

LM117QML-SP RHA 4.25-V to 41.25-V 3-Terminal Adjustable Regulator

1 Features

- Radiation hardness assured (RHA) up to a total ionizing dose (TID) of 100 krad(Si)
 - High dose rate (HDR) option at 50-300 rad(Si)/s
 - Low dose rate (LDR) option at 10 mrad(Si)/s
- Specified 0.5-A or 1.5-A output current options
- Adjustable output down to 1.2 V
- Current limit constant with temperature
- Output is short-circuit protected

2 Applications

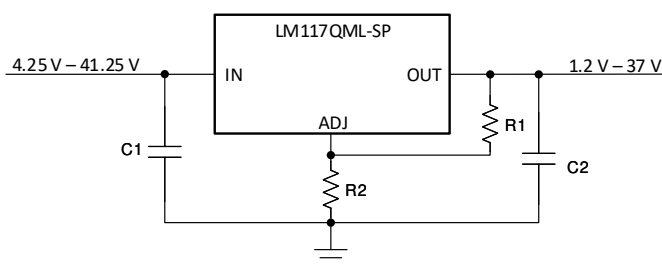
- [Satellite electrical power system \(EPS\)](#)
- Bias supply for PWM controllers

3 Description

The LM117QML-SP 3-terminal positive voltage linear regulator is capable of supplying either 0.5 A or 1.5 A over a 1.2-V to 37-V output range. It is simple to use and requires only two external resistors to set the output voltage.

The regulator is "floating" and sees only the input-to-output differential voltage, thus enabling supplies of several hundred volts to be regulated as long as the maximum input-to-output differential is not exceeded.

The flight-proven LM117QML-SP offers full overload protection such as current limit, thermal overload protection, and safe area protection. It is exceptionally versatile and can also be used as an adjustable switching regulator, a programmable output regulator, a precision current regulator, and more.



Typical Schematic

For high voltage applications, the [LM117HVQML-SP](#) is a pin-to-pin drop-in replacement suitable for up to 60 V. For the negative complement of the LM117QML-SP, see the [LM137QML-SP](#).

Device Information

PART NUMBER ⁽¹⁾	GRADE ⁽²⁾	PACKAGE ⁽³⁾
LM117GWRLQMLV	LDR	CFP SOIC (NAC) 16 pin 6.35 mm × 9.91 mm Mass = 0.467 g ⁽⁵⁾
5962R9951707VZA	Flight grade QMLV RHA 100 krad(Si)	
LM117GWRQMLV	HDR	TO-39 (NDT) 3 pin 8.26 mm × 8.26 mm Mass = 1.036 g ⁽⁵⁾
5962R9951706VZA	Flight grade QMLV RHA 100 krad(Si)	
LM117HRLQMLV	LDR	TO-3 (K) 2 pin 25.4 mm × 38.94 mm Mass = 12.291 g ⁽⁵⁾
5962R9951705VXA	Flight grade QMLV RHA 100 krad(Si)	
LM117HRQMLV	HDR	Die 2.18 mm × 2.36 mm
5962R9951703VXA	Flight grade QMLV RHA 100 krad(Si)	
LM117NDT/EM	Engineering samples ⁽⁴⁾	
LM117KRQMLV	HDR	
5962R9951704VYA	Flight grade QMLV RHA 100 krad(Si)	
LM117K/EM	Engineering samples ⁽⁴⁾	
LM117H MDE	LDR	
5962R9951705V9A	Flight grade QMLV RHA 100 krad(Si)	
LM117H MDR	HDR	
5962R9951703V9A	Flight grade QMLV RHA 100 krad(Si)	

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) For additional information about part grade, view [SLYB235](#).
- (3) The [TI Packaging](#) page can be referenced for additional packing details.
- (4) These units are intended for engineering evaluation only and are processed to a noncompliant flow. Not suitable for qualification, production, radiation testing, or flight use. Not warranted for performance over full MIL specified temperature range (–55°C to 125°C) or operating life.
- (5) Mass is accurate to ±10%.



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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
April 2021	*	Initial Release

5 Device Comparison Table

PART NUMBER	INPUT VOLTAGE RANGE	I _{OUT}	PART NUMBER SUFFIX	PACKAGE	RADIATION TESTING ⁽¹⁾
LM117QML-SP	4.25 V to 41.25 V	1.5 A	K	TO-3 (K) 2 pin	HDR 100 krad(Si)
		0.5 A	H	TO-39 (NDT) 3 pin	LDR 100 krad(Si)
					HDR 100 krad(Si)
			Die	LDR 100 krad(Si)	
				HDR 100 krad(Si)	
		GW	CFP SOIC (NAC) 16 pin	LDR 100 krad(Si)	
HDR 100 krad(Si)					
LM117HVQML-SP	4.25 V to 60 V	0.5 A	H	TO-39 (NDT) 3 pin	LDR 100 krad(Si)
					HDR 100 krad(Si)
				Die	LDR 100 krad(Si)
					HDR 100 krad(Si)
			GW	CFP SOIC (NAC) 16 pin	LDR 100 krad(Si)
					HDR 100 krad(Si)
LM137QML-SP	-41.25 V to -4.25 V	1.5 A	H	TO-39 (NDT) 3 pin	HDR 30 krad(Si)

(1) The [Device Information](#) table can be referenced for information on which part numbers correspond to LDR or HDR options.

6 Pin Configurations and Functions

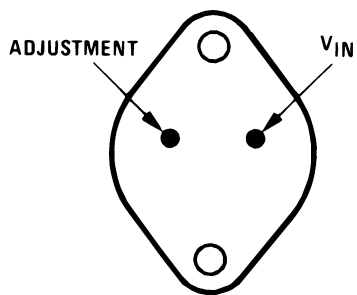


Figure 6-1. LM117K K Package
2-Pin TO-3 (Metal Can)
Bottom View

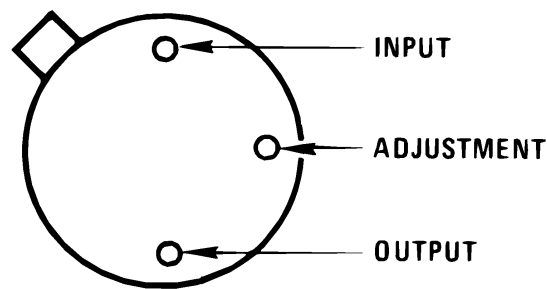


Figure 6-2. LM117H, LM117NDT NDT Package
3-Pin TO-39 (Metal Can)
Bottom View

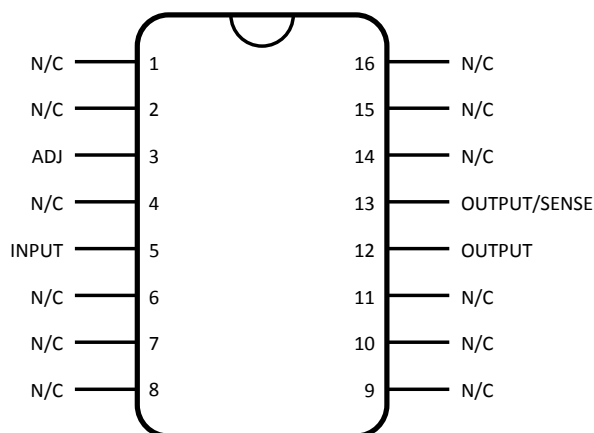


Figure 6-3. LM117GW NAC Package
16-Pin CFP SOIC
Top View

Table 6-1. Pin Functions

NAME	PIN			I/O	DESCRIPTION
	TO-3	TO-39	CFP SOIC		
ADJ	1	2	3	—	Adjust pin
V_{IN}	2	1	5	I	Input voltage pin for the regulator
V_{OUT}	CASE	3, CASE	12	O	Output voltage pin for the regulator
OUTPUT/SENSE	—	—	13	—	Used to sense the output voltage. Must be connected to V_{OUT} for proper operation.
N/C	—	—	1, 2, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16	—	No connection. These pins have no internal connections and may be grounded or left floating. They may also be connected to the board heatsink and used for thermal dissipation.

7 Specifications

7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
	Power dissipation ⁽²⁾	Internally limited		
	Input-output voltage differential	-0.3	40	V
T _{stg}	Storage temperature	-65	150	°C
T _{Jmax}	Maximum junction temperature		150	°C
	Lead temperature metal package		300	°C

- Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is P_{Dmax} = (T_{Jmax} - T_A) / θ_{JA} or the number given in the Absolute Maximum Ratings, whichever is lower. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2 W for the TO-39 and CFP packages, and 20 W for the TO-3 package.

7.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM) ^{(1) (2)}	±3000 V

- JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- Human body model, 100 pF discharged through a 1.5-kΩ resistor.

7.3 Recommended Operating Conditions

		MIN	MAX	UNIT
T _A	Operating temperature	-55	125	°C
V _{IN}	Input voltage	4.25	41.25	V

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾			PACKAGE			UNIT
			TO-3 (K) 2 pin (LM117K)	TO-39 (NDT) 3 pin (LM117H)	CFP SOIC (NAC) 16 pin (LM117GW)	
R _{θJA}	Junction-to-ambient thermal resistance	Still air	39	186	130	°C/W
		500 LF/min air flow	14	64	80	
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance		1.9	21	7	°C/W

- For more information, see the [Semiconductor and IC package thermal metrics](#) application report.

7.5 Electrical Characteristics: 0.5–A I_{OUT} Devices (LM117H, LM117GW)

Over operating temperature range (T = –55°C to 125°C) unless otherwise noted.

