

## Low Quiescent Current LDO

### Features

- 1.6  $\mu$ A Typical Quiescent Current
- Input Operating Voltage Range: 2.3V to 6.0V
- Output Voltage Range: 1.2V to 5.0V
- 250 mA Output Current for output voltages  $\geq$  2.5V
- 200 mA Output Current for output voltages  $<$  2.5V
- Low Dropout (LDO) voltage
  - 178 mV typical @ 250 mA for  $V_{OUT} = 2.8V$
- 0.4% Typical Output Voltage Tolerance
- Standard Output Voltage Options:
  - 1.2V, 1.8V, 2.5V, 3.0V, 3.3V, 5.0V
- Stable with 1.0  $\mu$ F Ceramic Output capacitor
- Short Circuit Protection
- Overtemperature Protection

### Applications

- Battery-powered Devices
- Battery-powered Alarm Circuits
- Smoke Detectors
- CO<sup>2</sup> Detectors
- Pagers and Cellular Phones
- Smart Battery Packs
- Low Quiescent Current Voltage Reference
- PDAs
- Digital Cameras
- Microcontroller Power

### Related Literature

- AN765, "Using Microchip's Micropower LDOs", DS00765, Microchip Technology Inc., 2002
- AN766, "Pin-Compatible CMOS Upgrades to BiPolar LDOs", DS00766, Microchip Technology Inc., 2002
- AN792, "A Method to Determine How Much Power a SOT23 Can Dissipate in an Application", DS00792, Microchip Technology Inc., 2001

### General Description

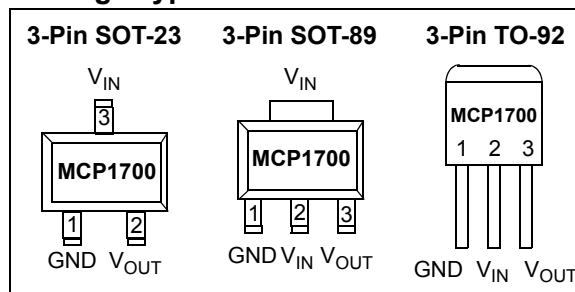
The MCP1700 is a family of CMOS low dropout (LDO) voltage regulators that can deliver up to 250 mA of current while consuming only 1.6  $\mu$ A of quiescent current (typical). The input operating range is specified from 2.3V to 6.0V, making it an ideal choice for two and three primary cell battery-powered applications, as well as single cell Li-Ion-powered applications.

The MCP1700 is capable of delivering 250 mA with only 178 mV of input to output voltage differential ( $V_{OUT} = 2.8V$ ). The output voltage tolerance of the MCP1700 is typically  $\pm 0.4\%$  at  $+25^{\circ}C$  and  $\pm 3\%$  maximum over the operating junction temperature range of  $-40^{\circ}C$  to  $+125^{\circ}C$ .

Output voltages available for the MCP1700 range from 1.2V to 5.0V. The LDO output is stable when using only 1  $\mu$ F output capacitance. Ceramic, tantalum or aluminum electrolytic capacitors can all be used for input and output. Overcurrent limit and overtemperature shutdown provide a robust solution for any application.

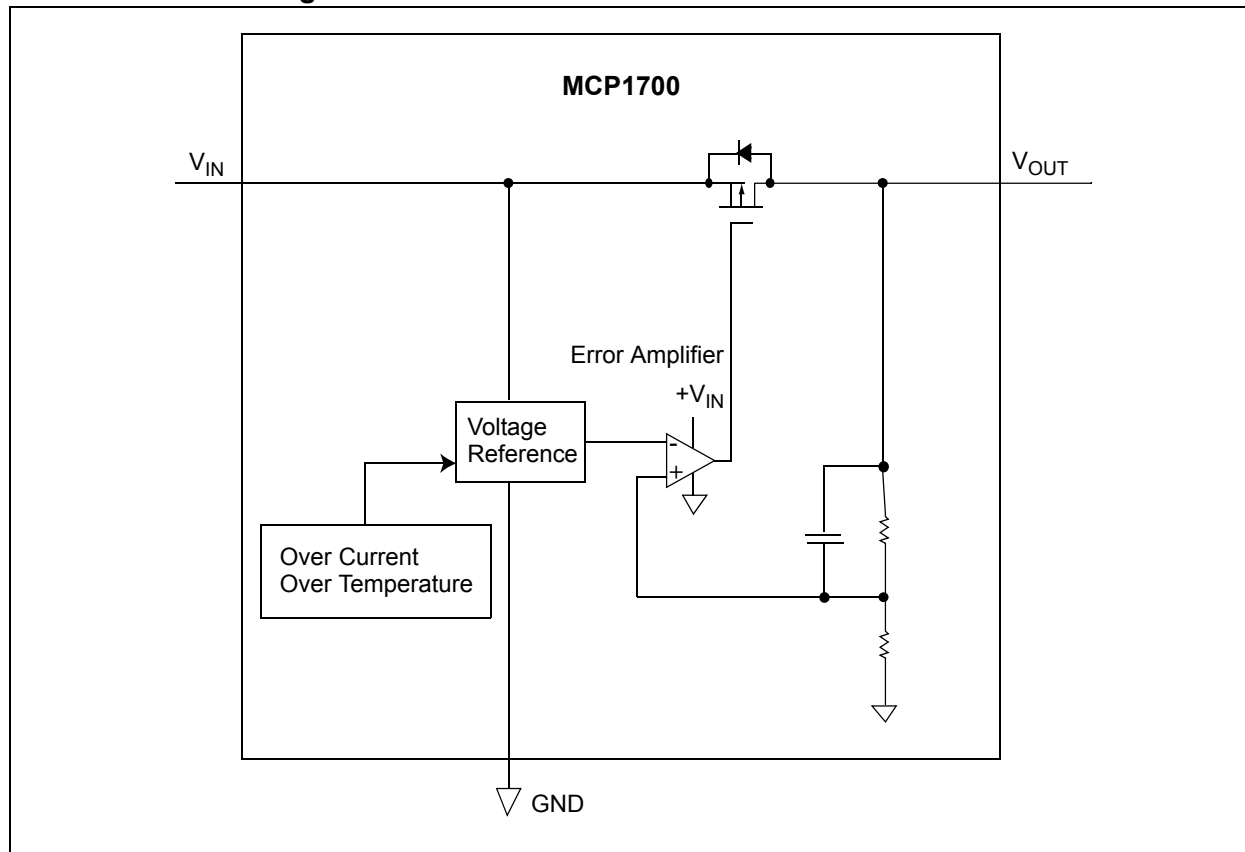
Package options include the SOT-23, SOT-89 and TO-92.

### Package Types

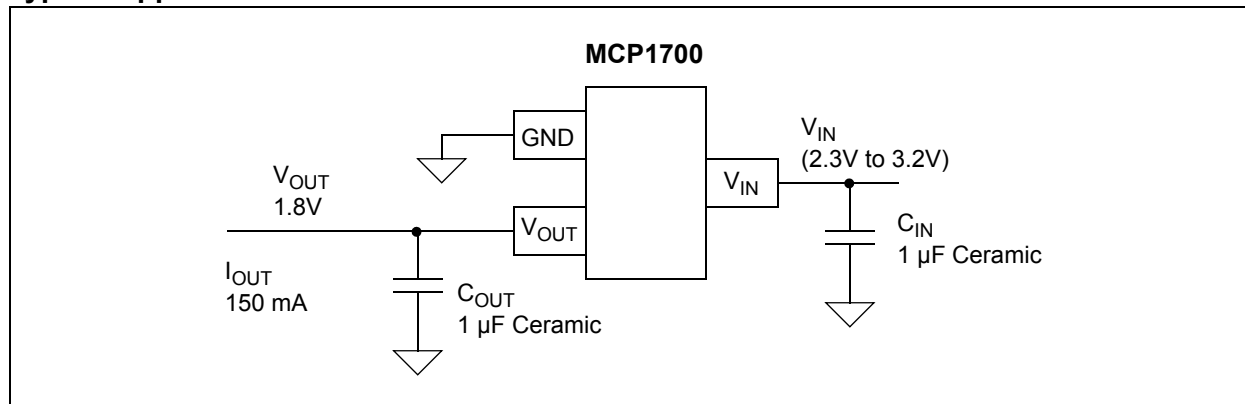


# MCP1700

## Functional Block Diagrams



## Typical Application Circuits



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD}$  ..... +6.5V  
 All inputs and outputs w.r.t. .... ( $V_{SS}-0.3V$ ) to ( $V_{IN}+0.3V$ )  
 Peak Output Current ..... Internally Limited  
 Storage temperature ..... -65°C to +150°C  
 Maximum Junction Temperature ..... 150°C  
 Operating Junction Temperature ..... -40°C to +125°C  
 ESD protection on all pins (HBM;MM) .....  $\geq 4$  kV;  $\geq 400V$

† **Notice:** Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

### DC CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise specified, all limits are established for  $V_{IN} = V_R + 1$ ,  $I_{LOAD} = 100 \mu A$ ,  $C_{OUT} = 1 \mu F$  (X7R),  $C_{IN} = 1 \mu F$  (X7R),  $T_A = +25^\circ C$ .

