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NCP4589

300 mA, Tri-Mode, LDO Linear Voltage Regulator

The NCP4589 is a CMOS 300 mA LDO which switches to a low power mode under light current loads. The device automatically switches back to a fast response mode as the output load increases above 3 mA (typ.). The device can be placed in permanent fast mode through a mode select pin. The family is available in a variety of packages: SC−70, SOT23 and a small, ultra thin 1.2 x 1.2 x 0.4 mm XDFN.

Features

- Operating Input Voltage Range: 1.4 V to 5.25 V
- Output Voltage Range: 0.8 to 4.0 V (available in 0.1 V steps)
- Supply Current: Low Power Mode – 1.0 μA at V_{OUT} < 1.85 V
  Fast Mode – 55 μA
  Standby Mode – 0.1 μA
- Dropout Voltage: 230 mV Typ. at I_{OUT} = 300 mA, V_{OUT} = 2.8 V
- ±1% Output Voltage Accuracy (V_{OUT} > 2 V, T_J = 25 °C)
- High PSRR: 70 dB at 1 kHz (Fast response mode)
- Line Regulation 0.02%/V Typ.
- Current Fold Back Protection
- Stable with Ceramic Capacitors
- Available in 1.2x1.2 XDFN, SC−70 and SOT23 Package
- These are Pb−free Devices

Typical Applications

- Battery Powered Equipments
- Portable Communication Equipments
- Cameras, Image Sensors and Camcorders

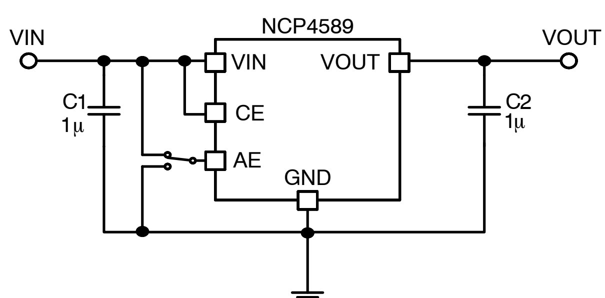

Figure 1. Typical Application Schematic

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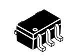
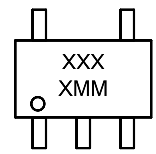
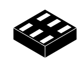
MARKING DIAGRAMS

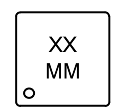


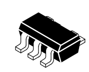
SC−70
CASE 419A



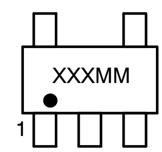


XDFN6
CASE 711AA





SOT−23−5
CASE 1212



XXXX = Specific Device Code
MM = Date Code

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 27 of this data sheet.

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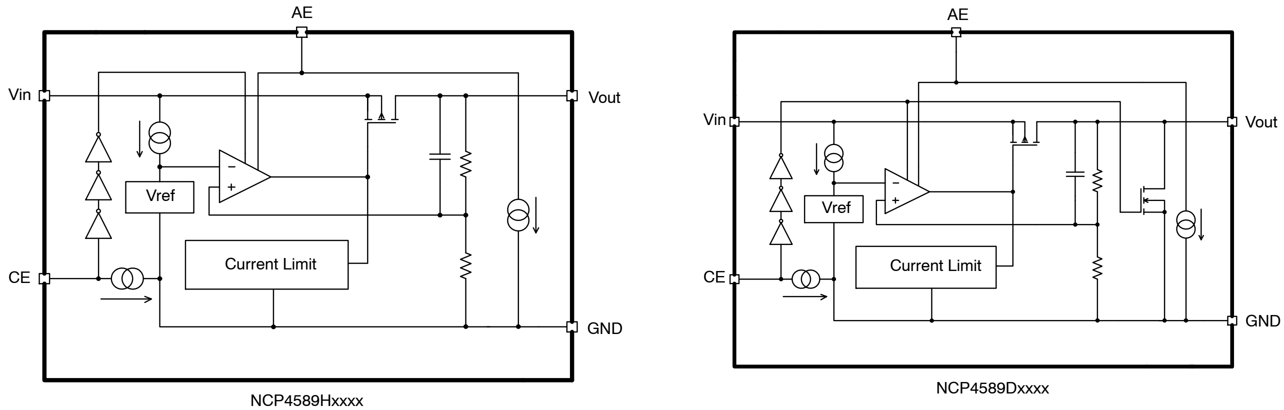

Figure 2. Simplified Schematic Block Diagram

PIN FUNCTION DESCRIPTION

Pin No. XDFN	Pin No. SC−70	Pin No. SOT23	Pin Name	Description
4	4	1	VIN	Input pin
2	2	2	GND	Ground
3	5	3	CE	Chip enable pin
6	3	5	VOUT	Output pin
1	1	4	AE	Auto Eco Pin
5	–	–	NC	No connection

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	V_{IN}	6.0	V
Output Voltage	V_{OUT}	−0.3 to V_{IN} + 0.3	V
Chip Enable Input	V_{CE}	−0.3 to 6.0	V
Auto Eco Input	V_{AE}	−0.3 to 6.0	V
Output Current	I_{OUT}	400	mA
Power Dissipation XDFN	P_D	400	mW
Power Dissipation SC70		380	
Power Dissipation SOT23		420	
Junction Temperature	T_J	−40 to 150	°C
Storage Temperature	T_{STG}	−55 to 125	°C
Operation Temperature	T_A	−40 to 85	°C
ESD Capability, Human Body Model (Note 2)	ESD_{HBM}	2000	V
ESD Capability, Machine Model (Note 2)	ESD_{MM}	200	V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Refer to ELECTRICAL CHARACTERISTIS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:
   ESD Human Body Model tested per AEC−Q100−002 (EIA/JESD22−A114)
   ESD Machine Model tested per AEC−Q100−003 (EIA/JESD22−A115)
   Latchup Current Maximum Rating tested per JEDEC standard: JESD78.

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, XDFN Thermal Resistance, Junction−to−Air	$R_{\theta JA}$	250	°C/W
Thermal Characteristics, SOT23 Thermal Resistance, Junction−to−Air	$R_{\theta JA}$	238	°C/W
Thermal Characteristics, SC−70 Thermal Resistance, Junction−to−Air	$R_{\theta JA}$	263	°C/W

ELECTRICAL CHARACTERISTICS

−40°C ≤ T_A ≤ 85°C; V_{IN} = $V_{OUT(NOM)}$ + 1 V; I_{OUT} = 1 mA; C_{IN} = C_{OUT} = 1 μF; unless otherwise noted. Typical values are at T_A = +25°C.

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
Operating Input Voltage	(Note NO TAG)		V_{IN}	1.4		5.25	V
Output Voltage (Fast Mode)	T_A = +25°C, I_{OUT} = 5 mA	V_{OUT} > 2 V	V_{OUT}	x0.99		x1.01	V
		V_{OUT} ≤ 2 V		−20		20	mV
	−40°C ≤ T_A ≤ 85°C, I_{OUT} = 5 mA	V_{OUT} > 2 V		x0.975		x1.015	V
		V_{OUT} ≤ 2 V		−50		30	mV
Output Voltage Temp. Coefficient	T_A = −40 to 85°C				±50		ppm/°C
Line Regulation	V_{IN} = V_{OUT} + 0.5 V to 5 V V_{IN} ≥ 1.4 V	I_{OUT} = 1 mA, (Low Power Mode)	$Line_{Reg}$			0.50	%/V
		I_{OUT} = 10 mA, (Fast Mode)			0.02	0.20	
Load Regulation	I_{OUT} = 1 mA to 10 mA	V_{OUT} > 2.0 V	$Line_{Reg}$	−1.0		1.0	%
		V_{OUT} ≤ 2.0 V		−20		20	mV
	I_{OUT} = 10 mA to 300 mA				35	80	mV
Dropout Voltage	I_{OUT} = 300 mA	0.8 V ≤ V_{OUT} < 0.9 V	V_{DO}		0.62	0.85	V
		0.9 V ≤ V_{OUT} < 1.0 V			0.55	0.78	
		1.0 V ≤ V_{OUT} < 1.5 V			0.48	0.70	
		1.5 V ≤ V_{OUT} < 2.6 V			0.34	0.50	
		2.6 V ≤ V_{OUT} < 4.0 V			0.23	0.35	
Output Current			I_{OUT}	300			mA
Short Current Limit	V_{OUT} = 0 V		I_{SC}		50		mA
Quiescent Current	I_{OUT} = 0 mA, Low Power Mode (Note 3)	V_{OUT} ≤ 1.85 V	I_Q		1.0	4.0	μA
		V_{OUT} > 1.85 V			1.5	4.0	
Supply Current	I_{OUT} = 10 mA, Fast Mode		I_{GND}		55		μA
Standby Current	V_{CE} = 0 V, T_A = 25°C		I_{STB}		0.1	1	μA
Fast Mode Switch−Over Current	I_{OUT} = light to heavy load		I_{OUTH}			8.0	mA
Low Power Switch−Over Current	I_{OUT} = heavy to light load		I_{OUTL}	1.0	2.0		mA
CE Pin Threshold Voltage	CE Input Voltage “H”		V_{CEH}	1.0			V
	CE Input Voltage “L”		V_{CEL}			0.4	
CE Pull Down Current			I_{CEPD}		0.1		μA
AE Pin Threshold Voltage	AE Input Voltage “H”		V_{AEH}	1.0			V
	AE Input Voltage “L”		V_{AEL}			0.4	

3. The value of supply current is excluding the Pull−down constant current of CE and AE Pin

ELECTRICAL CHARACTERISTICS

$-40°C \le T_A \le 85°C$; $V_{IN} = V_{OUT(NOM)} + 1$ V; $I_{OUT} = 1$ mA; $C_{IN} = C_{OUT} = 1$ μF; unless otherwise noted. Typical values are at $T_A = +25°C$.

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
AE Pull Down Current		I_{AEPD}		0.1		μA
Power Supply Rejection Ratio	$V_{IN} = V_{OUT} + 1$ V or 2.2 V whichever is higher, $\Delta V_{IN} = 0.2$ V_{pk-pk}, $I_{OUT} = 30$ mA, f = 1 kHz, Fast Mode	PSRR		70		dB
Output Noise Voltage	$V_{OUT} = 1.0$ V, $I_{OUT} = 30$ mA, f = 10 Hz to 100 kHz	V_N		90		μV_{rms}
Low Output N−channel Tr. On Resistance	$V_{IN} = 4$ V, $V_{CE} = 0$ V	R_{LOW}		50		Ω

3. The value of supply current is excluding the Pull−down constant current of CE and AE Pin

TYPICAL CHARACTERISTICS

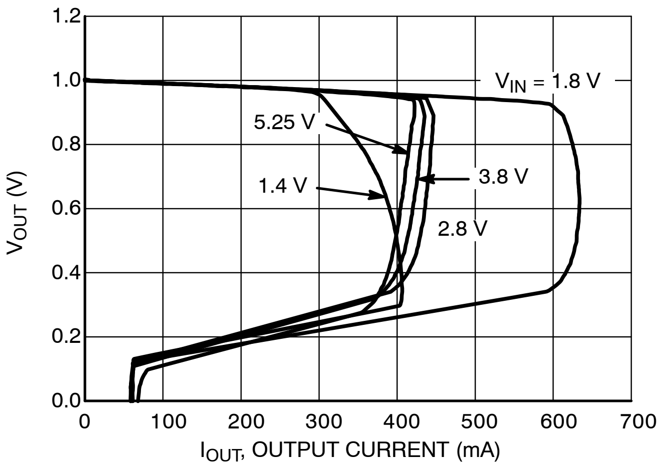

Figure 3. Output Voltage vs. Output Current 1.0 V Version (T_J = 25°C)

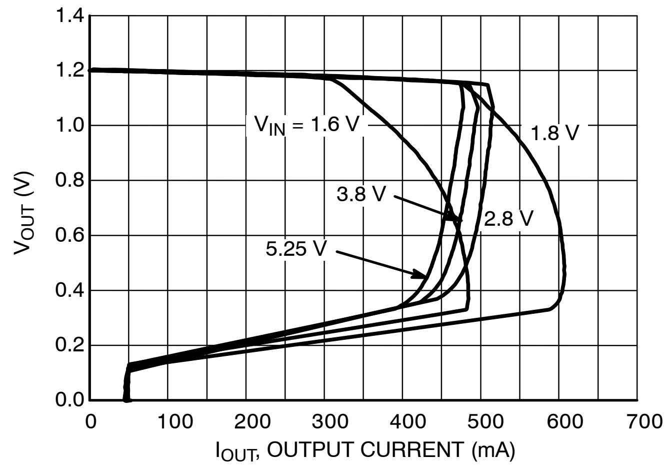

Figure 4. Output Voltage vs. Output Current 1.2 V Version (T_J = 25°C)

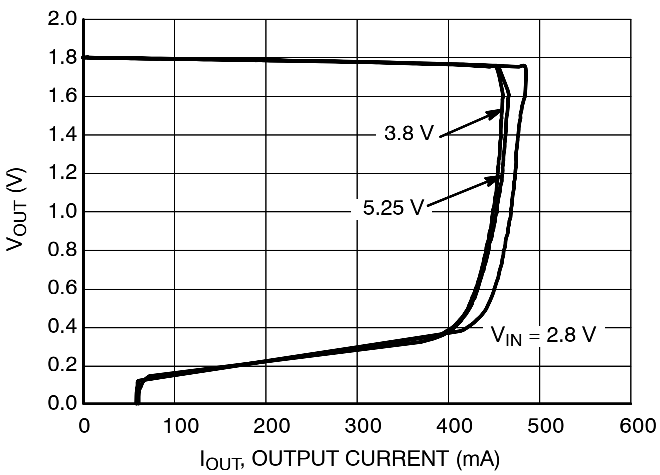

Figure 5. Output Voltage vs. Output Current 1.8 V Version (T_J = 25°C)

