NCP1117

Product Preview
1.0 A Low-Dropout Positive Fixed and Adjustable Voltage Regulators

The NCP1117 series are low dropout positive voltage regulators that are capable of providing an output current that is in excess of 1.0 A with a maximum dropout voltage of 1.2 V at 800 mA over temperature. This series contains eight fixed output voltages of 1.5 V, 1.8 V, 2.0 V, 2.5 V, 2.85 V, 3.3 V, 5.0 V, and 12 V that have no minimum load requirement to maintain regulation. Also included is an adjustable output version that can be programmed from 1.25 V to 18.8 V with two external resistors. On chip trimming adjusts the reference/output voltage to within ±1.0% accuracy. Internal protection features consist of output current limiting, safe operating area compensation, and thermal shutdown. The NCP1117 series can operate with up to 20 V input. Devices are available in SOT–223 and DPAK packages.

Features
- Output Current in Excess of 1.0 A
- 1.2 V Maximum Dropout Voltage at 800 mA Over Temperature
- Fixed Output Voltages of 1.5 V, 1.8 V, 2.0 V, 2.5 V, 2.85 V, 3.3 V, 5.0 V, and 12 V
- Adjustable Output Voltage Option
- No Minimum Load Requirement for Fixed Voltage Output Devices
- Reference/Output Voltage Trimmed to ±1.0%
- Current Limit, Safe Operating and Thermal Shutdown Protection
- Operation to 20 V Input

Applications
- Consumer and Industrial Equipment Point of Regulation
- Active SCSI Termination for 2.85 V Version
- Switching Power Supply Post Regulation
- Hard Drive Controllers
- Battery Chargers
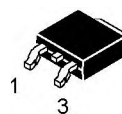
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SOT–223
ST SUFFIX
CASE 318H

(Top View)

Pin: 1. Adjust/Ground
2. Output
3. Input

Heatsink tab is connected to pin 2.

DPAK
DT SUFFIX
CASE 369A

(Top View)

ORDERING INFORMATION
See detailed ordering and shipping information in the package dimensions section on page 625 of this data sheet.

DEVICE MARKING INFORMATION
See general marking information in the device marking section on page 626 of this data sheet.
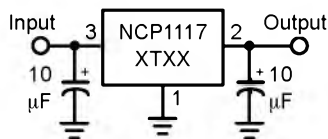
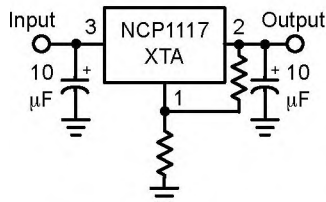## TYPICAL APPLICATIONS

Figure 1. Fixed Output Regulator

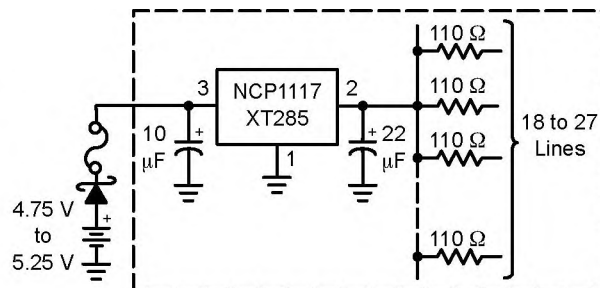Figure 2. Adjustable Output Regulator

Figure 3. Active SCSI Bus Terminator

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NCP1117

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	V_{in}	20	V
Output Short Circuit Duration (Notes 2 and 3)	–	Infinite	–

Power Dissipation and Thermal Characteristics
Case 318H (SOT–223)
   Power Dissipation (Note 2)
   Thermal Resistance, Junction–to–Ambient, Minimum Size Pad
   Thermal Resistance, Junction–to–Case
Case 369A (DPAK)
   Power Dissipation (Note 2)
   Thermal Resistance, Junction–to–Ambient, Minimum Size Pad
   Thermal Resistance, Junction–to–Case
	
	P_D
	$R_{\theta JA}$
	$R_{\theta JC}$
	
	P_D
	$R_{\theta JA}$
	$R_{\theta JC}$
		
		Internally Limited
		160
		15
		
		Internally Limited
		67
		6.0
			
			W
			°C/W
			°C/W
			
			W
			°C/W
			°C/W

Operating Junction Temperature Range	T_J	–55 to 150	°C
Storage Temperature Range	T_{stg}	–65 to 150	°C

1. This device series contains ESD protection and exceeds the following tests:
   Human Body Model 2000 V per MIL–STD–883, Method 3015.
   Machine Model Method 200 V.

2. Internal thermal shutdown protection limits the die temperature to approximately 175°C. Proper heatsinking is required to prevent activation. The maximum package power dissipation is:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

3. The regulator output current must not exceed 1.0 A with V_{in} greater than 12 V.

ELECTRICAL CHARACTERISTICS (C_{in} = 10 μF, C_{out} = 10 μF, for typical value T_J = 25°C, for min and max values T_J = 0°C to 125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit

Reference Voltage, Adjustable Output Devices
  (V_{in}–V_{out} = 2.0 V, I_{out} = 10 mA, T_J = 25°C)
  (V_{in}–V_{out} = 1.4 V to 10 V, I_{out} = 10 mA to 800 mA, T_J = 0°C to 125°C)
	V_{ref}	
		1.238
		1.225
			
			1.25
			–
				
				1.262
				1.270
					V

Output Voltage, Fixed Output Devices	V_{out}				V
1.5 V (V_{in} = 3.5 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 2.9 V to 11.5 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		1.485 1.470	1.500 –	1.515 1.530	
1.8 V (V_{in} = 3.8 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 3.2 V to 11.8 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		1.782 1.755	1.800 –	1.818 1.845	
2.0 V (V_{in} = 4.0 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 3.4 V to 12 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		1.970 1.960	2.000 –	2.030 2.040	
2.5 V (V_{in} = 4.5 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 3.9 V to 10 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		2.475 2.450	2.500 –	2.525 2.550	

