**LM723/LM723C Voltage Regulator**

**General Description**

The LM723/LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA, but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. The LM723/LM723C is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

The LM723C is identical to the LM723 except that the LM723C has its performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

**Features**

- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator

**Connection Diagrams**

**Dual-In-Line Package**

Order Number LM723J/883 or LM723CN
See NS Package J14A or N14A

**Metal Can Package**

Order Number LM723H, LM723H/883 or LM723CH
See NS Package H10C

Note: Pin 5 connected to case.
Connection Diagrams (Continued)

Equivalent Circuit

*Pin numbers refer to metal can package.

Typical Application

Note: \( R_3 = \frac{R_1 R_2}{R_1 + R_2} \)
for minimum temperature drift.

Typical Performance

- Regulated Output Voltage: 5V
- Line Regulation (\( \Delta V_{IN} = 3V \)): 0.5mV
- Load Regulation (\( \Delta I_L = 50\ mA \)): 1.5mV

FIGURE 1. Basic Low Voltage Regulator
(\( V_{OUT} = 2 \) to 7 Volts)
Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

(Note 10)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM723</th>
<th>LM723C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Regulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{IN} = 12V$ to $V_{IN} = 15V$</td>
<td></td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>$-55^\circ C \leq T_A \leq +125^\circ C$</td>
<td></td>
<td>0.3</td>
<td>0.01</td>
</tr>
<tr>
<td>$0^\circ C \leq T_A \leq +70^\circ C$</td>
<td></td>
<td>0.2</td>
<td>0.02</td>
</tr>
<tr>
<td>Load Regulation</td>
<td></td>
<td>0.03</td>
<td>0.15</td>
</tr>
<tr>
<td>$I_L = 1 mA$ to $I_L = 50 mA$</td>
<td></td>
<td>0.03</td>
<td>0.15</td>
</tr>
<tr>
<td>$-55^\circ C \leq T_A \leq +125^\circ C$</td>
<td></td>
<td>0.6</td>
<td>0.03</td>
</tr>
<tr>
<td>$0^\circ C \leq T_A \leq +70^\circ C$</td>
<td></td>
<td>0.6</td>
<td>0.03</td>
</tr>
<tr>
<td>Ripple Rejection</td>
<td>$f = 50$ Hz to $10$ kHz, $C_{REF} = 0$</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>$f = 50$ Hz to $10$ kHz, $C_{REF} = 5 \mu F$</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>Average Temperature Coefficient of Output Voltage (Note 8)</td>
<td>$-55^\circ C \leq T_A \leq +125^\circ C$</td>
<td>0.002</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>$0^\circ C \leq T_A \leq +70^\circ C$</td>
<td>0.003</td>
<td>0.015</td>
</tr>
<tr>
<td>Short Circuit Current Limit</td>
<td>$R_{SCP} = 100\Omega$, $V_{OUT} = 0$</td>
<td>65</td>
<td>65</td>
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<tr>
<td>Reference Voltage</td>
<td></td>
<td>6.95</td>
<td>7.15</td>
</tr>
<tr>
<td>Output Noise Voltage</td>
<td>$BW = 100$ Hz to $10$ kHz, $C_{REF} = 0$</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>$BW = 100$ Hz to $10$ kHz, $C_{REF} = 5 \mu F$</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Long Term Stability</td>
<td></td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Standby Current Drain</td>
<td>$I_L = 0$, $V_{IN} = 30V$</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td></td>
<td>9.5</td>
<td>40</td>
</tr>
<tr>
<td>Output Voltage Range</td>
<td></td>
<td>2.0</td>
<td>37</td>
</tr>
<tr>
<td>Input-Output Voltage Differential</td>
<td></td>
<td>3.0</td>
<td>38</td>
</tr>
<tr>
<td>$\theta_{JA}$</td>
<td></td>
<td>Molded DIP</td>
<td>105</td>
</tr>
<tr>
<td>$\theta_{JA}$ Cavity DIP</td>
<td></td>
<td>150</td>
<td>θC/W</td>
</tr>
<tr>
<td>$\theta_{JA}$ H10C Board Mount In Still Air</td>
<td></td>
<td>165</td>
<td>165</td>
</tr>
<tr>
<td>$\theta_{JA}$ H10C Board Mount In 400 LF/Min Air Flow</td>
<td></td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>$\theta_{JC}$</td>
<td></td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

Note 1: “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

Note 2: See derating curves for maximum power rating above 25°C.