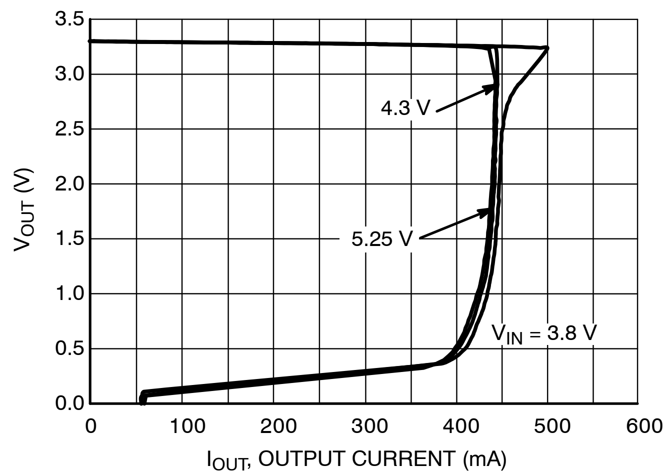

Figure 6. Output Voltage vs. Output Current 3.3 V Version (T_J = 25°C)

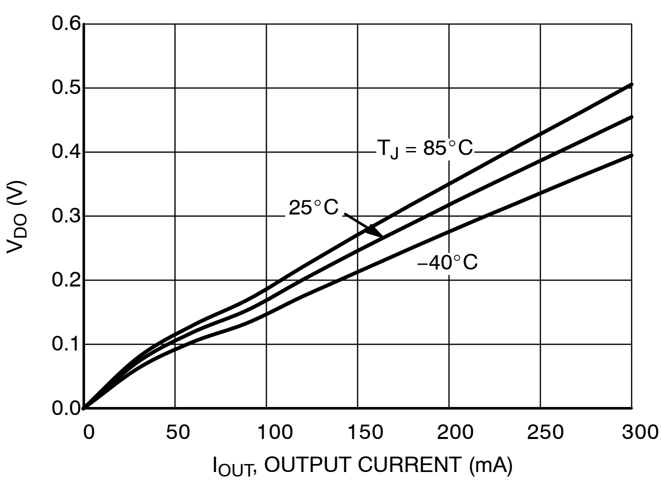

Figure 7. Dropout Voltage vs. Output Current 1.0 V Version

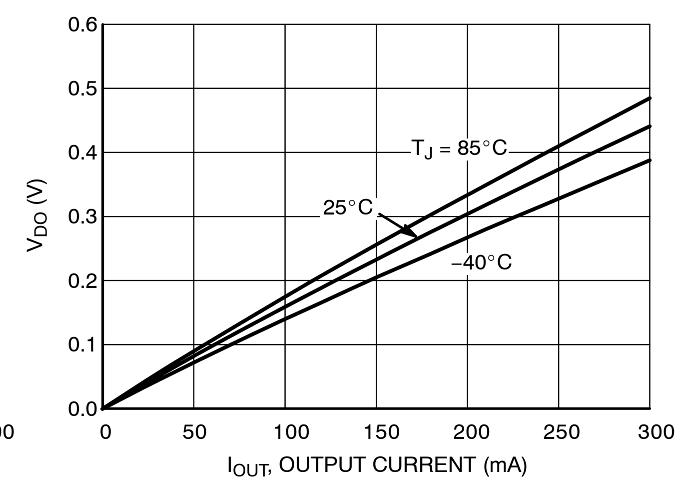

Figure 8. Dropout Voltage vs. Output Current 1.2 V Version

TYPICAL CHARACTERISTICS

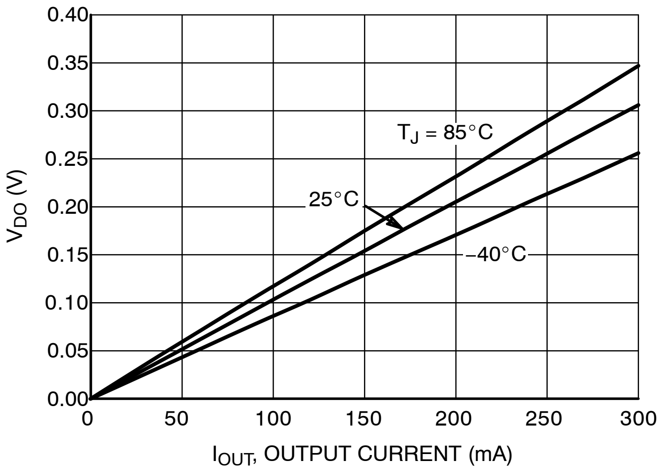

Figure 9. Dropout Voltage vs. Output Current 1.8 V Version

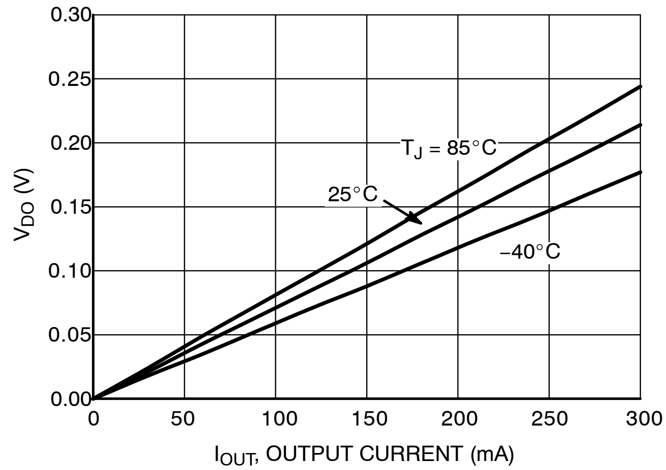

Figure 10. Dropout Voltage vs. Output Current 3.3 V Version

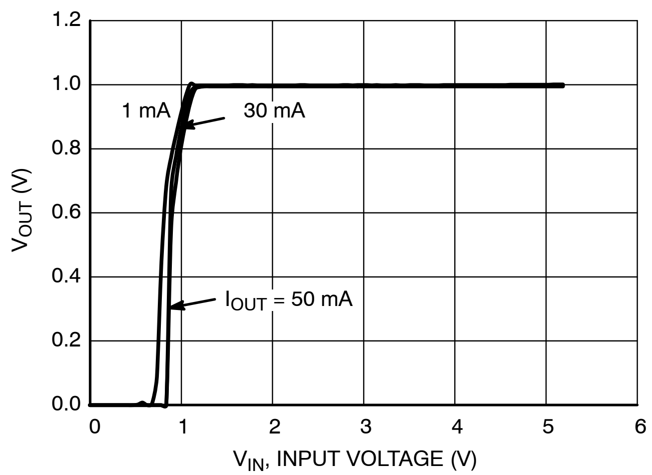

Figure 11. Output Voltage vs. Input Voltage, 1.0 V Version

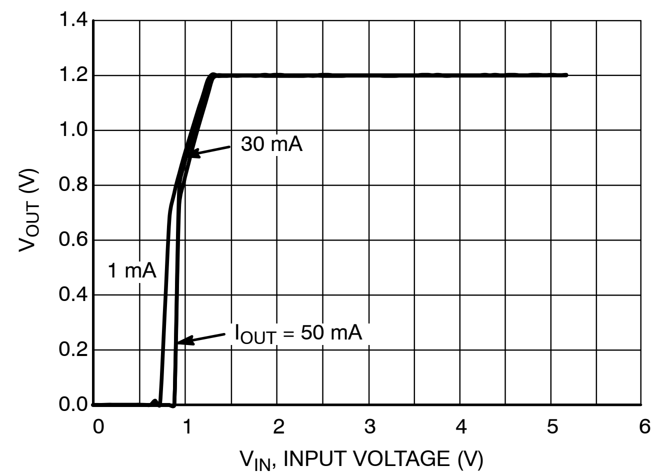

Figure 12. Output Voltage vs. Input Voltage, 1.2 V Version

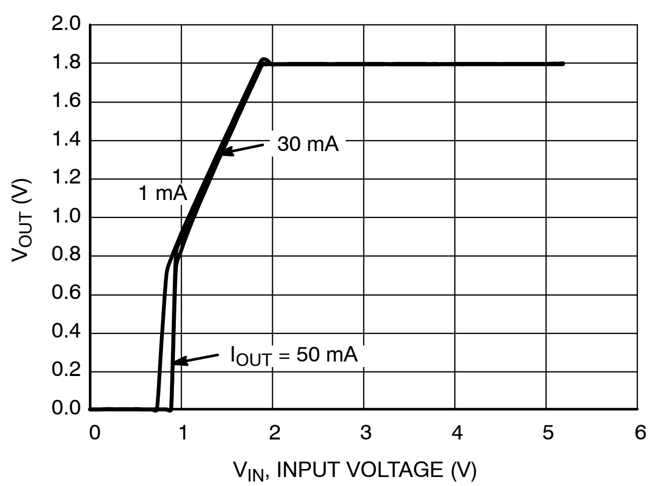

Figure 13. Output Voltage vs. Input Voltage, 1.8 V Version

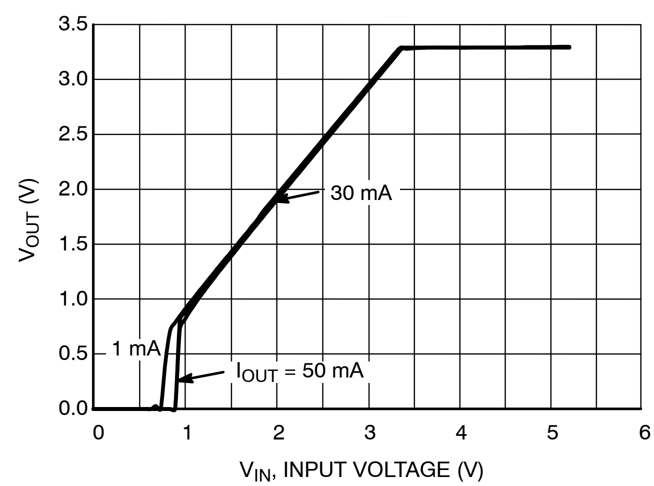

Figure 14. Output Voltage vs. Input Voltage, 3.3 V Version

TYPICAL CHARACTERISTICS

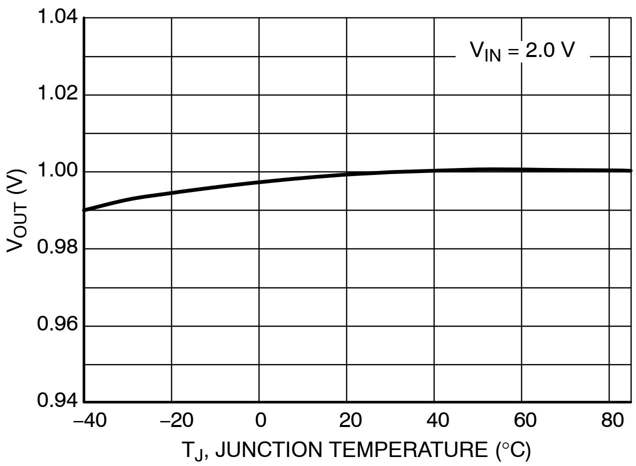

Figure 15. Output Voltage vs. Temperature, 1.0 V Version

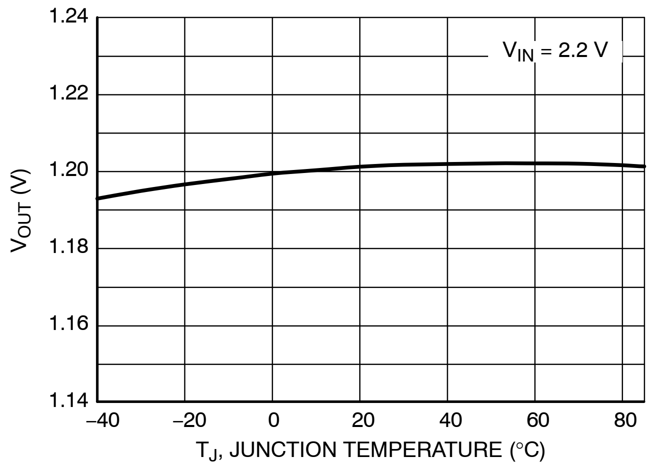

Figure 16. Output Voltage vs. Temperature, 1.2 V Version

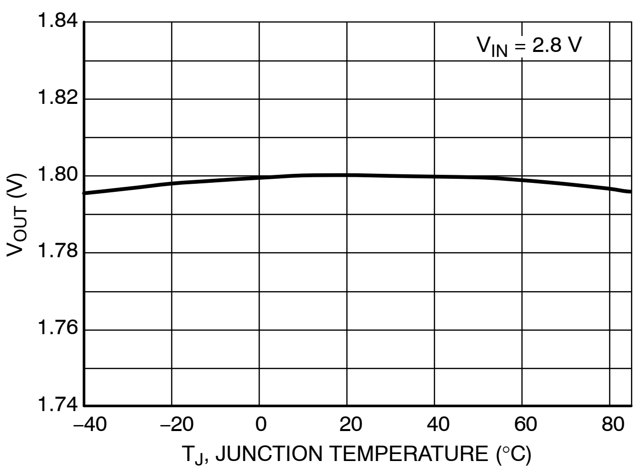

Figure 17. Output Voltage vs. Temperature, 1.8 V Version

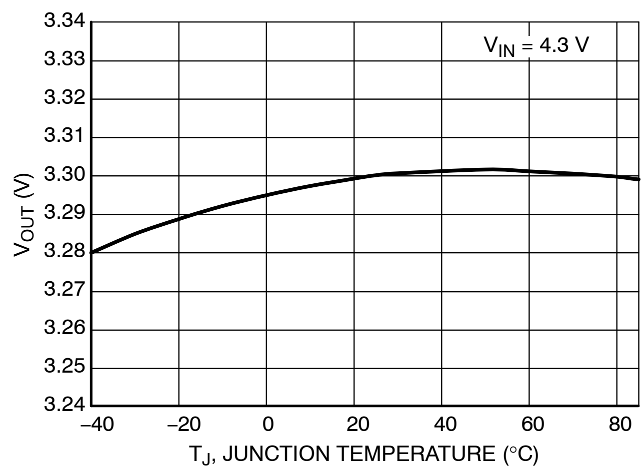

Figure 18. Supply Current vs. Input Voltage, 3.3 V Version

