. The data sheet specification for thermal resistance for the H package is therefore written to reflect this.

In all cases proper mounting is required to ensure the best possible heat flow from the die to the heat sink. Thermal compound at the case-to-heat sink interface is strongly recommended. In the case of the H package, mounting the device so that heat can flow out the bottom of the case will significantly lower thermal resistance (≈ a factor of 2). If the case of the device must be electrically isolated, a thermally conductive spacer can be used as long as its added contribution to thermal resistance is considered. Note that the case of all devices in this series is electrically connected to the output.

**TYPICAL APPLICATIONS**

**5V, 1.5A Regulator**

![5V, 1.5A Regulator Diagram]

**SCSI-2 Active Termination**

![SCSI-2 Active Termination Diagram]
**TYPICAL APPLICATIONS**

### 1.2V to 15V Adjustable Regulator

![1.2V to 15V Adjustable Regulator Diagram](LT1086_Typical_Appl_1)

*Needed if device is far from filter capacitors*

\[ V_{OUT} = 1.25V \left(1 + \frac{R_2}{R_T}\right) \]

### 5V Regulator with Shutdown

![5V Regulator with Shutdown Diagram](LT1086_Typical_Appl_2)

### Battery Charger

![Battery Charger Diagram](LT1086_Typical_Appl_3)

\[ I_f = \frac{V_{OUT} - 1.25}{-R_S \left(1 + \frac{R_2}{R_T}\right)} \]

\[ \frac{dI_f}{dV_{OUT}} = \frac{1}{-R_S \left(1 + \frac{R_2}{R_T}\right)} \]

### Adjusting Output Voltage of Fixed Regulators

![Adjusting Output Voltage of Fixed Regulators Diagram](LT1086_Typical_Appl_4)

*Optional improves ripple rejection*

### Regulator with Reference

![Regulator with Reference Diagram](LT1086_Typical_Appl_5)

### Protected High Current Lamp Driver

![Protected High Current Lamp Driver Diagram](LT1086_Typical_Appl_6)

### Remote Sensing

![Remote Sensing Diagram](LT1086_Typical_Appl_7)
**TYPICAL APPLICATIONS**

### High Efficiency Dual Linear Supply

```
12V
 IN  LT1086 • TA12
 OUT ADJ

1.5A

-12V
 IN  LT1086 • TA11
 OUT ADJ

1.5A
```

*1% FILM RESISTORS

MDA = MOTOROLA

L1 = PULSE ENGINEERING, INC. #PE-92106

---

**High Efficiency Dual Supply**

```
470 µF  2N6667 Q1
1000 µF  MBR360
2.4k
1k
510k
30k
20k*
20k*

-12V
1.5A
IN  LT1004-2.5
OUT ADJ
100 µF

12V
1.5A
IN  LT1086
OUT ADJ
100 µF
```

---

**Feedback Path**

```
5V OUTPUT
(TYPICAL)
470 µF

12V
1.5A
IN  LT1086
OUT ADJ
100 µF
```

---

*1% FILM RESISTORS

STANCOR P-8685

130VAC TO 90VAC

MDA201

2N6667 DARLINGTON

HEAT SINK

L1 = PULSE ENGINEERING, INC. #PE-92106

---

**HEAT SINK**

2N6667 DARLINGTON

HEAT SINK

2N6667 DARLINGTON

MDA201

470 µF

10k
1k
510k
30k
20k*

12V
1.5A
IN  LT1086
OUT ADJ
100 µF

-12V
1.5A
IN  LT1086
OUT ADJ
100 µF

---

**LINEAR TECHNOLOGY**

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**TYPICAL APPLICATIONS**

**Battery Backed Up Regulated Supply**

```
VIN   OUT
5.2V LINE 5V BATTERY
SELECT FOR CHARGE RATE
6.5V
```

**Improving Ripple Rejection**

```
VIN   OUT
R1 121Ω 1%
R2 365Ω 1%
C1 10µF*
VOUT = 5V
```

*C1 IMPROVES RIPPLE REJECTION. XC SHOULD BE ≈ R1 AT RIPPLE FREQUENCY*

**Automatic Light Control**

```
VIN   OUT
10µF
```

**Low Dropout Negative Supply**

```
VIN   OUT
10,000µF
VOUT = –12V
```

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

**H Package**

3-Lead TO-39 Metal Can
(LTC DWG # 05-08-1330)

*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND 0.045" BELOW THE REFERENCE PLANE*

**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS 0.016 – 0.024 (0.406 – 0.610)**
**PACKAGE DESCRIPTION**  Dimensions in inches (millimeters) unless otherwise noted.

**K Package**
2-Lead TO-3 Metal Can
(LTC DWG # 05-08-1310)

**M Package**
3-Lead Plastic DD Pak
(LTC DWG # 05-08-1460)

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.
LT1086 Series

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

T Package
3-Lead Plastic TO-220
(LTC DWG # 05-08-1420)

RELATED PARTS

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<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
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<td>LT1528</td>
<td>3A Low Dropout Regulator</td>
<td>0.55V Dropout for 5V to 4V Regulation</td>
</tr>
<tr>
<td>LT1587</td>
<td>3A Low Dropout Regulator</td>
<td>Fast Transient Response Reduces Decoupling Capacitance</td>
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