MCP1804

150 mA, 28V LDO Regulator With Shutdown

Features

- 150 mA Output Current
- Low Drop Out Voltage, 260 mV typical @ 20 mA, V_R = 3.3V
- 50 µA Typical Quiescent Current
- 0.01 µA Typical Shutdown Current
- Input Operating Voltage Range: 2.0V to 28.0V
- Standard Output Voltage Options (1.8V, 2.5V, 3.0V, 3.3V, 5.0V, 10.0V, 12.0V)
- Output Voltage Accuracy: ±2%
- Output voltages from 1.8V to 18.0V in 0.1V increments are available upon request
- Stable with Ceramic output capacitors
- Current Limit Protection With Current Foldback
- Shutdown pin
- High PSRR: 50 dB typical @ 1 kHz

Applications

- Cordless Phones, Wireless Communications
- PDAs, Notebook and Netbook Computers
- Digital Cameras
- Microcontroller Power
- Car Audio and Navigation Systems
- Home Appliances

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

Description

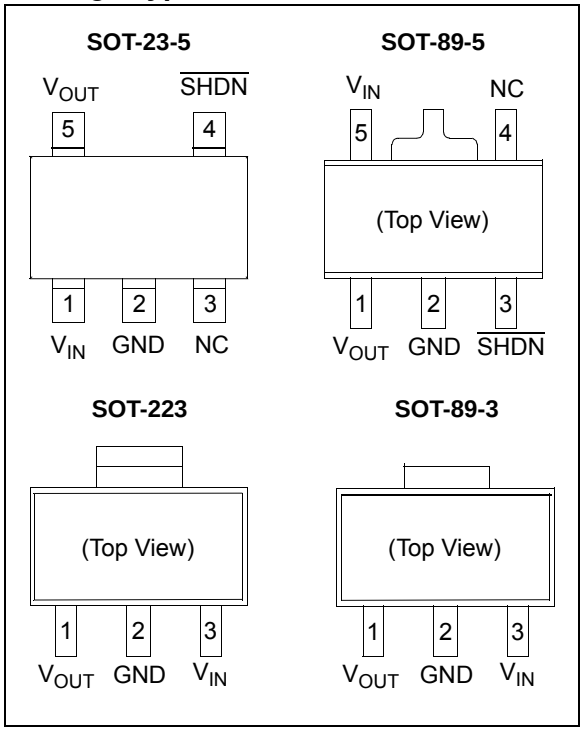
The MCP1804 is a family of CMOS low dropout (LDO) voltage regulators that can deliver up to 150 mA of current while consuming only 50 µA of quiescent current (typical, 1.8V ≤ V_{OUT} ≤ 5.0V). The input operating range is specified from 2.0V to 28.0V.

The MCP1804 is capable of delivering 100 mA with only 1300 mV (typical) of input to output voltage differential (V_{OUT} = 3.3V). The output voltage tolerance of the MCP1804 at +25°C is a maximum of ±2%. Line regulation is ±0.15% typical at +25°C.

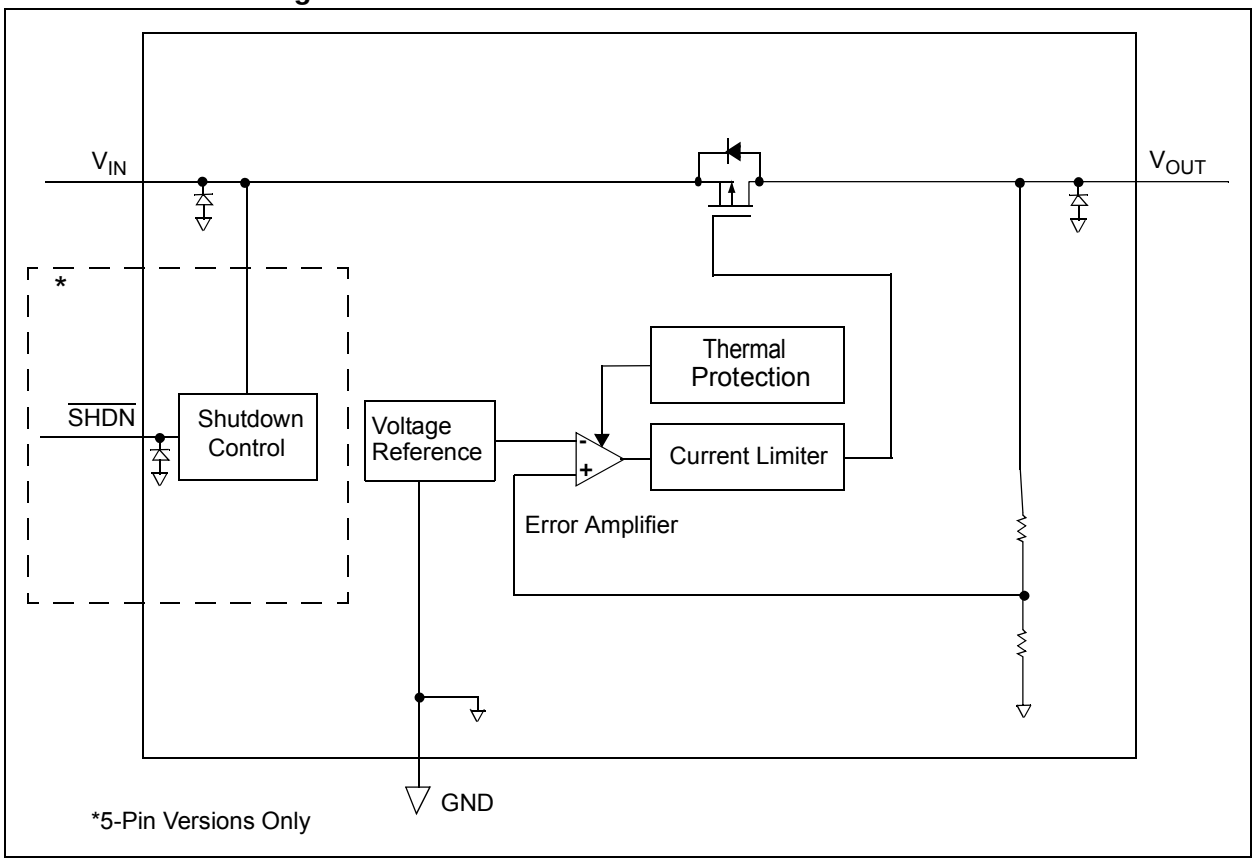
The LDO input and output is stable with 0.1 µF of input and output capacitance. Ceramic, tantalum or aluminum electrolytic capacitors can all be used for input and output. Overcurrent limit with current foldback to 40 mA (typical) provides short-circuit protection. A shutdown ($\overline{SHDN}$) function allows the output to be enabled or disabled. When disabled, the MCP1804 draws only 0.01 µA of current (typical).

Package options include the SOT-23-5 (SOT-25), SOT-89-3, SOT-89-5, and SOT-223-3.

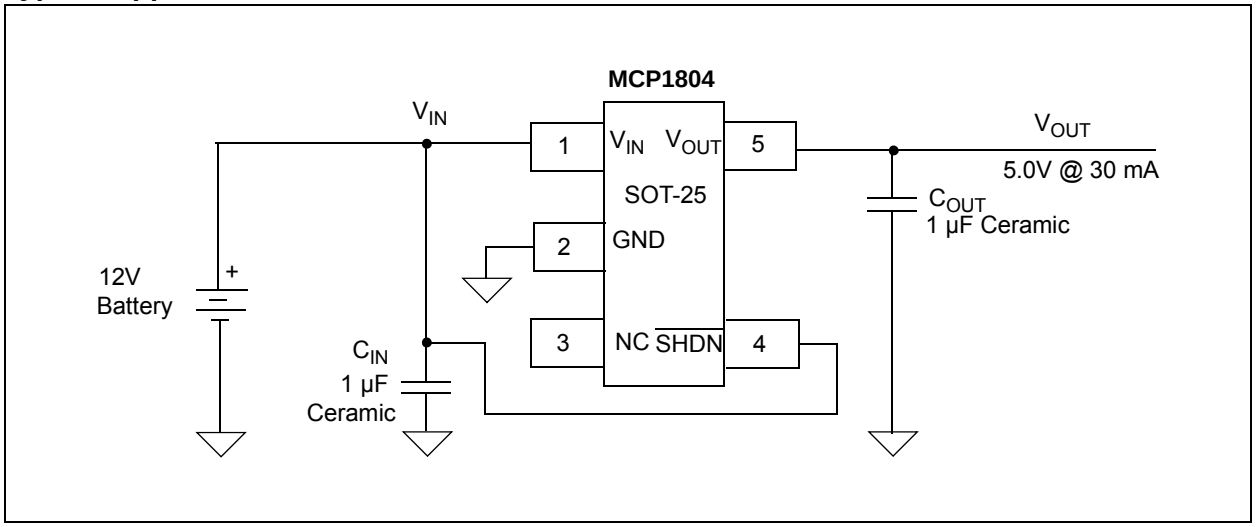
Package Types



Functional Block Diagram



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage ..... +30V
Output Current (Continuous)..... $P_D/(V_{IN}-V_{OUT})$mA
Output Current (Peak)..... 300 mA
Output Voltage ..... (V_{SS}-0.3V) to (V_{IN}+0.3V)
$\overline{SHDN}$ Voltage .....(V_{SS}-0.3V) to +30V

† **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.

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all limits are established for $V_{IN} = V_R + 2.0V$, **Note 1**, C_{OUT} = 1 µF (X7R), C_{IN} = 1 µF (X7R), $V_{\overline{SHDN}} = V_{IN}$, T_A = +25°C

Parameters	Sym	Min	Typ	Max	Units	Conditions
Input / Output Characteristics						
Input Operating Voltage	V_{IN}	2.0	—	28.0	V	**Note 1**
Input Quiescent Current	I_q					I_L = 0 mA
		—	50	105	µA	1.8V ≤ V_{OUT} ≤ 5.0V
		—	60	115	µA	5.1V ≤ V_{OUT} ≤ 12.0V
		—	65	125	µA	12.1V ≤ V_{OUT} ≤ 18.0V
Shutdown Current	I_{SHDN}	—	0.01	0.10	µA	$\overline{SHDN}$ = 0V
Maximum Output Current	I_{OUT_mA}					$V_{IN} = V_R + 3.0V$
		100	—	—	mA	V_{OUT} < 3.0V
		150	—	—	mA	V_{OUT} ≥ 3.0V
Current Limiter	I_{LIMIT}	—	200	—	mA	
Output Short Circuit Current	I_{OUT_SC}	—	40	—	mA	
Output Voltage Regulation	V_{OUT}	V_R-2.0%	V_R	V_R+2.0%	V	I_{OUT} = 10 mA, **Note 2**
V_{OUT} Temperature Coefficient	TCV_{OUT}	—	±100	—	ppm/°C	I_{OUT} = 20 mA, -40°C ≤ T_A ≤ +85°C, **Note 3**
Line Regulation	$\Delta V_{OUT}/(V_{OUT} X \Delta V_{IN})$					(V_R + 2V) ≤ V_{IN} ≤ 28V, **Note 1**
		—	0.05	0.10	%/V	I_{OUT} = 5 mA
		—	0.15	0.30	%/V	I_{OUT} = 13 mA
Load Regulation	$\Delta V_{OUT}/V_{OUT}$					I_L = 1.0 mA to 50 mA, **Note 4**
		—	50	90	mV	1.8V ≤ V_{OUT} ≤ 5.0V
		—	110	175	mV	5.1V ≤ V_{OUT} ≤ 12.0V
		—	180	275	mV	12.1V ≤ V_{OUT} ≤ 18.0V

Note 1: The minimum V_{IN} must meet one condition: $V_{IN} \geq (V_R + 2.0V)$.

2: V_R is the nominal regulator output voltage with an input voltage of $V_{IN} = V_R + 2.0V$. For example: V_R = 1.8V, 2.5V, 3.0V, 3.3V, etc.