**Boldface** type applies for junction temperatures,  $T_J$  (**Note 6**) of -40°C to +125°C.

| Parameters                            | Sym  | Min  | Typ             | Max  | Units                | Conditions   |
|---------------------------------------|--|--|-----------------|--|----------------------|--|
| <b>Input / Output Characteristics</b> |  |  |                 |  |                      |  |
| Input Operating Voltage               | $V_{IN}$                                   | <b>2.3</b>   | —               | <b>6.0</b>   | V                    | <b>Note 1</b>  |
| Input Quiescent Current               | $I_q$                                      | —  | 1.6             | <b>4</b>   | $\mu A$              | $I_L = 0$ mA, $V_{IN} = V_R + 1V$  |
| Maximum Output Current                | $I_{OUT\_mA}$                              | <b>250</b><br><b>200</b>                                       | —               | —  | mA                   | For $V_R \geq 2.5V$<br>For $V_R < 2.5V$  |
| Output Short Circuit Current          | $I_{OUT\_SC}$                              | —  | 408             | —  | mA                   | $V_{IN} = V_R + V$ , $V_{OUT} = GND$ ,<br>Current (peak current) measured<br>10 ms after short is applied. |
| Output Voltage Regulation             | $V_{OUT}$                                  | <b><math>V_R-3.0\%</math></b><br><b><math>V_R-2.0\%</math></b> | $V_R \pm 0.4\%$ | <b><math>V_R+3.0\%</math></b><br><b><math>V_R+2.0\%</math></b> | V                    | <b>Note 2</b>  |
| $V_{OUT}$ Temperature Coefficient     | $TCV_{OUT}$                                | —  | 50              | —  | ppm/°C               | <b>Note 3</b>  |
| Line Regulation                       | $\Delta V_{OUT} / (V_{OUT} \Delta V_{IN})$ | <b>-1.0</b>  | $\pm 0.75$      | <b>+1.0</b>  | %/V                  | $(V_R+1)V \leq V_{IN} \leq 6V$   |
| Load Regulation                       | $\Delta V_{OUT} / V_{OUT}$                 | <b>-1.5</b>  | $\pm 1.0$       | <b>+1.5</b>  | %                    | $I_L = 0.1$ mA to 250 mA for $V_R \geq 2.5V$<br>$I_L = 0.1$ mA to 200 mA for $V_R < 2.5V$<br><b>Note 4</b> |
| Dropout Voltage<br>$V_R > 2.5V$       | $V_{IN}-V_{OUT}$                           | —  | 178             | <b>350</b>   | mV                   | $I_L = 250$ mA, ( <b>Note 1, Note 5</b> )  |
| Dropout Voltage<br>$V_R < 2.5V$       | $V_{IN}-V_{OUT}$                           | —  | 150             | <b>350</b>   | mV                   | $I_L = 200$ mA, ( <b>Note 1, Note 5</b> )  |
| Output Rise Time                      | $T_R$                                      | —  | 500             | —  | $\mu s$              | 10% $V_R$ to 90% $V_R$ $V_{IN} = 0V$ to 6V,<br>$R_L = 50\Omega$ resistive                                  |
| Output Noise                          | $e_N$                                      | —  | 3               | —  | $\mu V / (Hz)^{1/2}$ | $I_L = 100$ mA, $f = 1$ kHz, $C_{OUT} = 1 \mu F$   |

**Note 1:** The minimum  $V_{IN}$  must meet two conditions:  $V_{IN} \geq 2.3V$  and  $V_{IN} \geq (V_R + 3.0\%) + V_{DROPOUT}$ .

**2:**  $V_R$  is the nominal regulator output voltage. For example:  $V_R = 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 4.0V, 5.0V$ . The input voltage ( $V_{IN} = V_R + 1.0V$ );  $I_{OUT} = 100 \mu A$ .

**3:**  $TCV_{OUT} = (V_{OUT-HIGH} - V_{OUT-LOW}) \cdot 10^6 / (V_R \cdot \Delta \text{Temperature})$ ,  $V_{OUT-HIGH}$  = highest voltage measured over the temperature range.  $V_{OUT-LOW}$  = lowest voltage measured over the temperature range.

**4:** Load regulation is measured at a constant junction temperature using low duty cycle pulse testing. Changes in output voltage due to heating effects are determined using thermal regulation specification  $TCV_{OUT}$ .

**5:** Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its measured value with a  $V_R + 1V$  differential applied.

**6:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e.,  $T_A$ ,  $T_J$ ,  $\theta_{JA}$ ). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum 150°C rating. Sustained junction temperatures above 150°C can impact the device reliability.

**7:** The junction temperature is approximated by soaking the device under test at an ambient temperature equal to the desired Junction temperature. The test time is small enough such that the rise in the Junction temperature over the ambient temperature is not significant.

# MCP1700

## DC CHARACTERISTICS (CONTINUED)

**Electrical Characteristics:** Unless otherwise specified, all limits are established for  $V_{IN} = V_R + 1$ ,  $I_{LOAD} = 100 \mu A$ ,  $C_{OUT} = 1 \mu F$  (X7R),  $C_{IN} = 1 \mu F$  (X7R),  $T_A = +25^\circ C$ .

**Boldface** type applies for junction temperatures,  $T_J$  (**Note 6**) of  $-40^\circ C$  to  $+125^\circ C$ .

| Parameters                          | Sym      | Min | Typ | Max | Units      | Conditions   |
|-------------------------------------|----------|-----|-----|-----|------------|--|
| Power Supply Ripple Rejection Ratio | PSRR     | —   | 44  | —   | dB         | $f = 100 \text{ Hz}$ , $C_{OUT} = 1 \mu F$ , $I_L = 50 \text{ mA}$ , $V_{INAC} = 100 \text{ mV pk-pk}$ , $C_{IN} = 0 \mu F$ , $V_R = 1.2V$ |
| Thermal Shutdown Protection         | $T_{SD}$ | —   | 140 | —   | $^\circ C$ | $V_{IN} = V_R + 1$ , $I_L = 100 \mu A$   |

- Note 1:** The minimum  $V_{IN}$  must meet two conditions:  $V_{IN} \geq 2.3V$  and  $V_{IN} \geq (V_R + 3.0\%) + V_{DROPOUT}$ .
- 2:**  $V_R$  is the nominal regulator output voltage. For example:  $V_R = 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 4.0V, 5.0V$ . The input voltage ( $V_{IN} = V_R + 1.0V$ );  $I_{OUT} = 100 \mu A$ .
- 3:**  $TCV_{OUT} = (V_{OUT-HIGH} - V_{OUT-LOW}) \times 10^6 / (V_R \times \Delta \text{Temperature})$ ,  $V_{OUT-HIGH}$  = highest voltage measured over the temperature range.  $V_{OUT-LOW}$  = lowest voltage measured over the temperature range.
- 4:** Load regulation is measured at a constant junction temperature using low duty cycle pulse testing. Changes in output voltage due to heating effects are determined using thermal regulation specification  $TCV_{OUT}$ .
- 5:** Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its measured value with a  $V_R + 1V$  differential applied.
- 6:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e.,  $T_A$ ,  $T_J$ ,  $\theta_{JA}$ ). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum  $150^\circ C$  rating. Sustained junction temperatures above  $150^\circ C$  can impact the device reliability.
- 7:** The junction temperature is approximated by soaking the device under test at an ambient temperature equal to the desired Junction temperature. The test time is small enough such that the rise in the Junction temperature over the ambient temperature is not significant.

## TEMPERATURE SPECIFICATIONS

**Electrical Characteristics:** Unless otherwise specified, all limits are established for  $V_{IN} = V_R + 1$ ,  $I_{LOAD} = 100 \mu A$ ,  $C_{OUT} = 1 \mu F$  (X7R),  $C_{IN} = 1 \mu F$  (X7R),  $T_A = +25^\circ C$ .

**Boldface** type applies for junction temperatures,  $T_J$  (**Note 1**) of  $-40^\circ C$  to  $+125^\circ C$ .

| Parameters                        | Sym           | Min | Typ   | Max  | Units        | Conditions                             |
|-----------------------------------|---------------|-----|-------|------|--------------|--|
| <b>Temperature Ranges</b>         |               |     |       |      |              |  |
| Specified Temperature Range       | $T_A$         | -40 |       | +125 | $^\circ C$   |  |
| Operating Temperature Range       | $T_A$         | -40 |       | +125 | $^\circ C$   |  |
| Storage Temperature Range         | $T_A$         | -65 |       | +150 | $^\circ C$   |  |
| <b>Thermal Package Resistance</b> |               |     |       |      |              |  |
| Thermal Resistance, SOT-23        | $\theta_{JA}$ | —   | 336   | —    | $^\circ C/W$ | Minimum Trace Width Single Layer Board |
|                                   |               | —   | 230   | —    | $^\circ C/W$ | Typical FR4 4-layer Application        |
| Thermal Resistance, SOT-89        | $\theta_{JA}$ | —   | 52    | —    | $^\circ C/W$ | Typical, 1 square inch of copper       |
| Thermal Resistance, TO-92         | $\theta_{JA}$ | —   | 131.9 | —    | $^\circ C/W$ | EIA/JEDEC JESD51-751-7 4-Layer Board   |

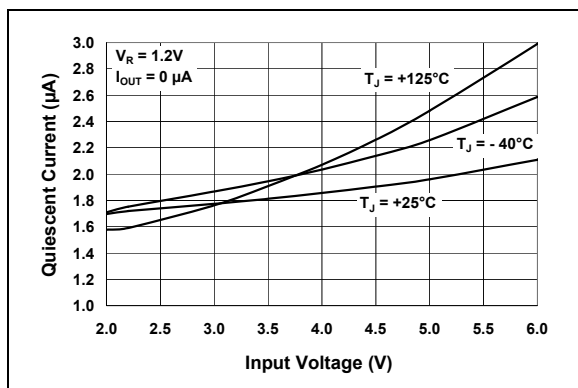
- Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e.,  $T_A$ ,  $T_J$ ,  $\theta_{JA}$ ). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum  $150^\circ C$  rating. Sustained junction temperatures above  $150^\circ C$  can impact the device reliability.