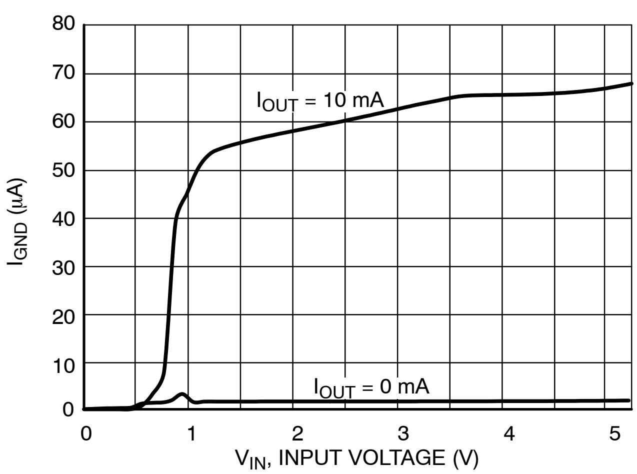

Figure 19. Supply Current vs. Input Voltage, 1.0 V Version

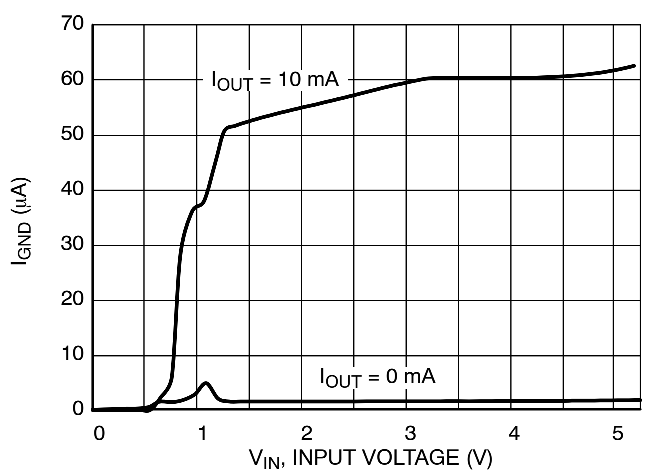

Figure 20. Supply Current vs. Input Voltage, 1.2 V Version

TYPICAL CHARACTERISTICS

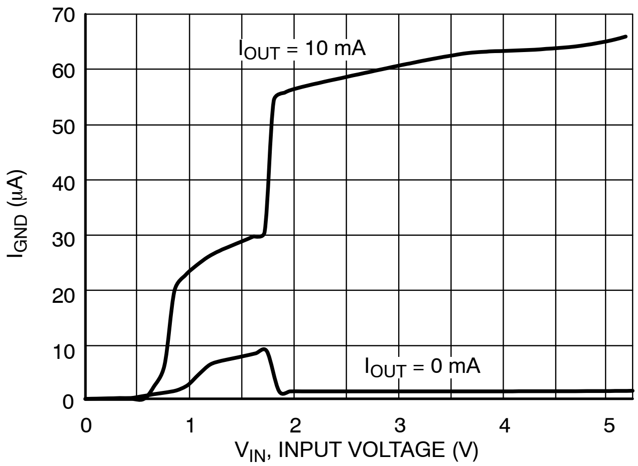

Figure 21. Supply Current vs. Input Voltage, 1.8 V Version

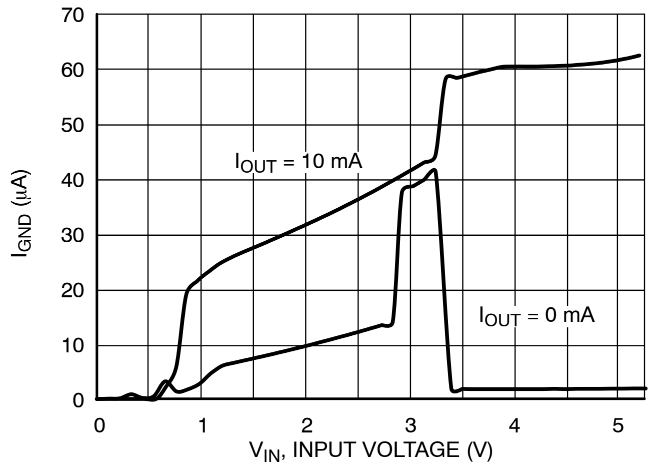

Figure 22. Supply Current vs. Input Voltage, 3.3 V Version

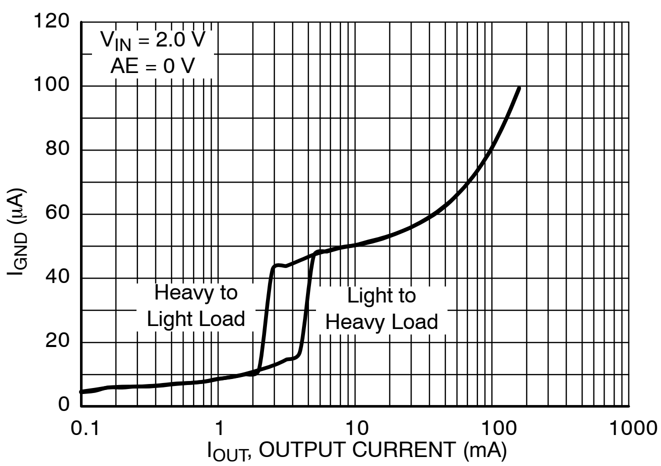

Figure 23. Supply Current vs. Output Current, 1.0 V Version

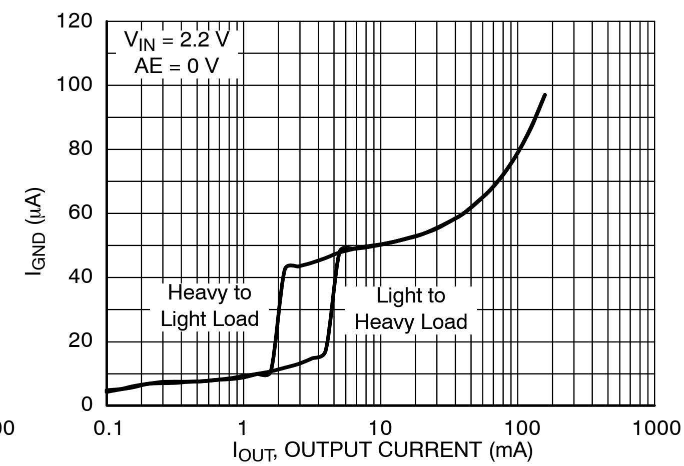

Figure 24. Supply Current vs. Output Current, 1.2 V Version

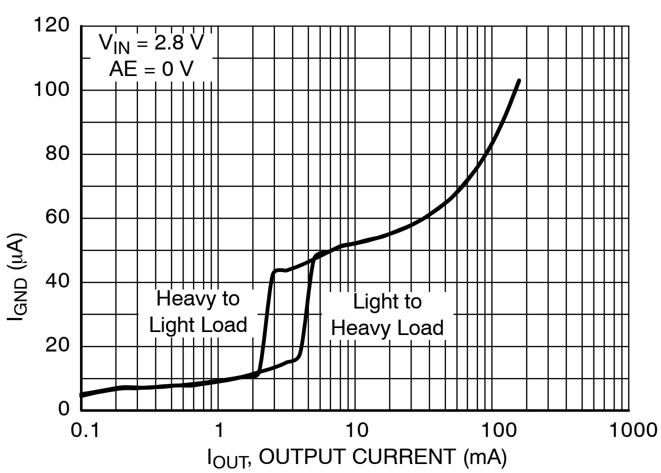

Figure 25. Supply Current vs. Output Current, 1.8 V Version

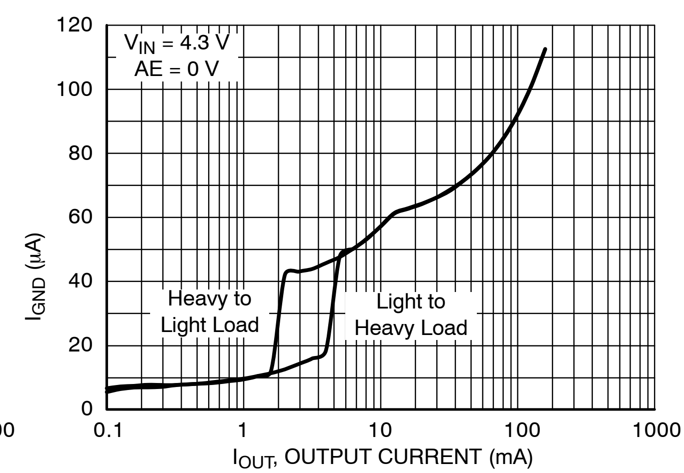

Figure 26. Supply Current vs. Output Current, 3.3 V Version

TYPICAL CHARACTERISTICS

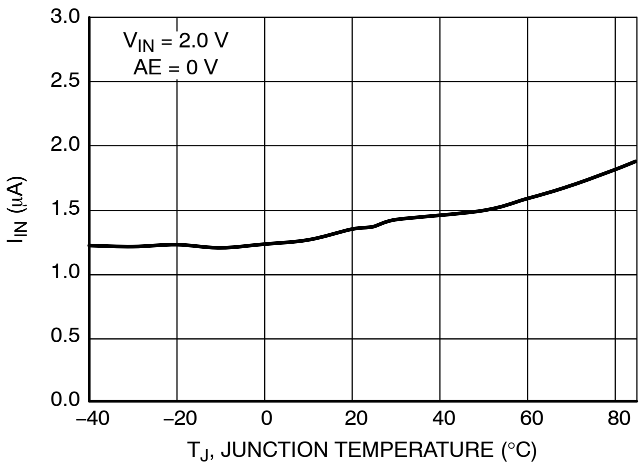

Figure 27. Supply Current vs. Temperature, 1.0 V Version

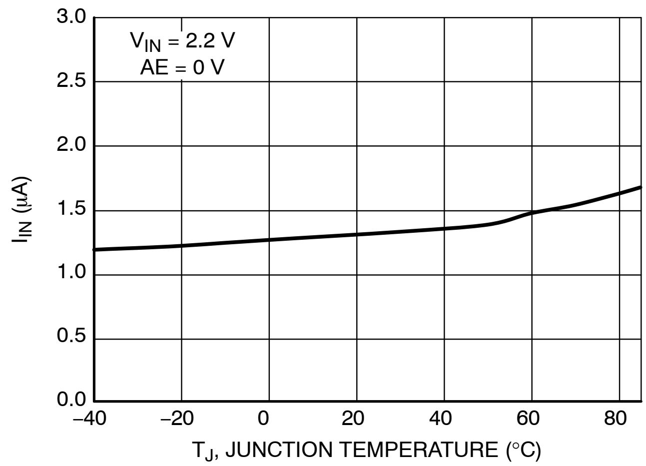

Figure 28. Supply Current vs. Temperature, 1.2 V Version

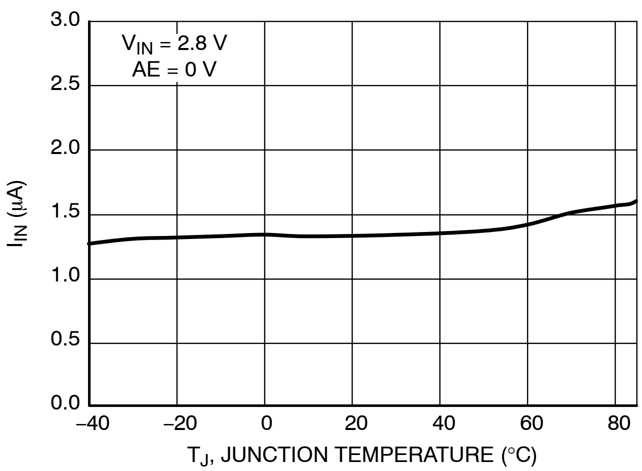

Figure 29. Supply Current vs. Temperature, 1.8 V Version

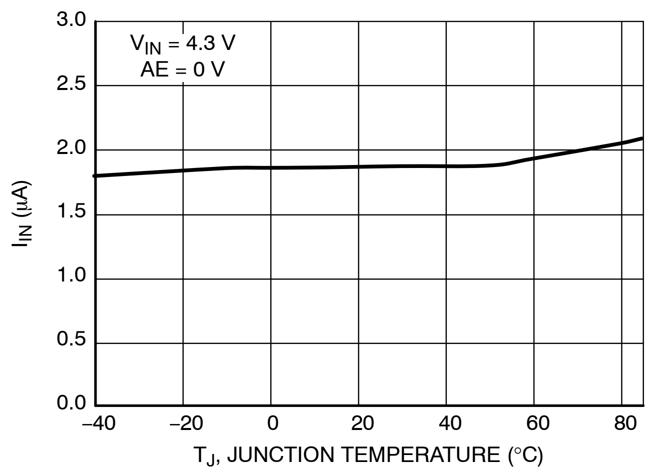

Figure 30. Supply Current vs. Temperature, 3.3 V Version

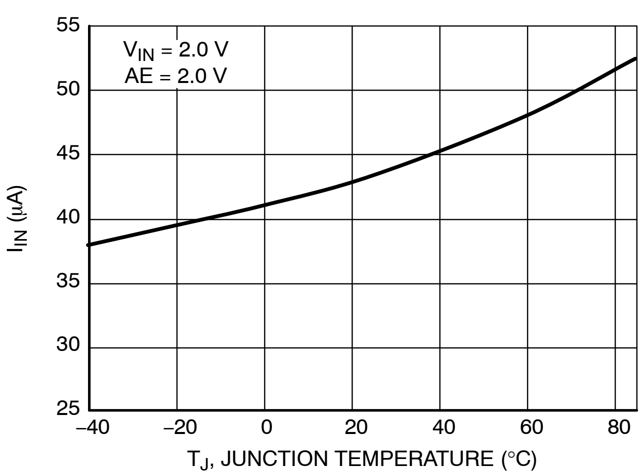