3: $TCV_{OUT} = (V_{OUT-HIGH} - V_{OUT-LOW}) * 10^6 / (V_R * \Delta Temperature)$, $V_{OUT-HIGH}$ = 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 an applied input voltage of V_R + 2.0V.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all limits are established for $V_{IN} = V_R + 2.0V$, **Note 1**, $C_{OUT} = 1\ \mu F$ (X7R), $C_{IN} = 1\ \mu F$ (X7R), $V_{\overline{SHDN}} = V_{IN}$, $T_A = +25°C$

Parameters	Sym	Min	Typ	Max	Units	Conditions
Dropout Voltage **Note 1**, **Note 5**	$V_{DROPOUT}$					$I_L = 20$ mA
		—	550	710	mV	$1.8V \le V_R \le 1.9V$
		—	450	600	mV	$2.0V \le V_R \le 2.1V$
		—	390	520	mV	$2.2V \le V_R \le 2.4V$
		—	310	450	mV	$2.5V \le V_R \le 2.9V$
		—	260	360	mV	$3.0V \le V_R \le 3.9V$
		—	220	320	mV	$4.0V \le V_R \le 4.9V$
		—	190	280	mV	$5.0V \le V_R \le 6.4V$
		—	170	230	mV	$6.5V \le V_R \le 8.0V$
		—	130	190	mV	$8.1V \le V_R \le 10.0V$
		—	120	170	mV	$10.1V \le V_R \le 18.0V$
						$I_L = 100$ mA
		—	2200	2700	mV	$1.8V \le V_R \le 1.9V$
		—	1900	2600	mV	$2.0V \le V_R \le 2.1V$
		—	1700	2200	mV	$2.2V \le V_R \le 2.4V$
		—	1500	1900	mV	$2.5V \le V_R \le 2.9V$
		—	1300	1700	mV	$3.0V \le V_R \le 3.9V$
		—	1100	1500	mV	$4.0V \le V_R \le 4.9V$
		—	1000	1300	mV	$5.0V \le V_R \le 6.4V$
		—	800	1150	mV	$6.5V \le V_R \le 8.0V$
		—	700	950	mV	$8.1V \le V_R \le 10.0V$
		—	650	850	mV	$10.1V \le V_R \le 18.0V$
$\overline{SHDN}$ "H" Voltage	V_{SHDN_H}	1.1	—	V_{IN}	V	$V_{IN} = 28V$
$\overline{SHDN}$ "L" Voltage	V_{SHDN_L}	0	—	0.35	V	$V_{IN} = 28V$
$\overline{SHDN}$ Current	I_{SHDN}	-0.1	—	0.1	µA	$V_{IN} = 28V$, V_{SHDN} = GND or V_{IN}
Power Supply Ripple Rejection Ratio	PSRR	—	50	—	dB	f = 1 kHz, $I_L = 20$ mA, $V_{INAC} = 0.5V$ pk-pk, $C_{IN} = 0\ \mu F$
Thermal Shutdown Protection	TSD	—	150	—	°C	T_J
Thermal Shutdown Hysteresis	ΔTSD	—	25	—	°C	

Note 1: The minimum V_{IN} must meet one condition: $V_{IN} \ge (V_R + 2.0V)$.

2: V_R is the nominal regulator output voltage with an input voltage of $V_{IN} = V_R + 2.0V$. For example: $V_R = 1.8V$, 2.5V, 3.0V, 3.3V, etc.

3: $TCV_{OUT} = (V_{OUT\text{-}HIGH} - V_{OUT\text{-}LOW}) * 10^6 / (V_R * \Delta Temperature)$, $V_{OUT\text{-}HIGH}$ = highest voltage measured over the temperature range. $V_{OUT\text{-}LOW}$ = 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 an applied input voltage of $V_R + 2.0V$.

TEMPERATURE SPECIFICATIONS

Parameters	Sym	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Operating Temperature Range	T_A	-40		+85	°C	
Storage Temperature Range	Tstg	-55		+125	°C	
Thermal Package Resistance						
Thermal Resistance, 5LD SOT-23	θ_{JA} θ_{JC}	— —	256 81	— —	°C/W	EIA/JEDEC JESD51-7 FR-4 0.063 4-Layer Board
Thermal Resistance, 3LD SOT-89 5LD SOT-89	θ_{JA} θ_{JC}	— —	180 100	— —	°C/W	EIA/JEDEC JESD51-7 FR-4 0.063 4-Layer Board
Thermal Resistance, 3LD SOT-223	θ_{JA} θ_{JC}	— —	62 15	— —	°C/W	EIA/JEDEC JESD51-7 FR-4 0.063 4-Layer Board

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: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

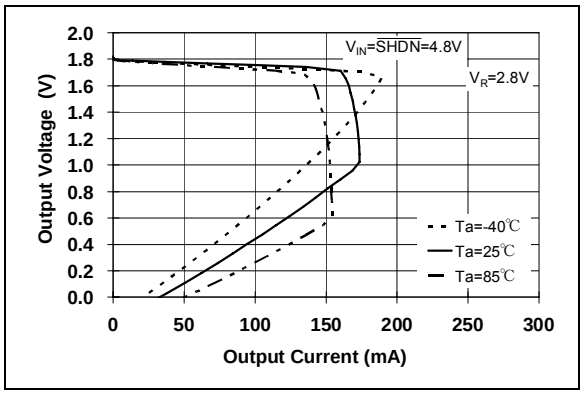


FIGURE 2-1: *Output Voltage vs. Output Current.*

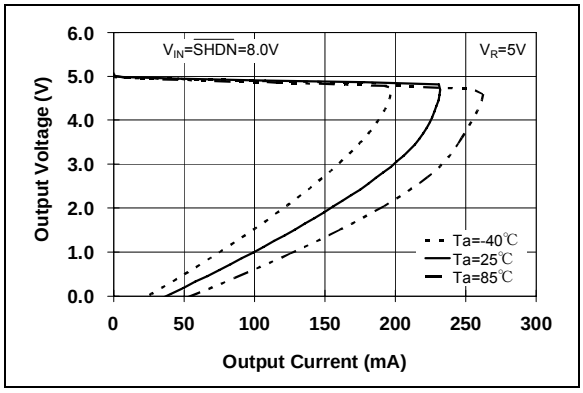


FIGURE 2-2: *Output Voltage vs. Output Current.*

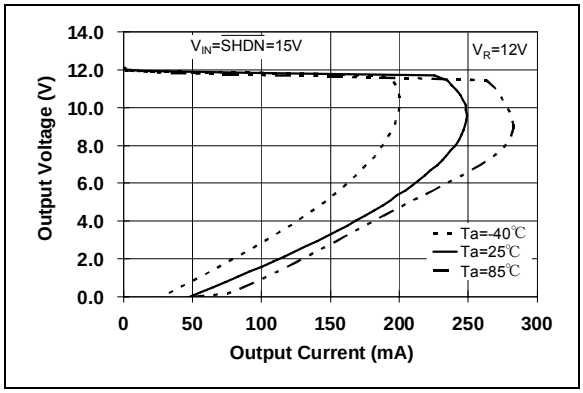


FIGURE 2-3: *Output Voltage vs. Output Current.*

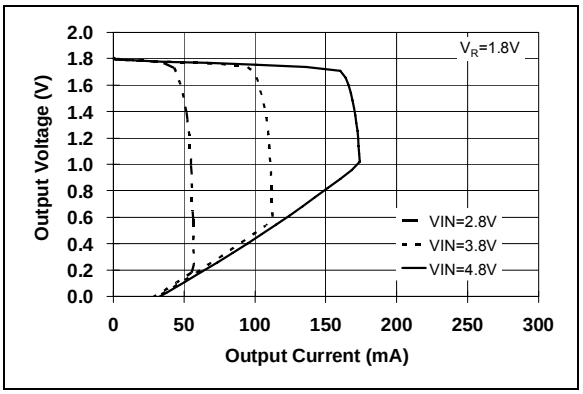


FIGURE 2-4: *Output Voltage vs. Output Current.*

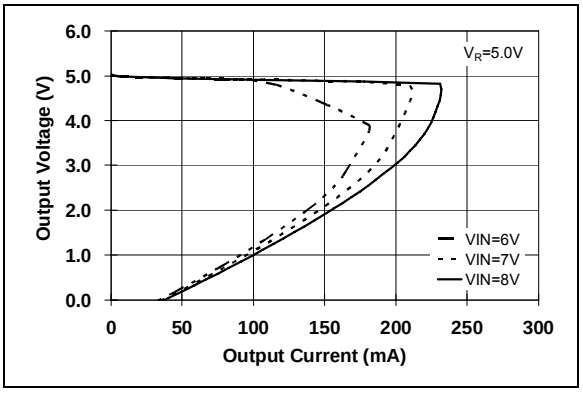


FIGURE 2-5: *Output Voltage vs. Output Current.*

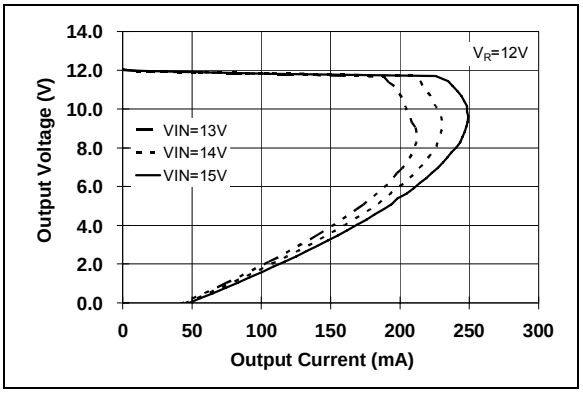


FIGURE 2-6: *Output Voltage vs. Output Current.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