PARAMETER		TEST CONDITIONS ⁽¹⁾		SUBGROUP ⁽²⁾	MIN	MAX	UNIT		
V _O	Output voltage	V _I = 4.25 V, I _L = –5 mA		1, 2, 3		1.3	V		
			25°C Post-radiation	1	1.2	1.35			
		V _I = 4.25 V, I _L = –500 mA		1, 2, 3		1.3		1.2	1.35
			25°C Post-radiation	1	1.2	1.35			
		V _I = 41.25 V, I _L = –5 mA		1, 2, 3		1.3		1.2	1.35
			25°C Post-radiation	1	1.2	1.35			
V _I = 41.25V, I _L = –50mA		1, 2, 3		1.3	1.2	1.35			
25°C Post-radiation	1	1.2	1.35						
V _{RLine}	Line regulation	4.25 V ≤ V _I ≤ 41.25 V, I _L = –5 mA	25°C	1	–9	9	mV		
			125°C, –55°C	2, 3	–23	23			
			25°C Post-radiation	1	–25	25			
V _{RLoad}	Load regulation	V _I = 6.25 V, –500 mA ≤ I _L ≤ –5 mA		1, 2, 3	–12	12	mV		
		V _I = 41.25 V, –50 mA ≤ I _L ≤ –5 mA		1, 2, 3	–12	12			
V _{RTh}	Thermal regulation	V _I = 14.6 V, I _L = –500 mA	25°C	1	–12	12	mV		
I _{Adj}	Adjust pin current	V _I = 4.25 V, I _L = –5 mA		1, 2, 3	–100	–15	μA		
		V _I = 41.25 V, I _L = –5 mA		1, 2, 3	–100	–15			
ΔI _{Adj} /Line	Adjust pin current change	4.25 V ≤ V _I ≤ 41.25 V, I _L = –5 mA		1, 2, 3	–5	5	μA		
ΔI _{Adj} /Load	Adjust pin current change	V _I = 6.25 V, –500 mA ≤ I _L ≤ –5 mA		1, 2, 3	–5	5	μA		
I _Q	Minimum load current	V _I = 4.25 V, Forced V _O = 1.4 V		1, 2, 3	–3	–0.5	mA		
		V _I = 14.25 V, Forced V _O = 1.4 V		1, 2, 3	–3	–0.5			
		V _I = 41.25 V, Forced V _O = 1.4 V		1, 2, 3	–5	–1			
I _{os}	Output short circuit current	V _I = 4.25 V		1, 2, 3	–1.8	–0.5	A		
		V _I = 40 V		1, 2, 3	–0.5	–0.05			
V _O (Recov)	Output voltage recovery	V _I = 4.25 V, R _L = 2.5 Ω, C _L = 20 μF		1, 2, 3		1.3	V		
			25°C Post-radiation	1	1.2	1.35			
		V _I = 40 V, R _L = 250 Ω		1, 2, 3		1.3		1.2	1.35
			25°C Post-radiation	1	1.2	1.35			
V _{Start}	Voltage start-up	V _I = 4.25 V, R _L = 2.5 Ω, C _L = 20 μF, I _L = –500 mA		1, 2, 3	1.2	1.3	V		
V _{NO}	Output noise voltage	V _I = 6.25 V, I _L = –50 mA	25°C	7		120	μV _{RMS}		
ΔV _O / ΔV _I	Line transient response	V _I = 6.25 V, ΔV _I = 3 V, I _L = –10 mA	25°C	7		6	mV/V		

7.5 Electrical Characteristics: 0.5–A I_{OUT} Devices (LM117H, LM117GW) (continued)

Over operating temperature range (T = –55°C to 125°C) unless otherwise noted.

PARAMETER		TEST CONDITIONS ⁽¹⁾	SUBGROUP ⁽²⁾	MIN	MAX	UNIT
$\Delta V_O / \Delta I_L$	Load transient response	$V_I = 6.25\text{V}$, $\Delta I_L = -200\text{ mA}$, $I_L = -50\text{ mA}$	25°C 7		0.6	mV/mA
$\Delta V_I / \Delta V_O$	Ripple rejection	$V_I = 6.25\text{ V}$, $I_L = -125\text{ mA}$, $E_I = 1\text{ V}_{\text{RMS}}$ at $f = 2400\text{ Hz}$	25°C 4	65		dB
			25°C Post-radiation 4	60		

- (1) Pre- and post-irradiation limits are identical for the parameters above unless specified by the test conditions.
(2) For subgroup definitions, see [Quality Conformance Inspection](#) table.

7.6 Parameter Drift: 0.5–A I_{OUT} Devices (LM117H, LM117GW)

The following deltas are for Group C (Life Test). Data is measured at 25°C.

PARAMETER		TEST CONDITIONS	SUBGROUP ⁽¹⁾	MIN	MAX	UNIT
V _O	Output voltage	$V_I = 4.25\text{ V}$, $I_L = -5\text{ mA}$	1	–0.01	0.01	V
		$V_I = 4.25\text{ V}$, $I_L = -500\text{ mA}$	1	–0.01	0.01	
		$V_I = 41.25\text{ V}$, $I_L = -5\text{ mA}$	1	–0.01	0.01	
		$V_I = 41.25\text{ V}$, $I_L = -50\text{ mA}$	1	–0.01	0.01	
V _{RLine}	Line regulation	$4.25\text{ V} \leq V_I \leq 41.25\text{ V}$, $I_L = -5\text{ mA}$	1	–4.0	4.0	mV
I _{Adj}	Adjust pin current	$V_I = 4.25\text{ V}$, $I_L = -5\text{ mA}$	1	–10	10	μA
		$V_I = 41.25\text{ V}$, $I_L = -5\text{ mA}$	1	–10	10	
V _O (Recov)	Output voltage recovery	$V_I = 4.25\text{ V}$, $R_L = 2.5\ \Omega$, $C_L = 20\ \mu\text{F}$	1	–0.01	0.01	V
		$V_I = 40\text{ V}$, $R_L = 250\ \Omega$	1	–0.01	0.01	

- (1) For subgroup definitions, see [Quality Conformance Inspection](#) table.

7.7 Electrical Characteristics: 1.5–A I_{OUT} Devices (LM117K)

Over operating temperature range (T = –55°C to 125°C) unless otherwise noted.

PARAMETER		TEST CONDITIONS ⁽¹⁾		SUBGROUP ⁽²⁾	MIN	MAX	UNIT
V _O	Output voltage	V _I = 4.25 V, I _L = –5 mA		1, 2, 3	1.2	1.3	V
			25°C Post-radiation	1		1.35	
		V _I = 4.25 V, I _L = –1.5 A		1, 2, 3	1.2	1.3	
			25°C Post-radiation	1		1.35	
		V _I = 41.25 V, I _L = –5 mA		1, 2, 3	1.2	1.3	
			25°C Post-radiation	1		1.35	
V _I = 41.25 V, I _L = –200 mA		1, 2, 3	1.2	1.3			
	25°C Post-radiation	1		1.35			
V _{RLine}	Line regulation	4.25 V ≤ V _I ≤ 41.25 V, I _L = –5 mA	25°C	1	–9	9	mV
			125°C, –55°C	2, 3	–23	23	
			25°C Post-radiation	1	–25	25	
V _{RLoad}	Load regulation	V _I = 6.25 V, –1.5 A ≤ I _L ≤ –5 mA	25°C	1	–3.5	3.5	mV
			125°C, –55°C	2, 3	–12	12	
			25°C Post-radiation	1	–7	7	
		V _I = 41.25 V, –200 mA ≤ I _L ≤ –5 mA	25°C	1	–3.5	3.5	
			125°C, –55°C	2, 3	–12	12	
			25°C Post-radiation	1	–7	7	
V _{RTh}	Thermal regulation	V _I = 14.6 V, I _L = –1.5 A	25°C	1	–12	12	mV
I _{Adj}	Adjust pin current	V _I = 4.25 V, I _L = –5 mA		1, 2, 3	–100	–15	μA
		V _I = 41.25 V, I _L = –5 mA		1, 2, 3	–100	–15	
ΔI _{Adj} /Line	Adjust pin current change	4.25 V ≤ V _I ≤ 41.25 V, I _L = –5 mA		1, 2, 3	–5	5	μA
ΔI _{Adj} /Load	Adjust pin current change	V _I = 6.25 V, –1.5 A ≤ I _L ≤ –5 mA		1, 2, 3	–5	5	μA
I _Q	Minimum load current	V _I = 4.25 V, Forced V _O = 1.4 V		1, 2, 3	–3	–0.2	mA
		V _I = 14.25 V, Forced V _O = 1.4 V		1, 2, 3	–3	–0.2	
		V _I = 41.25 V, Forced V _O = 1.4 V		1, 2, 3	–5	–0.2	
I _{os}	Output short circuit current	V _I = 4.25 V		1, 2, 3	–3.5	–1.5	A
		V _I = 40 V		1, 2, 3	–1	–0.18	

7.7 Electrical Characteristics: 1.5–A I_{OUT} Devices (LM117K) (continued)

Over operating temperature range (T = –55°C to 125°C) unless otherwise noted.

PARAMETER		TEST CONDITIONS ⁽¹⁾		SUBGROUP ⁽²⁾	MIN	MAX	UNIT
V _O (Recov)	Output voltage recovery	V _I = 4.25 V, R _L = 0.833 Ω, C _L = 20 μF		1, 2, 3	1.2	1.3	V
			25°C Post-radiation	1		1.35	
		V _I = 40 V, R _L = 250 Ω		1, 2, 3	1.2	1.3	
			25°C Post-radiation	1		1.35	
V _{Start}	Voltage start-up	V _I = 4.25 V, R _L = 0.833 Ω, C _L = 20 μF, I _L = –1.5 A		1, 2, 3	1.2	1.3	V
V _{NO}	Output noise voltage	V _I = 6.25 V, I _L = –100 mA	25°C	7		120	μV _{RMS}
ΔV _O / ΔV _I	Line transient response	V _I = 6.25 V, ΔV _I = 3 V, I _L = –10 mA	25°C	7		18	mV
ΔV _O / ΔI _L	Load transient response	V _I = 6.25 V, ΔI _L = –400 mA, I _L = –100 mA	25°C	7		120	mV
ΔV _I / ΔV _O	Ripple rejection	V _I = 6.25 V, I _L = –500 mA, E _I = 1 V _{RMS} at f = 2400 Hz	25°C	4	65		dB
			25°C Post-radiation	4	60		

(1) Pre- and post-irradiation limits are identical for the parameters above unless specified by the test conditions.

(2) For subgroup definitions, see [Quality Conformance Inspection](#) table.

7.8 Parameter Drift: 1.5–A I_{OUT} Devices (LM117K)

The following deltas are for Group C (Life Test). Data is measured at 25°C.