## 2.0 TYPICAL PERFORMANCE CURVES

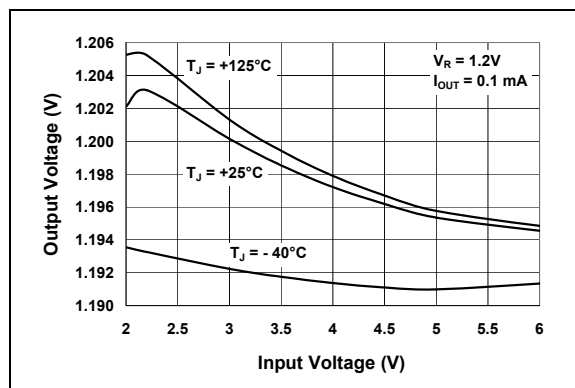
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

**Note:** Unless otherwise indicated:  $V_R = 1.8V$ ,  $C_{OUT} = 1 \mu F$  Ceramic (X7R),  $C_{IN} = 1 \mu F$  Ceramic (X7R),  $I_L = 100 \mu A$ ,  $T_A = +25^\circ C$ ,  $V_{IN} = V_R + V$ .

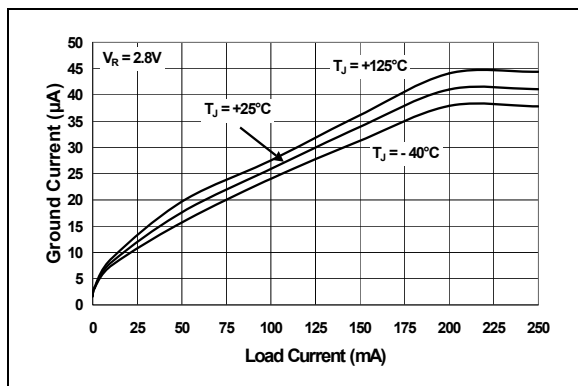
**Note:** Junction Temperature ( $T_J$ ) is approximated by soaking the device under test to an ambient temperature equal to the desired junction temperature. The test time is small enough such that the rise in Junction temperature over the Ambient temperature is not significant.



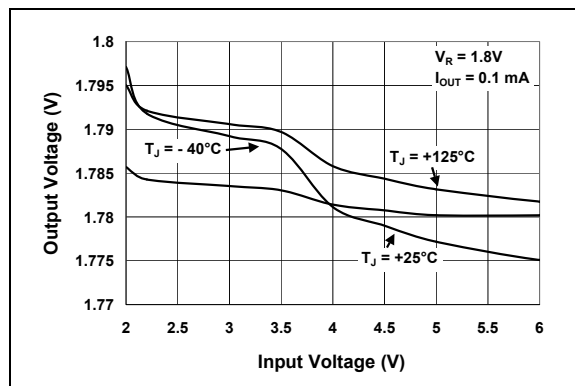
**FIGURE 2-1:** Input Quiescent Current vs. Input Voltage.



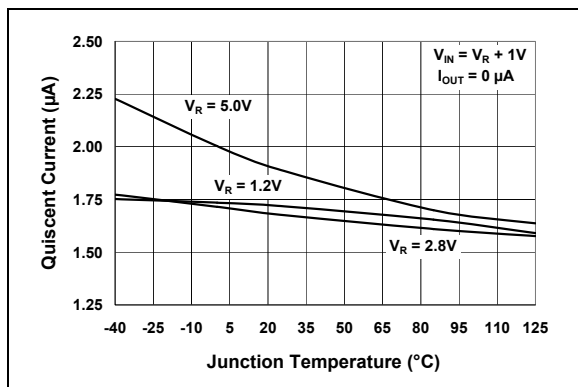
**FIGURE 2-4:** Output Voltage vs. Input Voltage ( $V_R = 1.2V$ ).



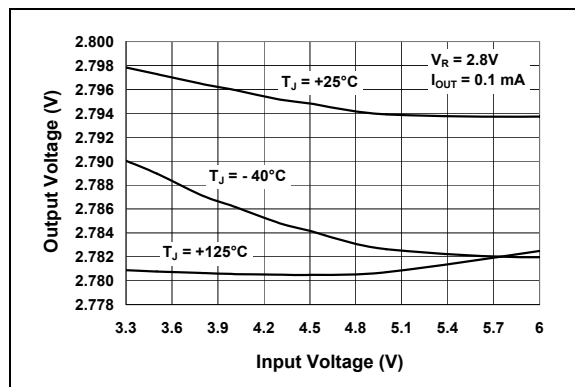
**FIGURE 2-2:** Ground Current vs. Load Current.



**FIGURE 2-5:** Output Voltage vs. Input Voltage ( $V_R = 1.8V$ ).



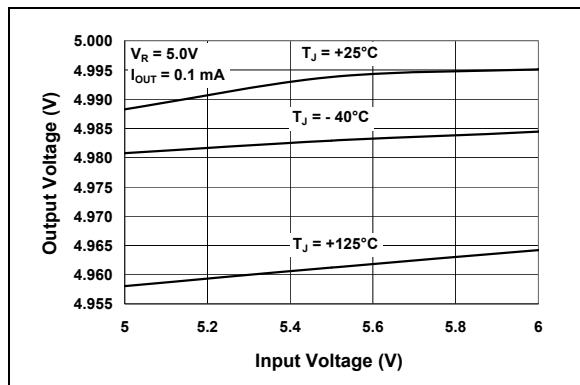
**FIGURE 2-3:** Quiescent Current vs. Junction Temperature.



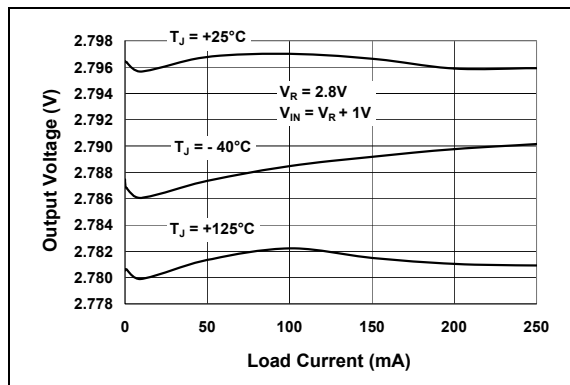
**FIGURE 2-6:** Output Voltage vs. Input Voltage ( $V_R = 2.8V$ ).

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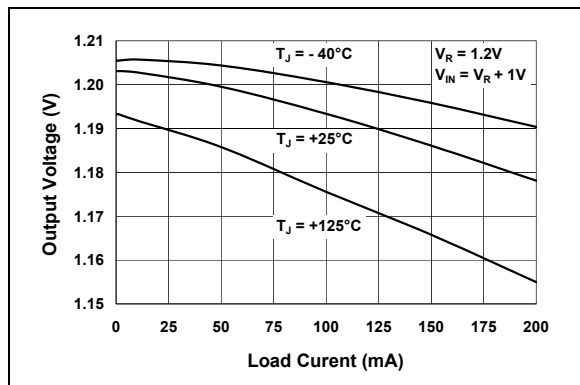
**Note:** Unless otherwise indicated:  $V_R = 1.8V$ ,  $C_{OUT} = 1 \mu F$  Ceramic (X7R),  $C_{IN} = 1 \mu F$  Ceramic (X7R),  $I_L = 100 \mu A$ ,  $T_A = +25^\circ C$ ,  $V_{IN} = V_R + 1V$ .



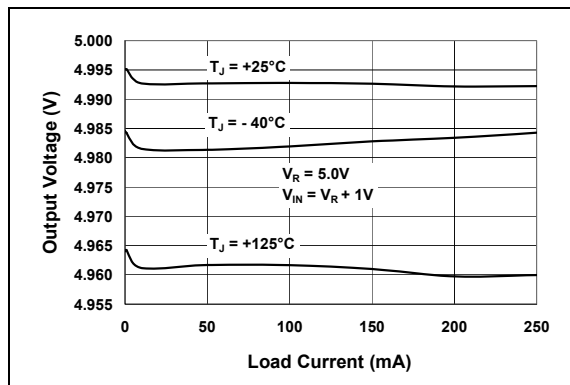
**FIGURE 2-7:** Output Voltage vs. Input Voltage ( $V_R = 5.0V$ ).



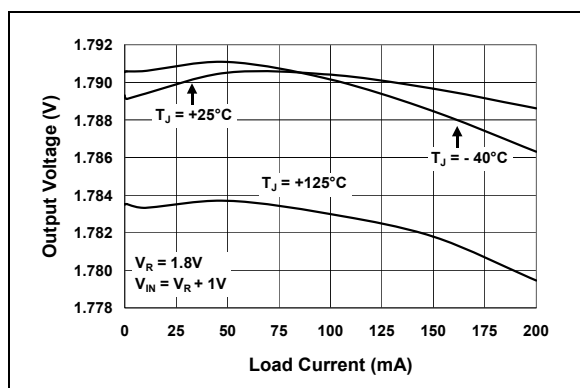
**FIGURE 2-10:** Output Voltage vs. Load Current ( $V_R = 2.8V$ ).



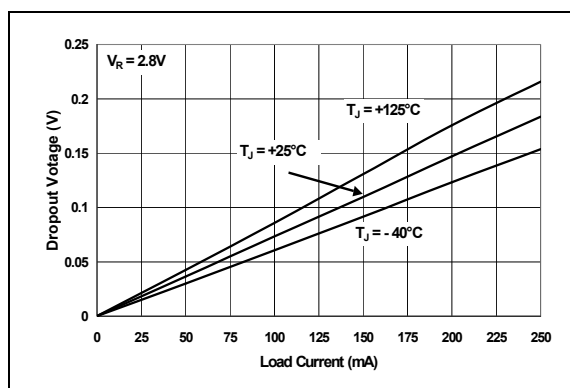
**FIGURE 2-8:** Output Voltage vs. Load Current ( $V_R = 1.2V$ ).