Figure 31. Supply Current vs. Temperature, 1.0 V Version

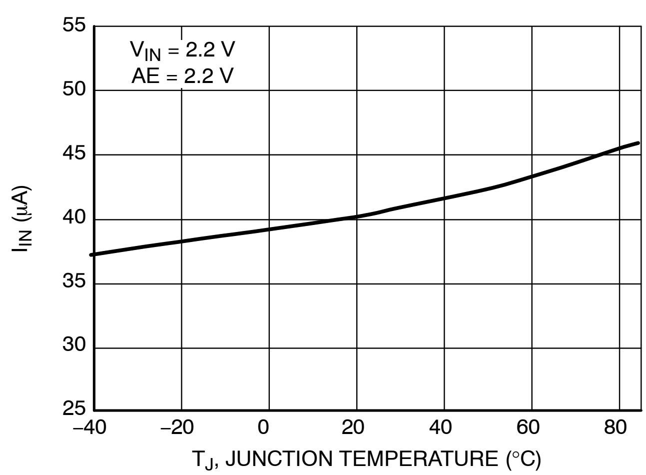

Figure 32. Supply Current vs. Temperature, 1.2 V Version

TYPICAL CHARACTERISTICS

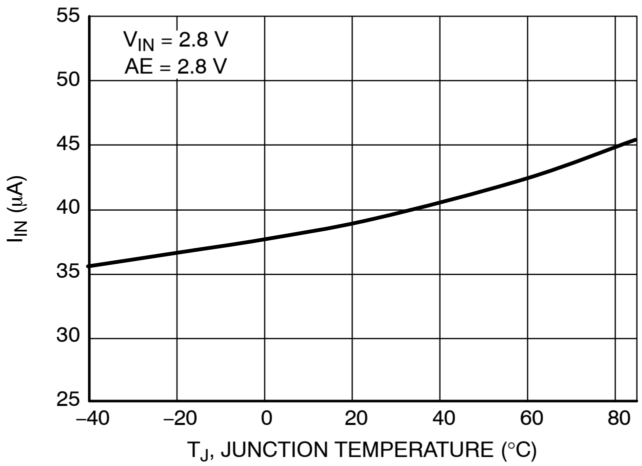

Figure 33. Supply Current vs. Temperature, 1.8 V Version

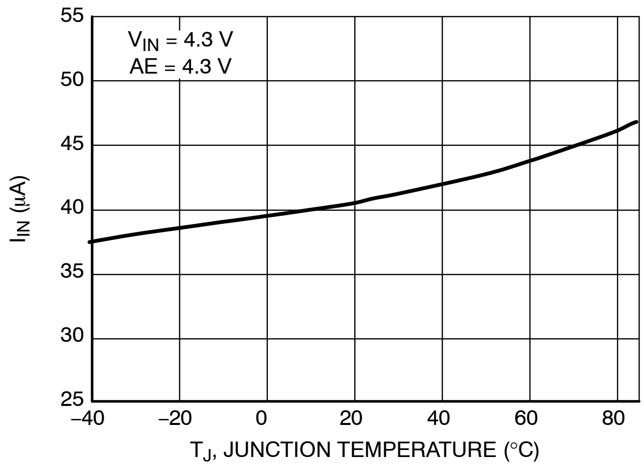

Figure 34. Supply Current vs. Temperature, 3.3 V Version

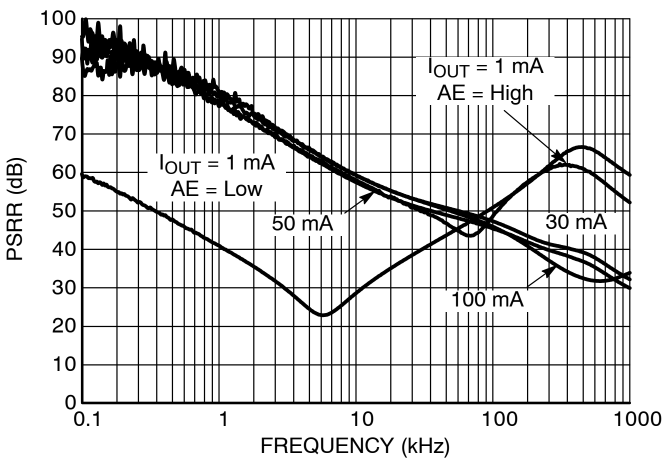

Figure 35. PSRR, 1.0 V Version, V_{IN} = 2.2 V

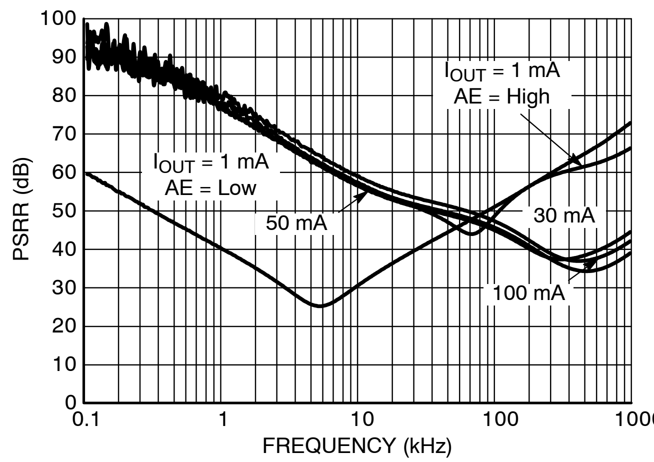

Figure 36. PSRR, 1.2 V Version, V_{IN} = 2.2 V

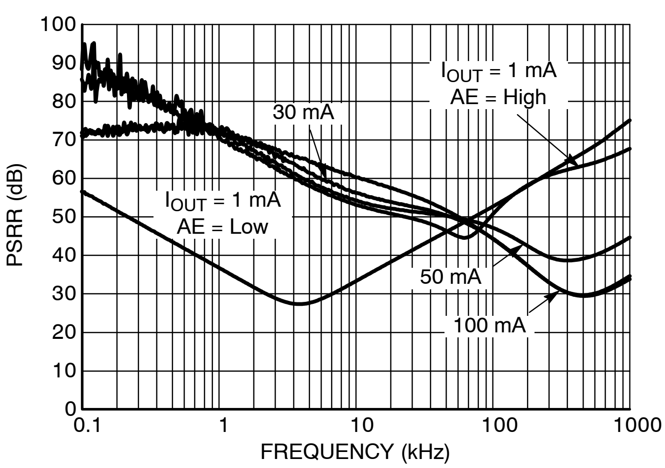

Figure 37. PSRR, 1.8 V Version, V_{IN} = 3.8 V

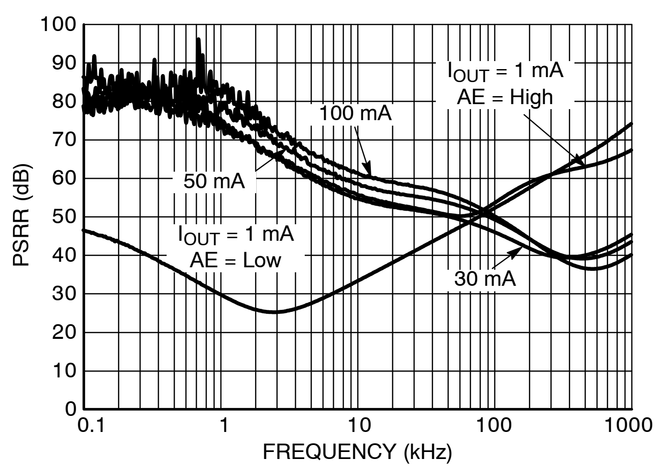

Figure 38. PSRR, 3.3 V Version, V_{IN} = 4.3 V

TYPICAL CHARACTERISTICS

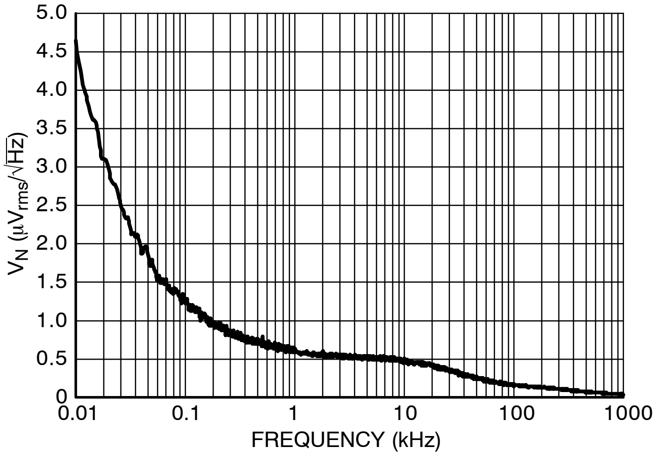

Figure 39. Output Voltage Noise, 1.0 V Version, V_{IN} = 2.0 V, I_{OUT} = 30 mA

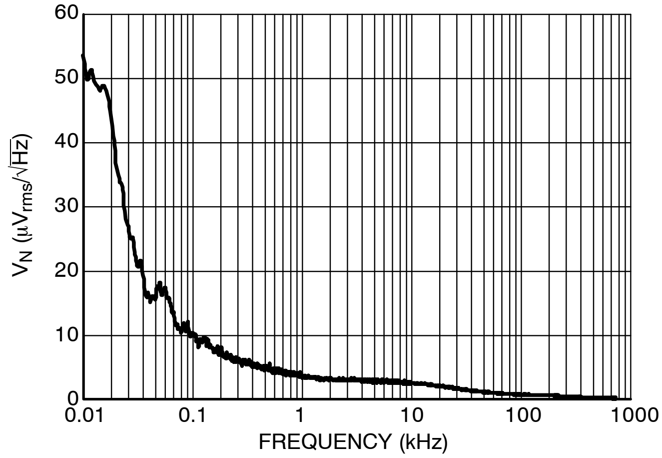

Figure 40. Output Voltage Noise, 1.2 V Version, V_{IN} = 2.2 V, I_{OUT} = 30 mA

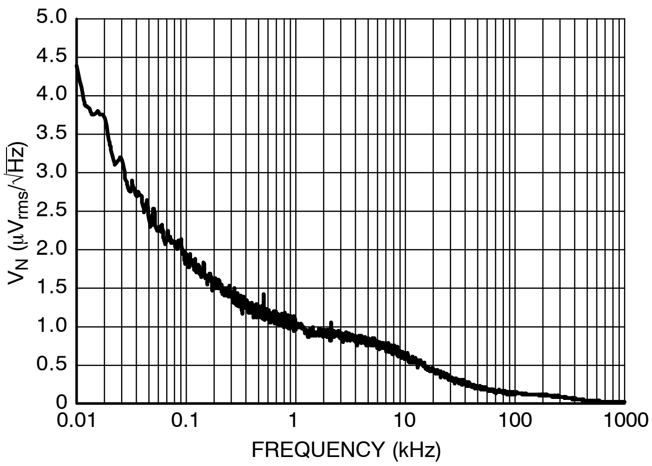

Figure 41. Output Voltage Noise, 1.8 V Version, V_{IN} = 2.8 V, I_{OUT} = 30 mA

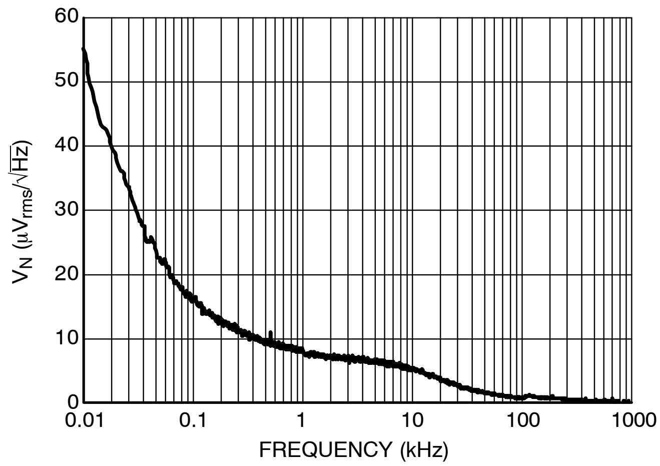

Figure 42. Output Voltage Noise, 3.3 V Version, V_{IN} = 4.3 V, I_{OUT} = 30 mA

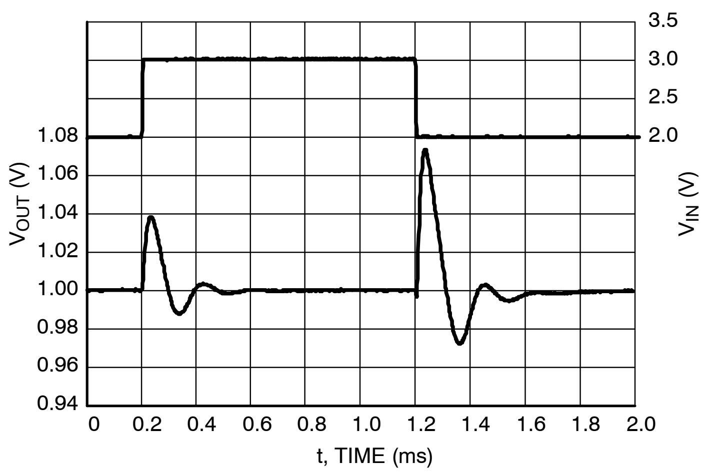

Figure 43. Line Transients, 1.0 V Version, t_R = t_F = 5 µs, I_{OUT} = 1 mA, AE = 0 V