PARAMETER		TEST CONDITIONS		SUBGROUP ⁽¹⁾	MIN	MAX	UNIT
V _O	Output voltage	V _I = 4.25 V, I _L = –5 mA		1	–0.01	0.01	V
		V _I = 4.25 V, I _L = –1.5 A		1	–0.01	0.01	
		V _I = 41.25 V, I _L = –5 mA		1	–0.01	0.01	
		V _I = 41.25 V, I _L = –200 mA		1	–0.01	0.01	
V _{RLine}	Line regulation	4.25 V ≤ V _I ≤ 41.25 V, I _L = –5 mA		1	–4.0	4.0	mV
I _{Adj}	Adjust pin current	V _I = 4.25 V, I _L = –5 mA		1	–10	10	μA
		V _I = 41.25 V, I _L = –5 mA		1	–10	10	
V _O (Recov)	Output voltage recovery	V _I = 4.25 V, R _L = 0.833 Ω, C _L = 20 μF		1	–0.01	0.01	V
		V _I = 40 V, R _L = 250 Ω		1	–0.01	0.01	

(1) For subgroup definitions, see [Quality Conformance Inspection](#) table.

7.9 Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

SUBGROUP	DESCRIPTION	TEMP (°C)
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55

7.10 Typical Characteristics

Output capacitor = 0 μ F unless otherwise noted

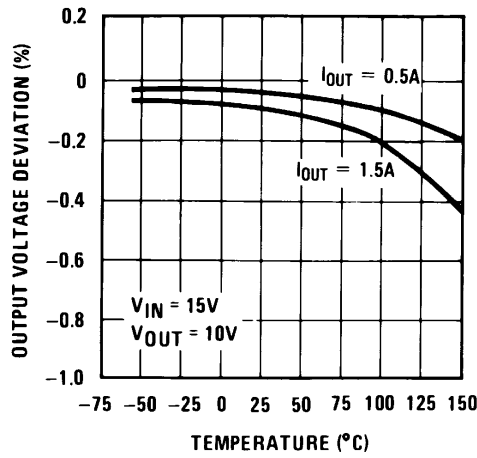


Figure 7-1. Load Regulation

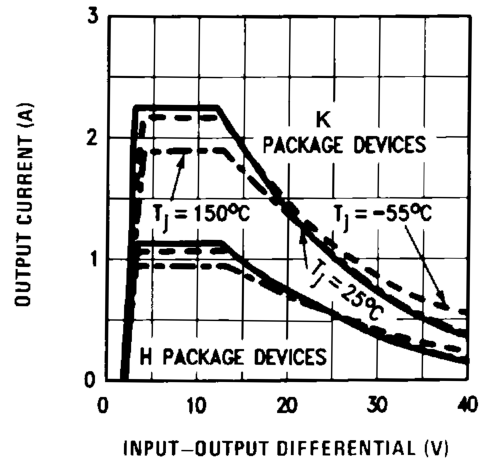


Figure 7-2. Current Limit

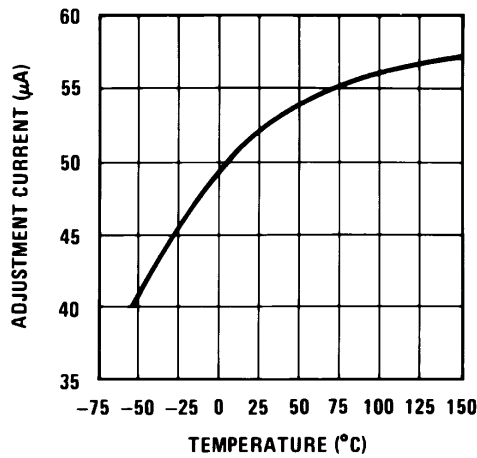


Figure 7-3. Adjustment Current

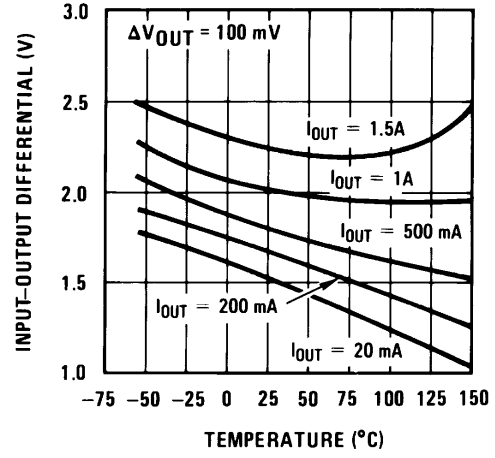


Figure 7-4. Dropout Voltage

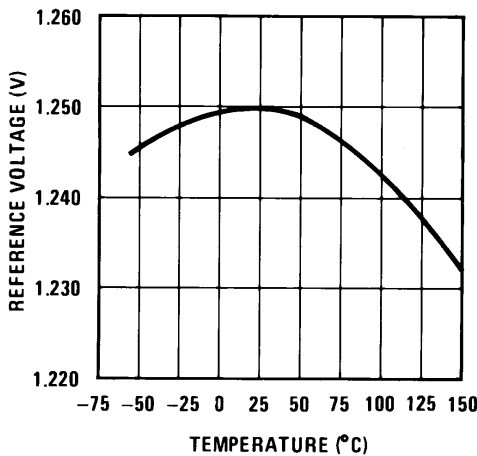


Figure 7-5. Temperature Stability

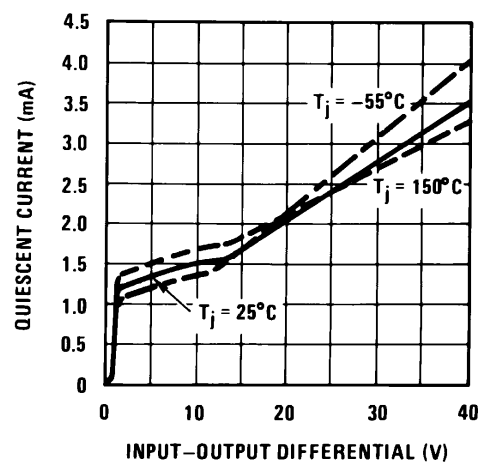


Figure 7-6. Minimum Operating Current

7.10 Typical Characteristics (continued)

Output capacitor = 0 μ F unless otherwise noted

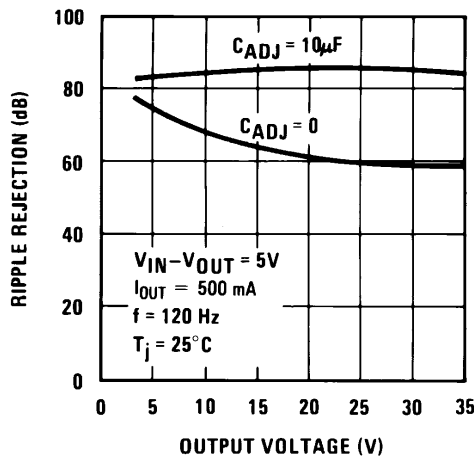


Figure 7-7. Ripple Rejection

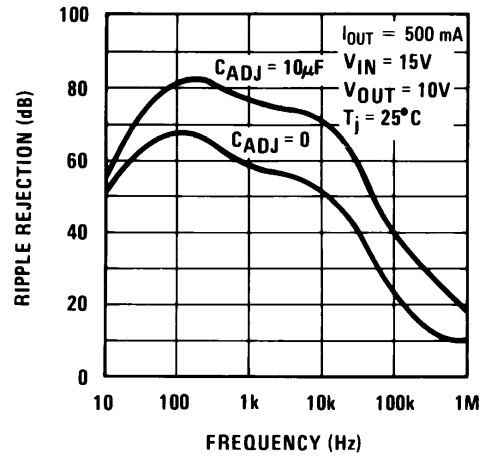


Figure 7-8. Ripple Rejection

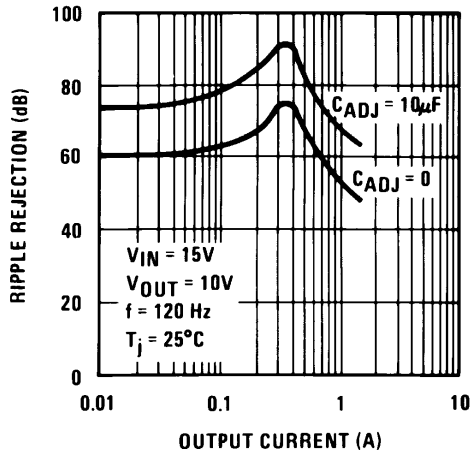


Figure 7-9. Ripple Rejection

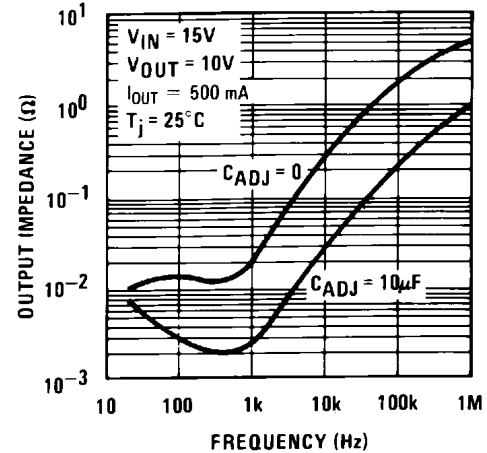


Figure 7-10. Output Impedance

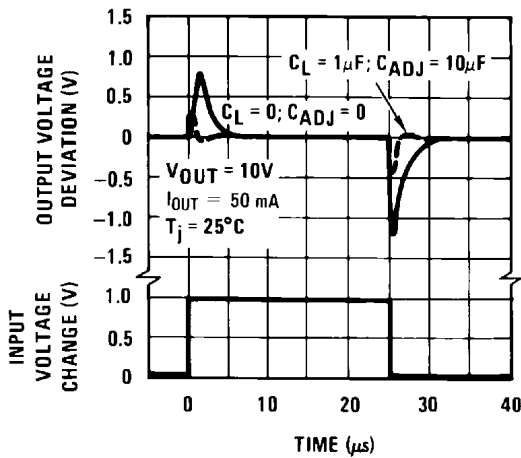


Figure 7-11. Line Transient Response

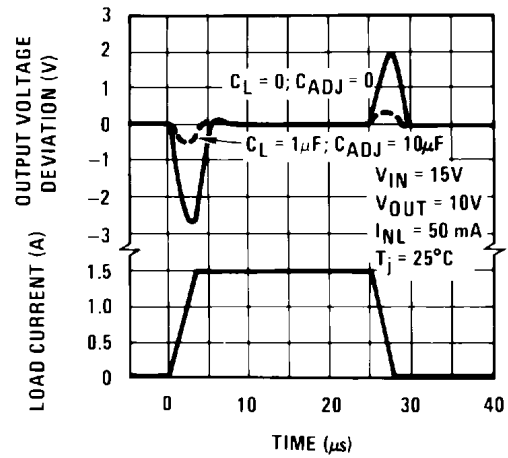


Figure 7-12. Load Transient Response

8 Detailed Description

8.1 Overview

The LM117QML-SP 3-terminal positive voltage linear regulator is capable of supplying either 0.5 A or 1.5 A over a 1.2-V to 37-V output range. It is simple to use and requires only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators.