**FIGURE 2-11:** Output Voltage vs. Load Current ( $V_R = 5.0V$ ).

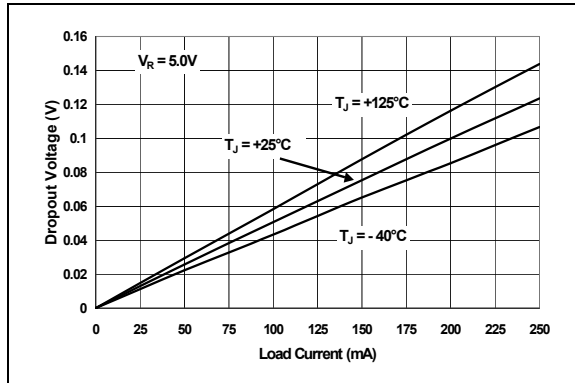


**FIGURE 2-9:** Output Voltage vs. Load Current ( $V_R = 1.8V$ ).

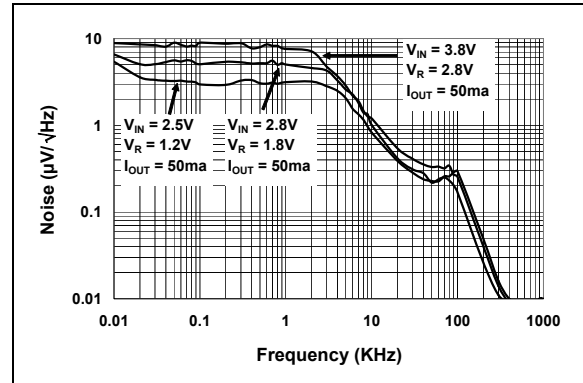


**FIGURE 2-12:** Dropout Voltage vs. Load Current ( $V_R = 2.8V$ ).

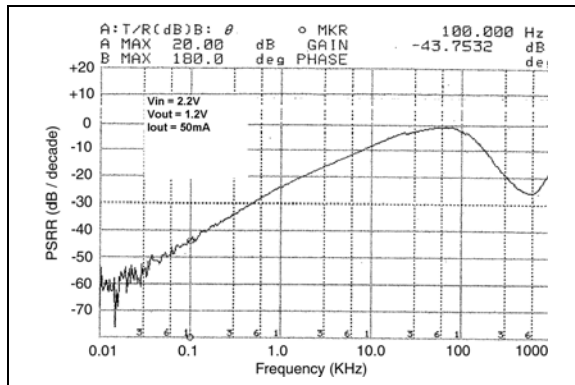
**Note:** Unless otherwise indicated:  $V_R = 1.8V$ ,  $C_{OUT} = 1 \mu F$  Ceramic (X7R),  $C_{IN} = 1 \mu F$  Ceramic (X7R),  $I_L = 100 \mu A$ ,  $T_A = +25^\circ C$ ,  $V_{IN} = V_R + 1V$ .



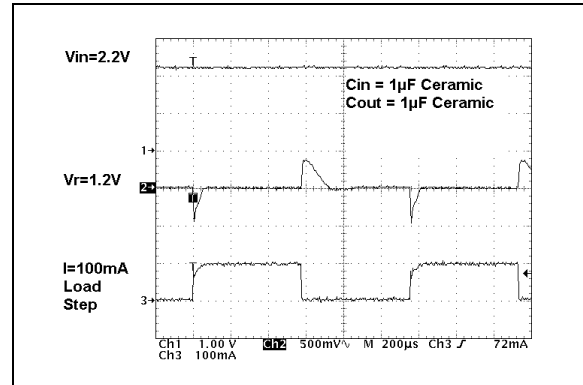
**FIGURE 2-13:** Dropout Voltage vs. Load Current ( $V_R = 5.0V$ ).



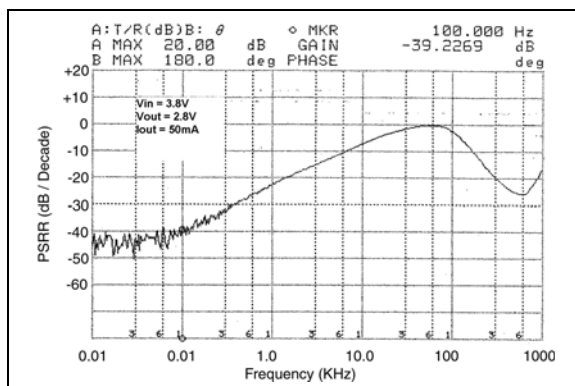
**FIGURE 2-16:** Noise vs. Frequency.



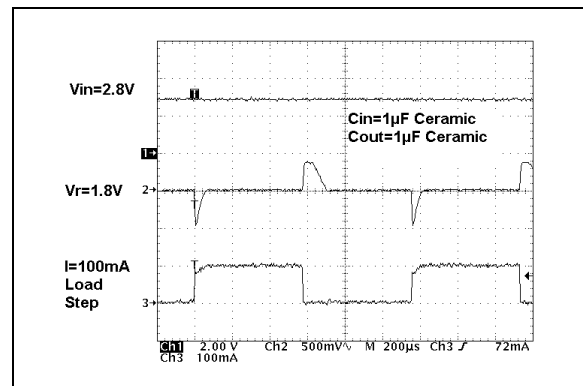
**FIGURE 2-14:** Power Supply Ripple Rejection vs. Frequency ( $V_R = 1.2V$ ).



**FIGURE 2-17:** Dynamic Load Step ( $V_R = 1.2V$ ).



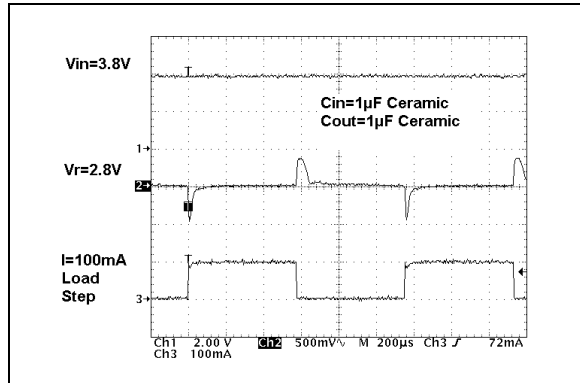
**FIGURE 2-15:** Power Supply Ripple Rejection vs. Frequency ( $V_R = 2.8V$ ).



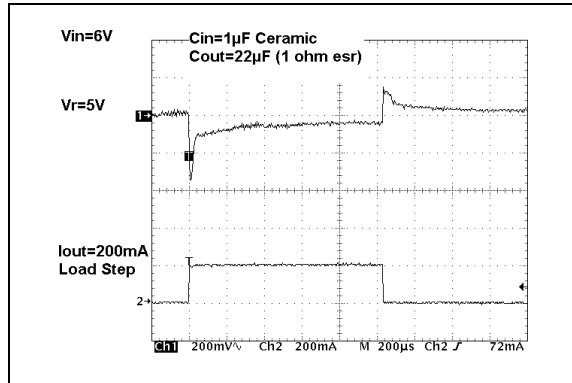
**FIGURE 2-18:** Dynamic Load Step ( $V_R = 1.8V$ ).

# MCP1700

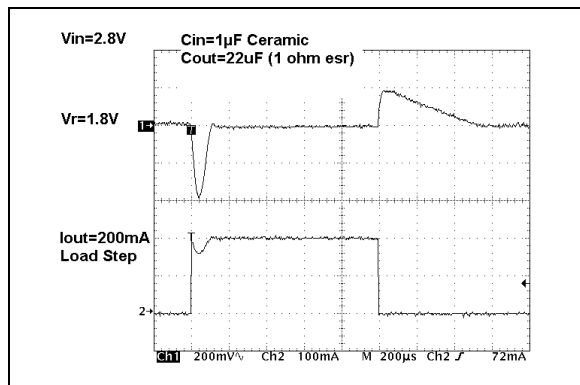
**Note:** Unless otherwise indicated:  $V_R = 1.8V$ ,  $C_{OUT} = 1\ \mu F$  Ceramic (X7R),  $C_{IN} = \mu F$  Ceramic (X7R),  $I_L = 100\ \mu A$ ,  $T_A = +25^\circ C$ ,  $V_{IN} = V_R + 1V$ .



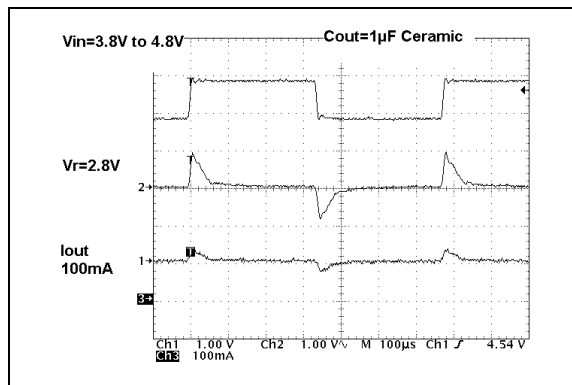
**FIGURE 2-19:** Dynamic Load Step ( $V_R = 2.8V$ ).



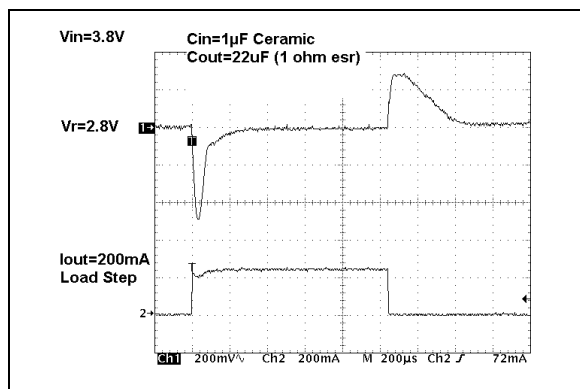
**FIGURE 2-22:** Dynamic Load Step ( $V_R = 5.0V$ ).