2.85 V (V_{in} = 4.85 V, I_{out} = 10 mA, T_J = 25 °C)
           (V_{in} = 4.25 V to 10 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)
           (V_{in} = 4.0 V, I_{out} = 0 mA to 500 mA, T_J = 0°C to 125°C)
		2.821
		2.790
		2.790
			2.850
			–
			–
				2.879
				2.910
				2.910	

3.3 V (V_{in} = 5.3 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 4.75 V to 10 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		3.267 3.235	3.300 –	3.333 3.365	
5.0 V (V_{in} = 7.0 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 6.5 V to 12 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		4.950 4.900	5.000 –	5.050 5.100	
12 V (V_{in} = 14 V, I_{out} = 10 mA, T_J = 25 °C) (V_{in} = 13.5 V to 20 V, I_{out} = 0 mA to 800 mA, T_J = 0°C to 125°C)		11.880 11.760	12.000 –	12.120 12.240	

ELECTRICAL CHARACTERISTICS (C_{in} = 10 μF, C_{out} = 10 μF, for typical value T_J = 25°C, for min and max values T_J = 0°C to 125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Line Regulation (Note 4)	Reg_{line}				
Adjustable (V_{in} = 2.75 V to 16.25 V, I_{out} = 10 mA)		–	0.04	0.1	%
1.5 V (V_{in} = 2.9 V to 11.5 V, I_{out} = 0 mA)		–	0.3	1.0	mV
1.8 V (V_{in} = 3.2 V to 11.8 V, I_{out} = 0 mA)		–	0.4	1.0	
2.0 V (V_{in} = 3.4 V to 12 V, I_{out} = 0 mA)		–	0.5	2.5	
2.5 V (V_{in} = 3.9 V to 10 V, I_{out} = 0 mA)		–	0.5	2.5	
2.85 V (V_{in} = 4.25 V to 10 V, I_{out} = 0 mA)		–	0.8	3.0	
3.3 V (V_{in} = 4.75 V to 15 V, I_{out} = 0 mA)		–	0.8	4.5	
5.0 V (V_{in} = 6.5 V to 15 V, I_{out} = 0 mA)		–	0.9	6.0	
12 V (V_{in} = 13.5 V to 20 V, I_{out} = 0 mA)		–	1.0	7.5	
Load Regulation (Note 4)	Reg_{line}				
Adjustable (I_{out} = 10 mA to 800 mA, V_{in} = 4.25 V)		–	0.2	0.4	%
1.5 V (I_{out} = 0 mA to 800 mA, V_{in} = 2.9 V)		–	2.3	5.5	mV
1.8 V (I_{out} = 0 mA to 800 mA, V_{in} = 3.2 V)		–	2.6	6.0	
2.0 V (I_{out} = 0 mA to 800 mA, V_{in} = 3.4 V)		–	3.0	6.0	
2.5 V (I_{out} = 0 mA to 800 mA, V_{in} = 3.9 V)		–	3.3	7.5	
2.85 V (I_{out} = 0 mA to 800 mA, V_{in} = 4.25 V)		–	3.8	8.0	
3.3 V (I_{out} = 0 mA to 800 mA, V_{in} = 4.75 V)		–	4.3	10	
5.0 V (I_{out} = 0 mA to 800 mA, V_{in} = 6.5 V)		–	6.7	15	
12 V (I_{out} = 0 mA to 800 mA, V_{in} = 13.5 V)		–	16	28	
Dropout Voltage (Measured at V_{out} – 100 mV)	$V_{in}-V_{out}$				V
(I_{out} = 100 mA)		–	0.95	1.10	
(I_{out} = 500 mA)		–	1.01	1.15	
(I_{out} = 800 mA)		–	1.07	1.20	
Output Current Limit ($V_{in}-V_{out}$ = 5.0 V, T_J = 25°C, Note 5)	I_{out}	1000	1500	2200	mA
Minimum Required Load Current for Regulation, Adjustable Output Devices (V_{in} = 15 V)	$I_{L(min)}$	–	0.8	5.0	mA
Quiescent Current	I_Q				mA
1.5 V (V_{in} = 11.5 V)		–	3.6	10	
1.8 V (V_{in} = 11.8 V)		–	4.2	10	
2.0 V (V_{in} = 12 V)		–	4.5	10	
2.5 V (V_{in} = 10 V)		–	5.2	10	
2.85 V (V_{in} = 10 V)		–	5.5	10	
3.3 V (V_{in} = 15 V)		–	6.0	10	
5.0 V (V_{in} = 15 V)		–	6.0	10	
12 V (V_{in} = 20 V)		–	6.0	10	
Thermal Regulation (T_A = 25°C, 30 ms Pulse)		–	0.01	0.1	%/W
Ripple Rejection ($V_{in}-V_{out}$ = 6.4 V, I_{out} = 500 mA, 10 V_{pp} 120 Hz Sinewave)	RR				dB
Adjustable		67	73	–	
1.5 V		66	72	–	
1.8 V		64	70	–	
2.0 V		64	70	–	
2.5 V		62	68	–	
2.85 V		62	68	–	
3.3 V		60	64	–	
5.0 V		57	61	–	
12 V		50	54	–	
Adjustment Pin Current (V_{in} = 11.25 V, I_{out} = 800 mA)	I_{adj}	–	52	120	μA
Adjust Pin Current Change ($V_{in}-V_{out}$ = 1.4 V to 10 V, I_{out} = 10 mA to 800 mA)	ΔI_{adj}	–	0.4	5.0	μA
Temperature Stability	S_T	–	0.5	–	%
Long Term Stability (T_A = 25°C, 1000 Hrs End Point Measurement)	S_t	–	0.3	–	%
RMS Output Noise (f = 10 Hz to 10 kHz)	N	–	0.003	–	%V_{out}

4. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

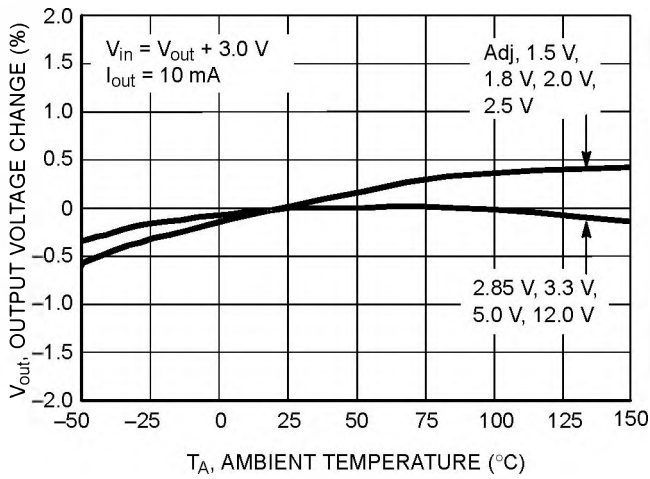5. The regulator output current must not exceed 1.0 A with V_{in} greater than 12 V.

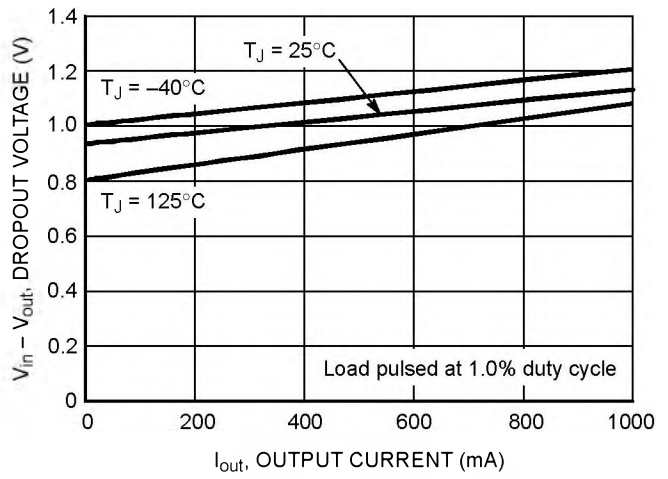**Figure 4. Output Voltage Change vs. Temperature**

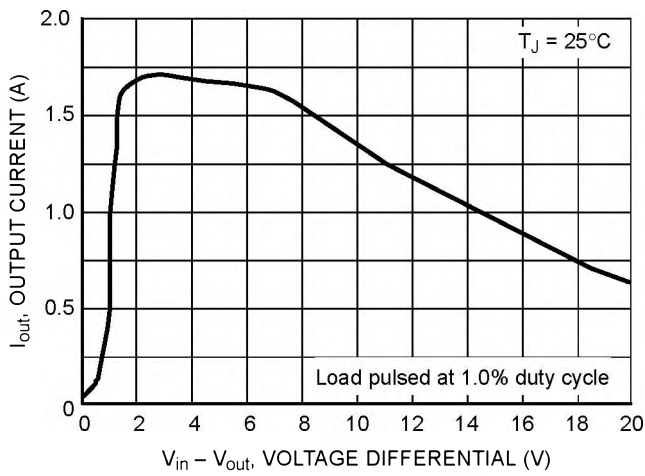**Figure 5. Dropout Voltage vs. Output Current**

Figure 6. Output Short Circuit Current vs. Differential Voltage
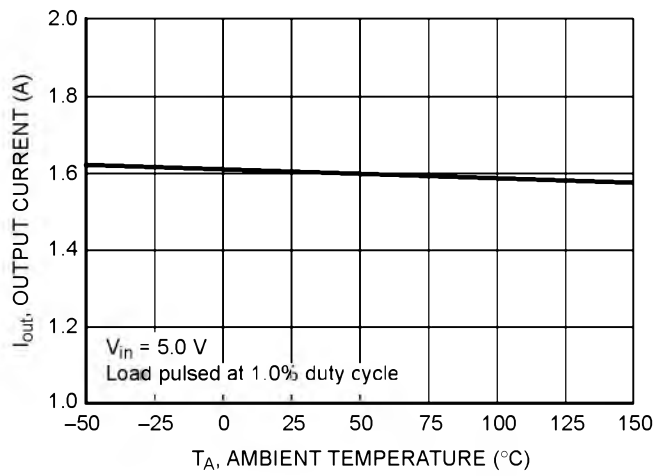

Figure 7. Output Short Circuit Current vs. Temperature
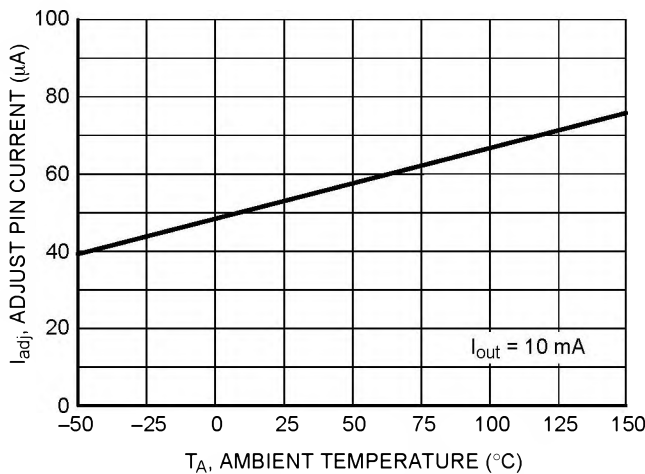