The regulator is "floating" and sees only the input-to-output differential voltage, thus enabling supplies of several hundred volts to be regulated as long as the maximum input-to-output differential is not exceeded (i.e. don't short circuit the output).

The LM117QML-SP offers full overload protection such as current limit, thermal overload protection, and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Typically, no capacitors are needed unless the device is situated more than 6 in from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

This device makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output it can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2 V where most loads draw little current.

8.2 Functional Block Diagram

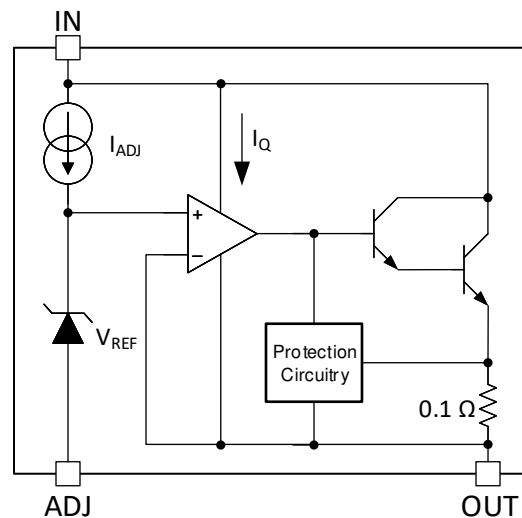


Figure 8-1. Functional Block Diagram

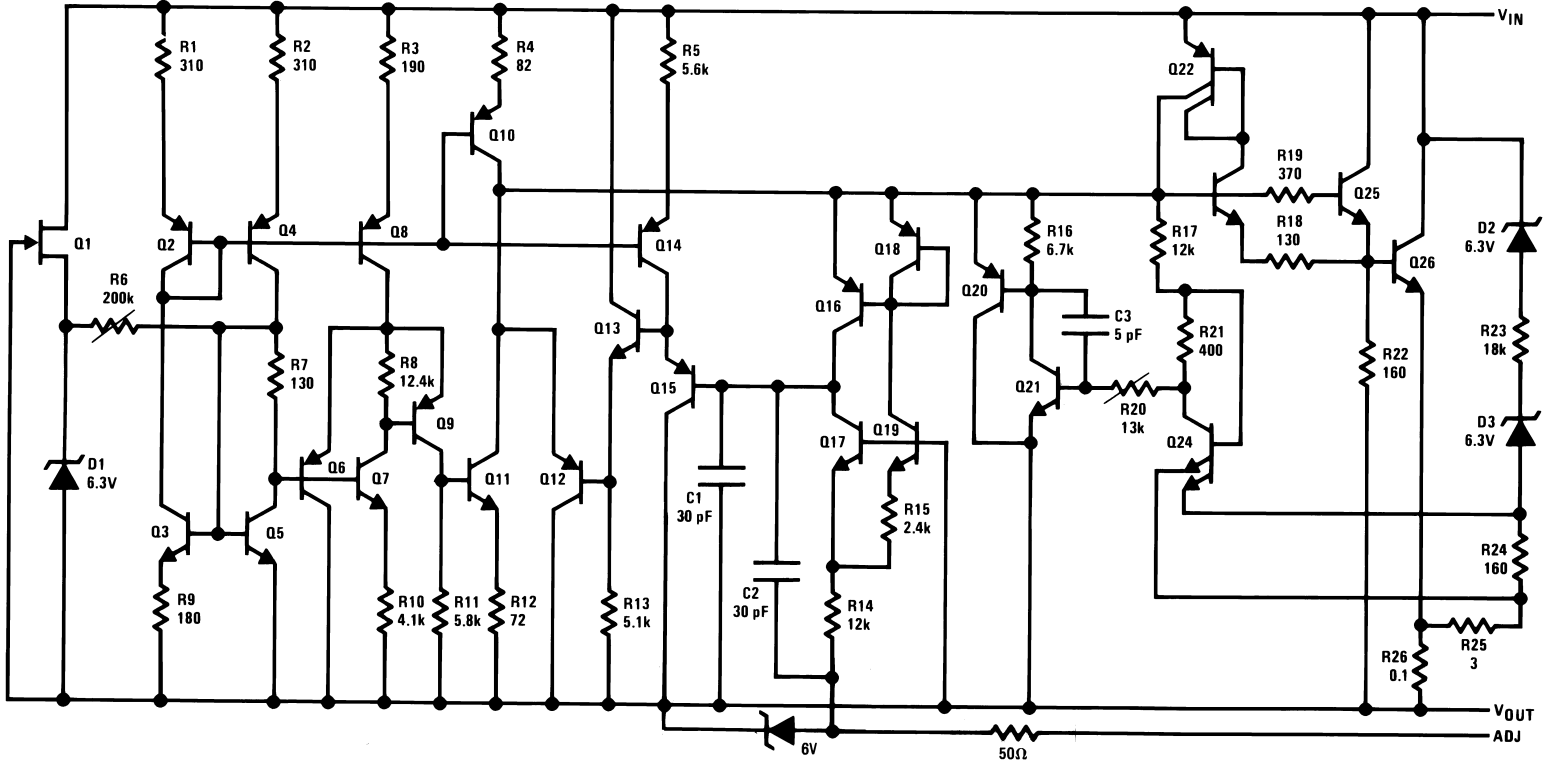
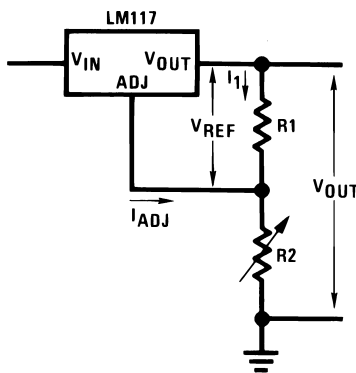


Figure 8-2. Simplified Device Schematic

8.3 Setting Output Voltage

In operation, the LM117 develops a nominal 1.25-V reference voltage, V_{REF} , between the output and adjustment terminal. The reference voltage is expressed across R1 and, since the voltage is constant, a constant current I_1 then flows through R2, giving an output voltage found by using Equation 1.

$$V_{OUT} = V_{REF} \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ} R_2 \quad (1)$$



Since the 100- μ A current from the adjustment terminal represents an error term, the LM117 was designed to minimize I_{ADJ} and make it relatively constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

To mitigate the requirement for an added load to sink the required output current, the resistor divider may be selected so that it alone can sink the largest specified output load current of 5 mA. This has the additional benefit of minimizing the I_{ADJ} error term (which varies over temperature).

8.4 External Capacitors

An input bypass capacitor is recommended. A 0.1- μF ceramic disc or 1- μF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will minimize the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM117 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10- μF bypass capacitor 80-dB ripple rejection is obtainable at any output level. Increases over 10 μF do not appreciably improve the ripple rejection at frequencies above 120 Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device (see [Section 8.6](#)).

In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 μF in aluminum electrolytic to equal 1- μF solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5 MHz. For this reason, 0.01- μF disc may seem to work better than a 0.1- μF disc as a bypass.

Although the LM117 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1- μF solid tantalum (or 25- μF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10 μF will merely improve the loop stability and output impedance.

8.5 Load Regulation

The LM117 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240 Ω) should be tied directly to the output (case) of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15-V regulator with 0.05- Ω resistance between the regulator and load will have a load regulation due to line resistance of $0.05 \Omega \times I_L$. If the set resistor is connected near the load the effective line resistance will be $0.05 \Omega (1 + R_2 / R_1)$ or in this case, 11.5 times worse.

[Figure 8-3](#) shows the effect of resistance between the regulator and 240- Ω set resistor.

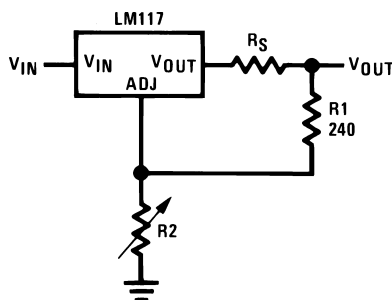


Figure 8-3. Regulator With Line Resistance in Output Lead

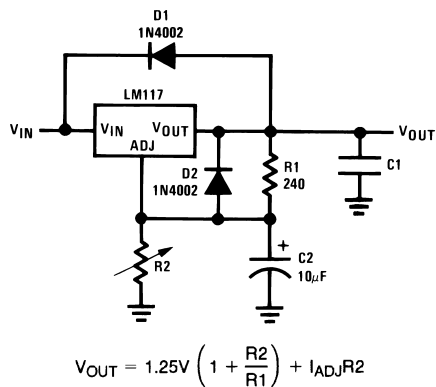
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO-39 package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

8.6 Protection Diodes

When external capacitors are used with an IC regulator, it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10- μF capacitors have low enough internal series resistance to deliver 20-A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN} . In the LM117, this discharge path is through a large junction that is able to sustain 15-A surge. This is not true of all types of positive regulators. For output capacitors of 25 μF or less, there is generally no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when *either* the input or output is shorted. Internal to the LM117 is a 50- Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25 V or less and 10- μF capacitance. Figure 8-4 shows an LM117 with protection diodes included for use with outputs greater than 25 V and high values of output capacitance.