TYPICAL CHARACTERISTICS

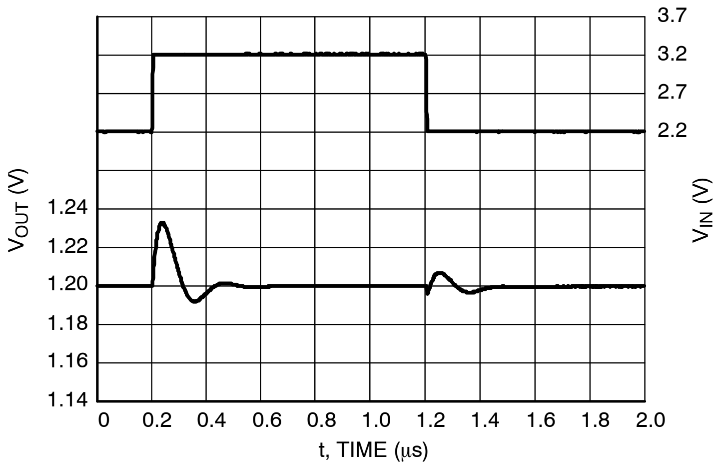

Figure 44. Line Transients, 1.2 V Version, t_R = t_F = 5 μs, I_{OUT} = 1 mA, AE = 0 V

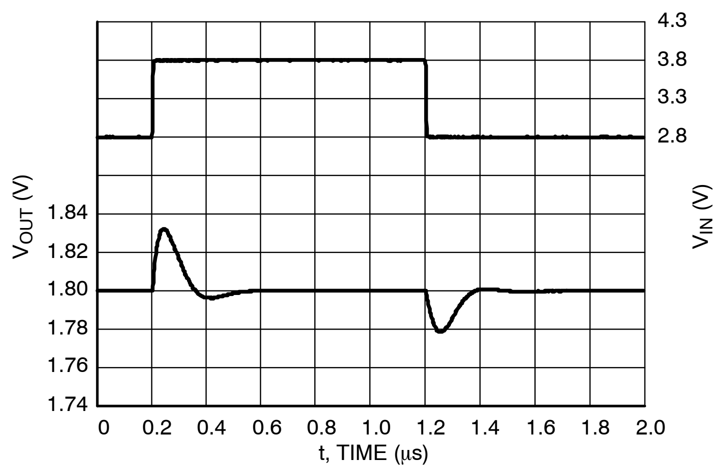

Figure 45. Line Transients, 1.8 V Version, t_R = t_F = 5 μs, I_{OUT} = 1 mA, AE = 0 V

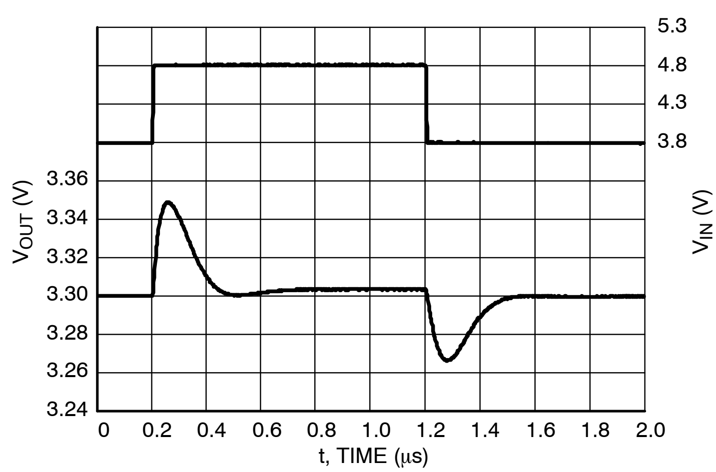

Figure 46. Line Transients, 3.3 V Version, t_R = t_F = 5 μs, I_{OUT} = 1 mA, AE = 0 V

TYPICAL CHARACTERISTICS

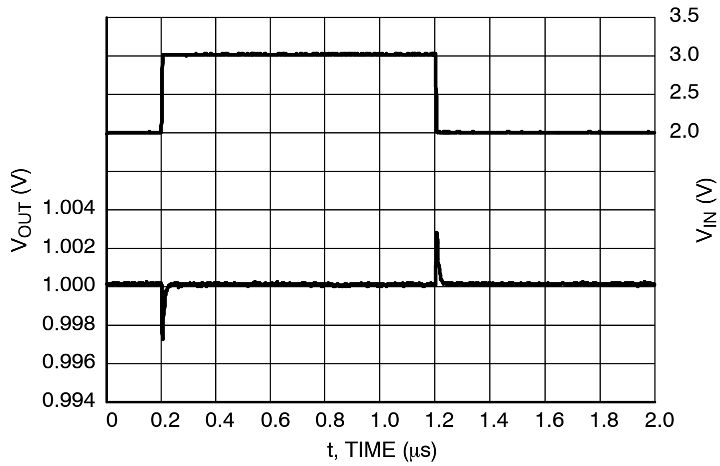

Figure 47. Line Transients, 1.0 V Version, t_R = t_F = 5 μs, I_{OUT} = 30 mA, AE = V_{IN} V

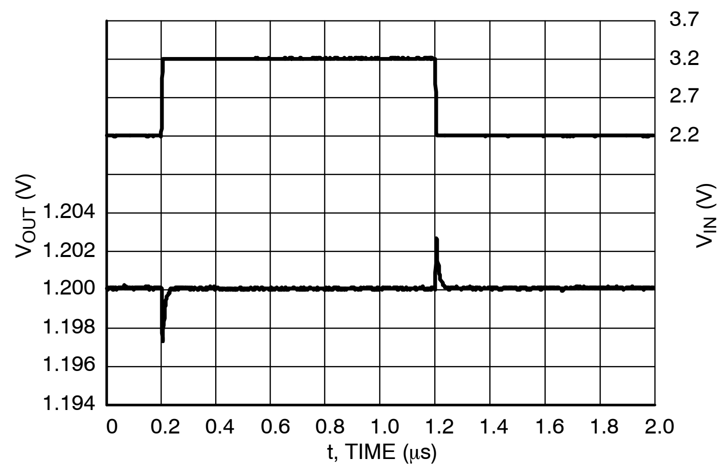

Figure 48. Line Transients, 1.2 V Version, t_R = t_F = 5 μs, I_{OUT} = 30 mA, AE = V_{IN} V

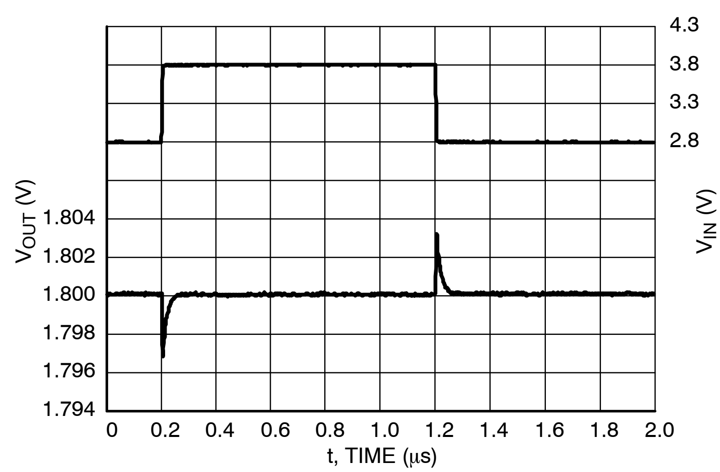

Figure 49. Line Transients, 1.8 V Version, t_R = t_F = 5 μs, I_{OUT} = 30 mA, AE = V_{IN} V

TYPICAL CHARACTERISTICS

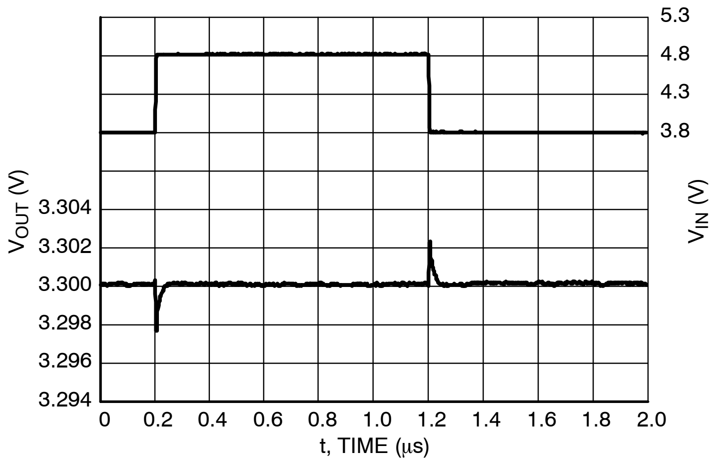

Figure 50. Line Transients, 3.3 V Version, t_R = t_F = 5 μs, I_{OUT} = 30 mA, AE = V_{IN} V

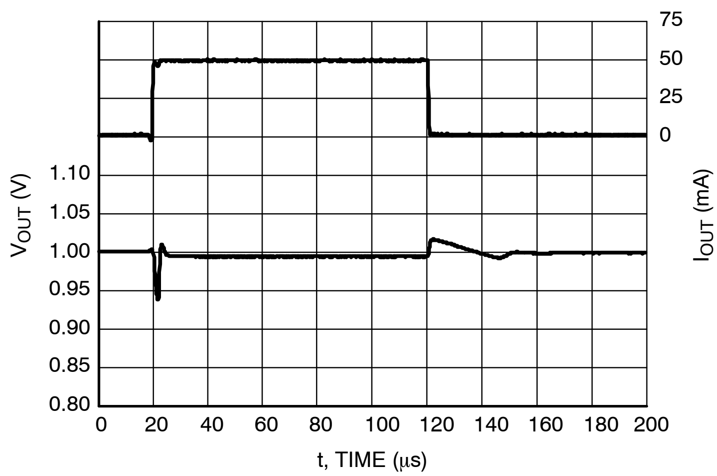

Figure 51. Load Transients, 1.0 V Version, I_{OUT} = 1 − 50 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.0 V, AE = 0 V

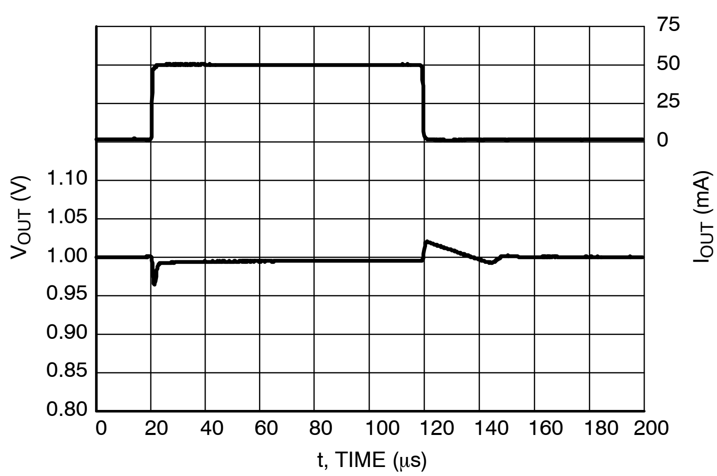

Figure 52. Load Transients, 1.0 V Version, I_{OUT} = 1 − 50 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.0 V, AE = V_{IN} V

TYPICAL CHARACTERISTICS

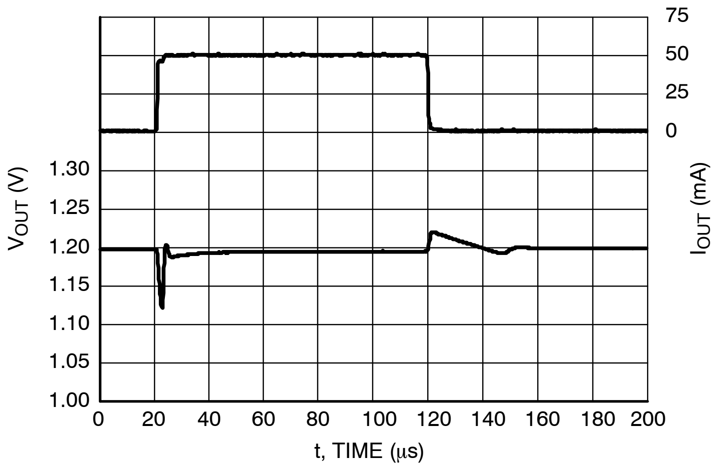

Figure 53. Load Transients, 1.2 V Version, I_{OUT} = 1 − 50 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.2 V, AE = 0 V