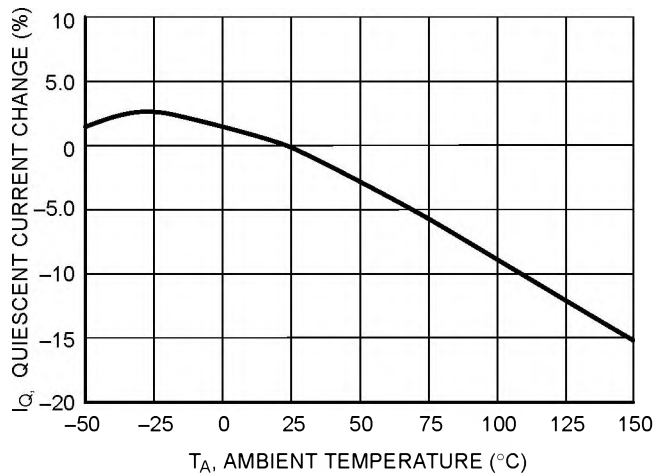**Figure 8. Adjust Pin Current vs. Temperature**

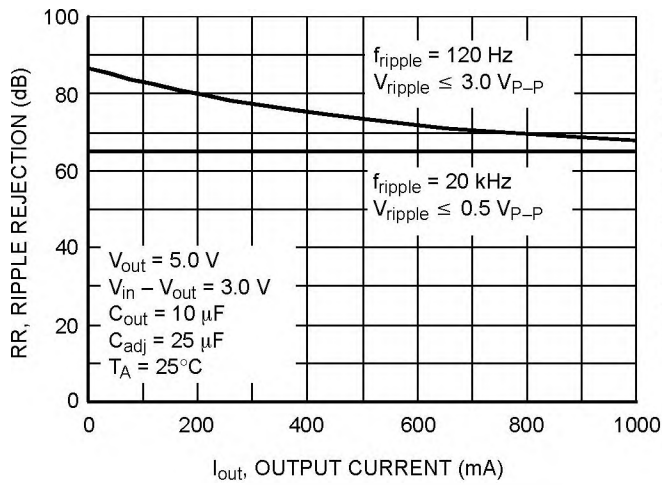**Figure 9. Quiescent Current Change vs. Temperature**

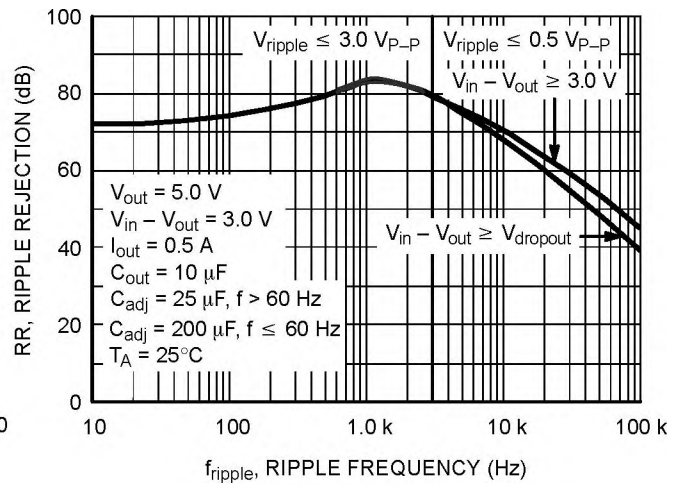Figure 10. NCP1117XTA Ripple Rejection
vs. Output Current

Figure 11. NCP1117XTA Ripple Rejection
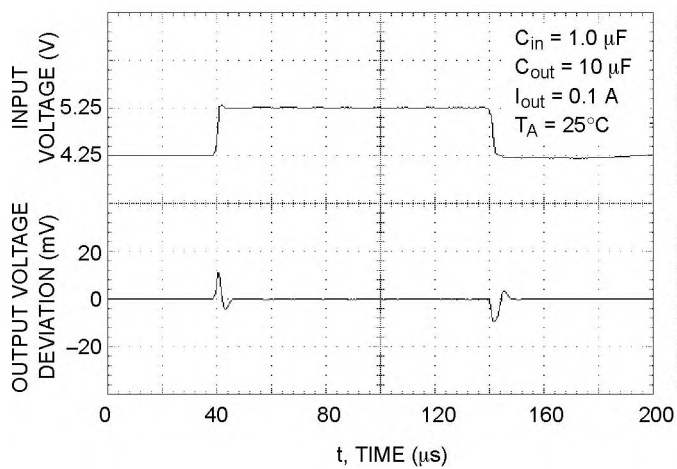vs. Frequency
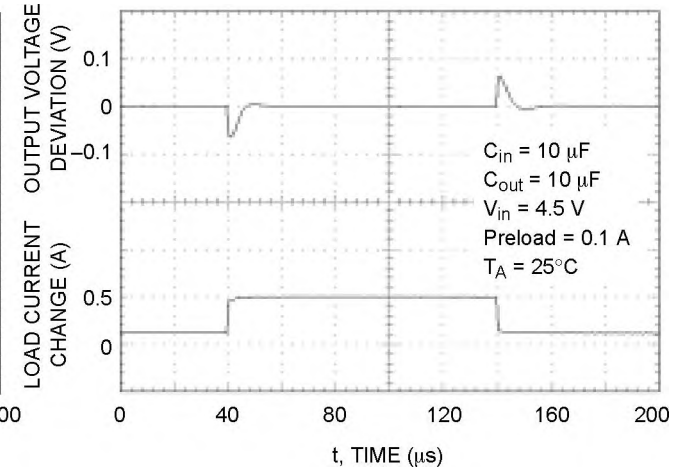

Figure 12. NCP1117XT285
Line Transient Response
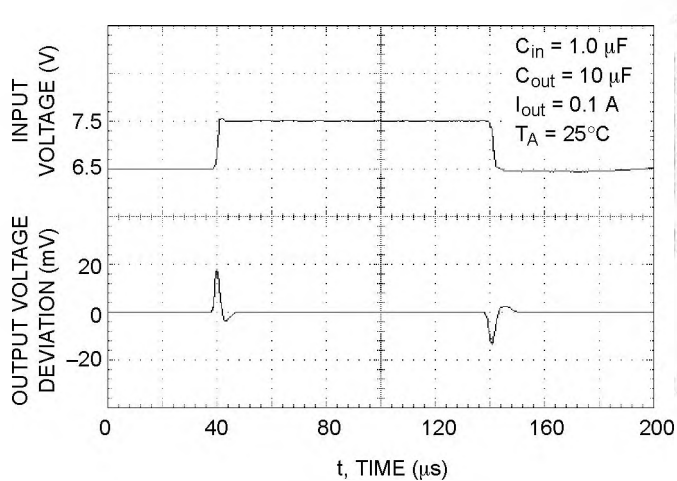