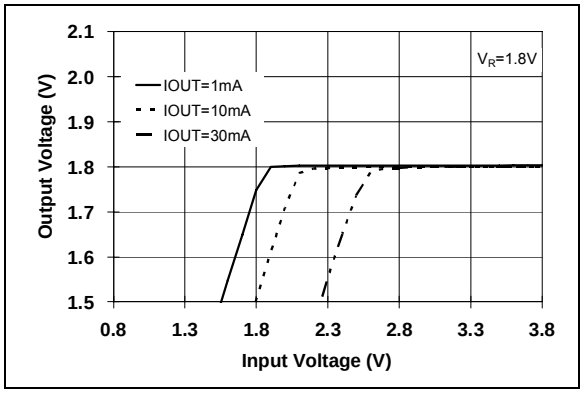


FIGURE 2-7: *Output Voltage vs. Input Voltage.*

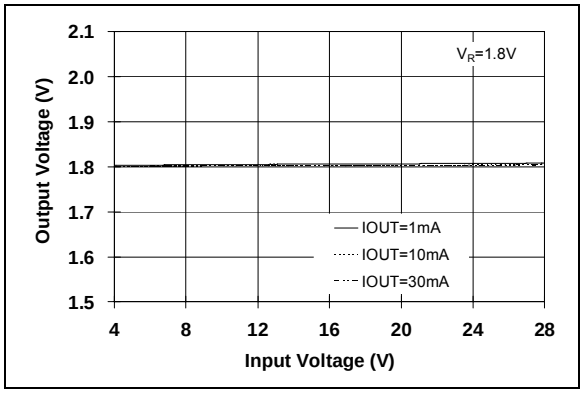


FIGURE 2-10: *Output Voltage vs. Input Voltage.*

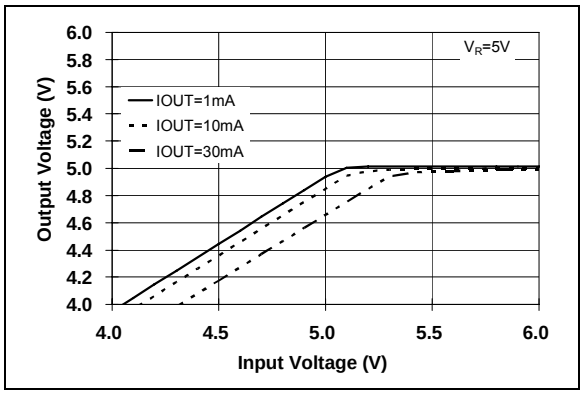


FIGURE 2-8: *Output Voltage vs. Input Voltage.*

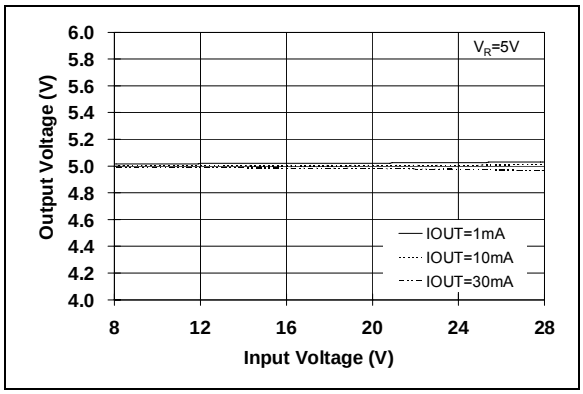


FIGURE 2-11: *Output Voltage vs. Input Voltage.*

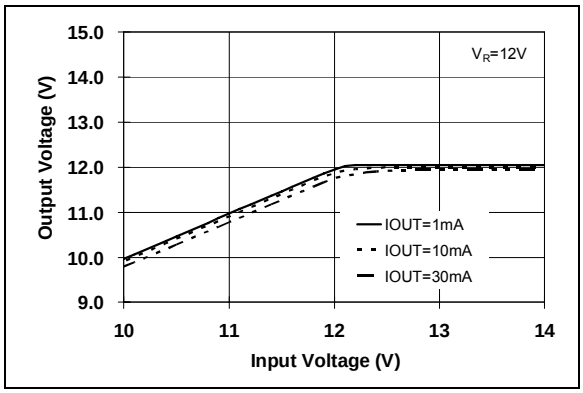


FIGURE 2-9: *Output Voltage vs. Input Voltage.*

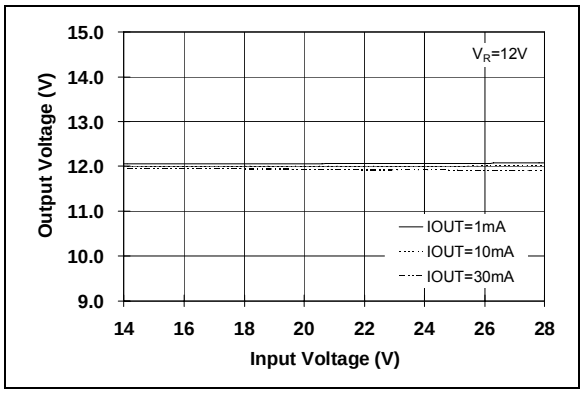


FIGURE 2-12: *Output Voltage vs. Input Voltage.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

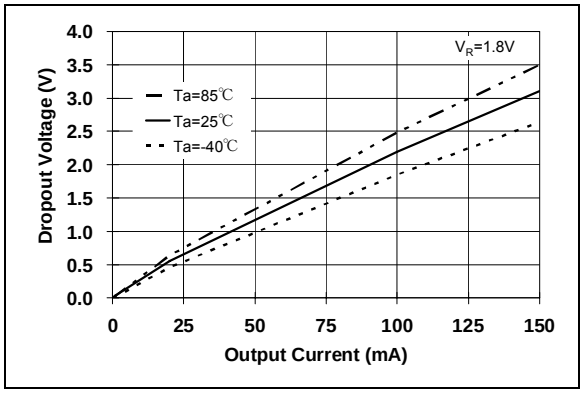


FIGURE 2-13: *Dropout Voltage vs. Load Current.*

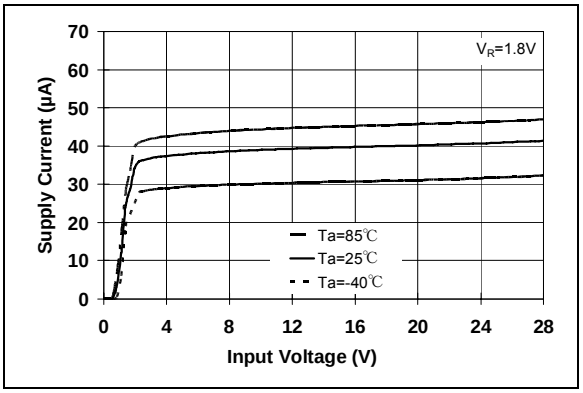


FIGURE 2-16: *Supply Current vs. Input Voltage.*

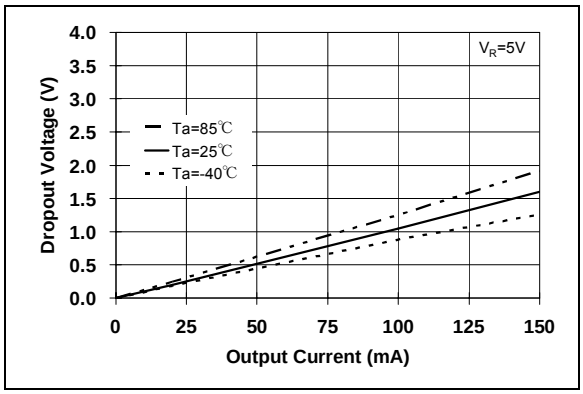


FIGURE 2-14: *Dropout Voltage vs. Load Current.*

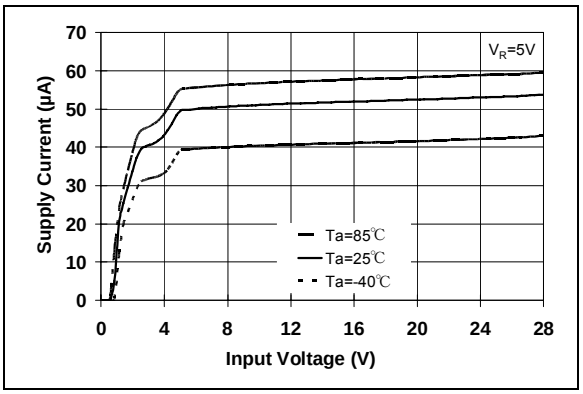


FIGURE 2-17: *Supply Current vs. Input Voltage.*

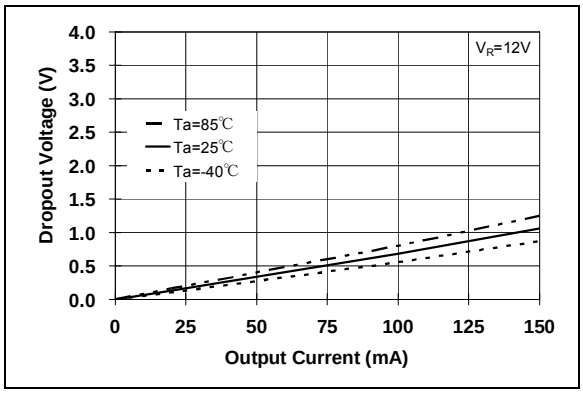


FIGURE 2-15: *Dropout Voltage vs. Load Current.*

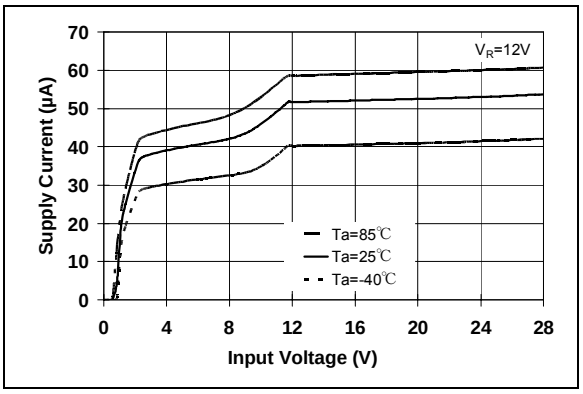


FIGURE 2-18: *Supply Current vs. Input Voltage.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

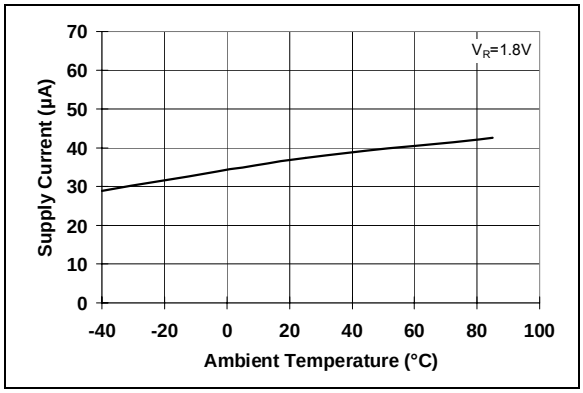


FIGURE 2-19: *Supply Current vs. Input Voltage.*

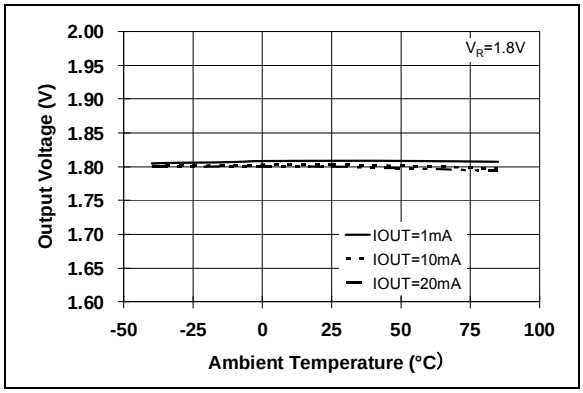


FIGURE 2-22: *Output Voltage vs. Ambient Temperature.*

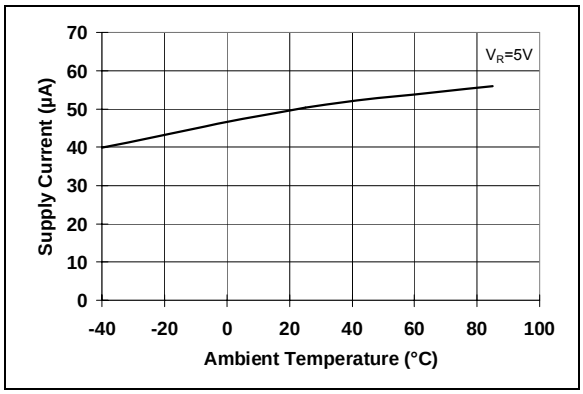


FIGURE 2-20: *Supply Current vs. Input Voltage.*

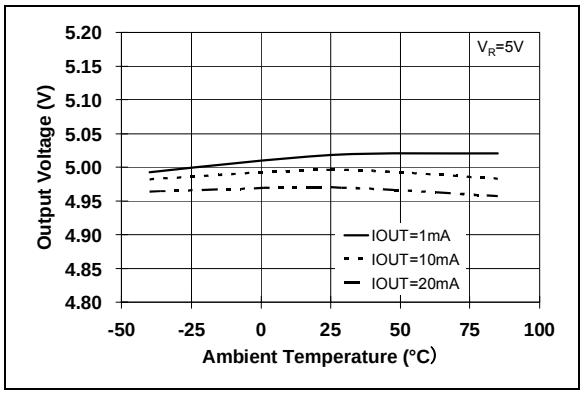


FIGURE 2-23: *Output Voltage vs. Ambient Temperature.*

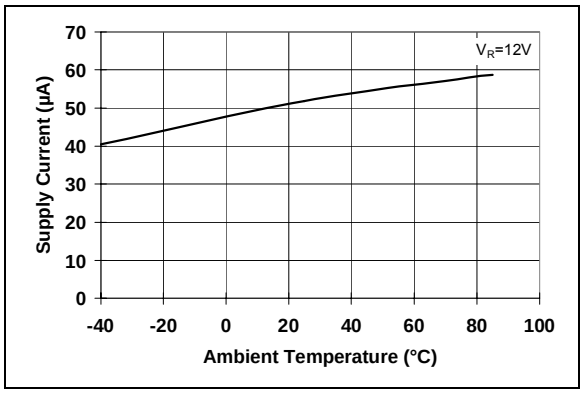


FIGURE 2-21: *Supply Current vs. Input Voltage.*

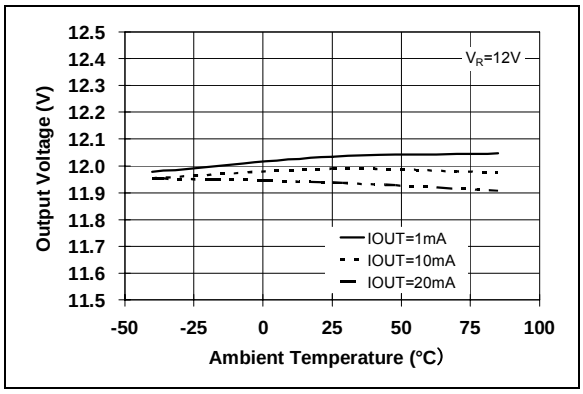


FIGURE 2-24: *Output Voltage vs. Ambient Temperature.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