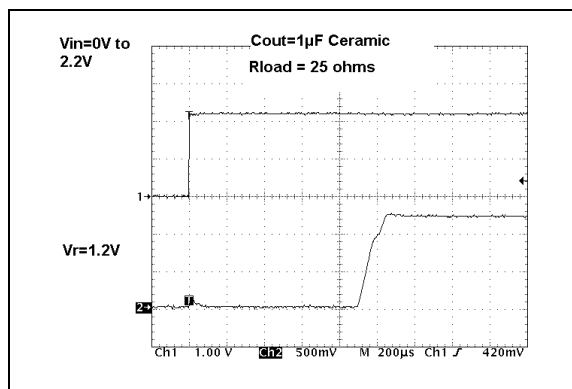
**FIGURE 2-20:** Dynamic Load Step ( $V_R = 1.8V$ ).



**FIGURE 2-23:** Dynamic Line Step ( $V_R = 2.8V$ ).



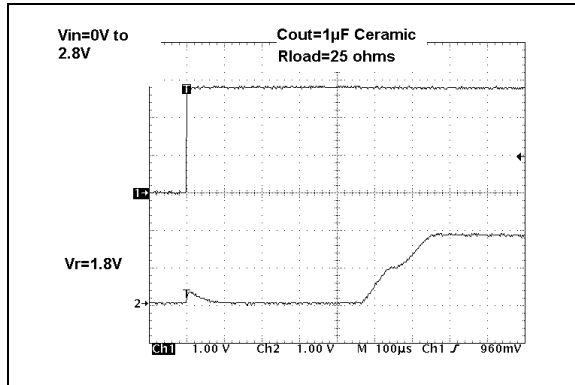
**FIGURE 2-21:** Dynamic Load Step ( $V_R = 2.8V$ ).



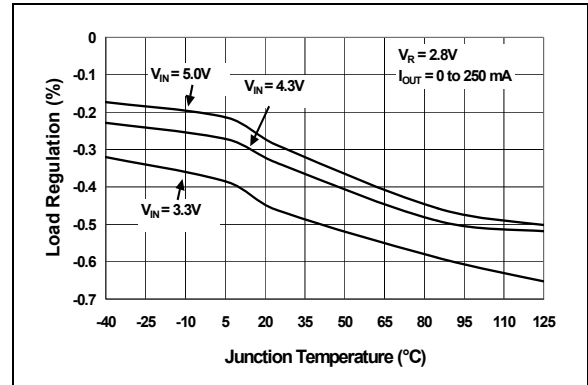
**FIGURE 2-24:** Startup From  $V_{IN}$  ( $V_R = 1.2V$ ).



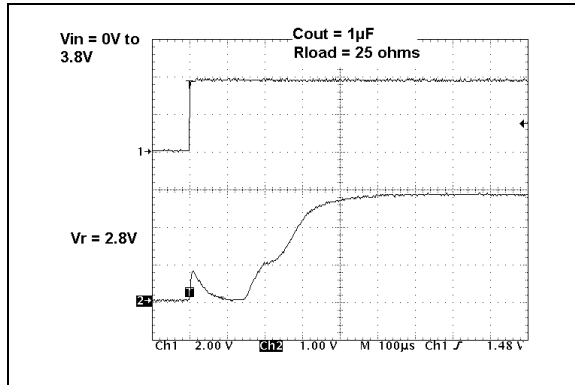
**Note:** Unless otherwise indicated:  $V_R = 1.8V$ ,  $C_{OUT} = 1\ \mu F$  Ceramic (X7R),  $C_{IN} = 1\ \mu F$  Ceramic (X7R),  $I_L = 100\ \mu A$ ,  $T_A = +25^\circ C$ ,  $V_{IN} = V_R + 1V$ .



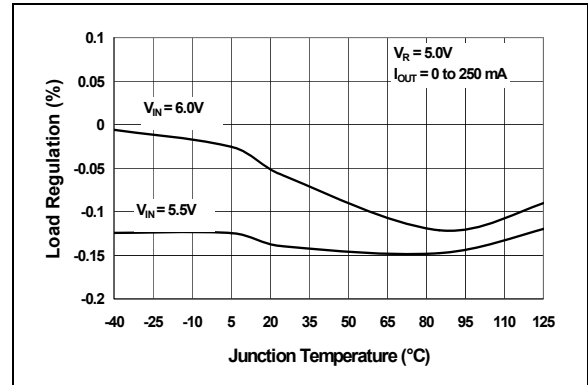
**FIGURE 2-25:** Start-up From  $V_{IN}$   
( $V_R = 1.8V$ ).



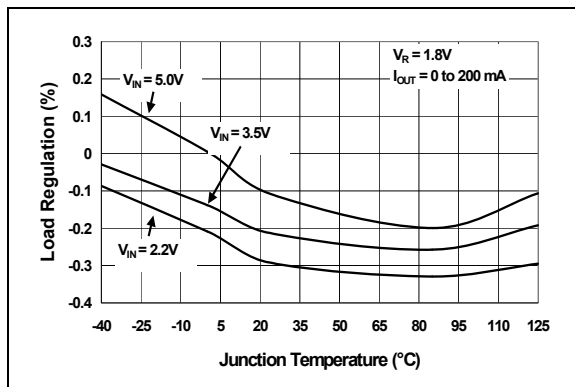
**FIGURE 2-28:** Load Regulation vs.  
Junction Temperature ( $V_R = 2.8V$ ).



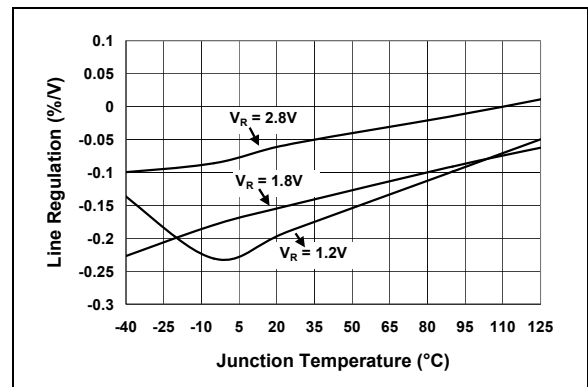
**FIGURE 2-26:** Start-up From  $V_{IN}$   
( $V_R = 2.8V$ ).



**FIGURE 2-29:** Load Regulation vs.  
Junction Temperature ( $V_R = 5.0V$ ).



**FIGURE 2-27:** Load Regulation vs.  
Junction Temperature ( $V_R = 1.8V$ ).



**FIGURE 2-30:** Line Regulation vs.  
Temperature ( $V_R = 1.2V, 1.8V, 2.8V$ ).

# MCP1700

## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

| Pin No.<br>SOT-23 | Pin No.<br>SOT-89 | Pin No.<br>TO-92 | Name             | Function                   |
|-------------------|-------------------|------------------|------------------|----------------------------|
| 1                 | 1                 | 1                | GND              | Ground Terminal            |
| 2                 | 3                 | 3                | V <sub>OUT</sub> | Regulated Voltage Output   |
| 3                 | 2                 | 2                | V <sub>IN</sub>  | Unregulated Supply Voltage |

### 3.1 Ground Terminal (GND)

Regulator ground. Tie GND to the negative side of the output and the negative side of the input capacitor. Only the LDO bias current (1.6  $\mu$ A typical) flows out of this pin; there is no high current. The LDO output regulation is referenced to this pin. Minimize voltage drops between this pin and the negative side of the load.

### 3.2 Regulated Output Voltage (V<sub>OUT</sub>)

Connect V<sub>OUT</sub> to the positive side of the load and the positive terminal of the output capacitor. The positive side of the output capacitor should be physically located as close to the LDO V<sub>OUT</sub> pin as is practical. The current flowing out of this pin is equal to the DC load current.

### 3.3 Unregulated Input Voltage Pin (V<sub>IN</sub>)

Connect V<sub>IN</sub> to the input unregulated source voltage. Like all low dropout linear regulators, low source impedance is necessary for the stable operation of the LDO. The amount of capacitance required to ensure low source impedance will depend on the proximity of the input source capacitors or battery type. For most applications, 1  $\mu$ F of capacitance will ensure stable operation of the LDO circuit. For applications that have load currents below 100 mA, the input capacitance requirement can be lowered. The type of capacitor used can be ceramic, tantalum or aluminum electrolytic. The low ESR characteristics of the ceramic will yield better noise and PSRR performance at high frequency.