Figure 13. NCP1117XT285
Load Transient Response
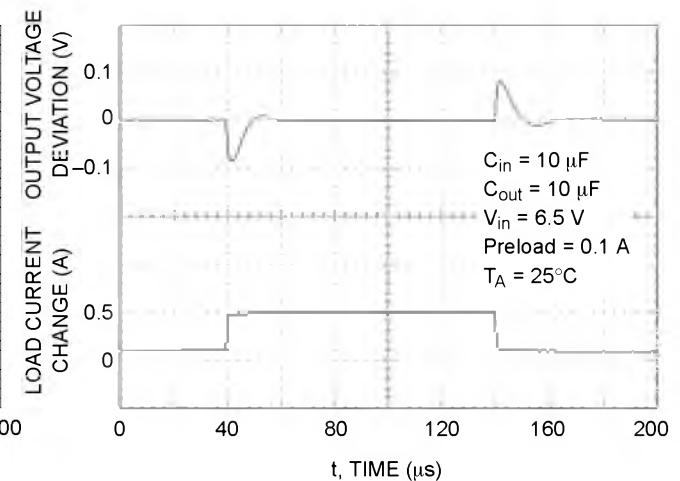

Figure 14. NCP1117XT50
Line Transient Response
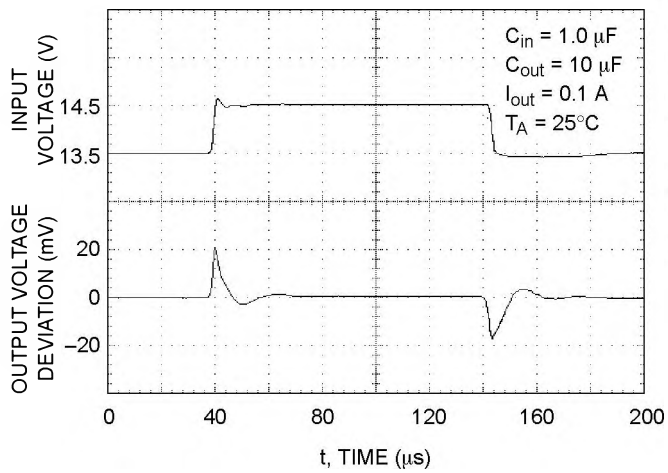

Figure 15. NCP1117XT50
Load Transient Response

Figure 16. NCP1117XT12 Line Transient Response
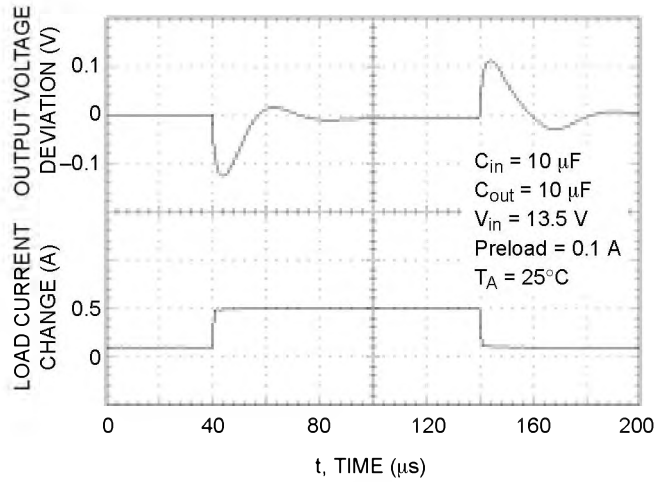
C_{in} = 1.0 μF
C_{out} = 10 μF
I_{out} = 0.1 A
T_A = 25°C

Figure 17. NCP1117XT12 Load Transient Response

C_{in} = 10 μF
C_{out} = 10 μF
V_{in} = 13.5 V
Preload = 0.1 A
T_A = 25°C

$P_{D(max)}$ for T_A = 50°C

Minimum Size Pad

2.0 oz. Copper

$R_{\theta JA}$

Figure 18. SOT–223 Thermal Resistance and Maximum Power Dissipation vs. P.C.B. Copper Length

$P_{D(max)}$ for T_A = 50°C

Minimum Size Pad
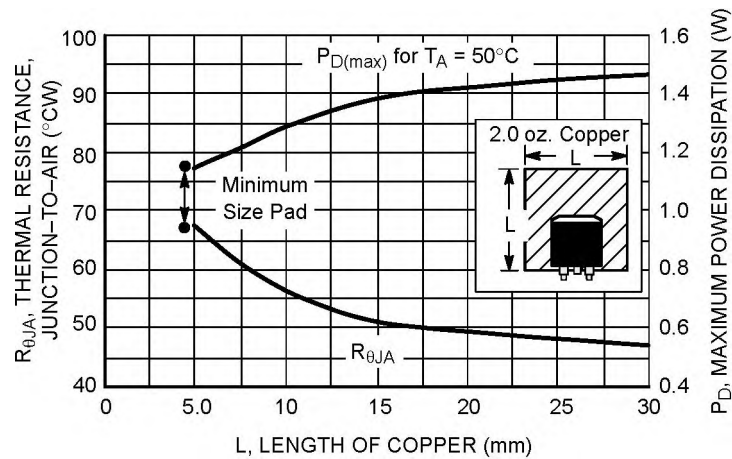
2.0 oz. Copper

$R_{\theta JA}$

Figure 19. DPAK Thermal Resistance and Maximum Power Dissipation vs. P.C.B. Copper Length

NCP1117

APPLICATIONS INFORMATION

Introduction

The NCP1117 features a significant reduction in dropout voltage along with enhanced output voltage accuracy and temperature stability when compared to older industry standard three–terminal adjustable regulators. These devices contain output current limiting, safe operating area compensation and thermal shutdown protection making them designer friendly for powering numerous consumer and industrial products. The NCP1117 series is pin compatible with the older LM317 and its derivative device types.