D1 protects against C1 (such as due to a V_{IN} short)

D2 protects against C2 (such as due to a V_{OUT} short)

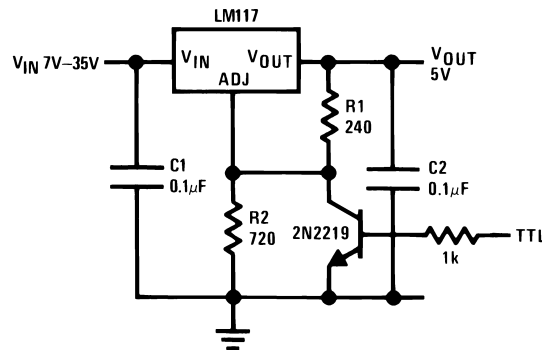
Figure 8-4. Regulator With Protection Diodes

9 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

9.1 Typical Applications



*Min. output \approx 1.2 V

Figure 9-1. 5-V Logic Regulator With Electronic Shutdown*

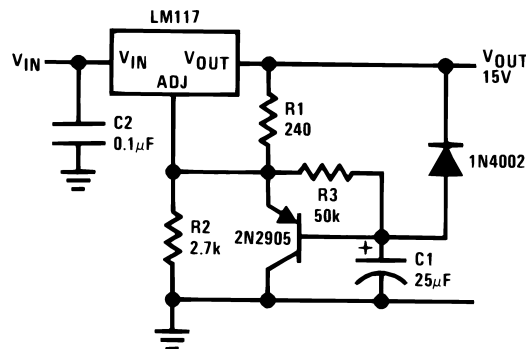
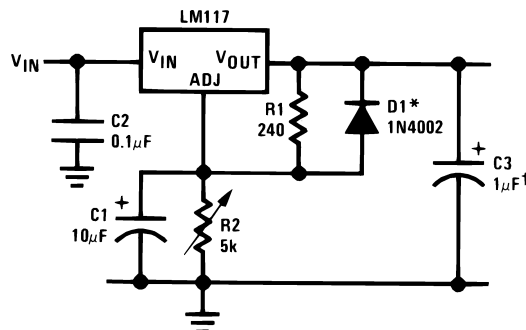


Figure 9-2. Slow Turn-On 15-V Regulator



†Solid tantalum

*Discharges C1 if output is shorted to ground

Figure 9-3. Adjustable Regulator With Improved Ripple Rejection

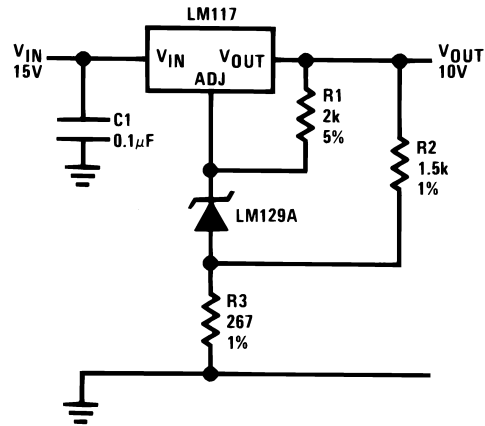
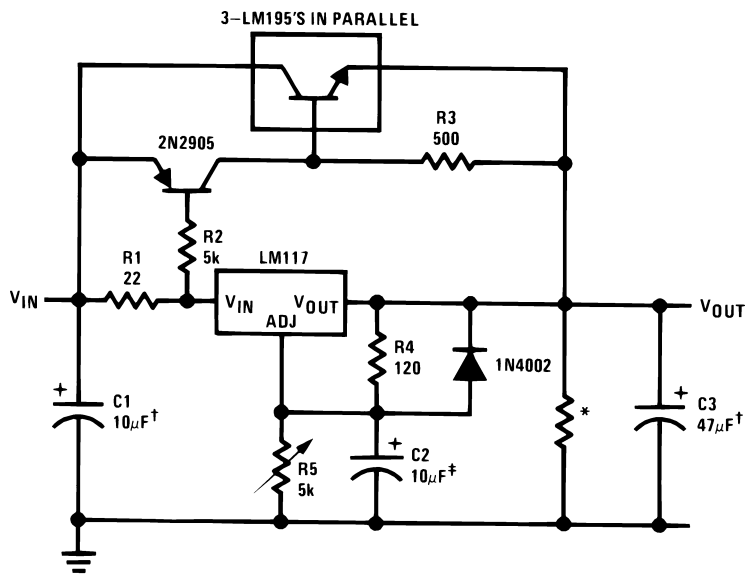


Figure 9-4. High Stability 10-V Regulator

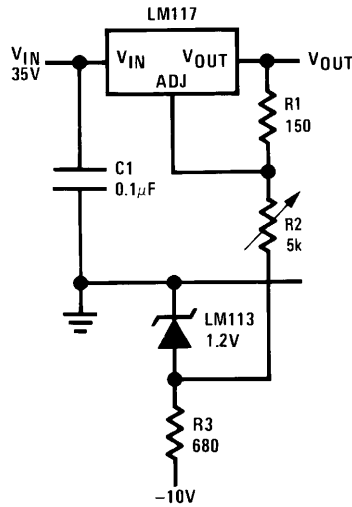


‡Optional, improves ripple rejection

†Solid tantalum

*Minimum load current = 30 mA

Figure 9-5. High Current Adjustable Regulator



Full output current not available at high input-output voltages

Figure 9-6. 0-V to 30-V Regulator

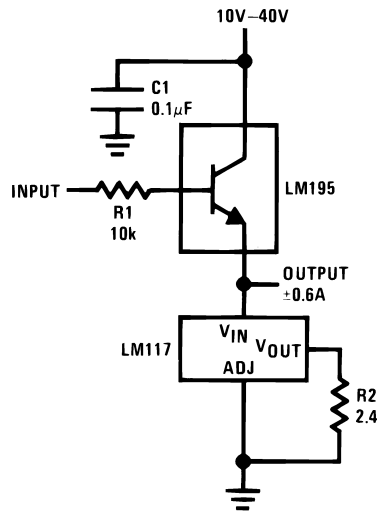
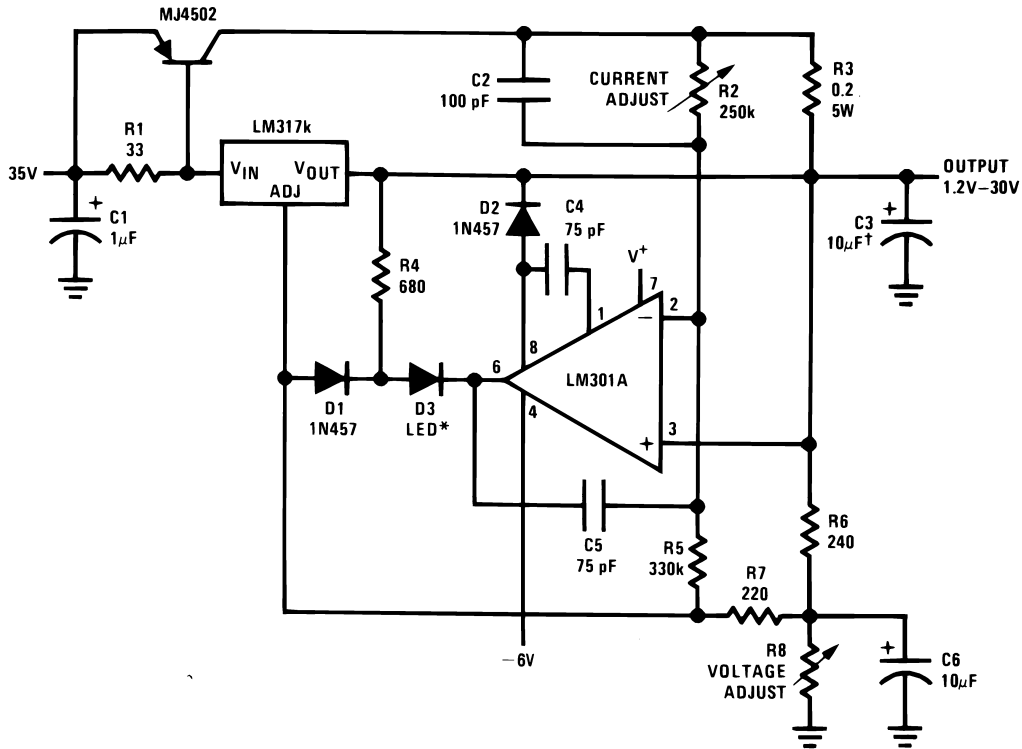


Figure 9-7. Power Follower



†Solid tantalum

*Lights in constant current mode

Figure 9-8. 5-A Constant Voltage/Constant Current Regulator

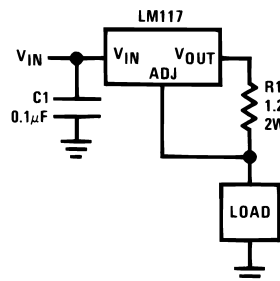
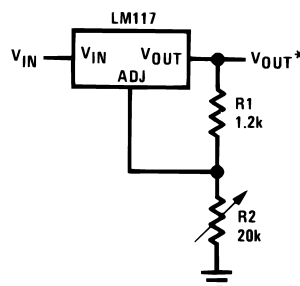


Figure 9-9. 1-A Current Regulator



*Specified load current requirement ≈ 5 mA

Figure 9-10. 1.2-V to 20-V Regulator With Minimum Program Current

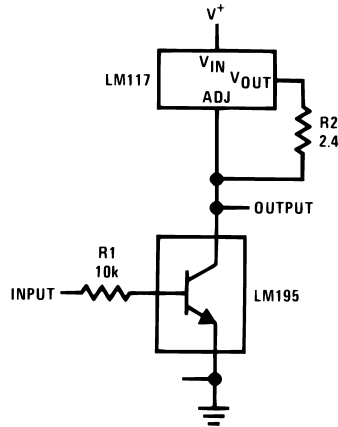
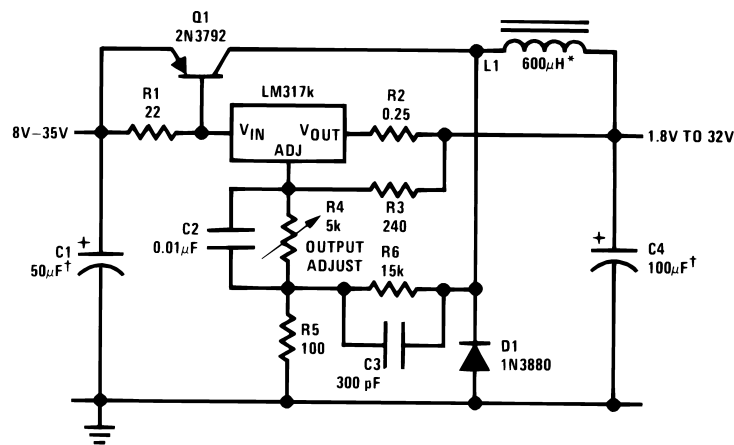