## 4.0 DETAILED DESCRIPTION

### 4.1 Output Regulation

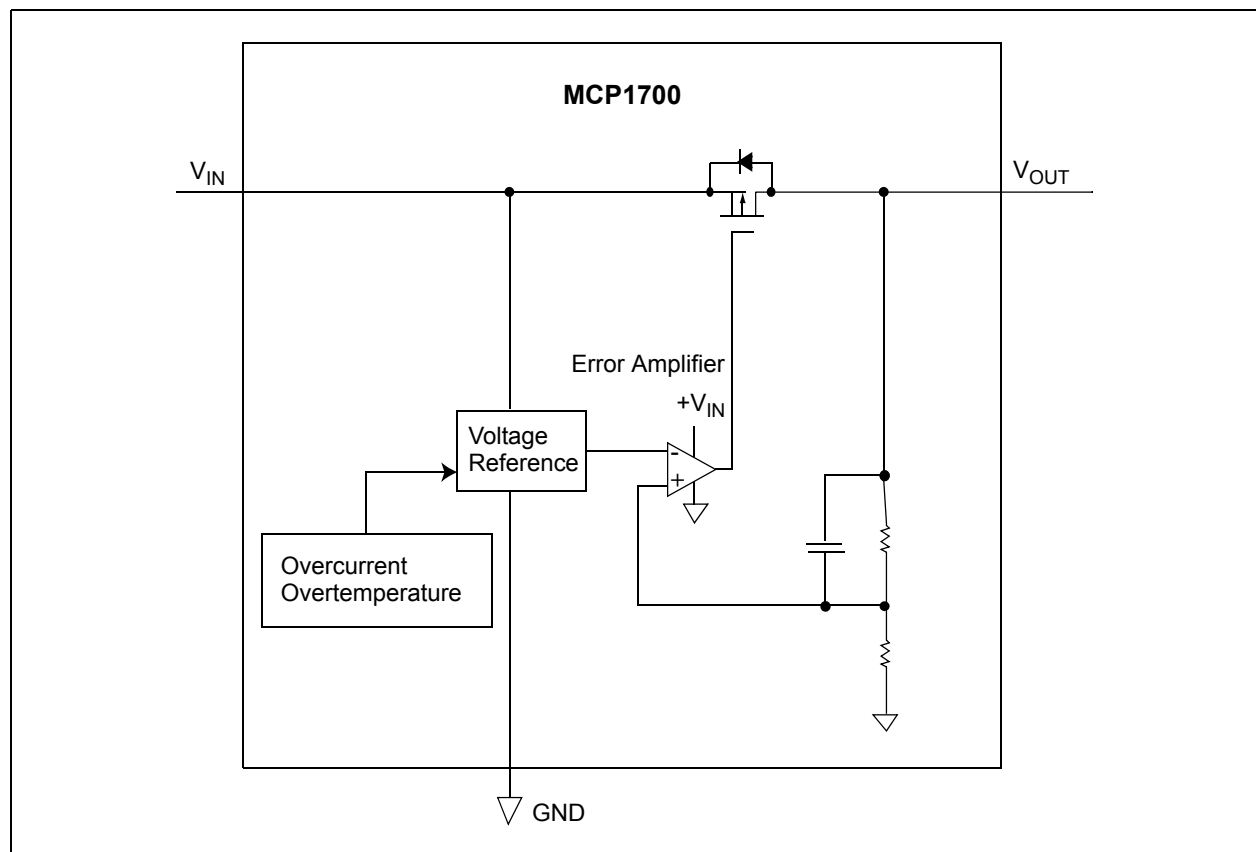
A portion of the LDO output voltage is fed back to the internal error amplifier and compared with the precision internal bandgap reference. The error amplifier output will adjust the amount of current that flows through the P-Channel pass transistor, thus regulating the output voltage to the desired value. Any changes in input voltage or output current will cause the error amplifier to respond and adjust the output voltage to the target voltage (refer to [Figure 4-1](#)).

### 4.2 Overcurrent

The MCP1700 internal circuitry monitors the amount of current flowing through the P-Channel pass transistor. In the event of a short-circuit or excessive output current, the MCP1700 will turn off the P-Channel device for a short period, after which the LDO will attempt to restart. If the excessive current remains, the cycle will repeat itself.

### 4.3 Overtemperature

The internal power dissipation within the LDO is a function of input-to-output voltage differential and load current. If the power dissipation within the LDO is excessive, the internal junction temperature will rise above the typical shutdown threshold of 140°C. At that point, the LDO will shut down and begin to cool to the typical turn-on junction temperature of 130°C. If the power dissipation is low enough, the device will continue to cool and operate normally. If the power dissipation remains high, the thermal shutdown protection circuitry will again turn off the LDO, protecting it from catastrophic failure.



**FIGURE 4-1:** Block Diagram.

# MCP1700

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## 5.0 FUNCTIONAL DESCRIPTION

The MCP1700 CMOS low dropout linear regulator is intended for applications that need the lowest current consumption while maintaining output voltage regulation. The operating continuous load range of the MCP1700 is from 0 mA to 250 mA ( $V_R \geq 2.5V$ ). The input operating voltage range is from 2.3V to 6.0V, making it capable of operating from two, three or four alkaline cells or a single Li-Ion cell battery input.

### 5.1 Input

The input of the MCP1700 is connected to the source of the P-Channel PMOS pass transistor. As with all LDO circuits, a relatively low source impedance ( $10\Omega$ ) is needed to prevent the input impedance from causing the LDO to become unstable. The size and type of the capacitor needed depends heavily on the input source type (battery, power supply) and the output current range of the application. For most applications (up to 100 mA), a 1  $\mu F$  ceramic capacitor will be sufficient to ensure circuit stability. Larger values can be used to improve circuit AC performance.

### 5.2 Output

The maximum rated continuous output current for the MCP1700 is 250 mA ( $V_R \geq 2.5V$ ). For applications where  $V_R < 2.5V$ , the maximum output current is 200 mA.

A minimum output capacitance of 1.0  $\mu F$  is required for small signal stability in applications that have up to 250 mA output current capability. The capacitor type can be ceramic, tantalum or aluminum electrolytic. The esr range on the output capacitor can range from  $0\Omega$  to  $2.0\Omega$ .

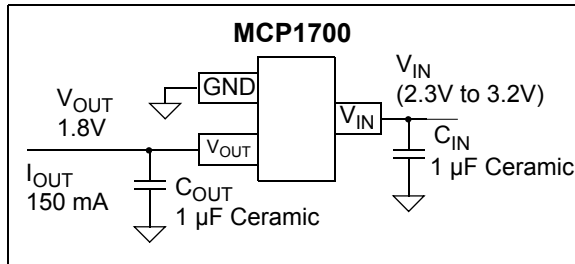
### 5.3 Output Rise time

When powering up the internal reference output, the typical output rise time of 500  $\mu s$  is controlled to prevent overshoot of the output voltage.

## 6.0 APPLICATION CIRCUITS & ISSUES

### 6.1 Typical Application

The MCP1700 is most commonly used as a voltage regulator. Its low quiescent current and low dropout voltage make it ideal for many battery-powered applications.



**FIGURE 6-1:** Typical Application Circuit.

#### 6.1.1 APPLICATION INPUT CONDITIONS

Package Type = SOT-23  
 Input Voltage Range = 2.3V to 3.2V  
 $V_{IN}$  maximum = 3.2V  
 $V_{OUT}$  typical = 1.8V  
 $I_{OUT}$  = 150 mA maximum

## 6.2 Power Calculations

### 6.2.1 POWER DISSIPATION

The internal power dissipation of the MCP1700 is a function of input voltage, output voltage and output current. The power dissipation, as a result of the quiescent current draw, is so low, it is insignificant ( $1.6 \mu A \times V_{IN}$ ). The following equation can be used to calculate the internal power dissipation of the LDO.

#### EQUATION 6-1:

$$P_{LDO} = (V_{IN(MAX)} - V_{OUT(MIN)}) \times I_{OUT(MAX)}$$

$P_{LDO}$  = LDO Pass device internal power dissipation

$V_{IN(MAX)}$  = Maximum input voltage

$V_{OUT(MIN)}$  = LDO minimum output voltage

The maximum continuous operating junction temperature specified for the MCP1700 is +125°C. To estimate the internal junction temperature of the MCP1700, the total internal power dissipation is multiplied by the thermal resistance from junction to ambient ( $R\theta_{JA}$ ). The thermal resistance from junction to ambient for the SOT-23 pin package is estimated at 230°C/W.

#### EQUATION 6-2:

$$T_{J(MAX)} = P_{TOTAL} \times R\theta_{JA} + T_{AMAX}$$

$T_{J(MAX)}$  = Maximum continuous junction temperature.

$P_{TOTAL}$  = Total device power dissipation.

$R\theta_{JA}$  = Thermal resistance from junction to ambient.

$T_{AMAX}$  = Maximum ambient temperature.

The maximum power dissipation capability for a package can be calculated given the junction-to-ambient thermal resistance and the maximum ambient temperature for the application. The following equation can be used to determine the package maximum internal power dissipation.

#### EQUATION 6-3:

$$P_{D(MAX)} = \frac{(T_{J(MAX)} - T_{A(MAX)})}{R\theta_{JA}}$$

$P_{D(MAX)}$  = Maximum device power dissipation.

$T_{J(MAX)}$  = Maximum continuous junction temperature.

$T_{A(MAX)}$  = Maximum ambient temperature.

$R\theta_{JA}$  = Thermal resistance from junction to ambient.

#### EQUATION 6-4:

$$T_{J(RISE)} = P_{D(MAX)} \times R\theta_{JA}$$

$T_{J(RISE)}$  = Rise in device junction temperature over the ambient temperature.

$P_{TOTAL}$  = Maximum device power dissipation.

$R\theta_{JA}$  = Thermal resistance from junction to ambient.

#### EQUATION 6-5:

$$T_J = T_{J(RISE)} + T_A$$

$T_J$  = Junction Temperature.

$T_{J(RISE)}$  = Rise in device junction temperature over the ambient temperature.

$T_A$  = Ambient temperature.

# MCP1700

## 6.3 Voltage Regulator

Internal power dissipation, junction temperature rise, junction temperature and maximum power dissipation are calculated in the following example. The power dissipation, as a result of ground current, is small enough to be neglected.