Note 3: Unless otherwise specified, $T_A = 25^\circ C$, $V_{IN} = V_C = 12V$, $V_{OUT} = 6V$, $V_Z = 0$, $V_{CC} = 6V$, $I_L = 1 mA$, $R_{SCP} = 0$, $C_1 = 100$ pf, $C_{REF} = 0$, and divider impedance is seen by error amplifier $\leq 10$ kΩ connected as shown in Figure 7. Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.

Note 4: $L_1$ is 40 turns of No. 20 enamelled copper wire wound on Ferroncore P36/22-3B7 pot core or equivalent with 0.009 in. air gap.

Note 5: Figures in parentheses may be used if R1/R2 divider is placed on opposite input of error amp.

Note 6: Replace R1/R2 in figures with divider shown in Figure 13.

Note 7: $V^+$ and $V_{CC}$ must be connected to a $+3V$ or greater supply.

Note 8: For metal can applications where $V_Z$ is required, an external 6.2V zener diode should be connected in series with $V_{OUT}$.
Electrical Characteristics (Note 3) (Note 10) (Continued)

Note 9: Guaranteed by correlation to other tests.
Note 10: A military RETS specification is available on request. At the time of printing, the LM723 RETS specification complied with the Min and Max limits in this table. The LM723E, H, and J may also be procured as a Standard Military Drawing.

Typical Performance Characteristics

Load Regulation Characteristics with Current Limiting

Current Limiting Characteristics

Load Transient Response

Output Impedence vs Frequency

Load & Line Regulation vs Input-Output Voltage Differential

Standby Current Drain vs Input Voltage

Output Impedence vs Frequency
Maximum Power Ratings

TABLE 1. Resistor Values (kΩ) for Standard Output Voltage

<table>
<thead>
<tr>
<th>Positive Output Voltage</th>
<th>Applicable Figures</th>
<th>Fixed Output ±5%</th>
<th>Output Adjustable ±10% (Note 6)</th>
<th>Negative Output Voltage</th>
<th>Applicable Figures</th>
<th>Fixed Output ±5%</th>
<th>Output Adjustable ±10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>+3.0</td>
<td>1, 5, 6, 9, 12 (4)</td>
<td>3.12</td>
<td>1.8 0.5 1.2</td>
<td>+100</td>
<td>7</td>
<td>3.57</td>
<td>102 2.2 10 91</td>
</tr>
<tr>
<td>+3.6</td>
<td>1, 5, 6, 9, 12 (4)</td>
<td>3.57</td>
<td>1.5 0.5 1.5</td>
<td>+250</td>
<td>7</td>
<td>3.57</td>
<td>255 2.2 10 240</td>
</tr>
<tr>
<td>+5.0</td>
<td>1, 5, 6, 9, 12 (4)</td>
<td>2.15</td>
<td>0.75 0.5 2.2</td>
<td>−6 (Note 7)</td>
<td>3, (10)</td>
<td>3.57</td>
<td>243 1.2 0.5 0.75</td>
</tr>
<tr>
<td>+6.0</td>
<td>1, 5, 6, 9, 12 (4)</td>
<td>1.15</td>
<td>0.5 0.5 2.7</td>
<td>−9</td>
<td>3, 10</td>
<td>3.48</td>
<td>53 1.2 0.5 2.0</td>
</tr>
<tr>
<td>+9.0</td>
<td>2, 4, (5, 6, 9, 12)</td>
<td>1.87</td>
<td>0.75 1.0 2.7</td>
<td>−12</td>
<td>3, 10</td>
<td>3.57</td>
<td>845 1.2 0.5 3.3</td>
</tr>
<tr>
<td>+12</td>
<td>2, 4, (5, 6, 9, 12)</td>
<td>4.87</td>
<td>2.0 1.0 3.0</td>
<td>−15</td>
<td>3, 10</td>
<td>3.65</td>
<td>115 1.2 0.5 4.3</td>
</tr>
<tr>
<td>+15</td>
<td>2, 4, (5, 6, 9, 12)</td>
<td>7.87</td>
<td>3.3 1.0 3.0</td>
<td>−28</td>
<td>3, 10</td>
<td>3.57</td>
<td>243 1.2 0.5 10</td>
</tr>
<tr>
<td>+28</td>
<td>2, 4, (5, 6, 9, 12)</td>
<td>21.0</td>
<td>5.6 1.0 2.0</td>
<td>−45</td>
<td>8</td>
<td>3.57</td>
<td>41.2 2.2 10 33</td>
</tr>
<tr>
<td>+45</td>
<td>7</td>
<td>3.57</td>
<td>48.7 2.2 39</td>
<td>−100</td>
<td>8</td>
<td>3.57</td>
<td>97.6 2.2 10 91</td>
</tr>
<tr>
<td>+75</td>
<td>7</td>
<td>3.57</td>
<td>78.7 2.2 68</td>
<td>−250</td>
<td>8</td>
<td>3.57</td>
<td>249 2.2 10 240</td>
</tr>
</tbody>
</table>