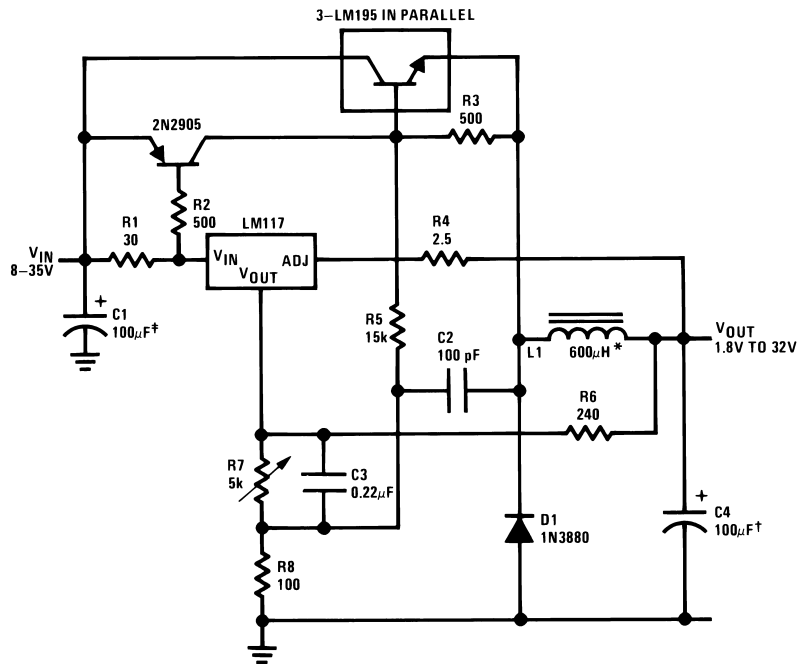
Figure 9-11. High Gain Amplifier



†Solid tantalum

*Core—Arnold A-254168-2 60 turns

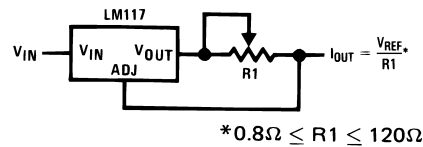
Figure 9-12. Low Cost 3-A Switching Regulator



†Solid tantalum

*Core—Arnold A-254168-2 60 turns

Figure 9-13. 4-A Switching Regulator With Overload Protection



$$*0.8\Omega \leq R1 \leq 120\Omega$$

Figure 9-14. Precision Current Limiter

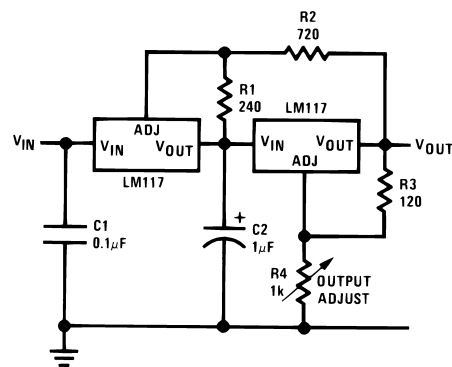
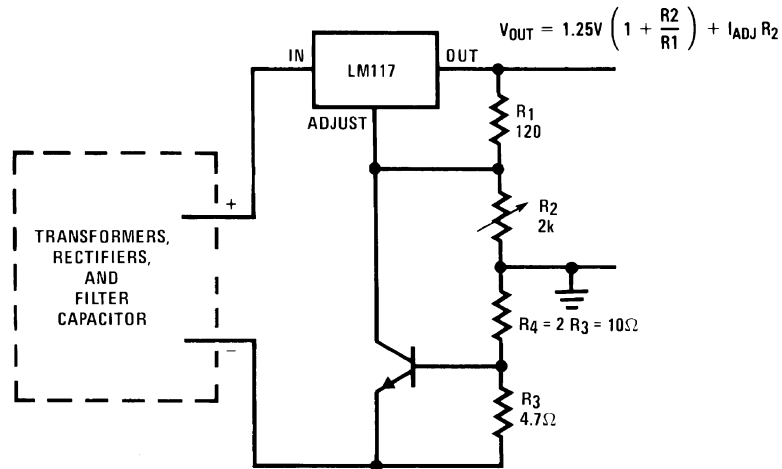


Figure 9-15. Tracking Preregulator

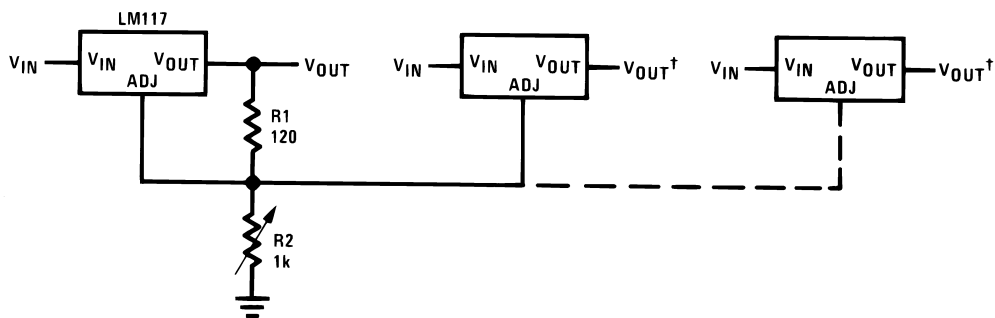


– Short circuit current is approximately $\frac{600 \text{ mV}}{R3}$, or 120 mA

(Compared to LM117's higher current limit)

–At 50 mA output only ¼ volt of drop occurs in R₃ and R₄

Figure 9-16. Current Limited Voltage Regulator



*All outputs within ±100 mV

†Minimum load = 10 mA

Figure 9-17. Adjusting Multiple On-Card Regulators With Single Control*

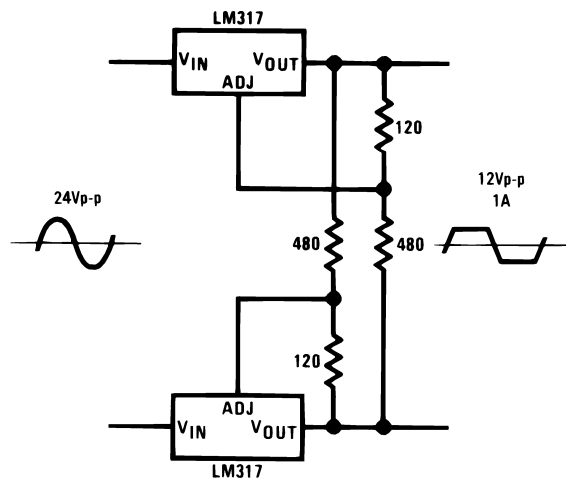
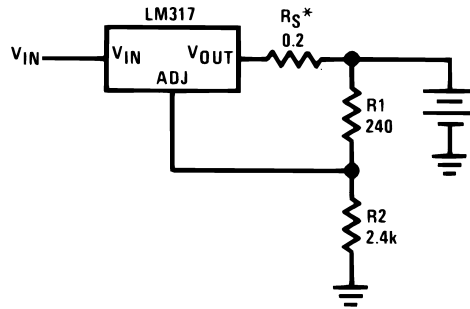


Figure 9-18. AC Voltage Regulator



* R_S —sets output impedance of charger: $Z_{OUT} = R_S \left(1 + \frac{R_2}{R_1} \right)$

Use of R_S allows low charging rates with fully charged battery.

Figure 9-19. 12-V Battery Charger

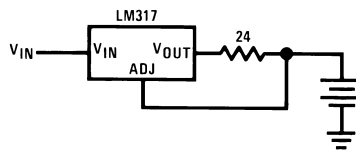


Figure 9-20. 50-mA Constant Current Battery Charger

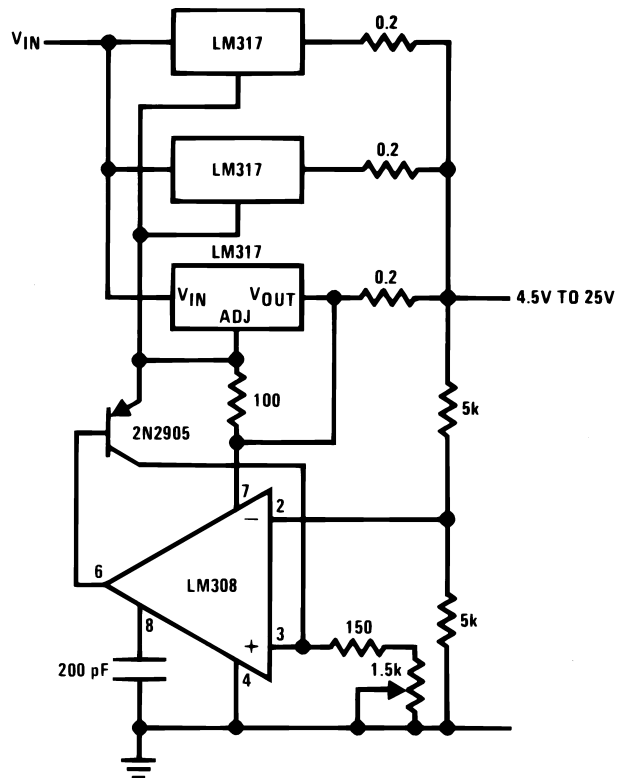
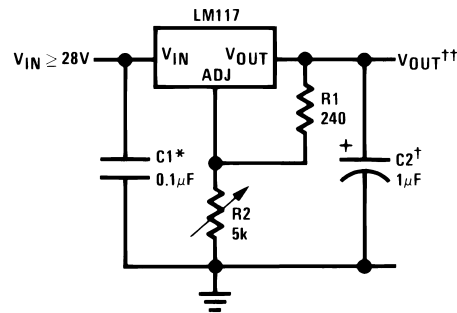


Figure 9-21. Adjustable 4-A Regulator



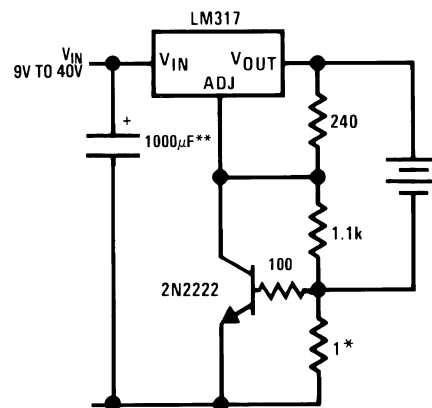
Full output current not available at high input-output voltages

*Needed if device is more than 6 in from filter capacitors.