### 6.3.1 POWER DISSIPATION EXAMPLE

#### Package

Package Type = SOT-23

Input Voltage

$$V_{IN} = 2.3V \text{ to } 3.2V$$

#### LDO Output Voltages and Currents

$$V_{OUT} = 1.8V$$

$$I_{OUT} = 150 \text{ mA}$$

#### Maximum Ambient Temperature

$$T_{A(MAX)} = +40^{\circ}\text{C}$$

#### Internal Power Dissipation

Internal Power dissipation is the product of the LDO output current times the voltage across the LDO ( $V_{IN}$  to  $V_{OUT}$ ).

$$P_{LDO(MAX)} = (V_{IN(MAX)} - V_{OUT(MIN)}) \times I_{OUT(MAX)}$$

$$P_{LDO} = (3.2V - (0.97 \times 1.8V)) \times 150 \text{ mA}$$

$$P_{LDO} = 218.1 \text{ milli-Watts}$$

### Device Junction Temperature Rise

The internal junction temperature rise is a function of internal power dissipation and the thermal resistance from junction to ambient for the application. The thermal resistance from junction to ambient ( $R_{\theta JA}$ ) is derived from an EIA/JEDEC standard for measuring thermal resistance for small surface mount packages. The EIA/JEDEC specification is JESD51-7, "High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages". The standard describes the test method and board specifications for measuring the thermal resistance from junction to ambient. The actual thermal resistance for a particular application can vary depending on many factors, such as copper area and thickness. Refer to AN792, "A Method to Determine How Much Power a SOT-23 Can Dissipate in an Application", (DS00792), for more information regarding this subject.

$$T_{J(RISE)} = P_{TOTAL} \times R_{\theta JA}$$

$$T_{J(RISE)} = 218.1 \text{ milli-Watts} \times 230.0^{\circ}\text{C/Watt}$$

$$T_{J(RISE)} = 50.2^{\circ}\text{C}$$

### Junction Temperature Estimate

To estimate the internal junction temperature, the calculated temperature rise is added to the ambient or offset temperature. For this example, the worst-case junction temperature is estimated below.

$$T_J = T_{J(RISE)} + T_{A(MAX)}$$

$$T_J = 90.2^{\circ}\text{C}$$

### Maximum Package Power Dissipation at +40°C Ambient Temperature

$$\text{SOT-23 } (230.0^{\circ}\text{C/Watt} = R_{\theta JA})$$

$$P_{D(MAX)} = (125^{\circ}\text{C} - 40^{\circ}\text{C}) / 230^{\circ}\text{C/W}$$

$$P_{D(MAX)} = 369.6 \text{ milli-Watts}$$

$$\text{SOT-89 } (52^{\circ}\text{C/Watt} = R_{\theta JA})$$

$$P_{D(MAX)} = (125^{\circ}\text{C} - 40^{\circ}\text{C}) / 52^{\circ}\text{C/W}$$

$$P_{D(MAX)} = 1.635 \text{ Watts}$$

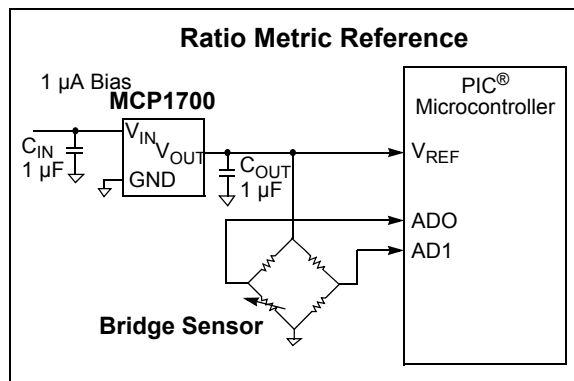
$$\text{TO-92 } (131.9^{\circ}\text{C/Watt} = R_{\theta JA})$$

$$P_{D(MAX)} = (125^{\circ}\text{C} - 40^{\circ}\text{C}) / 131.9^{\circ}\text{C/W}$$

$$P_{D(MAX)} = 644 \text{ milli-Watts}$$

## 6.4 Voltage Reference

The MCP1700 can be used not only as a regulator, but also as a low quiescent current voltage reference. In many microcontroller applications, the initial accuracy of the reference can be calibrated using production test equipment or by using a ratio measurement. When the initial accuracy is calibrated, the thermal stability and line regulation tolerance are the only errors introduced by the MCP1700 LDO. The low cost, low quiescent current and small ceramic output capacitor are all advantages when using the MCP1700 as a voltage reference.



**FIGURE 6-2:** Using the MCP1700 as a voltage reference.

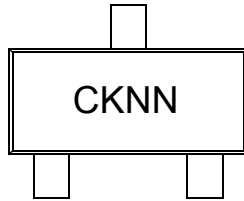
## 6.5 Pulsed Load Applications

For some applications, there are pulsed load current events that may exceed the specified 250 mA maximum specification of the MCP1700. The internal current limit of the MCP1700 will prevent high peak load demands from causing non-recoverable damage. The 250 mA rating is a maximum average continuous rating. As long as the average current does not exceed 250 mA, pulsed higher load currents can be applied to the MCP1700. The typical current limit for the MCP1700 is 550 mA ( $T_A + 25^{\circ}\text{C}$ ).

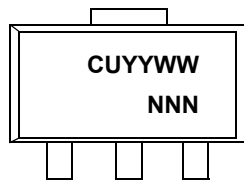
## 7.0 PACKAGING INFORMATION

### 7.1 Package Marking Information

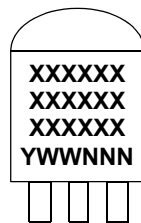
3-Pin SOT-23



3-Pin SOT-89



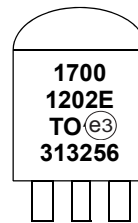
3-Pin TO-92



| Standard      |           |
|---------------|-----------|
| Extended Temp |           |
| Symbol        | Voltage * |
| CK            | 1.2       |
| CM            | 1.8       |
| CP            | 2.5       |
| CR            | 3.0       |
| CS            | 3.3       |
| CU            | 5.0       |

\* Custom output voltages available upon request.  
Contact your local Microchip sales office for more information.

Example:



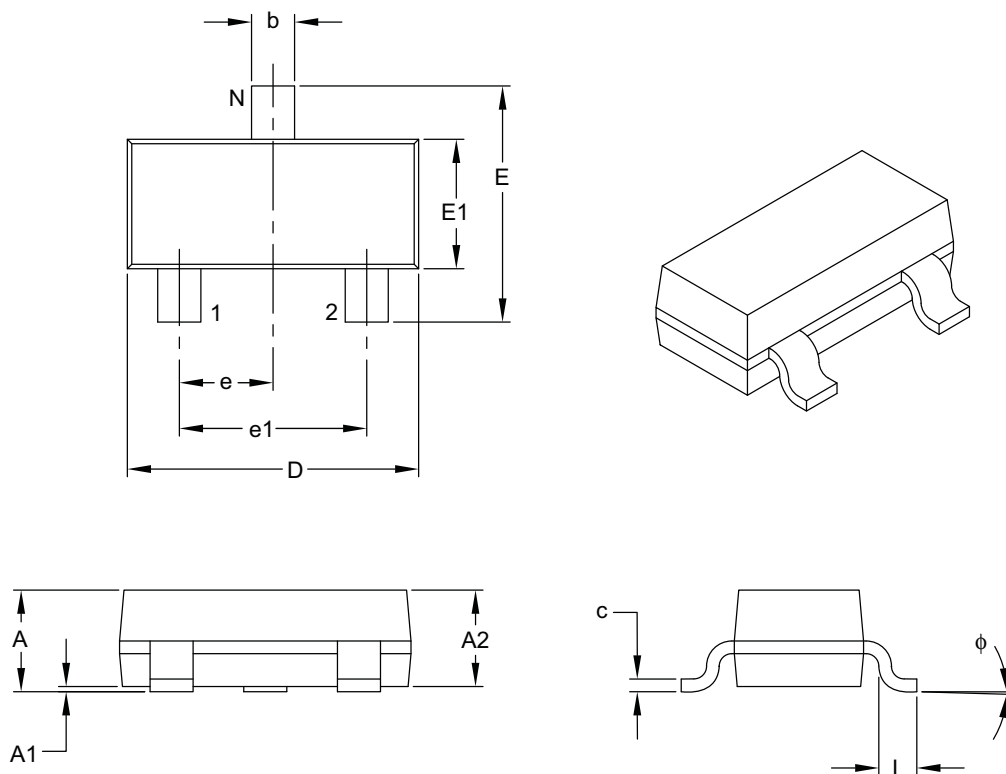
|                |        |  |
|----------------|--------|--|
| <b>Legend:</b> | XX...X | Customer-specific information  |
|                | Y      | Year code (last digit of calendar year)  |
|                | YY     | Year code (last 2 digits of calendar year)   |
|                | WW     | Week code (week of January 1 is week '01')   |
|                | NNN    | Alphanumeric traceability code   |
|                | (e3)   | Pb-free JEDEC designator for Matte Tin (Sn)  |
|                | *      | This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package. |

**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

# MCP1700

## 3-Lead Plastic Small Outline Transistor (TT or NB) [SOT-23]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Units                    |    | MILLIMETERS |      |      |
|--------------------------|----|-------------|------|------|
| Dimension Limits         |    | MIN         | NOM  | MAX  |
| Number of Pins           | N  | 3           |      |      |
| Lead Pitch               | e  | 0.95 BSC    |      |      |
| Outside Lead Pitch       | e1 | 1.90 BSC    |      |      |
| Overall Height           | A  | 0.89        | —    | 1.12 |
| Molded Package Thickness | A2 | 0.79        | 0.95 | 1.02 |
| Standoff                 | A1 | 0.01        | —    | 0.10 |
| Overall Width            | E  | 2.10        | —    | 2.64 |
| Molded Package Width     | E1 | 1.16        | 1.30 | 1.40 |
| Overall Length           | D  | 2.67        | 2.90 | 3.05 |
| Foot Length              | L  | 0.13        | 0.50 | 0.60 |
| Foot Angle               | φ  | 0°          | —    | 10°  |
| Lead Thickness           | c  | 0.08        | —    | 0.20 |
| Lead Width               | b  | 0.30        | —    | 0.54 |