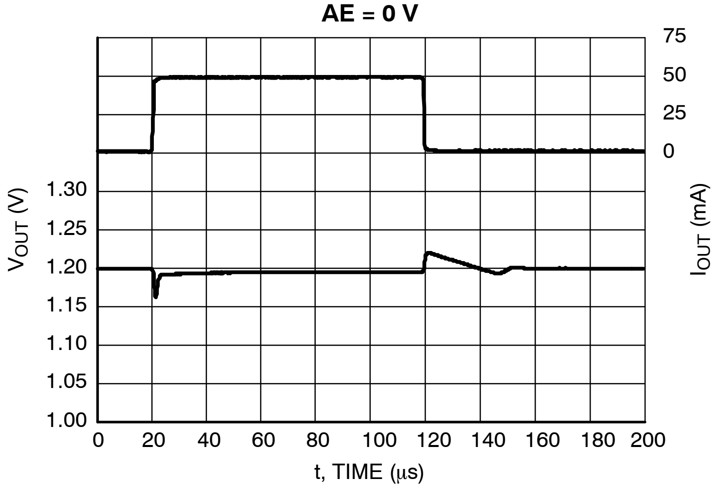

Figure 54. Load Transients, 1.2 V Version, I_{OUT} = 1 − 50 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.2 V, AE = V_{IN} V

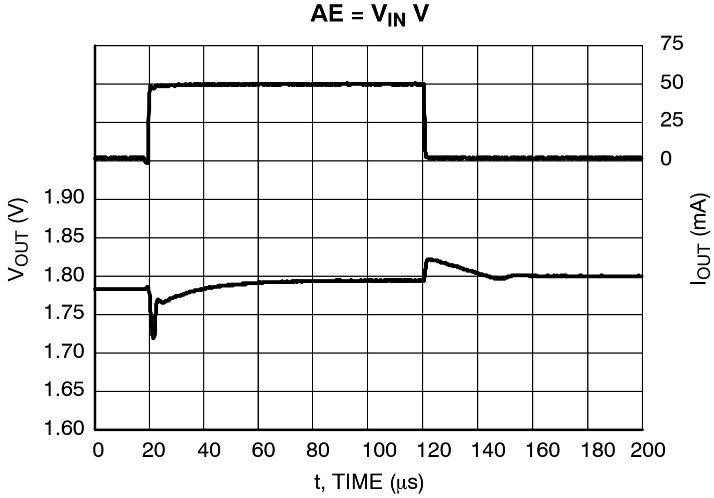

Figure 55. Load Transients, 1.8 V Version, I_{OUT} = 1 − 50 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.8 V, AE = 0 V

TYPICAL CHARACTERISTICS

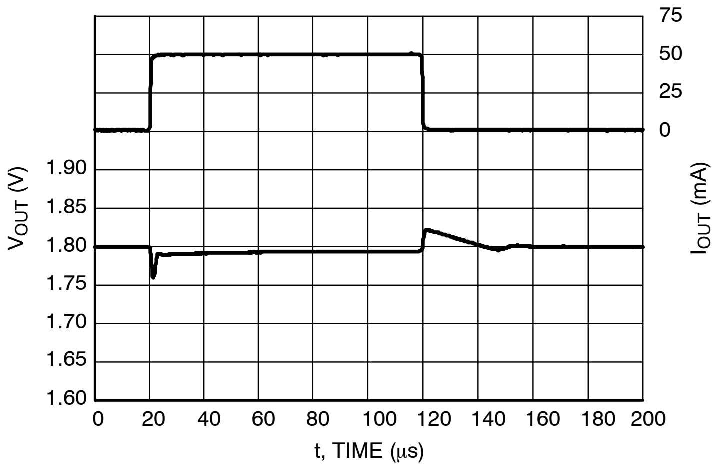

Figure 56. Load Transients, 1.8 V Version, I_{OUT} = 1 − 50 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.8 V, AE = V_{IN} V

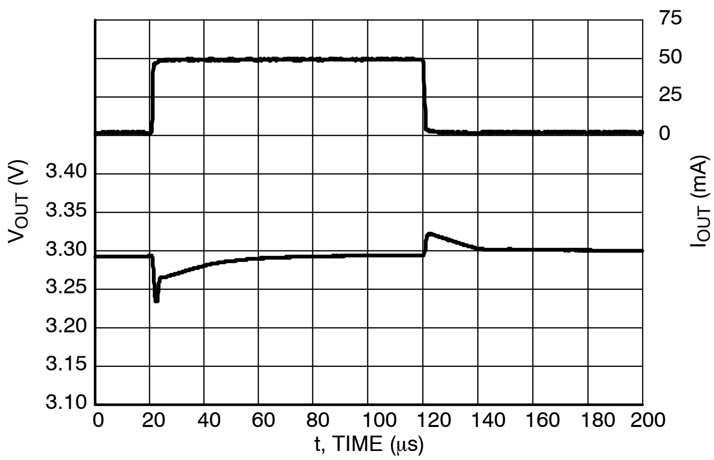

Figure 57. Load Transients, 3.3 V Version, I_{OUT} = 1 − 50 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 4.3 V, AE = 0 V

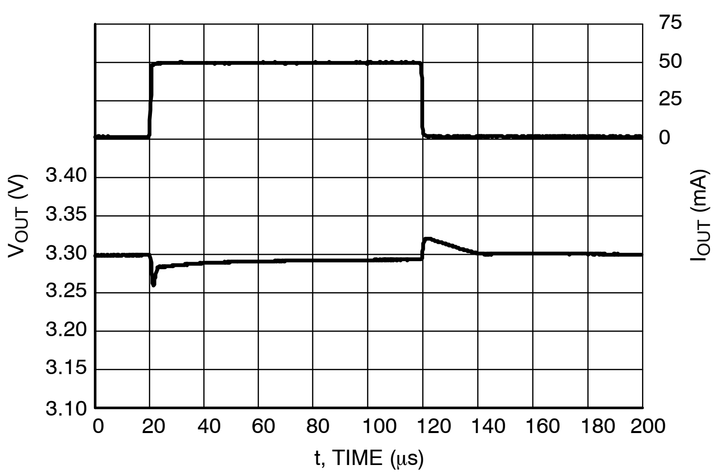

Figure 58. Load Transients, 3.3 V Version, I_{OUT} = 1 − 50 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 4.3 V, AE = V_{IN} V

TYPICAL CHARACTERISTICS

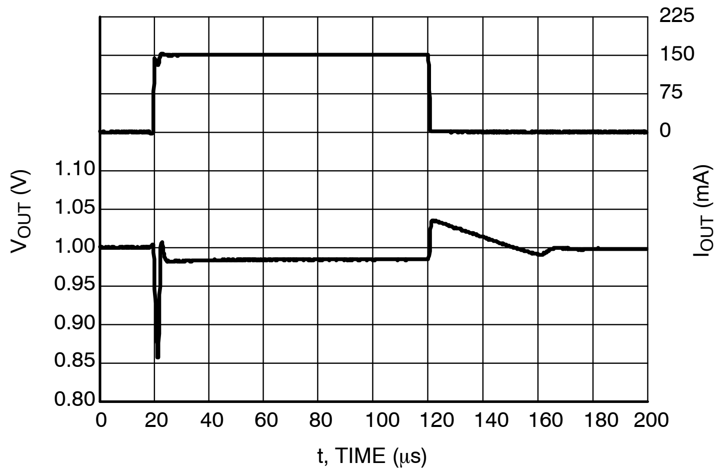

Figure 59. Load Transients, 1.0 V Version, I_{OUT} = 1 − 150 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.0 V, AE = 0 V

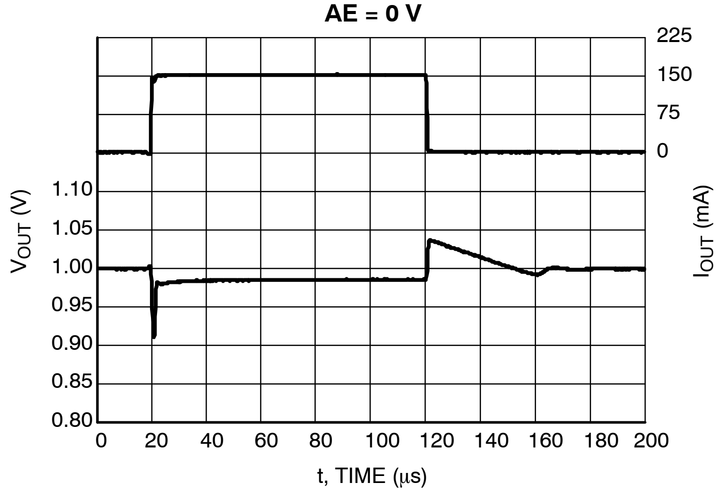

Figure 60. Load Transients, 1.0 V Version, I_{OUT} = 1 − 150 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.0 V, AE = V_{IN} V

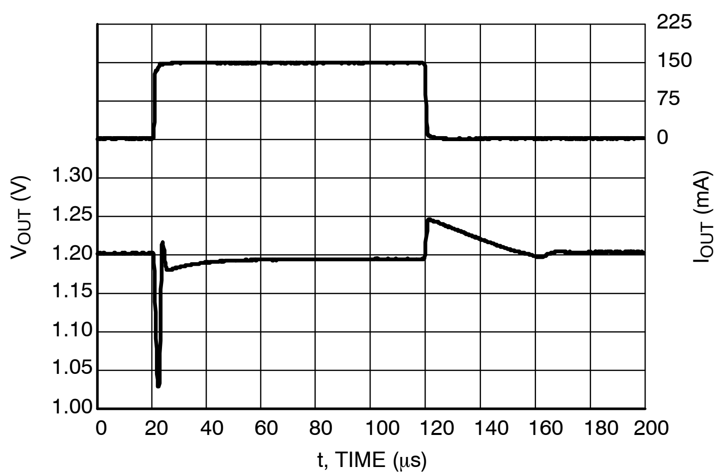

Figure 61. Load Transients, 1.2 V Version, I_{OUT} = 1 − 150 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.2 V, AE = 0 V

TYPICAL CHARACTERISTICS

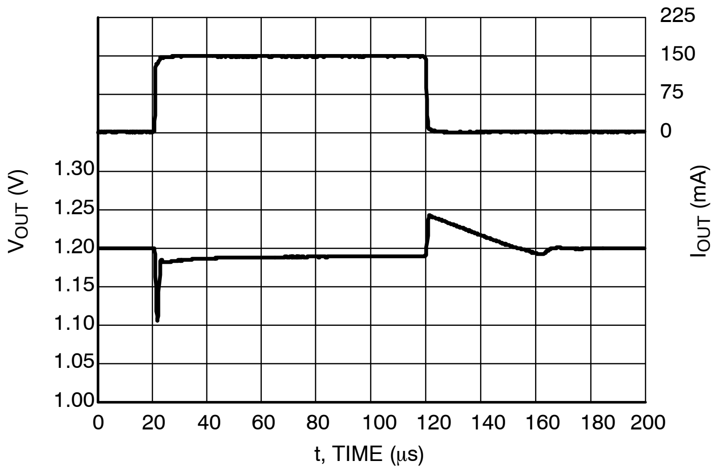

Figure 62. Load Transients, 1.2 V Version, I_{OUT} = 1 − 150 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.2 V, AE = V_{IN} V

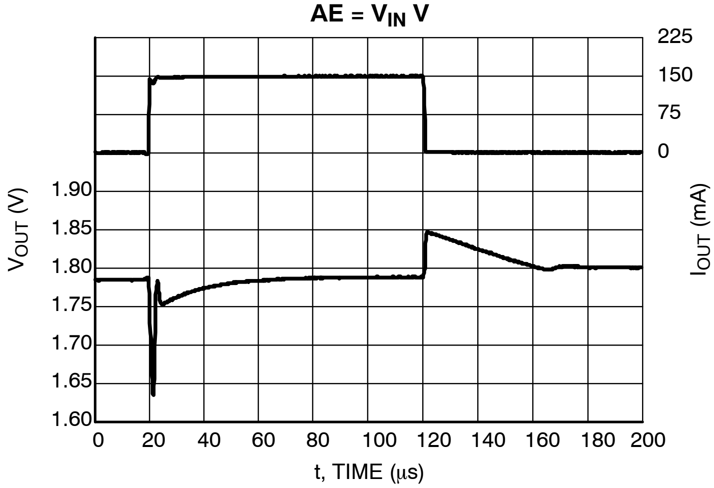

Figure 63. Load Transients, 1.8 V Version, I_{OUT} = 1 − 150 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.8 V, AE = 0 V

