LM117QML 3-Terminal Adjustable Regulator

Check for Samples: LM117QML

FEATURES

- **Available with Radiation Guarantee**
  - **High Dose Rate 100 krad(Si)**
  - **ELDRS Free 100 krad(Si)**
- **Specified max. 0.3% Load Regulation (LM117)**
- **Specified 0.5A or 1.5A Output Current**
- **Adjustable Output Down to 1.2V**
- **Current Limit Constant with Temperature**
- **80 dB Ripple Rejection**
- **Output is Short-Circuit Protected**

DESCRIPTION

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying either 0.5A or 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

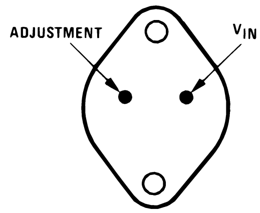
Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection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

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is “floating” and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 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 1.2V where most loads draw little current.

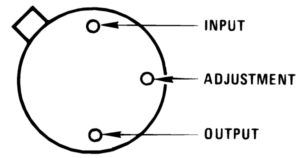
For the negative complement, see LM137 series data sheet.

CONNECTION DIAGRAMS



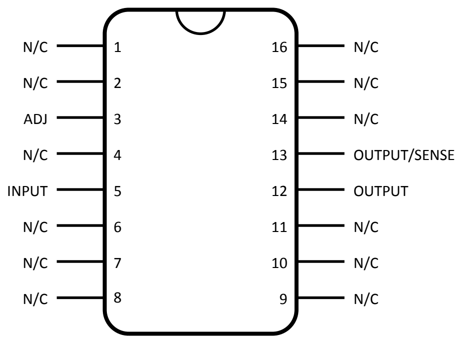
CASE IS OUTPUT

Figure 1. 2-Pin TO Metal Can Package Bottom View See K Package



CASE IS OUTPUT

Figure 2. 3-Pin PFM Metal Can Package Bottom View See NDT0003A Package



For the Ceramic SOIC device to function properly, the “Output” and “Output/Sense” pins must be connected on the users printed circuit board.

Figure 3. 16-Pin CLGA Top View See NAC0016A Package

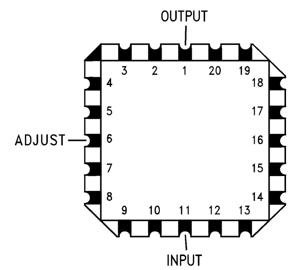
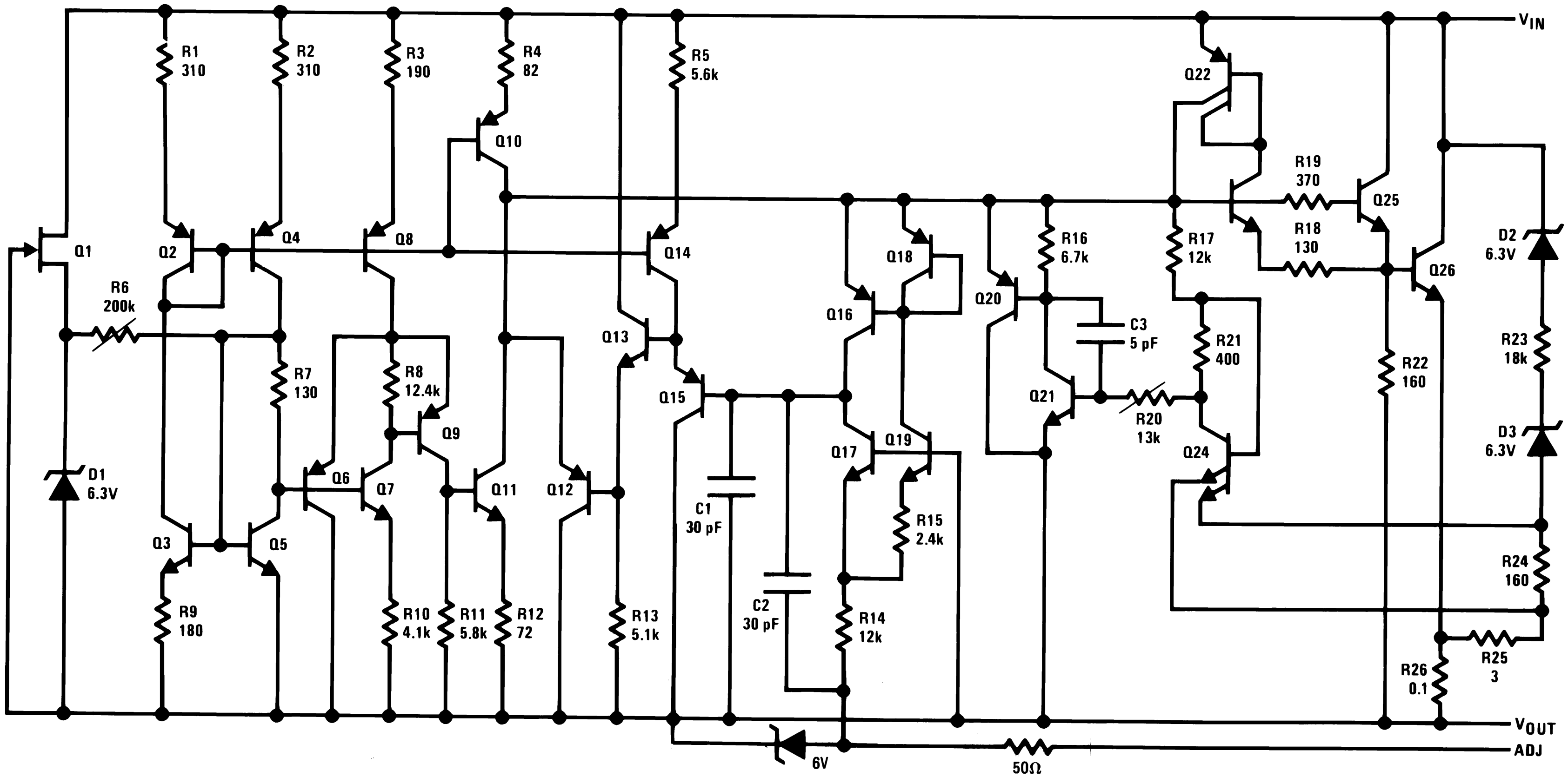