### Notes:

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

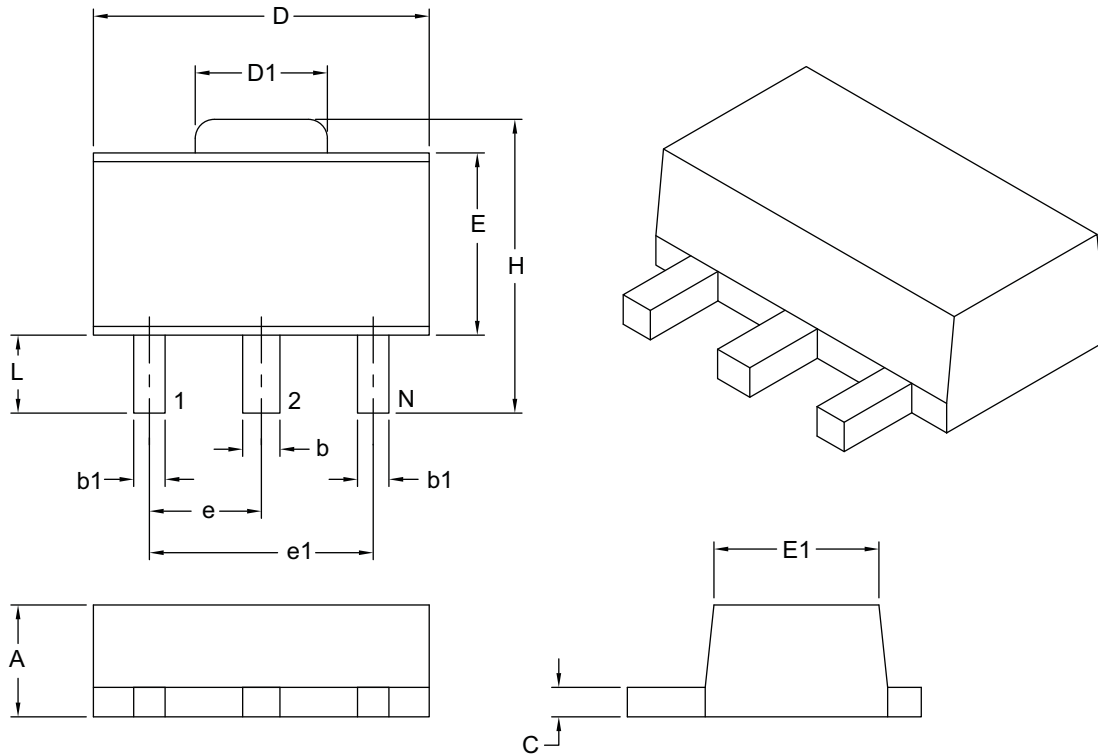
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-104B



## 3-Lead Plastic Small Outline Transistor Header (MB) [SOT-89]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Units                        |    | MILLIMETERS |      |
|------------------------------|----|-------------|------|
| Dimension Limits             |    | MIN         | MAX  |
| Number of Leads              | N  | 3           |      |
| Pitch                        | e  | 1.50 BSC    |      |
| Outside Lead Pitch           | e1 | 3.00 BSC    |      |
| Overall Height               | A  | 1.40        | 1.60 |
| Overall Width                | H  | 3.94        | 4.25 |
| Molded Package Width at Base | E  | 2.29        | 2.60 |
| Molded Package Width at Top  | E1 | 2.13        | 2.29 |
| Overall Length               | D  | 4.39        | 4.60 |
| Tab Length                   | D1 | 1.40        | 1.83 |
| Foot Length                  | L  | 0.79        | 1.20 |
| Lead Thickness               | c  | 0.35        | 0.44 |
| Lead 2 Width                 | b  | 0.41        | 0.56 |
| Leads 1 & 3 Width            | b1 | 0.36        | 0.48 |

### Notes:

- Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

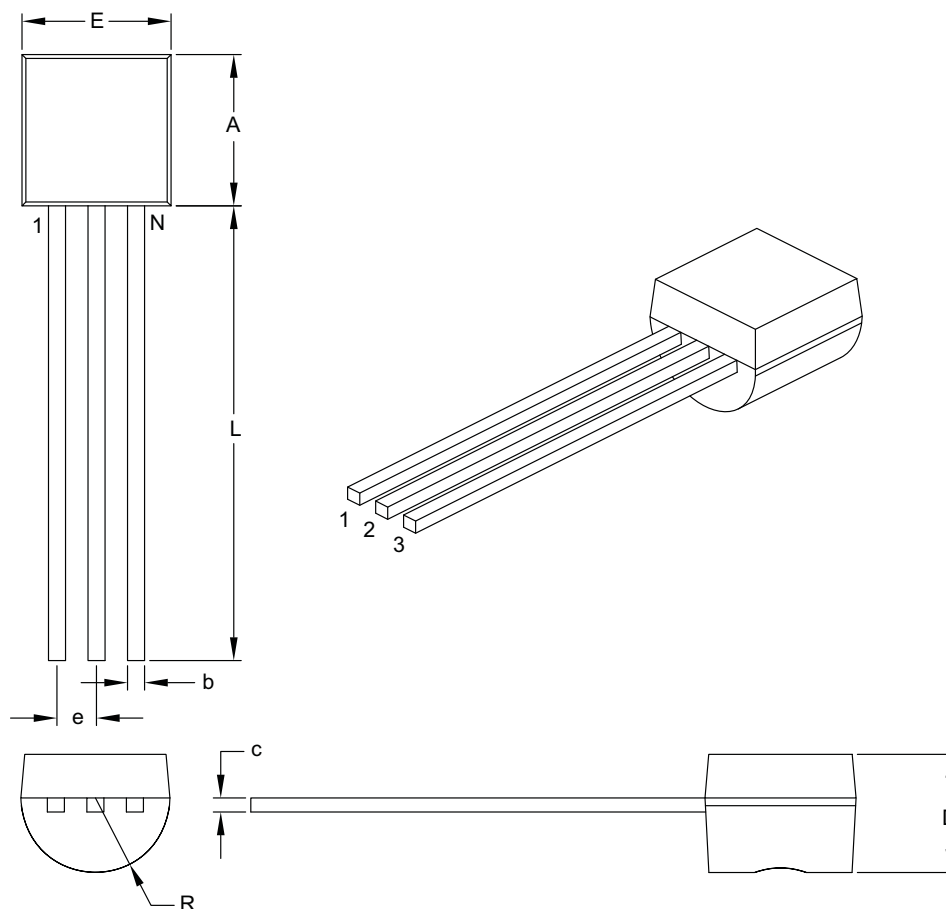
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-029B

# MCP1700

## 3-Lead Plastic Transistor Outline (TO or ZB) [TO-92]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



|                        |   | Units | INCHES   |      |
|------------------------|---|-------|----------|------|
| Dimension Limits       |   |       | MIN      | MAX  |
| Number of Pins         | N |       | 3        |      |
| Pitch                  | e |       | .050 BSC |      |
| Bottom to Package Flat | D |       | .125     | .165 |
| Overall Width          | E |       | .175     | .205 |
| Overall Length         | A |       | .170     | .210 |
| Molded Package Radius  | R |       | .080     | .105 |
| Tip to Seating Plane   | L |       | .500     | –    |
| Lead Thickness         | c |       | .014     | .021 |
| Lead Width             | b |       | .014     | .022 |

### Notes:

- Dimensions A and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .005" per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-101B

## APPENDIX A: REVISION HISTORY

### Revision B (February 2007)

- Updated Packaging Information.
- Corrected **Section “Product Identification System”**.
- Changed X5R to X7R in Notes to **“DC Characteristics”**, **“Temperature Specifications”**, and **“Typical Performance Curves”**.

### Revision A (November 2005)

- Original Release of this Document.

# MCP1700

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NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

| <u>PART NO.</u>   | <u>X-</u>   | <u>XXX</u>     | <u>X</u>  | <u>X</u>    | <u>XX</u> |
|---|-------------|----------------|-----------|-------------|-----------|
| MCP1700   | Tape & Reel | Voltage Output | Tolerance | Temp. Range | Package   |
| <div>Device: MCP1700: Low Quiescent Current LDO</div> <div>Tape and Reel: T: Tape and Reel only applies to SOT-23 and SOT-89 devices</div> <div>Standard Output Voltage: *<div>120 = 1.2V<br/>180 = 1.8V<br/>250 = 2.5V<br/>300 = 3.0V<br/>330 = 3.3V<br/>500 = 5.0V</div><div>* Custom output voltages available upon request. Contact your local Microchip sales office for more information</div></div> <div>Tolerance: 2 = 2%</div> <div>Temperature Range: E = -40°C to +125°C (Extended)</div> <div>Package: MB = Plastic Small Outline Transistor (SOT-89), 3-lead<br/>TO = Plastic Small Outline Transistor (TO-92), 3-lead<br/>TT = Plastic Small Outline Transistor SOT-23), 3-lead</div> |             |                |           |             |           |

Examples:

SOT-89 Package:

a) MCP1700T-1202E/MB: 1.2V V<sub>OUT</sub>

b) MCP1700T-1802E/MB: 1.8V V<sub>OUT</sub>

c) MCP1700T-2502E/MB: 2.5V V<sub>OUT</sub>

d) MCP1700T-3002E/MB: 3.0V V<sub>OUT</sub>

e) MCP1700T-3302E/MB: 3.3V V<sub>OUT</sub>

f) MCP1700T-5002E/MB: 5.0V V<sub>OUT</sub>

TO-92 Package:

g) MCP1700-1202E/TO: 1.2V V<sub>OUT</sub>

h) MCP1700-1802E/TO: 1.8V V<sub>OUT</sub>

i) MCP1700-2502E/TO: 2.5V V<sub>OUT</sub>

j) MCP1700-3002E/TO: 3.0V V<sub>OUT</sub>

k) MCP1700-3302E/TO: 3.3V V<sub>OUT</sub>

l) MCP1700-5002E/TO: 5.0V V<sub>OUT</sub>

SOT-23 Package:

a) MCP1700T-1202E/TT: 1.2V V<sub>OUT</sub>

b) MCP1700T-1802E/TT: 1.8V V<sub>OUT</sub>

c) MCP1700T-2502E/TT: 2.5V V<sub>OUT</sub>

d) MCP1700T-3002E/TT: 3.0V V<sub>OUT</sub>

e) MCP1700T-3302E/TT: 3.3V V<sub>OUT</sub>

f) MCP1700T-5002E/TT: 5.0V V<sub>OUT</sub>

# MCP1700

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NOTES:

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**Note the following details of the code protection feature on Microchip devices:**

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*Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona, Gresham, Oregon and Mountain View, California. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*



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