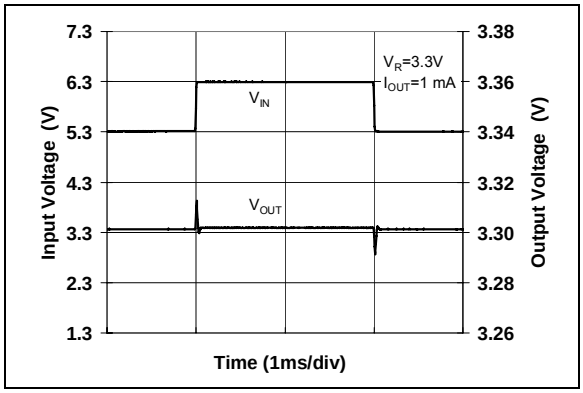


FIGURE 2-25: *Dynamic Line Response.*

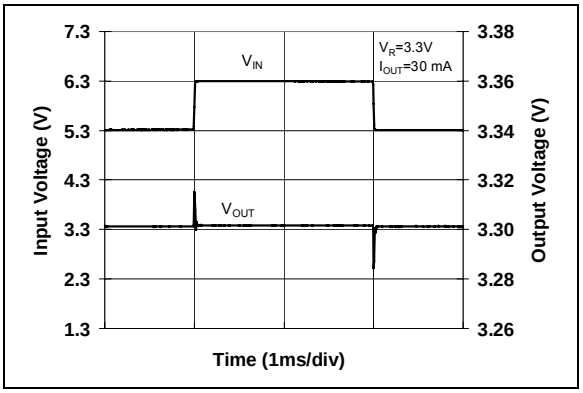


FIGURE 2-28: *Dynamic Line Response.*

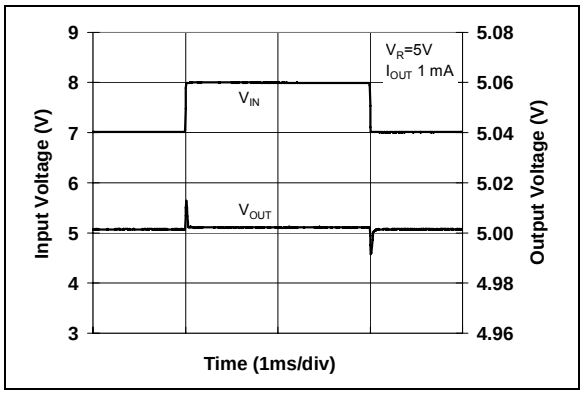


FIGURE 2-26: *Dynamic Line Response.*

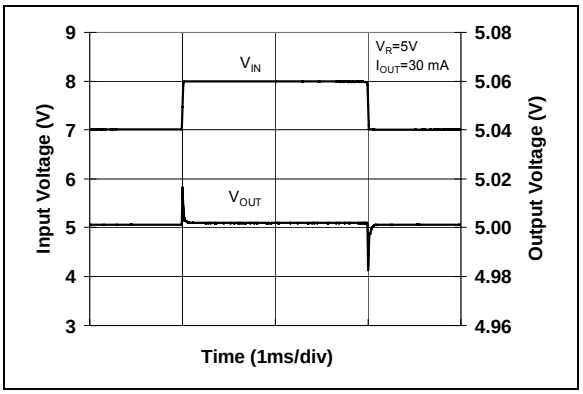


FIGURE 2-29: *Dynamic Line Response.*

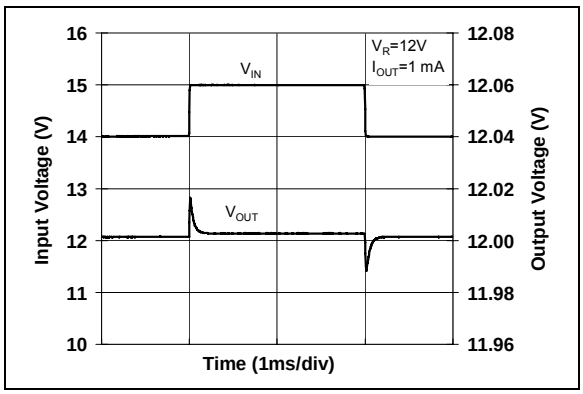


FIGURE 2-27: *Dynamic Line Response.*

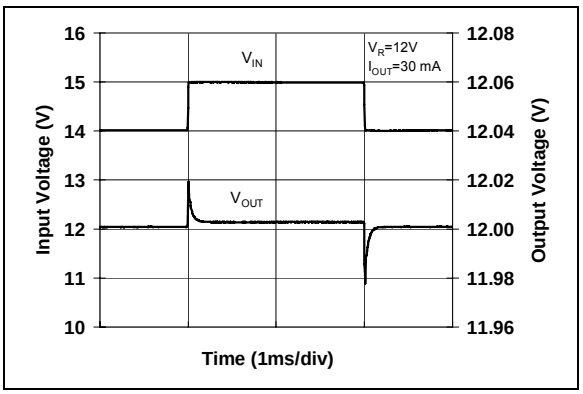


FIGURE 2-30: *Dynamic Line Response.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

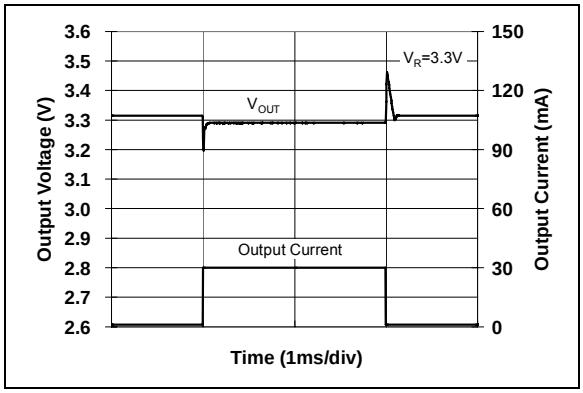


FIGURE 2-31: *Dynamic Load Response.*

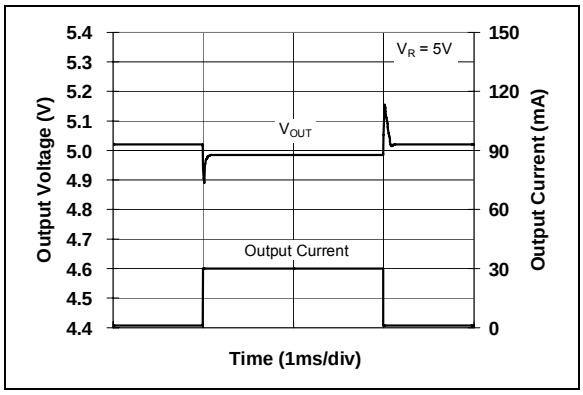


FIGURE 2-32: *Dynamic Load Response.*

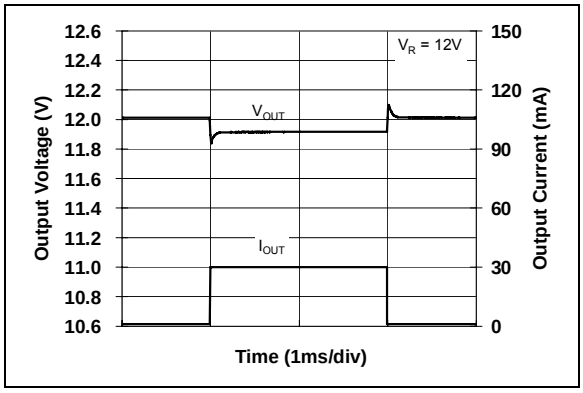


FIGURE 2-33: *Dynamic Load Response.*

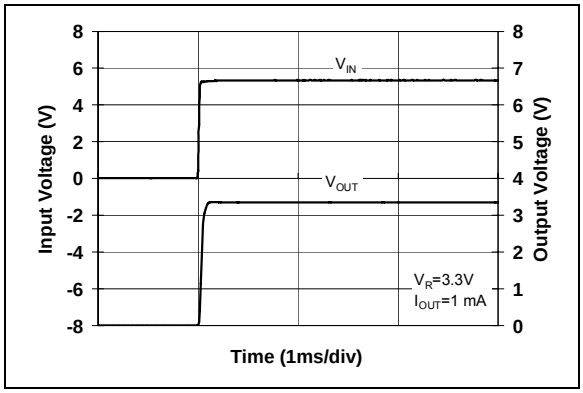


FIGURE 2-34: *Startup Response.*

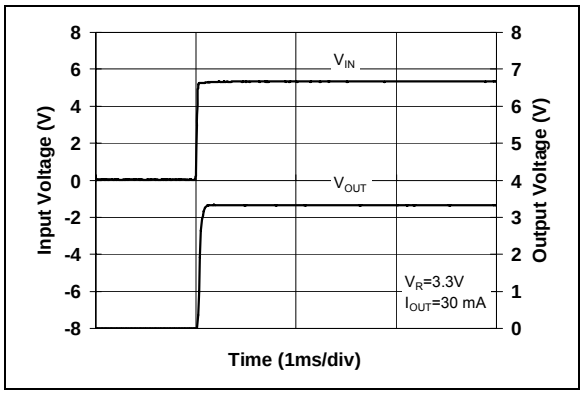


FIGURE 2-35: *Startup Response.*

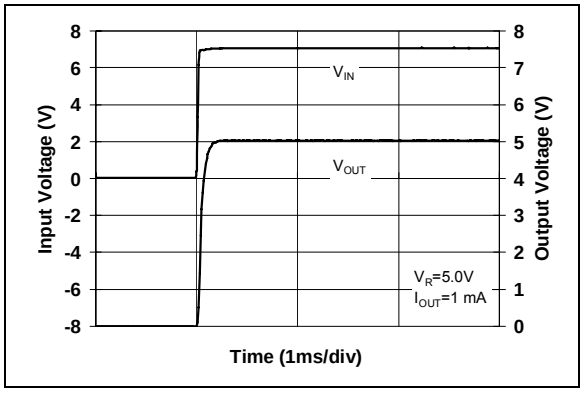


FIGURE 2-36: *Startup Response.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