TABLE 2. Formulae for Intermediate Output Voltages

| Outputs from +2 to +7 volts (Figures 1, 4, 5, 6, 9, 12) | VOUT = \( \frac{V_{REF} \times R2}{R1 + R2} \) | Outputs from +4 to +250 volts (Figure 7) | VOUT = \( \frac{V_{REF} \times R2 - R1}{R1} \) : R3 = R4 | Current Limiting |
| Current Limiting | I_{LIMIT} = \frac{V_{SENSE}}{R_{SC}} |
| Foldback Current Limiting | I_{KNEE} = \frac{V_{OUT} \times R3}{R_{SC} \times (R3 + R4)} |
| I_{SHORT CTK} = \frac{V_{SENSE} \times R_{SC} \times (R3 + R4)}{R4} |
Typical Applications

Note: R3 may be eliminated for minimum component count.

Typical Performance
- Regulated Output Voltage: 15V
- Line Regulation ($\Delta V_{IN} = 3V$): 1.5 mV
- Load Regulation ($\Delta I_L = 50 mA$): 4.5 mV

FIGURE 2. Basic High Voltage Regulator ($V_{OUT} = 7$ to 37 Volts)

Typical Performance
- Regulated Output Voltage: +15V
- Line Regulation ($\Delta V_{IN} = 3V$): 1.5 mV
- Load Regulation ($\Delta I_L = 1A$): 15 mV

FIGURE 4. Positive Voltage Regulator (External NPN Pass Transistor)

Typical Performance
- Regulated Output Voltage: −15V
- Line Regulation ($\Delta V_{IN} = 3V$): 1 mV
- Load Regulation ($\Delta I_L = 100 mA$): 2 mV

FIGURE 3. Negative Voltage Regulator
Typical Applications (Continued)

**FIGURE 5. Positive Voltage Regulator**
(External PNP Pass Transistor)

**Typical Performance**
- Regulated Output Voltage +5V
- Line Regulation ($\Delta V_{IN} = 3V$) 0.5 mV
- Load Regulation ($\Delta I_L = 1A$) 5 mV

**FIGURE 6. Foldback Current Limiting**

**Typical Performance**
- Regulated Output Voltage +5V
- Line Regulation ($\Delta V_{IN} = 3V$) 0.5 mV
- Load Regulation ($\Delta I_L = 10mA$) 1 mV
- Short Circuit Current 20 mA
Typical Applications (Continued)

**Typical Performance**

Regulated Output Voltage
- +50V

Line Regulation ($\Delta V_{IN} = 20V$)
- 15 mV

Load Regulation ($\Delta I_L = 50 mA$)
- 20 mV

**FIGURE 7. Positive Floating Regulator**

**Typical Performance**

Regulated Output Voltage
- −100V

Line Regulation ($\Delta V_{IN} = 20V$)
- 30 mV

Load Regulation ($\Delta I_L = 100 mA$)
- 20 mV

**FIGURE 8. Negative Floating Regulator**
Typical Applications (Continued)

**Typical Performance**

Regulated Output Voltage +5V
Line Regulation (ΔV_{IN} = 30V) 10 mV
Load Regulation (ΔI_{L} = 2A) 80 mV

**FIGURE 9. Positive Switching Regulator**

**Typical Performance**

Regulated Output Voltage −15V
Line Regulation (ΔV_{IN} = 20V) 8 mV
Load Regulation (ΔI_{L} = 2A) 6 mV

**FIGURE 10. Negative Switching Regulator**
Typical Applications (Continued)

Note: Current limit transistor may be used for shutdown if current limiting is not required.

Typical Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated Output Voltage</td>
<td>+5V</td>
</tr>
<tr>
<td>Line Regulation ($\Delta V_{IN} = 3V$)</td>
<td>0.5 mV</td>
</tr>
<tr>
<td>Load Regulation ($\Delta I_L = 50 mA$)</td>
<td>1.5 mV</td>
</tr>
</tbody>
</table>

FIGURE 11. Remote Shutdown Regulator with Current Limiting

FIGURE 12. Shunt Regulator
Typical Applications (Continued)

FIGURE 13. Output Voltage Adjust
(Note 6)

Schematic Diagram
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

Ceramic Dual-In-Line Package (J)
Order Number LM723J/883
NS Package J14A
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Molded Dual-In-Line Package (N)
Order Number LM723CN
NS Package N14A