Output Voltage

The typical application circuits for the fixed and adjustable output regulators are shown in Figures 20 and 21. The adjustable devices are floating voltage regulators. They develop and maintain the nominal 1.25 V reference voltage between the output and adjust pins. The reference voltage is programmed to a constant current source by resistor R1, and this current flows through R2 to ground to set the output voltage. The programmed current level is usually selected to be greater than the specified 5.0 mA minimum that is required for regulation. Since the adjust pin current, I_{adj}, is significantly lower and constant with respect to the programmed load current, it generates a small output voltage error that can usually be ignored. For the fixed output devices R1 and R2 are included within the device and the ground current I_{gnd}, ranges from 3.0 mA to 5.0 mA depending upon the output voltage.

External Capacitors

Input bypass capacitor C_{in} may be required for regulator stability if the device is located more than a few inches from the power source. This capacitor will reduce the circuit's sensitivity when powered from a complex source impedance and significantly enhance the output transient response. The input bypass capacitor should be mounted with the shortest possible track length directly across the regulator's input and ground terminals. A 10 μF ceramic or tantalum capacitor should be adequate for most applications.
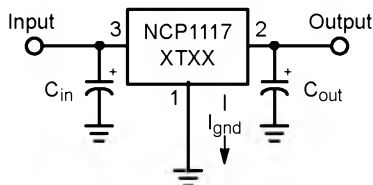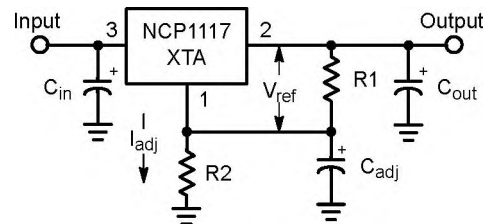
Figure 20. Fixed Output Regulator

Frequency compensation for the regulator is provided by capacitor C_{out} and its use is mandatory to ensure output stability. A minimum capacitance value of 4.7 μF with an equivalent series resistance (ESR) that is within the limits of 0.25 Ω to 2.2 Ω is required. The capacitor type can be ceramic, tantalum, or aluminum electrolytic as long as it meets the minimum capacitance value and ESR limits over the circuit's entire operating temperature range. Higher values of output capacitance can be used to enhance loop stability and transient response with the additional benefit of reducing output noise.

$$V_{out} = V_{ref}\left(1 + \frac{R2}{R1}\right) + I_{adj}\,R2$$

Figure 21. Adjustable Output Regulator

The output ripple will increase linearly for fixed and adjustable devices as the ratio of output voltage to the reference voltage increases. For example, with a 12 V regulator, the output ripple will increase by 12 V/1.25 V or 9.6 and the ripple rejection will decrease by 20 log of this ratio or 19.6 dB. The loss of ripple rejection can be restored to the values shown with the addition of bypass capacitor C_{adj}, shown in Figure 21. The reactance of C_{adj} at the ripple frequency must be less than the resistance of R1. The value of R1 can be selected to provide the minimum required load current to maintain regulation and is usually in the range of 100 Ω to 200 Ω.

$$C_{adj} > \frac{1}{2\pi\, f_{ripple}\, R1}$$

The minimum required capacitance can be calculated from the above formula. When using the device in an application that is powered from the AC line via a transformer and a full wave bridge, the value for C_{adj} is:

f_{ripple} = 120 Hz, R1 = 120 Ω, then C_{adj} > 11.1 μF

The value for C_{adj} is significantly reduced in applications where the input ripple frequency is high. If used as a post regulator in a switching converter under the following conditions:

f_{ripple} = 50 kHz, R1 = 120 Ω, then C_{adj} > 0.027 μF

Figures 10 and 11 shows the level of ripple rejection that is obtainable with the adjust pin properly bypassed.

NCP1117

Protection Diodes

The NCP1117 family has two internal low impedance diode paths that normally do not require protection when used in the typical regulator applications. The first path connects between V_{out} and V_{in}, and it can withstand a peak surge current of about 15 A. Normal cycling of V_{in} cannot generate a current surge of this magnitude. Only when V_{in} is shorted or crowbarred to ground and C_{out} is greater than 50 μF, it becomes possible for device damage to occur. Under these conditions, diode D1 is required to protect the device. The second path connects between C_{adj} and V_{out}, and it can withstand a peak surge current of about 150 mA. Protection diode D2 is required if the output is shorted or crowbarred to ground and C_{adj} is greater than 1.0 μF.
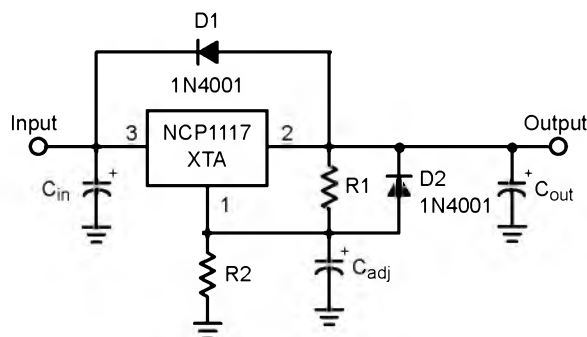

Figure 22. Protection Diode Placement

A combination of protection diodes D1 and D2 may be required in the event that V_{in} is shorted to ground and C_{adj} is greater than 50 μF. The peak current capability stated for the internal diodes are for a time of 100 μs with a junction temperature of 25°C. These values may vary and are to be used as a general guide.