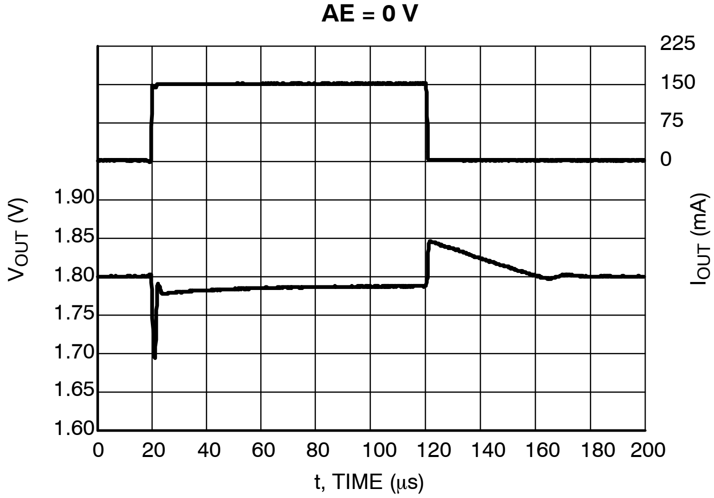

Figure 64. Load Transients, 1.8 V Version, I_{OUT} = 1 − 150 mA, t_R = t_F = 0.5 μs, V_{IN} = 2.8 V, AE = V_{IN} V

TYPICAL CHARACTERISTICS

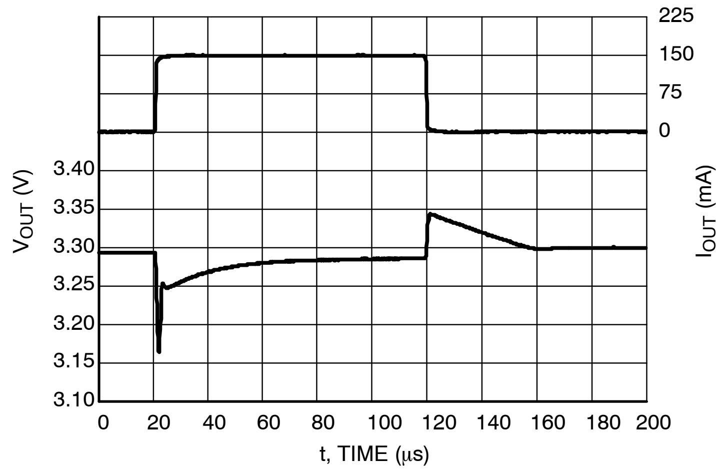

Figure 65. Load Transients, 3.3 V Version, I_{OUT} = 1 − 150 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 4.3 V, AE = 0 V

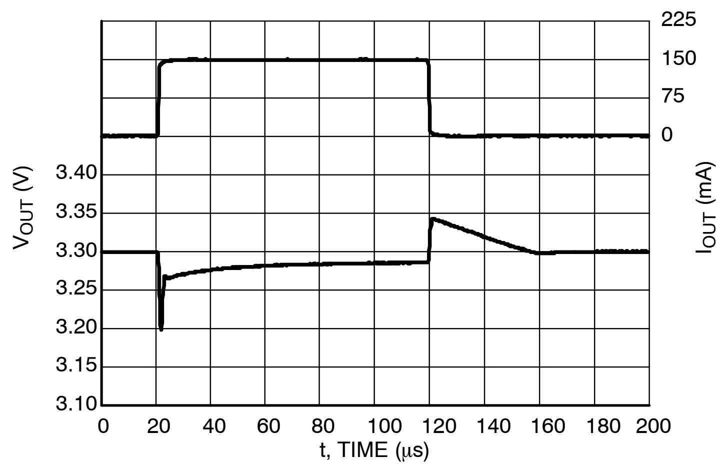

Figure 66. Load Transients, 3.3 V Version, I_{OUT} = 1 − 150 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 4.3 V, AE = V_{IN} V

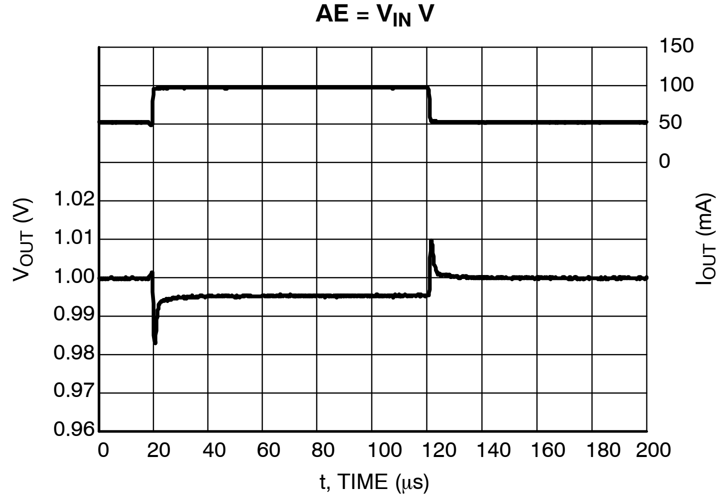

Figure 67. Load Transients, 1.0 V Version, I_{OUT} = 50 − 100 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.0 V, AE = 0 V

TYPICAL CHARACTERISTICS

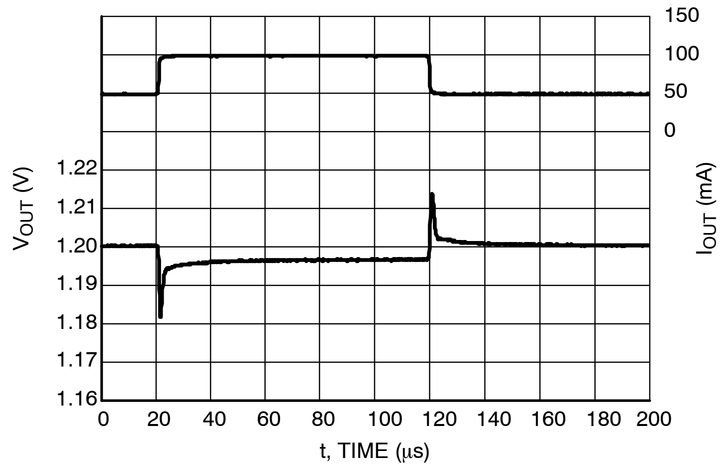

Figure 68. Load Transients, 1.2 V Version, I_{OUT} = 50 − 100 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.2 V, AE = V_{IN} V

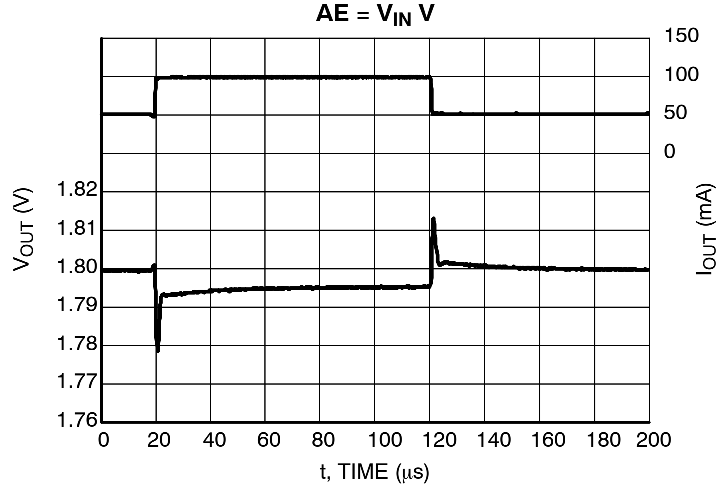

Figure 69. Load Transients, 1.8 V Version, I_{OUT} = 50 − 100 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 2.8 V, AE = V_{IN} V

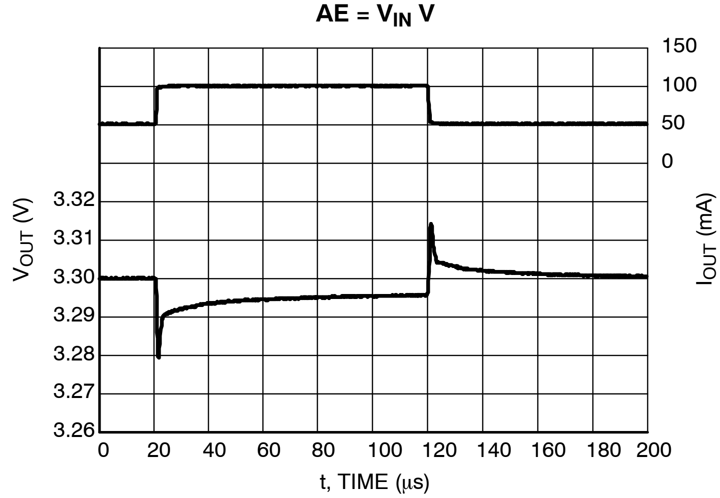

Figure 70. Load Transients, 3.3 V Version, I_{OUT} = 50 − 100 mA, $t_R = t_F$ = 0.5 μs, V_{IN} = 4.3 V, AE = V_{IN} V