†Optional, improves transient response. Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

$$\dagger\dagger V_{OUT} = 1.25V \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ}(R_2)$$

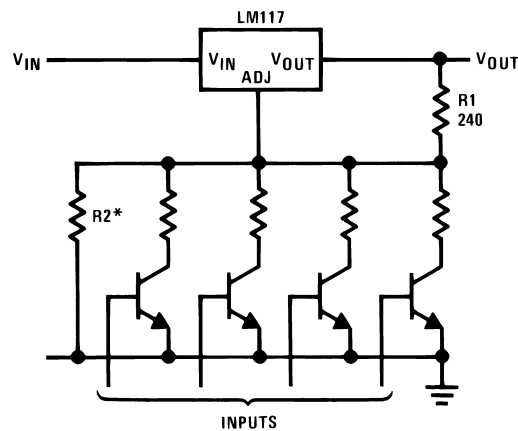
Figure 9-22. 1.2-V to 25-V Adjustable Regulator



*Sets peak current (0.6 A for 1 Ω)

**The 1000 μF is recommended to filter out input transients

Figure 9-23. Current Limited 6-V Charger



*Sets maximum V_OUT

Figure 9-24. Digitally Selected Outputs

10 Power Supply Recommendations

The input supply to the LM117QML-SP must be kept at a voltage level such that its maximum input to output differential voltage is not exceeded. The minimum dropout voltage must also be met with extra headroom when possible to keep the LM117QML-SP in regulation. An input capacitor is recommended, especially when the input pin is located more than 6 in away from the power supply source. For more information regarding capacitor selection, refer to [External Capacitors](#).

11 Layout

11.1 Layout Guidelines

Ensure wide enough traces for those carrying the load current in order to reduce the amount of parasitic trace inductance. Keep the feedback loop from VOUT to ADJ as short as possible. To improve PSRR, a bypass capacitor can be placed at the ADJ pin and must be located as close as possible to the IC. In cases when VIN shorts to ground, an external diode must be placed from VOUT to VIN to divert the surge current from the output capacitor and protect the IC. Similarly, in cases when a large bypass capacitor is placed at the ADJ pin and VOUT shorts to ground, an external diode must be placed from ADJ to VOUT to provide a path for the bypass capacitor to discharge. These diodes must be placed close to the corresponding LM117QML-SP pins to increase their effectiveness.

12 Device and Documentation Support

12.1 Device Support

12.1.1 Third-Party Products Disclaimer

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12.2 Documentation Support

12.2.1 Related Documentation

For related documentation see the following:

1. [LM117xRLQMLV ELDRS Report](#)
2. [LM117QML-SP SMD 5962R9951707VZA](#)
3. [High Reliability Part Numbering System](#)
4. [Applications for an Adjustable IC Power Regulator](#)
5. [Improving Power Supply Reliability with IC Power Regulators](#)
6. [A New Production Technique for Trimming Voltage Regulators](#)
7. [LDO basics: capacitor vs. capacitance](#)
8. [LDO Basics: Preventing reverse current](#)

12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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12.5 Trademarks

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12.6 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962R9951703V9A	ACTIVE	DIESALE	Y	0	42	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
5962R9951703VXA	ACTIVE	TO	NDT	3	20	Non-RoHS & Non-Green	Call TI	Call TI	-55 to 125	LM117HRQMLV 5962R9951703VXA Q ACO 5962R9951703VXA Q >T	Samples
5962R9951704VYA	ACTIVE	TO	K	2	50	Non-RoHS & Non-Green	Call TI	Call TI	-55 to 125	LM117KRQMLV 5962R99517 04VYA Q ACO 04VYA Q >T	Samples
5962R9951705V9A	ACTIVE	DIESALE	Y	0	42	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
5962R9951705VXA	ACTIVE	TO	NDT	3	20	Non-RoHS & Non-Green	Call TI	Call TI	-55 to 125	LM117HRLQMLV 5962R9951705VXA Q ACO 5962R9951705VXA Q >T	Samples
5962R9951706VZA	ACTIVE	CFP	NAC	16	88	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117GWR QMLV Q 5962R99517 06VZA ACO 06VZA >T	Samples
5962R9951707VZA	ACTIVE	CFP	NAC	16	88	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117GWRL QMLV Q 5962R99517 07VZA ACO 07VZA >T	Samples
LM117GWRLQMLV	ACTIVE	CFP	NAC	16	88	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117GWRL QMLV Q 5962R99517 07VZA ACO 07VZA >T	Samples
LM117GWRQMLV	ACTIVE	CFP	NAC	16	88	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117GWR QMLV Q 5962R99517 06VZA ACO	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
										06VZA >T	
LM117H MDE	ACTIVE	DIESALE	Y	0	42	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
LM117H MDR	ACTIVE	DIESALE	Y	0	42	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
LM117HRLQMLV	ACTIVE	TO	NDT	3	20	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HRLQMLV 5962R9951705VXA Q ACO 5962R9951705VXA Q >T	Samples
LM117HRQMLV	ACTIVE	TO	NDT	3	20	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117HRQMLV 5962R9951703VXA Q ACO 5962R9951703VXA Q >T	Samples
LM117K/EM	ACTIVE	TO	K	2	50	Non-RoHS & Non-Green	Call TI	Call TI	25 to 25	LM117K/EM EVAL ONLY T	Samples
LM117KRQMLV	ACTIVE	TO	K	2	50	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM117KRQMLV 5962R99517 04VYA Q ACO 04VYA Q >T	Samples
LM117NDT/EM	ACTIVE	TO	NDT	3	20	Non-RoHS & Non-Green	Call TI	Call TI	25 to 25	LM117NDT/EM EVAL ONLY	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

- (3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.
- (5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.
- (6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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OTHER QUALIFIED VERSIONS OF LM117QML-SP :

- Military : [LM117QML](#)

NOTE: Qualified Version Definitions:

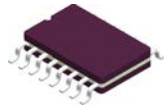
- Military - QML certified for Military and Defense Applications

TRAY


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
5962R9951703VXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
5962R9951704VYA	K	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
5962R9951705VXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117HRLQMLV	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117HRQMLV	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
LM117K/EM	K	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM117KRQMLV	K	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM117NDT/EM	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54

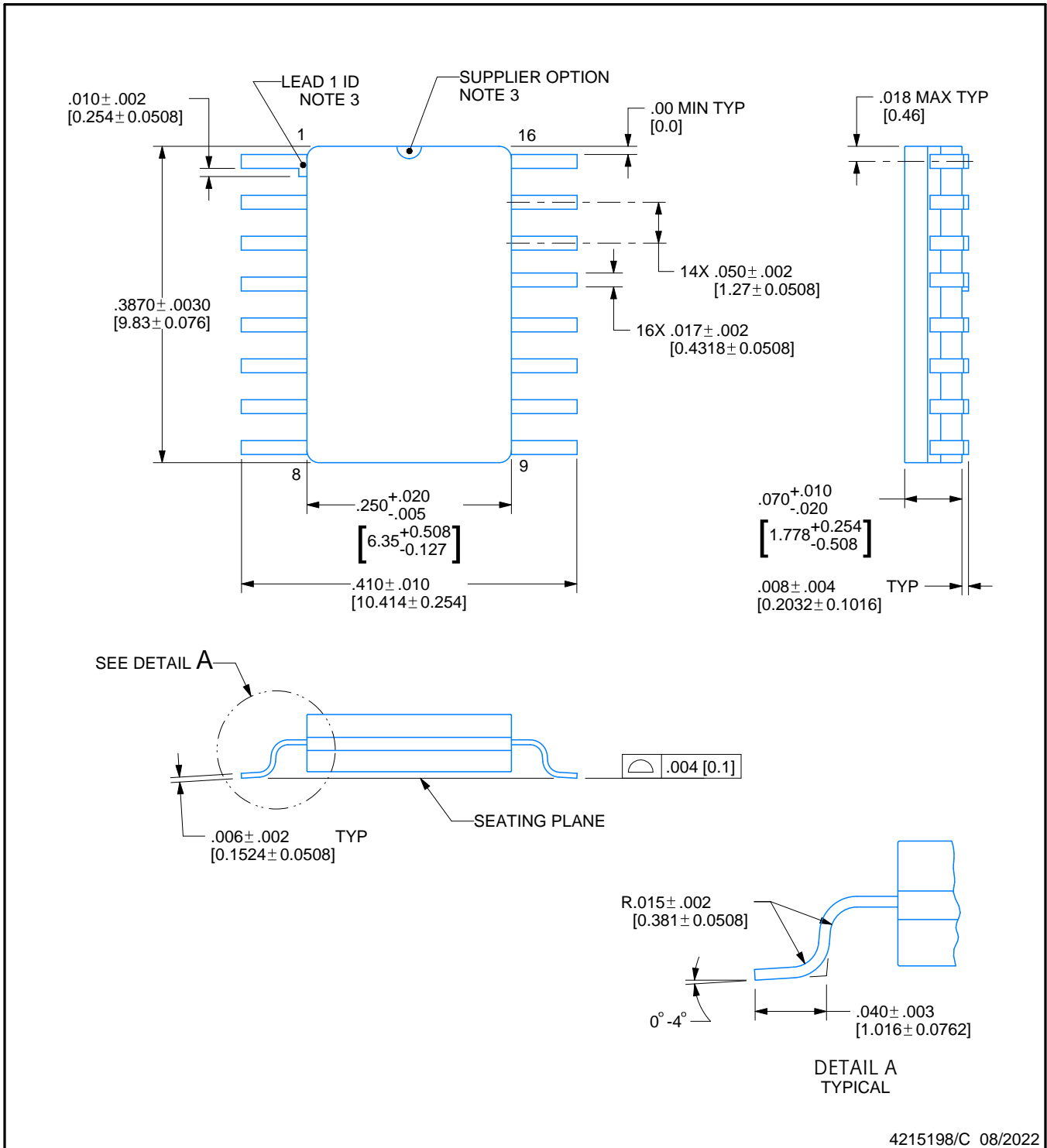


NAC0016A

PACKAGE OUTLINE

CFP - 2.33mm max height

CERAMIC FLATPACK



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NOTES:

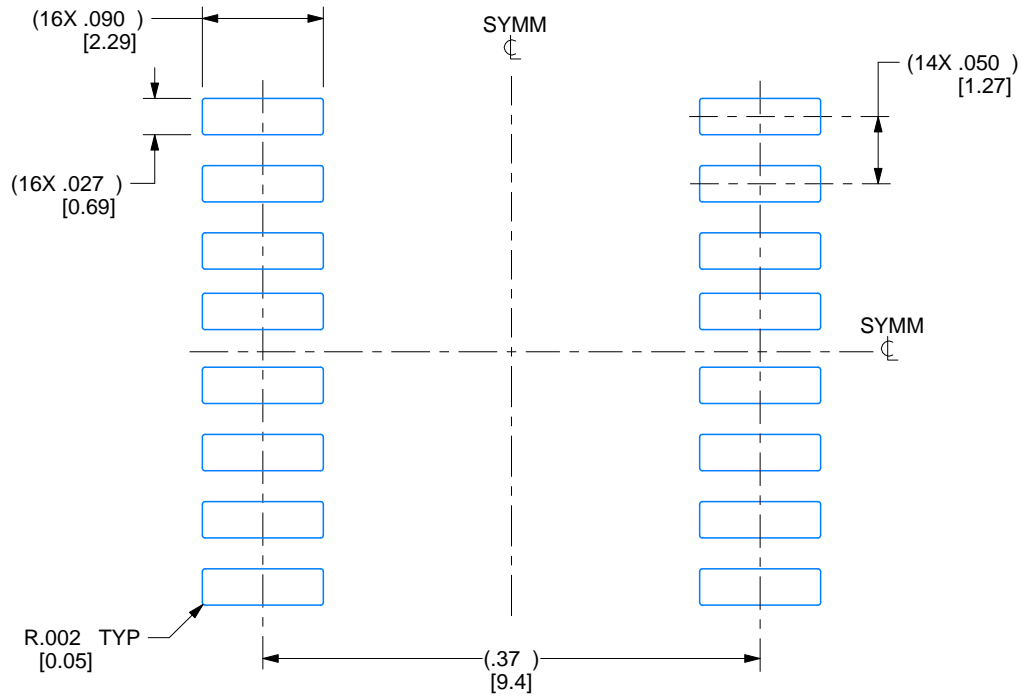
1. Controlling dimension is Inch. Values in [] are millimeters. Dimensions in () for reference only.
2. For solder thickness and composition, see the "Lead Finish Composition/Thickness" link in the packaging section of the Texas Instruments website
3. Lead 1 identification shall be:
 - a) A notch or other mark within this area
 - b) A tab on lead 1, either side
4. No JEDEC registration as of December 2021

EXAMPLE BOARD LAYOUT

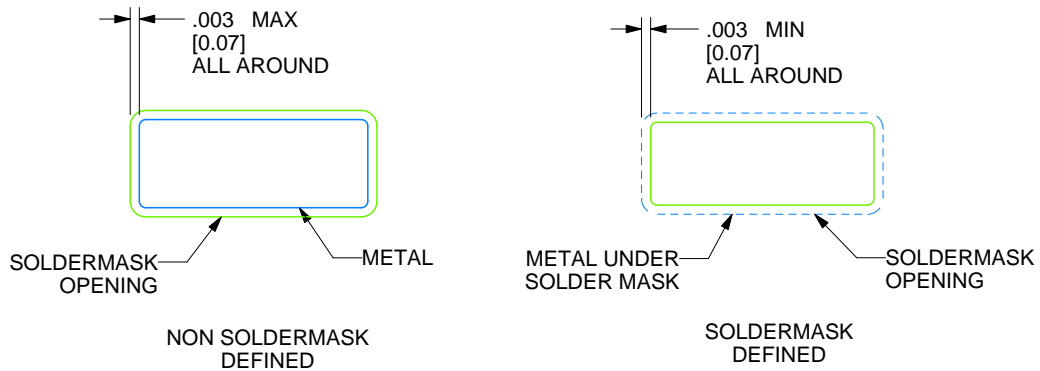
NAC0016A

CFP - 2.33mm max height

CERAMIC FLATPACK



RECOMMENDED LAND PATTERN

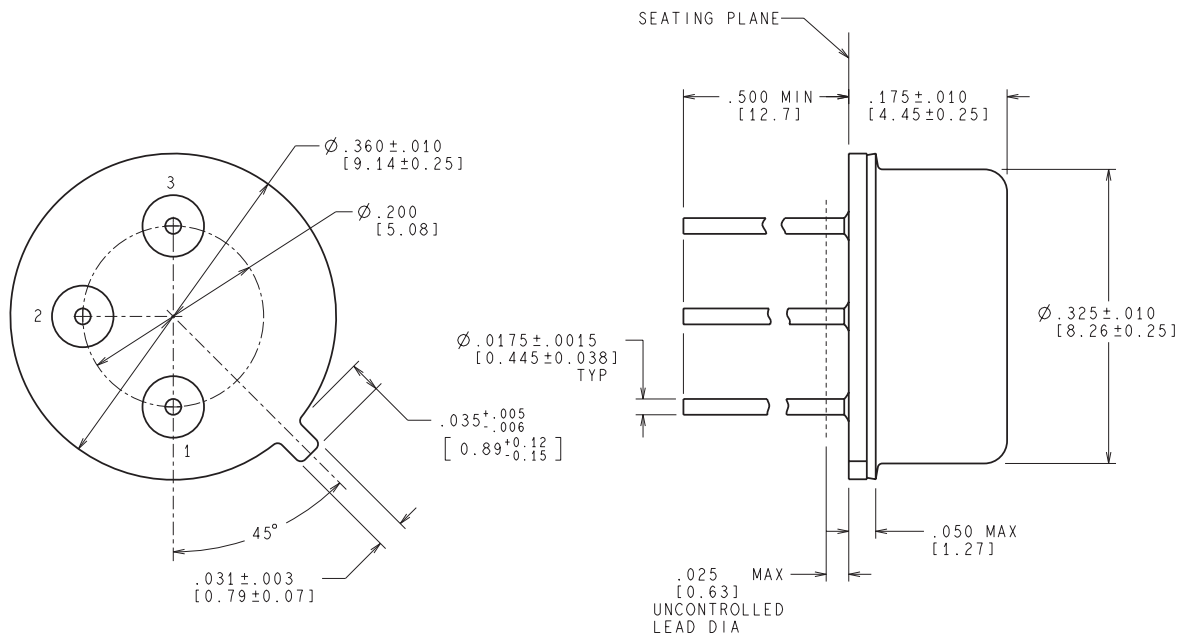


4215198/C 08/2022

REVISIONS

REV	DESCRIPTION	E.C.N.	DATE	BY/APP'D
A	RELEASE TO DOCUMENT CONTROL	2197879	12/30/2021	TINA TRAN / ANIS FAUZI
B	NO CHANGE TO DRAWING; REVISION FOR YODA RELEASE;	2198832	02/15/2022	K. SINCERBOX
C	.387±.003 WAS .39000±.00012;	2200917	08/08/2022	D. CHIN / K. SINCERBOX

NDT0003A

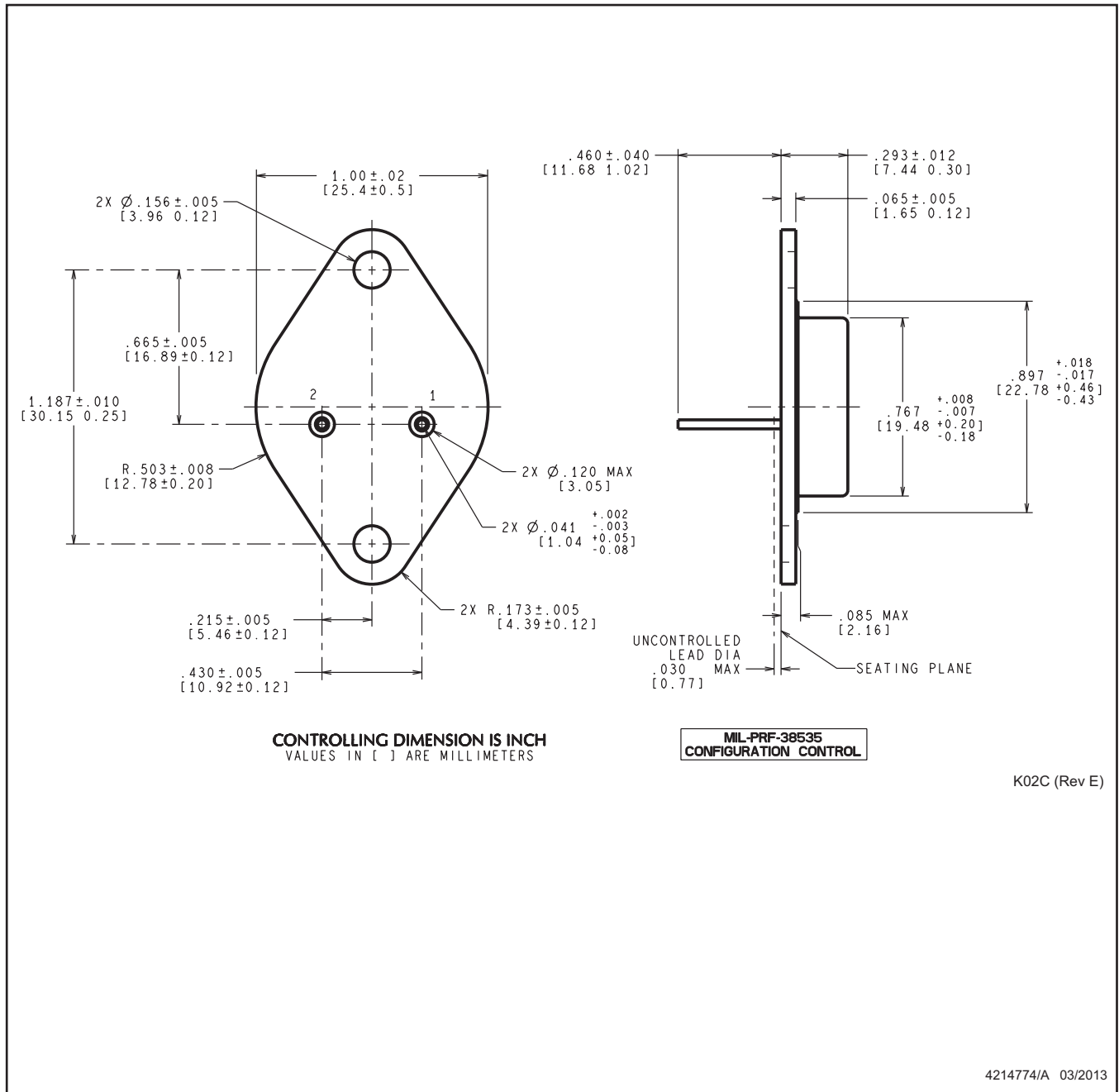


CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

K0002C



NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Leads not to be bent greater than 15°

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