Load Regulation

The NCP1117 series is capable of providing excellent load regulation; but since these are three terminal devices, only partial remote load sensing is possible. There are two conditions that must be met to achieve the maximum available load regulation performance. The first is that the top side of programming resistor R1 should be connected as close to the regulator case as practicable. This will minimize the voltage drop caused by wiring resistance RW + from appearing in series with reference voltage that is across R1.

The second condition is that the ground end of R2 should be connected directly to the load. This allows true Kelvin sensing where the regulator compensates for the voltage drop caused by wiring resistance RW –.
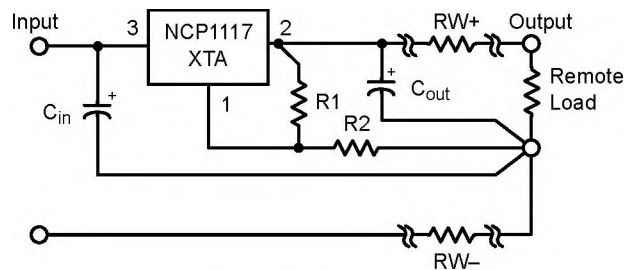

Figure 23. Load Sensing

Thermal Considerations

This series contains an internal thermal limiting circuit that is designed to protect the regulator in the event that the maximum junction temperature is exceeded. When activated, typically at 175°C, the regulator output switches off and then back on as the die cools. As a result, if the device is continuously operated in an overheated condition, the output will appear to be oscillating. This feature provides protection from a catastrophic device failure due to accidental overheating. It is not intended to be used as a substitute for proper heatsinking. The maximum device power dissipation can be calculated by:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

The devices are available in surface mount SOT–223 and DPAK packages. Each package has an exposed metal tab that is specifically designed to reduce the junction to air thermal resistance, $R_{\theta JA}$, by utilizing the printed circuit board copper as a heat dissipater. Figures 18 and 19 show typical $R_{\theta JA}$ values that can be obtained from a square pattern using economical single sided 2.0 ounce copper board material. The final product thermal limits should be tested and quantified in order to insure acceptable performance and reliability. The actual $R_{\theta JA}$ can vary considerably from the graphs shown. This will be due to any changes made in the copper aspect ratio of the final layout, adjacent heat sources, and air flow.
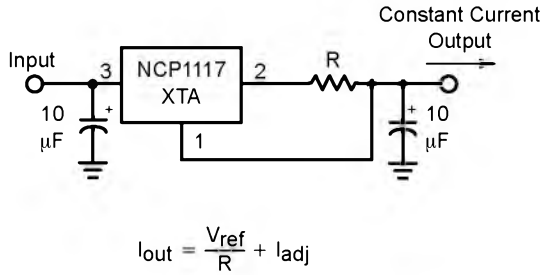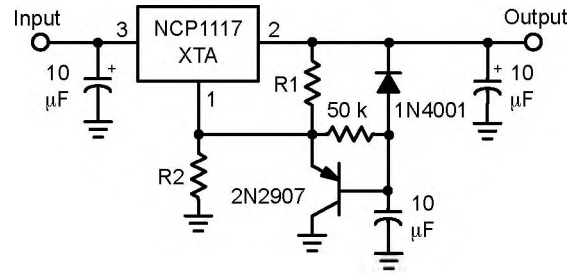
$$I_{out} = \frac{V_{ref}}{R} + I_{adj}$$

Figure 24. Constant Current Regulator

Figure 25. Slow Turn–On Regulator
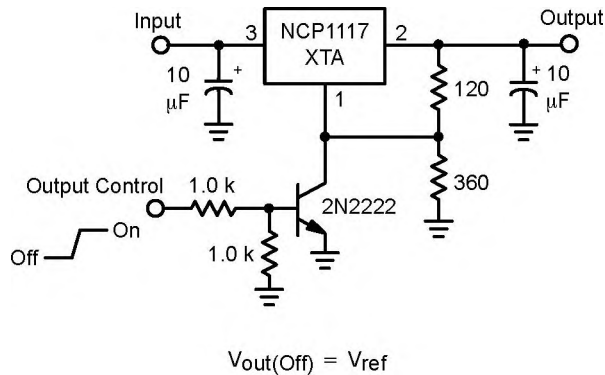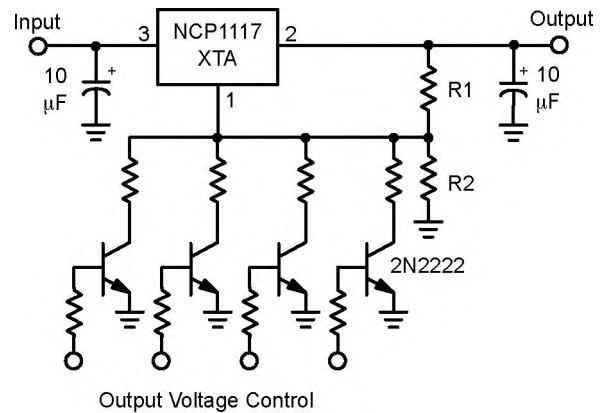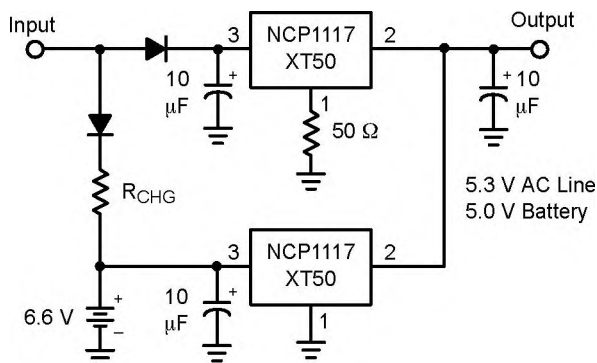

$$V_{out(Off)} = V_{ref}$$

Figure 26. Regulator with Shutdown

Resistor R2 sets the maximum output voltage. Each transistor reduces the output voltage when turned on.