TYPICAL CHARACTERISTICS

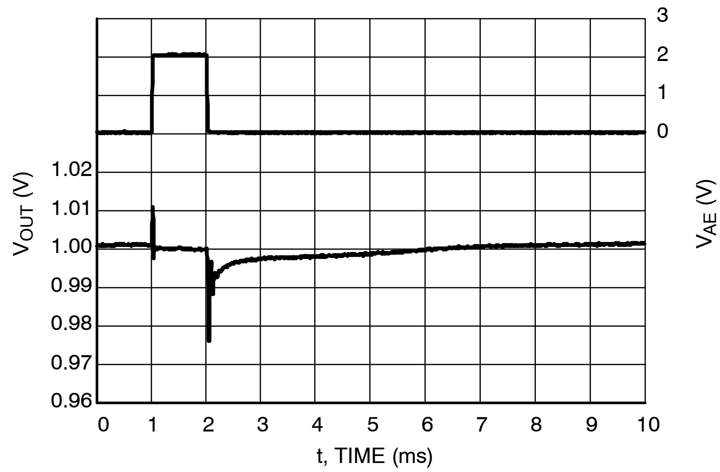

Figure 71. AE Switch Transients, 1.0 V Version, V_{IN} = 2.0 V, I_{OUT} = 1 mA

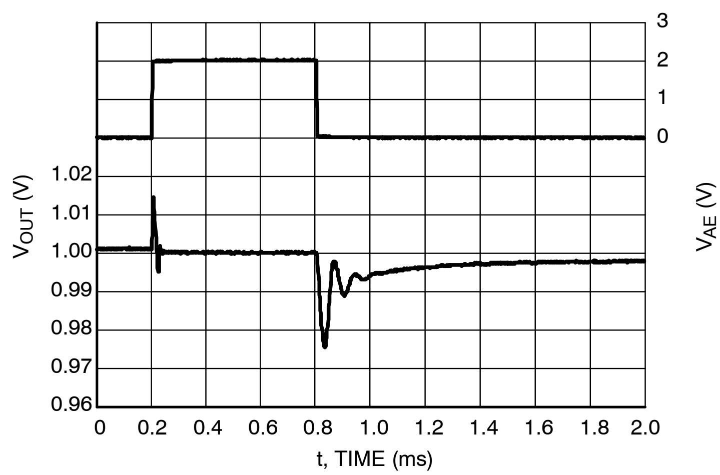

Figure 72. AE Switch Transients, 1.0 V Version, V_{IN} = 2.0 V, I_{OUT} = 1 mA

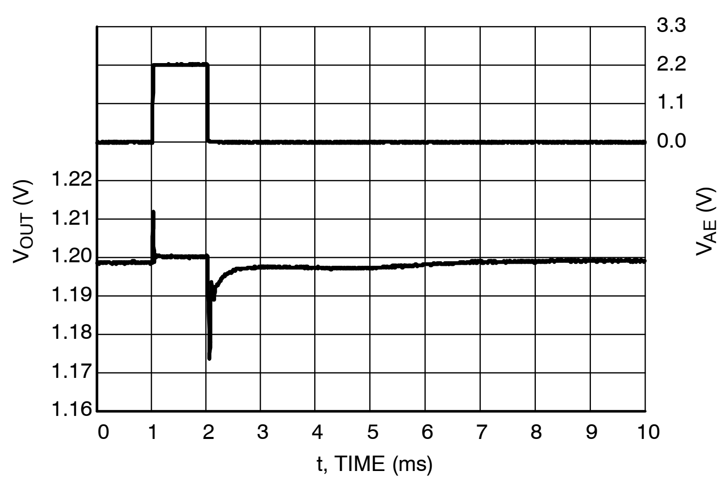

Figure 73. AE Switch Transients, 1.2 V Version, V_{IN} = 2.2 V, I_{OUT} = 1 mA

TYPICAL CHARACTERISTICS

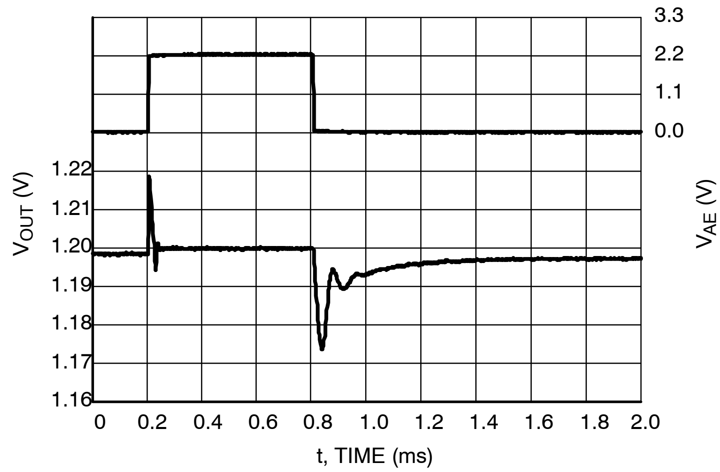

Figure 74. AE Switch Transients, 1.2 V Version, V_{IN} = 2.2 V, I_{OUT} = 1 mA

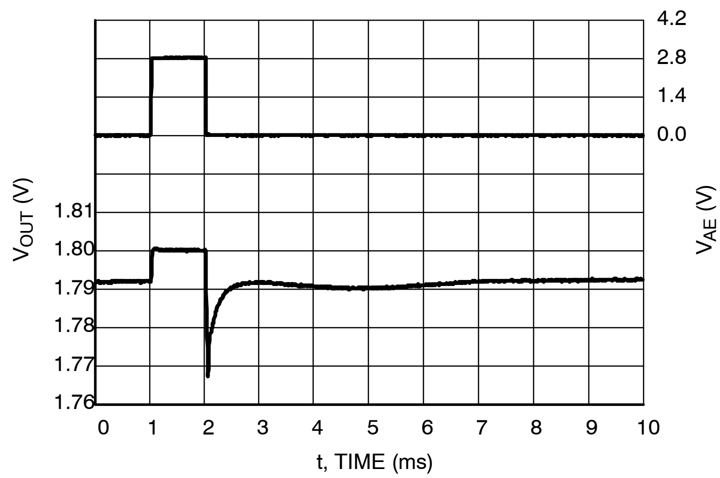

Figure 75. AE Switch Transients, 1.8 V Version, V_{IN} = 2.8 V, I_{OUT} = 1 mA

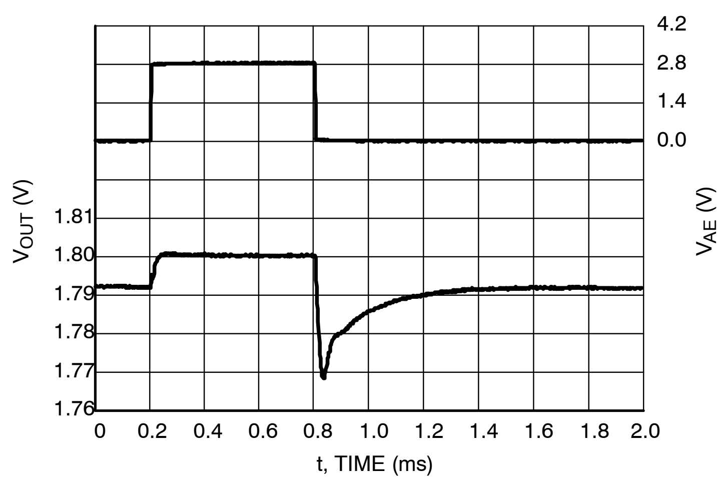

Figure 76. AE Switch Transients, 1.8 V Version, V_{IN} = 2.8 V, I_{OUT} = 1 mA

TYPICAL CHARACTERISTICS

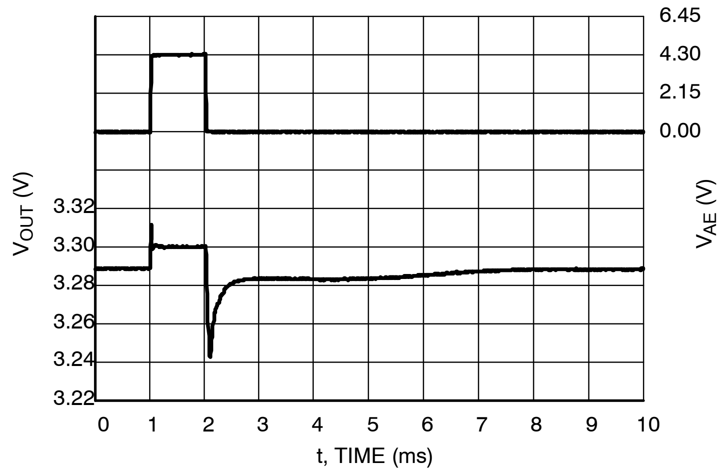

Figure 77. AE Switch Transients, 3.3 V Version, V_{IN} = 4.3 V, I_{OUT} = 1 mA

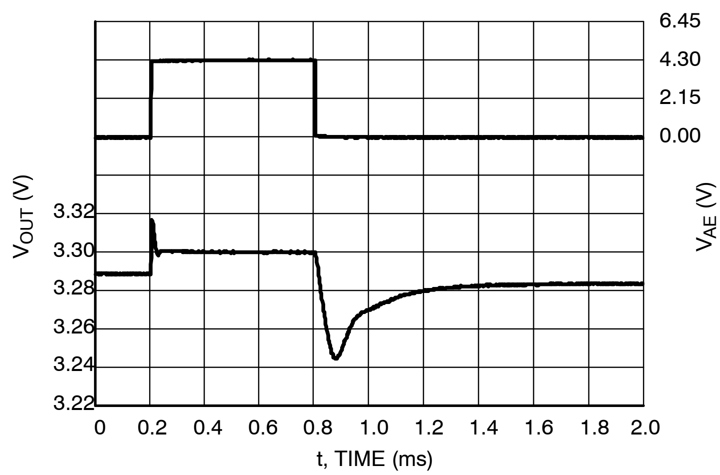

Figure 78. AE Switch Transients, 3.3 V Version, V_{IN} = 4.3 V, I_{OUT} = 1 mA

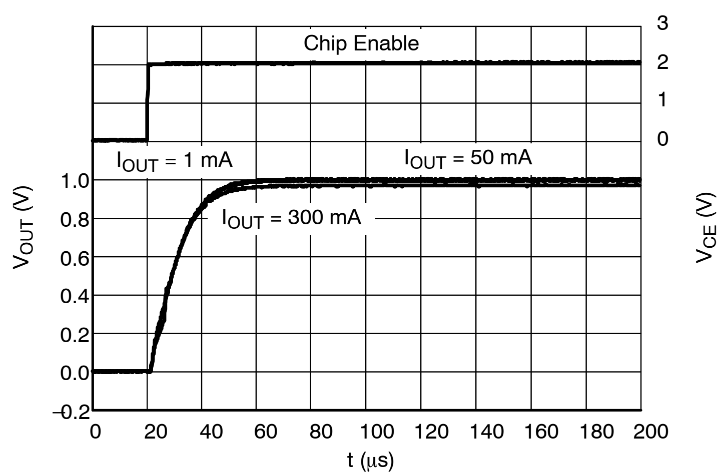

Figure 79. Start−up, 1.0 V Version, V_{IN} = 2.0 V

TYPICAL CHARACTERISTICS

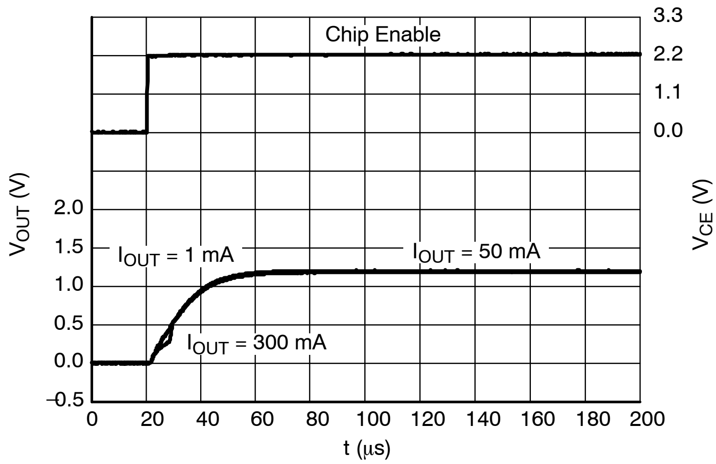

Figure 80. Start−up, 1.2 V Version, V_{IN} = 2.2 V

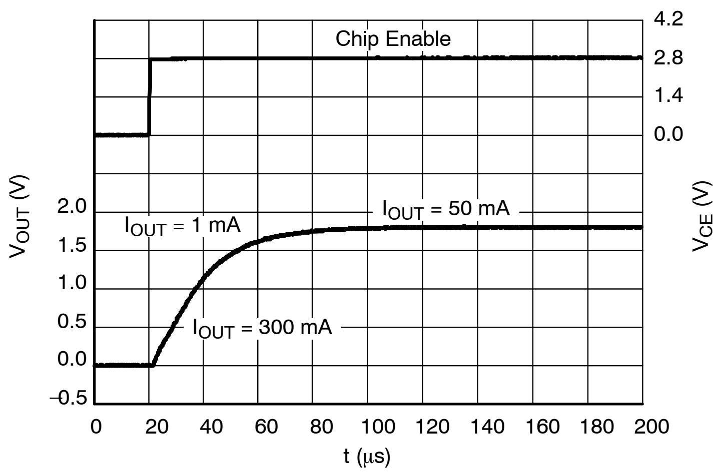

Figure 81. Start−up, 1.8 V Version, V_{IN} = 2.8 V

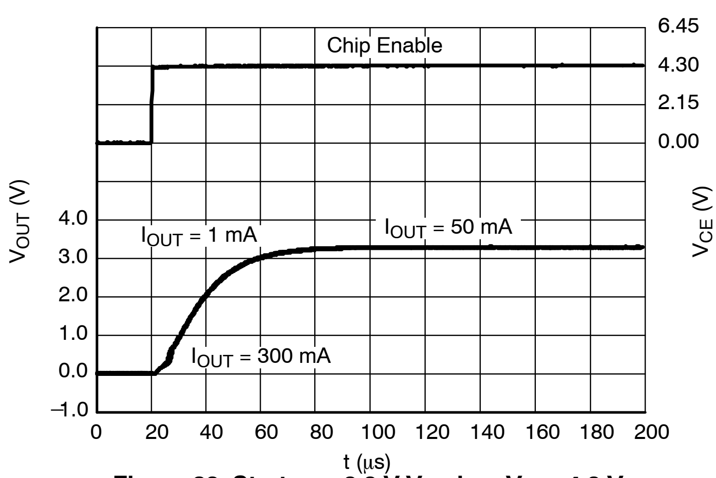

Figure 82. Start−up, 3.3 V Version, V_{IN} = 4.3 V

TYPICAL CHARACTERISTICS

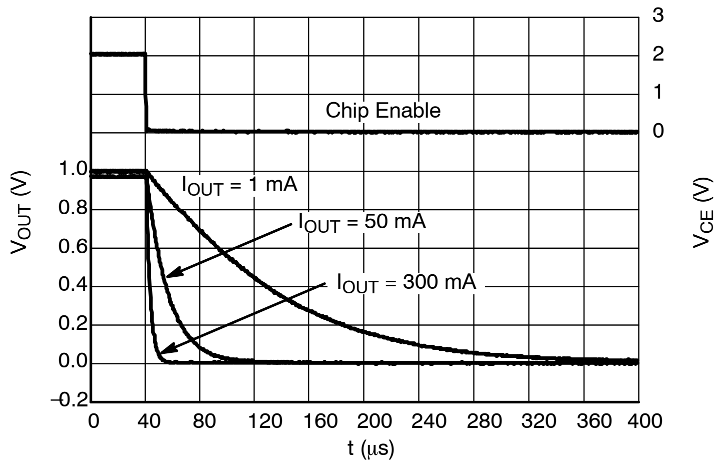

Figure 83. Shutdown, 1.0 V Version D, V_{IN} = 2.0 V

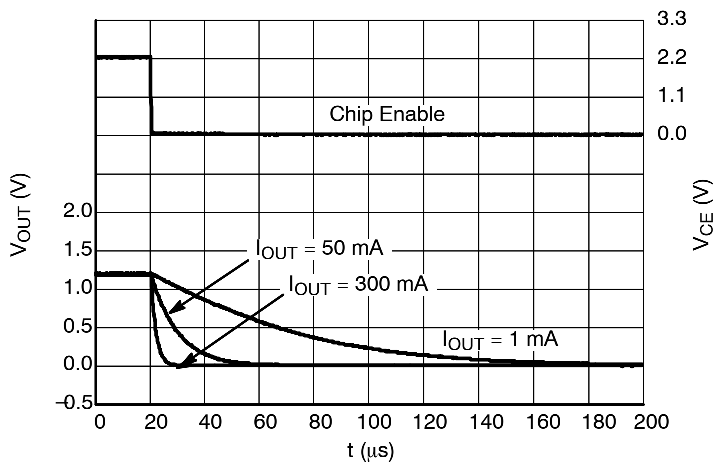

Figure 84. Shutdown, 1.2 V Version D, V_{IN} = 2.2 V

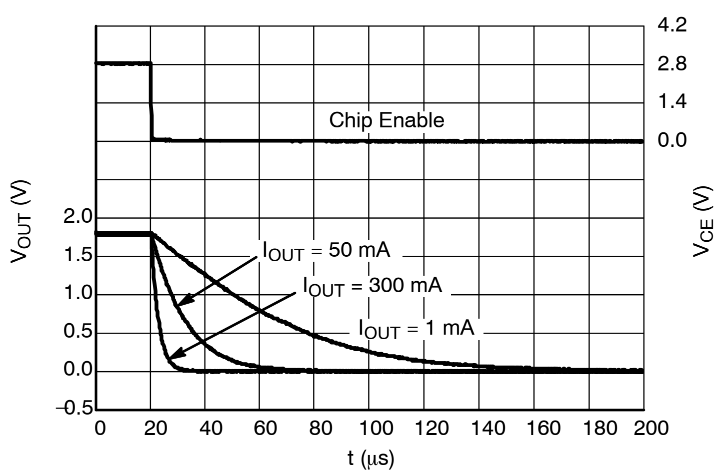

Figure 85. Shutdown, 1.8 V Version D, V_{IN} = 2.8 V