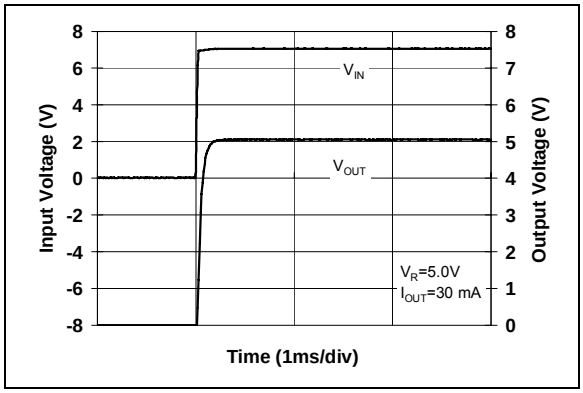


FIGURE 2-37: *Startup Response.*

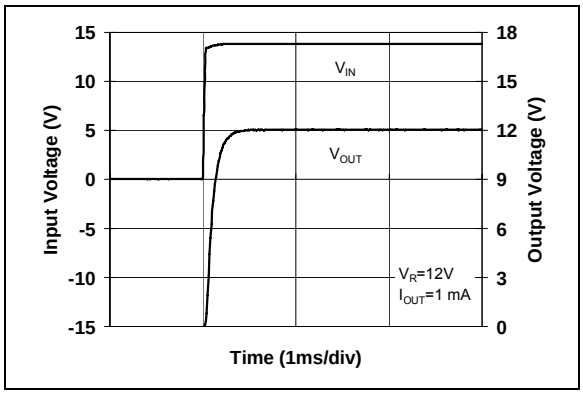


FIGURE 2-38: *Startup Response.*

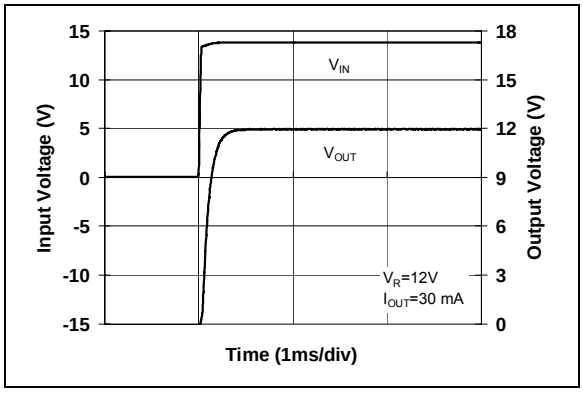


FIGURE 2-39: *Startup Response.*

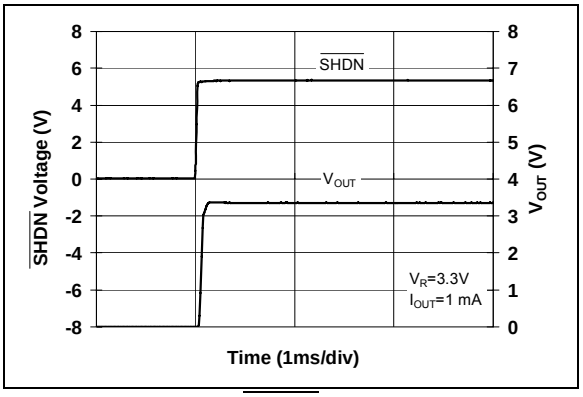


FIGURE 2-40: *$\overline{SHDN}$ Response.*

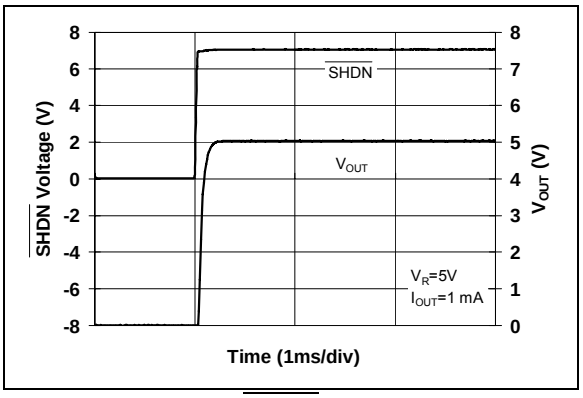


FIGURE 2-41: *$\overline{SHDN}$ Response.*

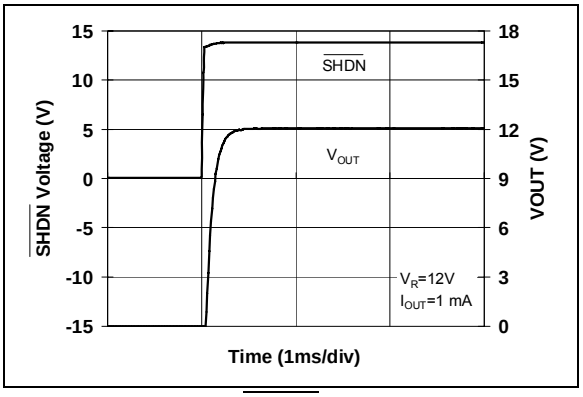


FIGURE 2-42: *$\overline{SHDN}$ Response.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

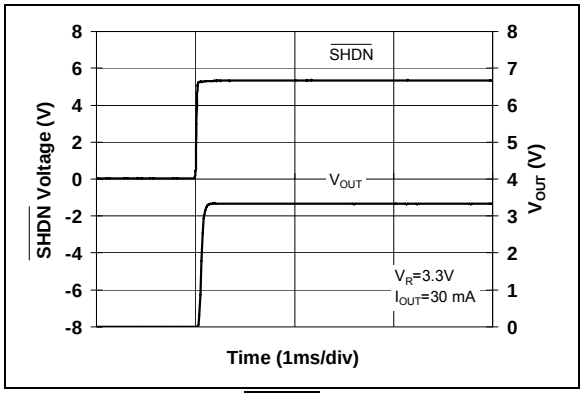


FIGURE 2-43: *$\overline{SHDN}$ Response.*

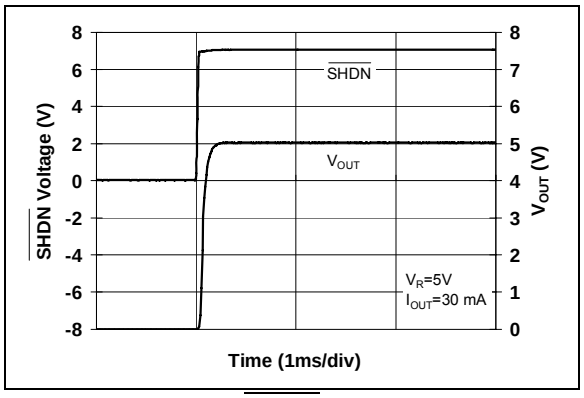


FIGURE 2-44: *$\overline{SHDN}$ Response.*

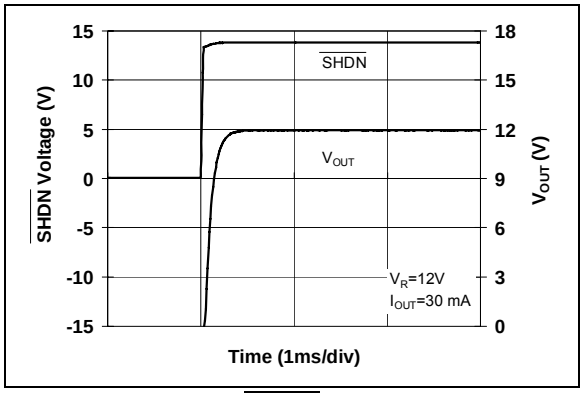


FIGURE 2-45: *$\overline{SHDN}$ Response.*

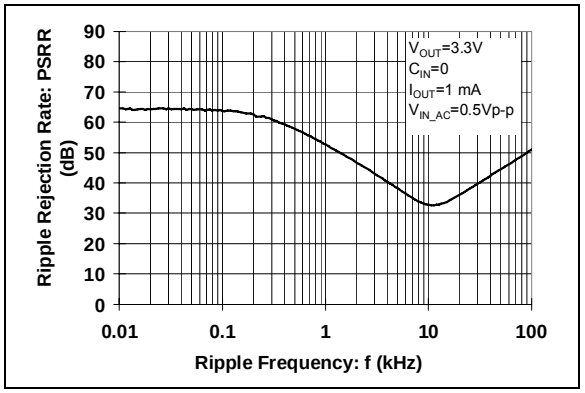


FIGURE 2-46: *PSRR 3.3V @ 1 mA.*

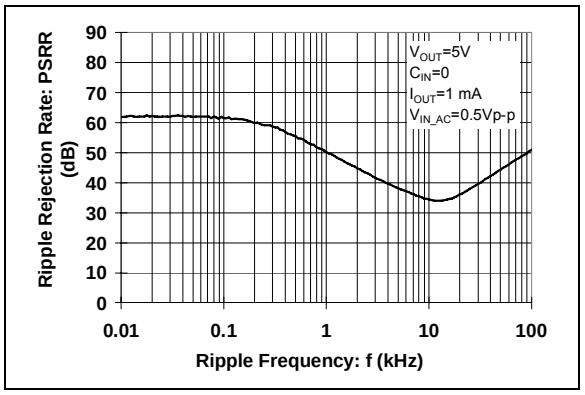


FIGURE 2-47: *PSRR 5.0V @ 1 mA.*

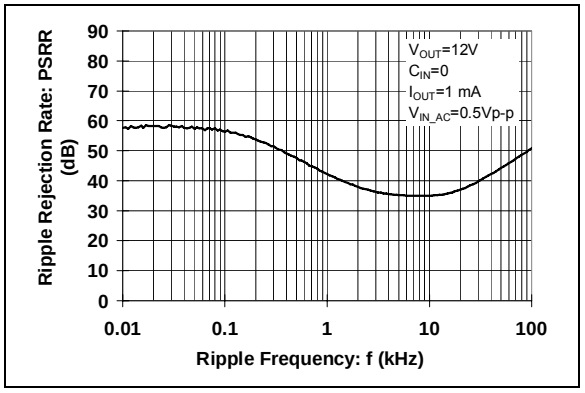


FIGURE 2-48: *PSRR 12.0V @ 1 mA.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

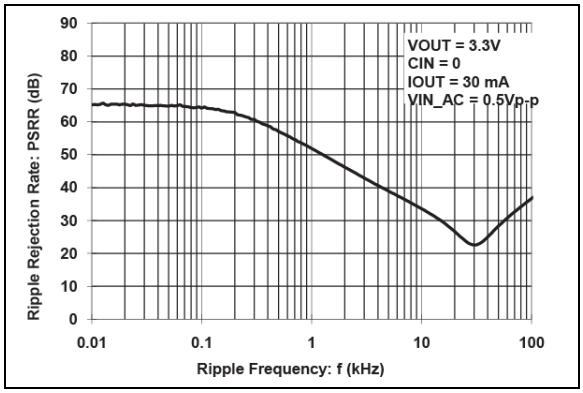


FIGURE 2-49: *PSRR 3.3V @ 30 mA.*

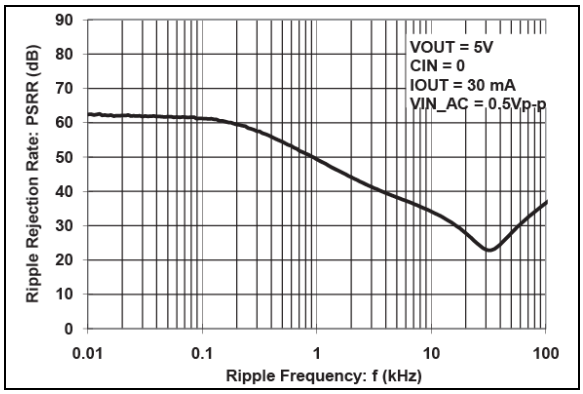


FIGURE 2-50: *PSRR 5.0V @ 30 mA.*

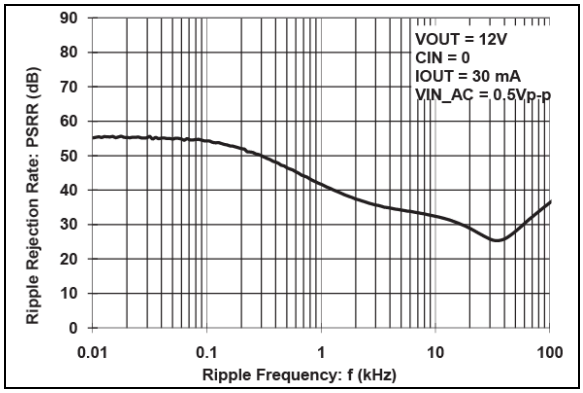


FIGURE 2-51: *PSRR 12V @ 30 mA.*

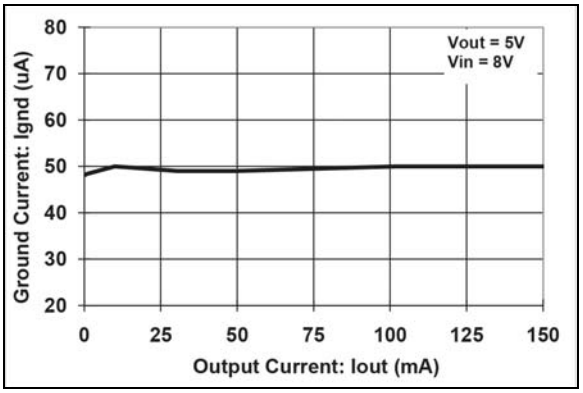


FIGURE 2-52: *PSRR 5V @ 30 mA.*

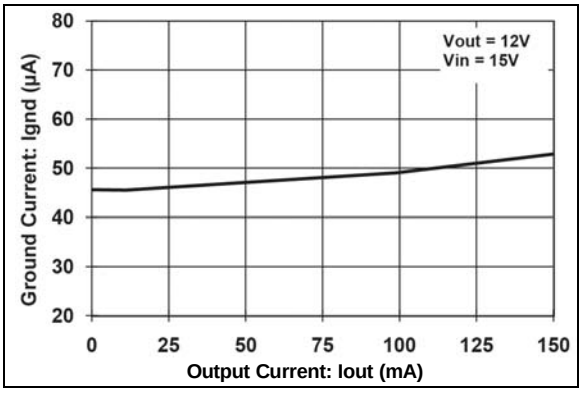


FIGURE 2-53: *Ground Current vs. Output Current.*

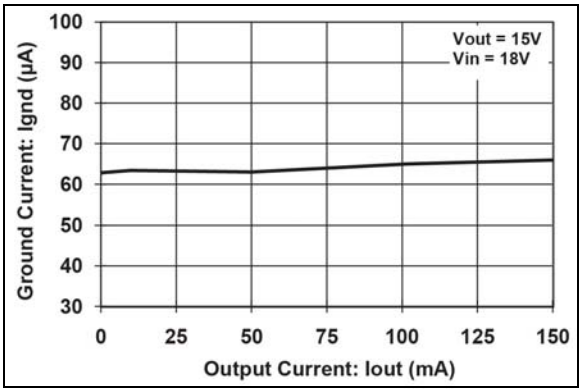


FIGURE 2-54: *Ground Current vs. Output Current.*

Note: Unless otherwise indicated: C_{OUT} = 1 µF Ceramic (X7R), C_{IN} = 1 µF Ceramic (X7R), T_A = +25°C, V_{IN} = V_R + 2.0V.