Figure 27. Digitally Controlled Regulator

5.3 V AC Line
5.0 V Battery

The 50 Ω resistor that is in series with the ground pin of the upper regulator level shifts its output 300 mV higher than the lower regulator. This keeps the lower regulator off until the input source is removed.

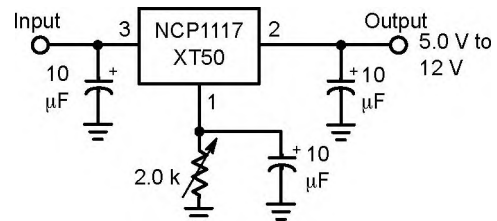**Figure 28. Battery Backed–Up Power Supply**

Figure 29. Adjusting Output of Fixed Voltage Regulators

NCP1117

MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS

The surface mount board layout is a critical portion of the total design. The footprint for the regulator package must be of correct size to insure a proper solder connection of the package tab and pins to the printed circuit board copper. With proper footprint pad sizes, the packages will self align when subjected to a solder reflow process.

SOT−223, Case 318H

DPAK, Case 369A

NCP1117

ORDERING INFORMATION

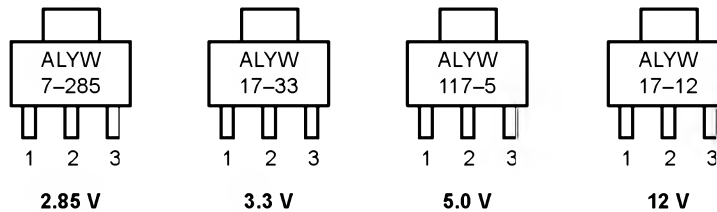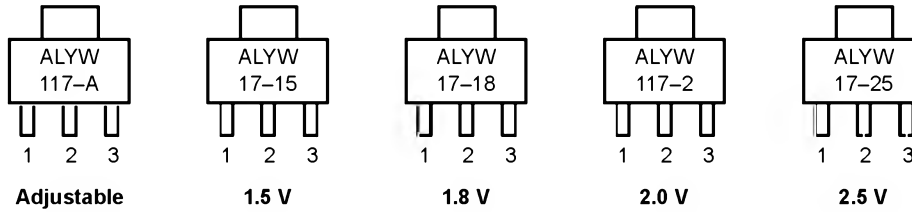| Device	Nominal Output Voltage	Package	Shipping
NCP1117DTA	Adjustable	DPAK	75 Units/Rail
NCP1117DTARK	Adjustable	DPAK	2500 Units/Tape & Reel
NCP1117STAT3	Adjustable	SOT–223	4000 Units/Tape & Reel
NCP1117DT15	1.5	DPAK	75 Units/Rail
NCP1117DT15RK	1.5	DPAK	2500 Units/Tape & Reel
NCP1117ST15T3	1.5	SOT–223	4000 Units/Tape & Reel
NCP1117DT18	1.8	DPAK	75 Units/Rail
NCP1117DT18RK	1.8	DPAK	2500 Units/Tape & Reel
NCP1117ST18T3	1.8	SOT–223	4000 Units/Tape & Reel
NCP1117DT20	2.0	DPAK	75 Units/Rail
NCP1117DT20RK	2.0	DPAK	2500 Units/Tape & Reel
NCP1117ST20T3	2.0	SOT–223	4000 Units/Tape & Reel
NCP1117DT25	2.5	DPAK	75 Units/Rail
NCP1117DT25RK	2.5	DPAK	2500 Units/Tape & Reel
NCP1117ST25T3	2.5	SOT–223	4000 Units/Tape & Reel
NCP1117DT285	2.85	DPAK	75 Units/Rail
NCP1117DT285RK	2.85	DPAK	2500 Units/Tape & Reel
NCP1117ST285T3	2.85	SOT–223	4000 Units/Tape & Reel
NCP1117DT33	3.3	DPAK	75 Units/Rail
NCP1117DT33RK	3.3	DPAK	2500 Units/Tape & Reel
NCP1117ST33T3	3.3	SOT–223	4000 Units/Tape & Reel
NCP1117DT50	5.0	DPAK	75 Units/Rail
NCP1117DT50RK	5.0	DPAK	2500 Units/Tape & Reel
NCP1117ST50T3	5.0	SOT–223	4000 Units/Tape & Reel
NCP1117DT12	12	DPAK	75 Units/Rail
NCP1117DT12RK	12	DPAK	2500 Units/Tape & Reel
NCP1117ST12T3	12	SOT–223	4000 Units/Tape & Reel

NCP1117

MARKING DIAGRAMS

SOT–223
ST SUFFIX
CASE 318H

ALYW	ALYW	ALYW	ALYW	ALYW
117–A	17–15	17–18	117–2	17–25

1 2 3   1 2 3   1 2 3   1 2 3   1 2 3

Adjustable   **1.5 V**   **1.8 V**   **2.0 V**   **2.5 V**

ALYW	ALYW	ALYW	ALYW
7–285	17–33	117–5	17–12

1 2 3   1 2 3   1 2 3   1 2 3

2.85 V   **3.3 V**   **5.0 V**   **12 V**

DPAK
DT SUFFIX
CASE 369A

117AJ	17–15	17–18	117–2	17–25
ALYWW	ALYWW	ALYWW	ALYWW	ALYWW

1 2 3   1 2 3   1 2 3   1 2 3   1 2 3

Adjustable   **1.5 V**   **1.8 V**   **2.0 V**   **2.5 V**

17285	17–33	117–5	17–12
ALYWW	ALYWW	ALYWW	ALYWW

1 2 3   1 2 3   1 2 3   1 2 3

2.85 V   **3.3 V**   **5.0 V**   **12 V**

A = Assembly Location
L = Wafer Lot
Y = Year
WW, W = Work Week