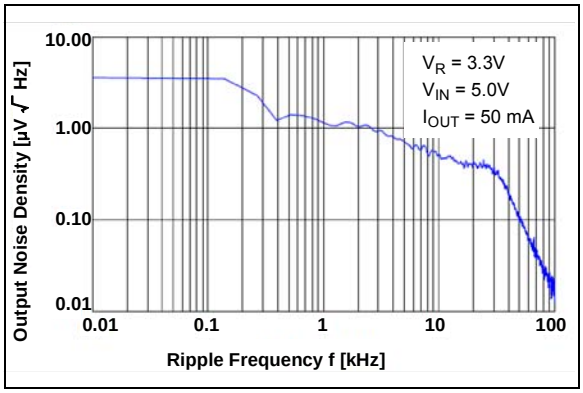


FIGURE 2-55: *Ground Current vs. Output Current.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: MCP1804 PIN FUNCTION TABLE

MCP1804				Symbol	Description
SOT-23-5	SOT-89-5	SOT-89-3	SOT-223-3		
1	5	3	3	V_{IN}	Unregulated Supply Voltage
2	2,TAB	2, TAB	2	GND	Ground Terminal
3	4	—	TAB	NC	No connection
4	3	—	—	$\overline{SHDN}$	Shutdown
5	1	1	1	V_{OUT}	Regulated Voltage Output

3.1 Unregulated Input Voltage (V_{IN})

Connect V_{IN} 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, 0.1 µF to 1.0 µF of capacitance will ensure stable operation of the LDO circuit. 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.

3.2 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 (50 to 60 µA 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.

3.3 Shutdown Input ($\overline{SHDN}$)

The $\overline{SHDN}$ input is used to turn the LDO output voltage on and off. When the $\overline{SHDN}$ input is at a logic-high level, the LDO output voltage is enabled. When the $\overline{SHDN}$ input is pulled to a logic-low level, the LDO output voltage is disabled and the LDO enters a low quiescent current shutdown state where the typical quiescent current is 0.01 µA. The $\overline{SHDN}$ pin does not have an internal pullup or pulldown resistor. The $\overline{SHDN}$ pin must be connected to either V_{IN} or GND to prevent the device from becoming unstable.

3.4 Regulated Output Voltage (V_{OUT})

Connect V_{OUT} 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_{OUT} pin as is practical. The current flowing out of this pin is equal to the DC load current. For most applications, 0.1 µF to 1.0 µF of capacitance will ensure stable operation of the LDO circuit. Larger values may be used to improve dynamic load response. 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 MCP1804 internal circuitry monitors the amount of current flowing through the P-Channel pass transistor. In the event that the load current reaches the current limiter level of 200 mA (typical), the current limiter circuit will operate and the output voltage will drop. As the output voltage drops, the internal current foldback circuit will further reduce the output voltage causing the output current to decrease. When the output is shorted, a typical output current of 50 mA flows.

4.3 Shutdown

The $\overline{\text{SHDN}}$ input is used to turn the LDO output voltage on and off. When the $\overline{\text{SHDN}}$ input is at a logic-high level, the LDO output voltage is enabled. When the $\overline{\text{SHDN}}$ input is pulled to a logic-low level, the LDO output voltage is disabled and the LDO enters a low quiescent current shutdown state where the typical quiescent current is 0.01 µA. The $\overline{\text{SHDN}}$ pin does not have an internal pullup or pulldown resistor. Therefore the $\overline{\text{SHDN}}$ pin must be pulled either high or low to prevent the device from becoming unstable. The internal device current will increase when the device is operational and current flows through the pullup or pull-down resistor to the $\overline{\text{SHDN}}$ pin internal logic. The $\overline{\text{SHDN}}$ pin internal logic is equivalent to an inverter input.

4.4 Output Capacitor

The MCP1804 requires a minimum output capacitance of 0.1 µF to 1.0 µF for output voltage stability. Ceramic capacitors are recommended because of their size, cost and environmental robustness qualities.

Aluminum-electrolytic and tantalum capacitors can be used on the LDO output as well. The output capacitor should be located as close to the LDO output as is practical. Ceramic materials X7R and X5R have low temperature coefficients.

Larger LDO output capacitors can be used with the MCP1804 to improve dynamic performance and power supply ripple rejection performance. Aluminum-electrolytic capacitors are not recommended for low temperature applications of < -25°C.

4.5 Input Capacitor

Low input source impedance is necessary for the LDO output to operate properly. When operating from batteries, or in applications with long lead length (> 10 inches) between the input source and the LDO, some input capacitance is recommended. A minimum of 0.1 µF to 1.0 µF is recommended for most applications.

For applications that have output step load requirements, the input capacitance of the LDO is very important. The input capacitance provides the LDO with a good local low-impedance source to pull the transient currents from in order to respond quickly to the output load step. For good step response performance, the input capacitor should be of equivalent or higher value than the output capacitor. The capacitor should be placed as close to the input of the LDO as is practical. Larger input capacitors will also help reduce any high-frequency noise on the input and output of the LDO and reduce the effects of any inductance that exists between the input source voltage and the input capacitance of the LDO.

4.6 Thermal Shutdown

The MCP1804 thermal shutdown circuitry protects the device when the internal junction temperature reaches the typical thermal limit value of +150°C. The thermal limit shuts off the output drive transistor. Device output will resume when the internal junction temperature falls below the thermal limit value by an amount equal to the thermal limit hysteresis value of +25°C.

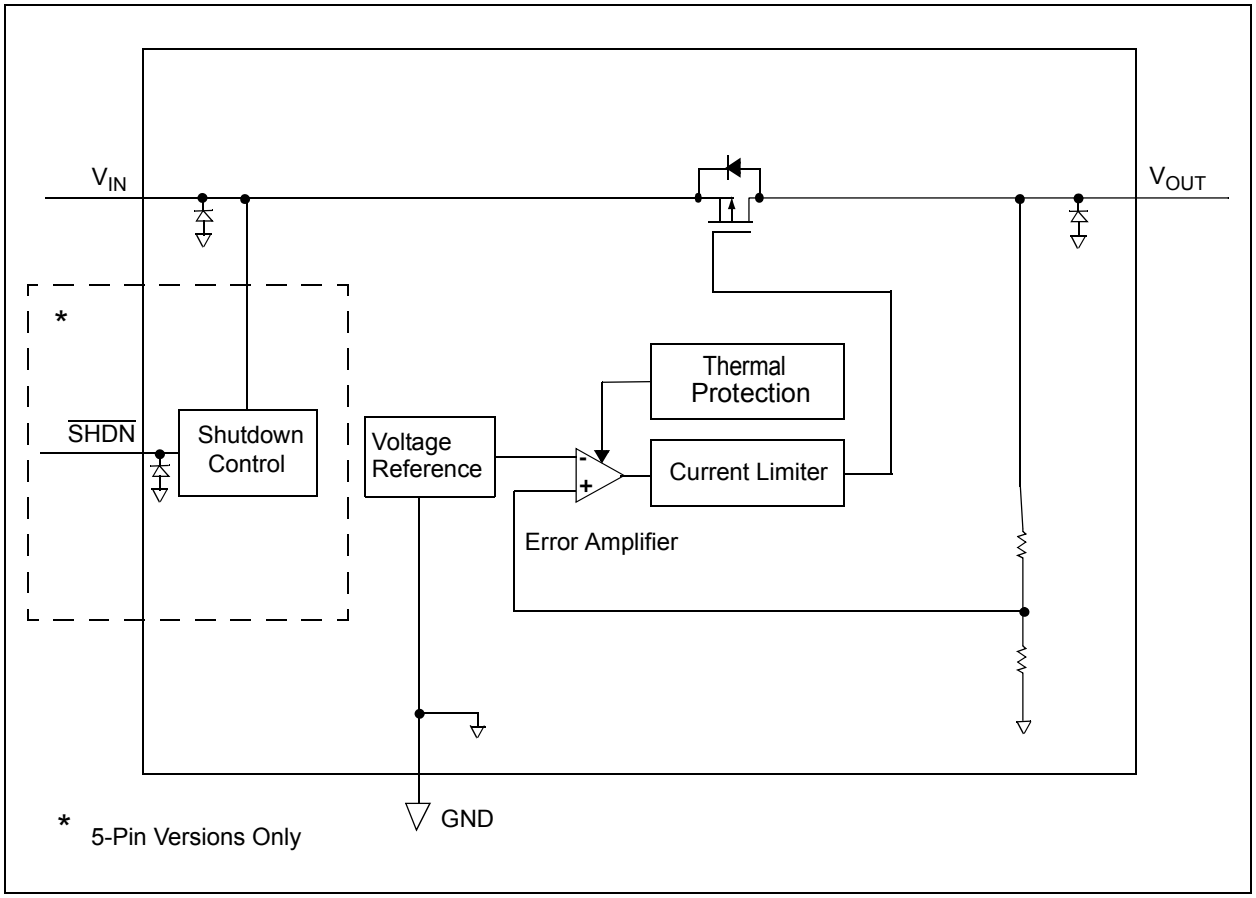


FIGURE 4-1: *Block Diagram.*

5.0 FUNCTIONAL DESCRIPTION

The MCP1804 CMOS linear regulator is intended for applications that need the low current consumption while maintaining output voltage regulation. The operating continuous load range of the MCP1804 is from 0 mA to 150 mA. The input operating voltage range is from 2.0V to 28.0V, making it capable of operating from a single 12V battery or single and multiple Li-Ion cell batteries.

5.1 Input

The input of the MCP1804 is connected to the source of the P-Channel PMOS pass transistor. As with all LDO circuits, a relatively low source impedance (< 10Ω) 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 a 0.1 µF 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 MCP1804 is 150 mA.

A minimum output capacitance of 0.1 µF to 1.0 µF is required for small signal stability in applications that have up to 150 mA output current capability. The capacitor type can be ceramic, tantalum or aluminum electrolytic.

6.0 APPLICATION CIRCUITS AND ISSUES

6.1 Typical Application

The MCP1804 is most commonly used as a voltage regulator. It's low quiescent current and wide input voltage make it ideal for Li-Ion and 12V battery-powered applications.

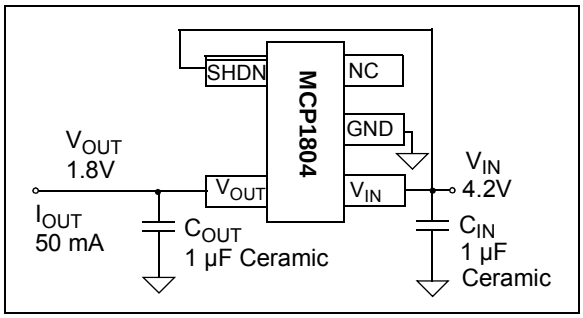


FIGURE 6-1: *Typical Application Circuit.*

6.1.1 APPLICATION INPUT CONDITIONS

Package Type	= SOT-23
Input Voltage Range	= 3.8V to 4.2V
V_{IN} maximum	= 4.6V
V_{OUT} typical	= 1.8V
I_{OUT}	= 50 mA maximum

6.2 Power Calculations

6.2.1 POWER DISSIPATION

The internal power dissipation of the MCP1804 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 (50.0 µA x V_{IN}). The following equation can be used to calculate the internal power dissipation of the LDO.

EQUATION 6-1:

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

Where:

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 temperature specified for the MCP1804 is +85°C. To estimate the internal junction temperature of the MCP1804, 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 256°C/W.

EQUATION 6-2:

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

Where:

$T_{J(MAX)}$	=	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:

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

Where:

$P_{D(MAX)}$	=	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:

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

Where:

$T_{J(RISE)}$	=	Rise in device junction temperature over the ambient temperature.
$P_{D(MAX)}$	=	Maximum device power dissipation.
$R\Theta_{JA}$	=	Thermal resistance from junction to ambient.

EQUATION 6-5:

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

Where:

T_J	=	Junction Temperature.
$T_{J(RISE)}$	=	Rise in device junction temperature over the ambient temperature.
T_A	=	Ambient temperature.

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} =	3.8V to 4.6V
LDO Output Voltages and Currents:	
V_{OUT} =	1.8V
I_{OUT} =	50 mA
Maximum Ambient Temperature:	
$T_{A(MAX)}$ =	+40°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}).	
$P_{LDO(MAX)}$ =	($V_{IN(MAX)}$ - $V_{OUT(MIN)}$) x $I_{OUT(MAX)}$
P_{LDO} =	(4.6V - (0.98 x 1.8V)) x 50 mA
P_{LDO} =	141.8 milli-Watts

6.3.1.1 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 SOT23 Can Dissipate in an Application"* (DS00792), for more information regarding this subject.

$$T_{J(RISE)} = P_{TOTAL} \times Rq_{JA}$$
$$T_{JRISE} = 141.8 \text{ milli-Watts} \times 256.0°C/Watt$$
$$T_{JRISE} = 36.3°C$$

6.3.1.2 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.

$$T_J = T_{JRISE} + T_{A(MAX)}$$
$$T_J = 76.3°C$$

Maximum Package Power Dissipation at +25°C Ambient Temperature (minimum PCB footprint)

SOT-23 (256°C/Watt = $R\theta_{JA}$):	
$P_{D(MAX)}$ =	(85°C - 25°C) / 256°C/W
$P_{D(MAX)}$ =	234 milli-Watts
SOT-89 (180°C/Watt = $R\theta_{JA}$):	
$P_{D(MAX)}$ =	(85°C - 25°C) / 180°C/W
$P_{D(MAX)}$ =	333 milli-Watts

6.4 Voltage Reference

The MCP1804 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 MCP1804 LDO. The low-cost, low quiescent current and small ceramic output capacitor are all advantages when using the MCP1804 as a voltage reference.

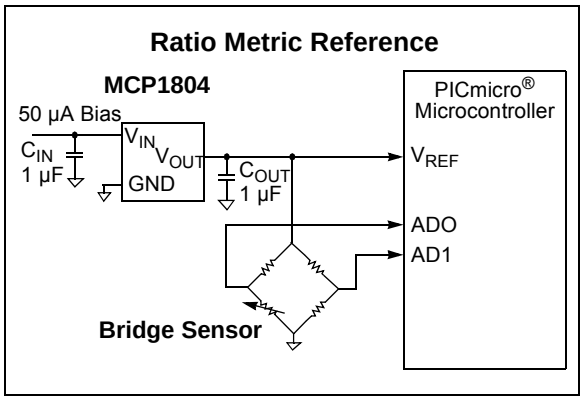


FIGURE 6-2: *Using the MCP1804 as a Voltage Reference.*

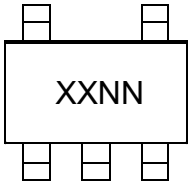
6.5 Pulsed Load Applications

For some applications, there are pulsed load current events that may exceed the specified 150 mA maximum specification of the MCP1804. The internal current limit of the MCP1804 will prevent high peak load demands from causing non-recoverable damage. The 150 mA rating is a maximum average continuous rating. As long as the average current does not exceed 150 mA nor the max power dissipation of the packaged device, pulsed higher load currents can be applied to the MCP1804. The typical current limit for the MCP1804 is 200 mA (T_A = +25°C).

7.0 PACKAGING INFORMATION

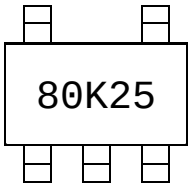
7.1 Package Marking Information

5-Lead SOT-23

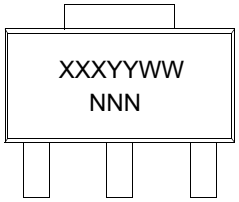


Part Number	Code
MCP1804T-1802I/OT	80KNN
MCP1804T-2502I/OT	80TNN
MCP1804T-3002I/OT	80ZNN
MCP1804T-3302I/OT	812NN
MCP1804T-5002I/OT	81MNN
MCP1804T-A002I/OT	839NN
MCP1804T-C002I/OT	83ZNN

Example:

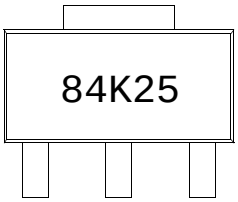


3-Lead SOT-89

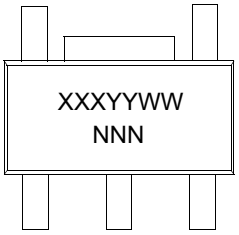


Part Number	Code
MCP1804T-1802I/MB	84KNN
MCP1804T-2502I/MB	84TNN
MCP1804T-3002I/MB	84ZNN
MCP1804T-3302I/MB	852NN
MCP1804T-5002I/MB	85MNN
MCP1804T-A002I/MB	879NN
MCP1804T-C002I/MB	87ZNN

Example:

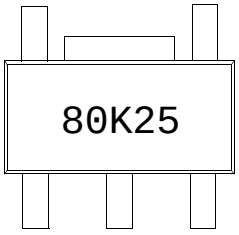


5-Lead SOT-89

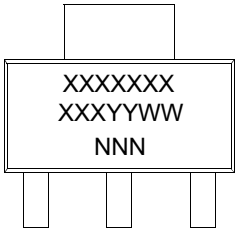


Part Number	Code
MCP1804T-1802I/MT	80KNN
MCP1804T-2502I/MT	80TNN
MCP1804T-3002I/MT	80ZNN
MCP1804T-3302I/MT	812NN
MCP1804T-5002I/MT	81MNN
MCP1804T-A002I/MT	839NN
MCP1804T-C002I/MT	83ZNN

Example:

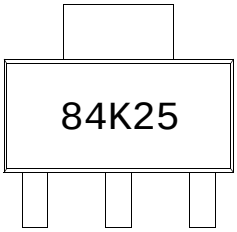


3-Lead SOT-223



Part Number	Code
MCP1804T-1802I/DB	84KNN
MCP1804T-2502I/DB	84TNN
MCP1804T-3002I/DB	84ZNN
MCP1804T-3302I/DB	852NN
MCP1804T-5002I/DB	85MNN
MCP1804T-A002I/DB	879NN
MCP1804T-C002I/DB	87ZNN

Example:

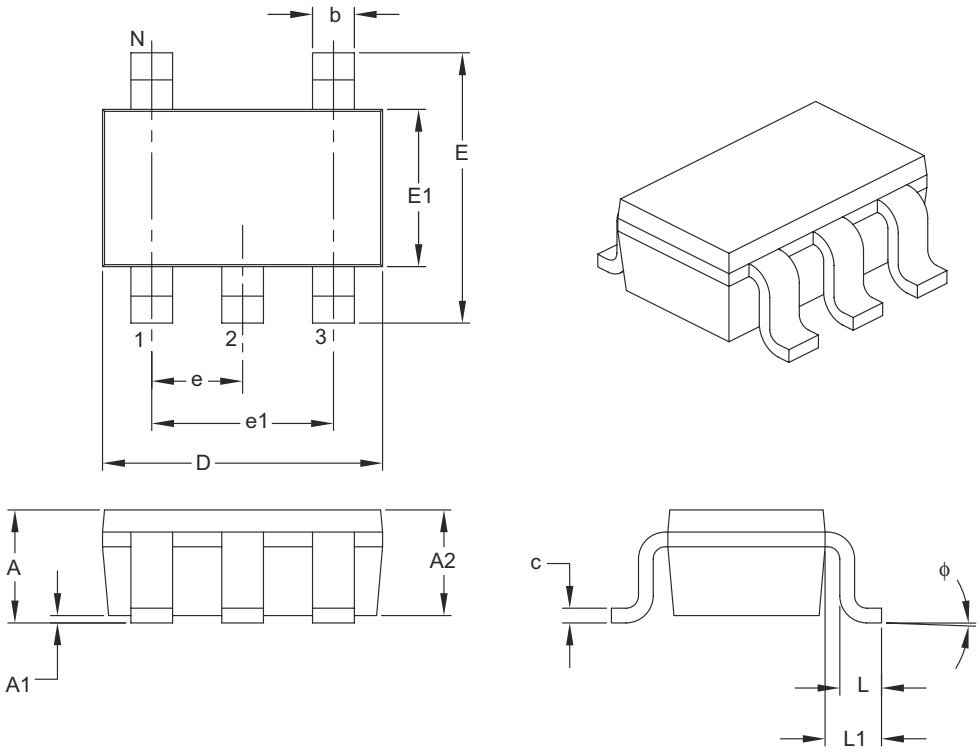


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free 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.

5-Lead Plastic Small Outline Transistor (OT) [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		5	
Lead Pitch	e		0.95 BSC	
Outside Lead Pitch	e1		1.90 BSC	
Overall Height	A	0.90	–	1.45
Molded Package Thickness	A2	0.89	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	ϕ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

Notes:

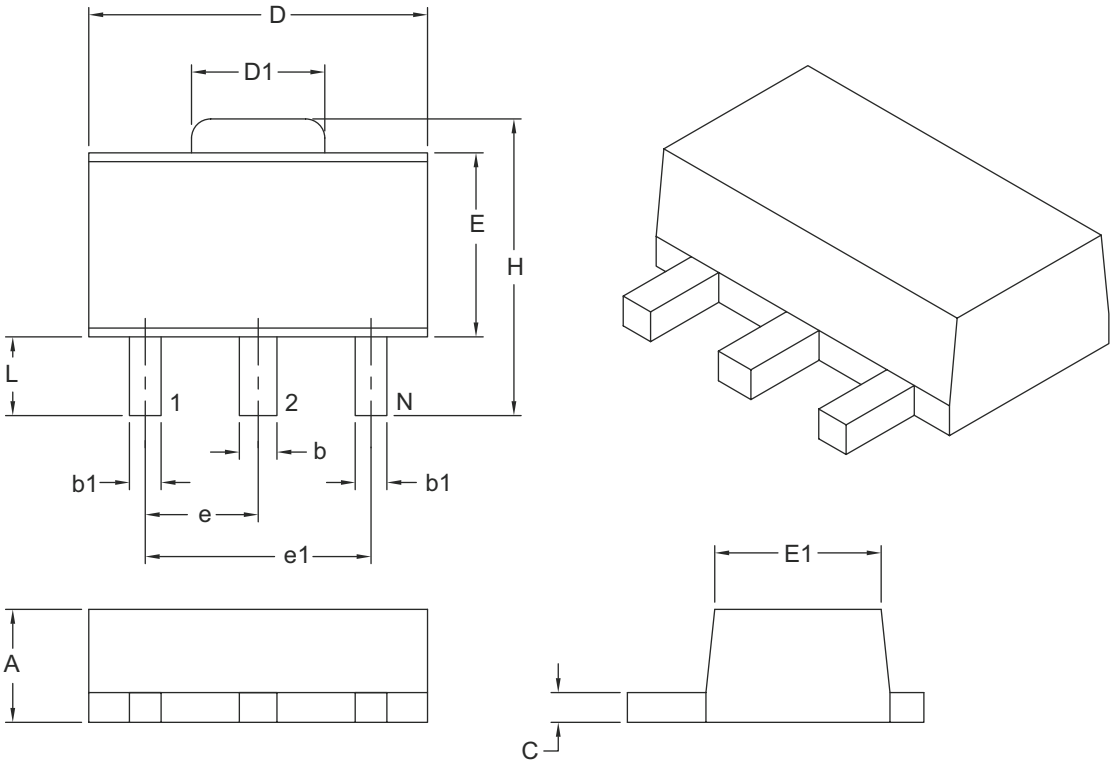
1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-091B

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:

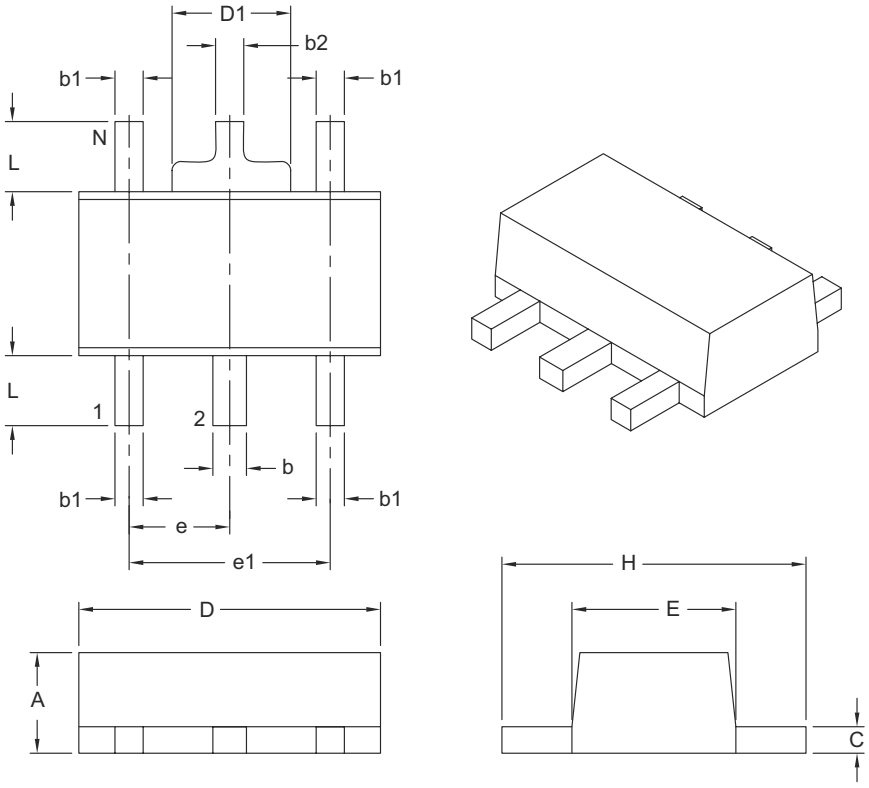
1. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-029B

5-Lead Plastic Small Outline Transistor Header (MT) [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	5	
Lead Pitch	e	1.50 BSC	
Outside Lead Pitch	e1	3.00 BSC	
Overall Height	A	1.40	1.60
Overall Width	H	3.94	4.50
Molded Package Width	E	2.29	2.60
Overall Length	D	4.40	4.60
Tab Width	D1	1.40	1.83
Foot Length	L	0.80	1.20
Lead Thickness	c	0.35	0.44
Lead 2 Width	b	0.41	0.56
Leads 1, 3, 4 & 5 Width	b1	0.36	0.48
Tab Lead Width	b2	0.32	0.48

Notes:

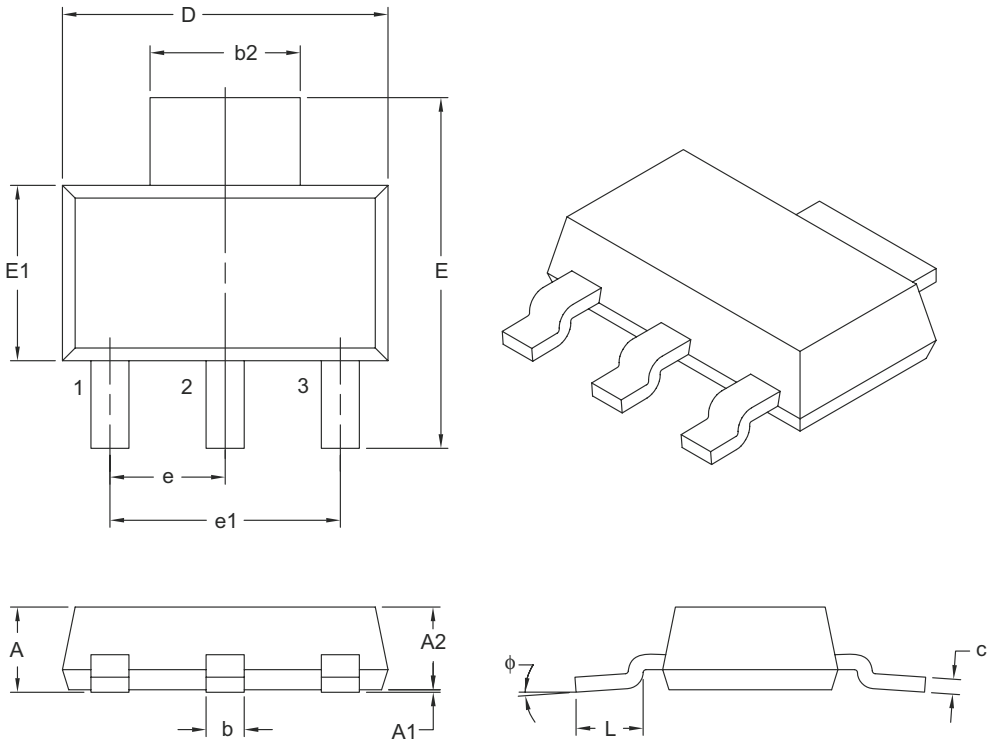
1. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-030B

3-Lead Plastic Small Outline Transistor (DB) [SOT-223]

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 Leads	N		3	
Lead Pitch	e		2.30 BSC	
Outside Lead Pitch	e1		4.60 BSC	
Overall Height	A	–	–	1.80
Standoff	A1	0.02	–	0.10
Molded Package Height	A2	1.50	1.60	1.70
Overall Width	E	6.70	7.00	7.30
Molded Package Width	E1	3.30	3.50	3.70
Overall Length	D	6.30	6.50	6.70
Lead Thickness	c	0.23	0.30	0.35
Lead Width	b	0.60	0.76	0.84
Tab Lead Width	b2	2.90	3.00	3.10
Foot Length	L	0.75	–	–
Lead Angle	φ	0°	–	10°

Notes:

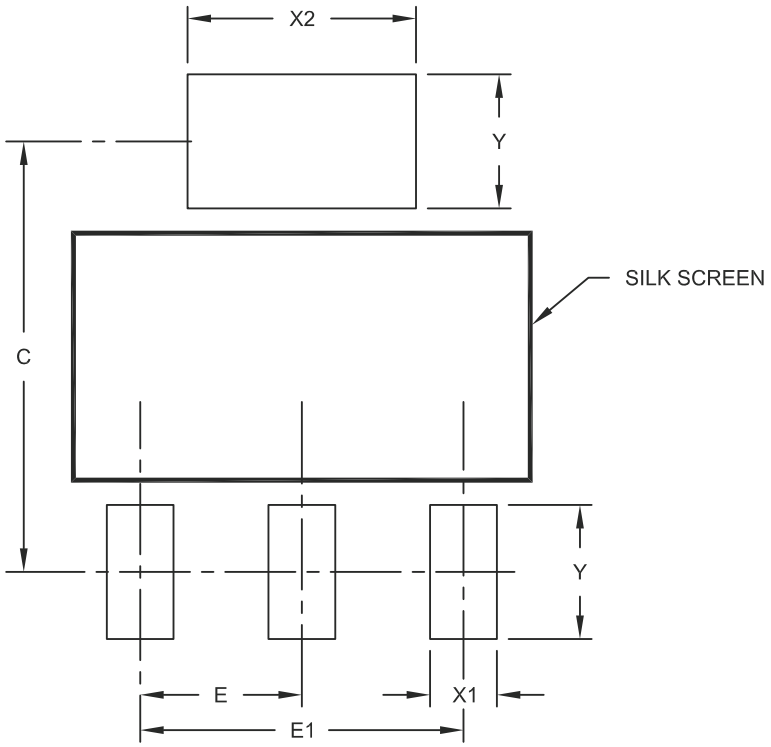
1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-032B

3-Lead Plastic Small Outline Transistor (DB) [SOT-223]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		2.30 BSC	
Overall Pitch	E1		4.60 BSC	
Contact Pad Spacing	C		6.10	
Contact Pad Width	X1			0.95
Contact Pad Width	X2			3.25
Contact Pad Length	Y			1.90

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2032A

NOTES:

APPENDIX A: REVISION HISTORY

Revision C (June 2011)

The following is the list of modifications:

1. Added seven new characterization graphs to **Section 2.0 "Typical Performance Curves"** (Figure 2-49 - Figure 2-55).
2. Changed layout of Table 3-1. Added separate column for SOT-223-3.
3. Updated Package Marking drawings and examples in the Packaging Information section.
4. Added new voltage option to Product Identification System table.

Revision B (November 2009)

The following is the list of modifications:

- Electrical characteristics, $\overline{\text{SHDN}}$ "H" Voltage item: Changed to $\overline{\text{SHDN}}$ "L" Voltage.

Revision A (September 2009)

- Original Release of this Document.

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	T	-XX	XX	X	/XX
Device	Tape and Reel	Voltage	Output Voltage Tolerance	Temperature Range	Package

Device	MCP1804T:	LDO Voltage Regulator (Tape and Reel)
Voltage Options	18 = 1.8V 25 = 2.5V 30 = 3.0V 33 = 3.3V 50 = 5.0V A0 = 10V C0 = 12V J0 = 18V	
Output Voltage Tolerance	02 = ±2%	
Temperature Range	I = -40°C to +85°C (Industrial)	
Package	DB = 3-lead Plastic Small OutlineTransistor (SOT-223) MB = 3-lead Plastic Small OutlineTransistor (SOT-89) MT = 5-lead Plastic Small OutlineTransistor (SOT-89) OT = 5-lead Plastic Small OutlineTransistor (SOT-23)	

Examples:

a) MCP1804T-1802I/OT: 1.8V, 5-LD SOT-23
b) MCP1804T-2502I/OT: 2.5V, 5-LD SOT-23
c) MCP1804T-3002I/OT: 3.0V, 5-LD SOT-23
d) MCP1804T-3302I/OT: 3.3V, 5-LD SOT-23
e) MCP1804T-5002I/OT: 5.0V, 5-LD SOT-23
f) MCP1804T-A002I/OT: 10V, 5-LD SOT-23
g) MCP1804T-C002I/OT: 12V, 5-LD SOT-23

a) MCP1804T-1802I/MB: 1.8V, 5-LD SOT-89
b) MCP1804T-2502I/MB: 2.5V, 5-LD SOT-89
c) MCP1804T-3002I/MB: 3.0V, 5-LD SOT-89
d) MCP1804T-3302I/MB: 3.3V, 5-LD SOT-89
e) MCP1804T-5002I/MB: 5.0V, 5-LD SOT-89
f) MCP1804T-A002I/MB: 10V, 5-LD SOT-89
g) MCP1804T-C002I/MB: 12V, 5-LD SOT-89

a) MCP1804T-1802I/MT: 1.8V, 5-LD SOT-89
b) MCP1804T-2502I/MT: 2.5V, 5-LD SOT-89
c) MCP1804T-3002I/MT: 3.0V, 5-LD SOT-89
d) MCP1804T-3302I/MT: 3.3V, 5-LD SOT-89
e) MCP1804T-5002I/MT: 5.0V, 5-LD SOT-89
f) MCP1804T-A002I/MT: 10V, 5-LD SOT-89
g) MCP1804T-C002I/MT: 12V, 5-LD SOT-89

a) MCP1804T-1802I/DB: 1.8V, 3-LD SOT-223
b) MCP1804T-2502I/DB: 2.5V, 3-LD SOT-223
c) MCP1804T-3002I/DB: 3.0V, 3-LD SOT-223
d) MCP1804T-3302I/DB: 3.3V, 3-LD SOT-223
e) MCP1804T-5002I/DB: 5.0V, 3-LD SOT-223
f) MCP1804T-A002I/DB: 10V, 3-LD SOT-223
g) MCP1804T-C002I/DB: 12V, 3-LD SOT-223

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