Figure 4. 20-Pin LCCC Top View See NAJ0020A Package

Table 1. LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO	1.5A
H	PFM	0.5A
WG, GW	CLGA	0.5A
E	LCCC	0.5A

Schematic Diagram



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[1]

Power Dissipation[2]			Internally Limited
Input-Output Voltage Differential			+40V, −0.3V
Storage Temperature			−65°C ≤ T_A ≤ +150°C
Maximum Junction Temperature (T_{Jmax}			+150°C
Lead Temperature Metal Package			300°C
Thermal Resistance	θ_{JA}	T0 Still Air	39°C/W
		T0 500LF/Min Air flow	14°C/W
		PFM Still Air	186°C/W
		PFM 500LF/Min Air flow	64°C/W
		CLGA Still Air (LM117WG)	115°C/W
		CLGA 500LF/Min Air flow (LM117WG)	66°C/W
		CLGA Still Air “GW”	130°C/W
		CLGA 500LF/Min Air flow (LM117GW)	80°C/W
		LCCC Still Air	88°C/W
		LCCC 500LF/Min Air flow	62°C/W
	θ_{JC}	T0	1.9°C/W
		PFM Metal Can	21°C/W
		CLGA (LM117WG)[3]	3.4°C/W
		CLGA (LM117GW)	7°C/W
		LCCC	12°C/W
Package Weight		PFM Metal Can	960mg
		CLGA (LM117WG)	365mg
		CLGA (LM117GW)	410mg
ESD Tolerance [4]			3KV

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

(2) 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 $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ 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 2W for the PFM, LCCC, and CLGA packages, and 20W for the TO package."

(3) The package material for these devices allows much improved heat transfer over our standard ceramic packages. In order to take full advantage of this improved heat transfer, heat sinking must be provided between the package base (directly beneath the die), and either metal traces on, or thermal vias through, the printed circuit board. Without this additional heat sinking, device power dissipation must be calculated using θ_{JA}, rather than θ_{JC}, thermal resistance. It must not be assumed that the device leads will provide substantial heat transfer out the package, since the thermal resistance of the leadframe material is very poor, relative to the material of the package base. The stated θ_{JC} thermal resistance is for the package material only, and does not account for the additional thermal resistance between the package base and the printed circuit board. The user must determine the value of the additional thermal resistance and must combine this with the stated value for the package, to calculate the total allowed power dissipation for the device.

(4) Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Recommended Operating Conditions

Operating Temperature Range	−55°C ≤ T_A ≤ +125°C
Input Voltage Range	4.25V to 41.25V

Table 2. 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
12	Settling time at	+25
13	Settling time at	+125
14	Settling time at	-55

LM117H & LM117WG Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, I_L = 8mA

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
I_{Adj}	Adjustment Pin Current	V_{Diff} = 3V			100	µA	1
		V_{Diff} = 3.3V			100	µA	2, 3
		V_{Diff} = 40V			100	µA	1, 2, 3
I_Q	Minimum Load Current	V_{Diff} = 3V, V_O = 1.7V			5.0	mA	1
		V_{Diff} = 3.3V, V_O = 1.7V			5.0	mA	2, 3
		V_{Diff} = 40V, V_O = 1.7V			5.0	mA	1, 2, 3
V_{Ref}	Reference Voltage	V_{Diff} = 3V		1.2	1.3	V	1
		V_{Diff} = 3.3V		1.2	1.3	V	2, 3
		V_{Diff} = 40V		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-8.9	8.9	mV	1
		3.3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-22.2	22.2	mV	2, 3
V_{RLoad}	Load Regulation	V_{Diff}= 3V, I_L = 10mA to 500mA		-15	15	mV	1
		V_{Diff}= 3.3V, I_L = 10mA to 500mA		-15	15	mV	2, 3
		V_{Diff}= 40V, I_L = 10mA to 150mA		-15	15	mV	1
		V_{Diff}= 40V, I_L = 10mA to 100mA		-15	15	mV	2, 3
ΔI_{Adj} / Load	Adjustment Current Change	V_{Diff} = 3V, I_L = 10mA to 500mA		-5.0	5.0	µA	1
		V_{Diff} = 3.3V, I_L = 10mA to 500mA		-5.0	5.0	µA	2, 3
		V_{Diff} = 40V, I_L = 10mA to 150mA		-5.0	5.0	µA	1
		V_{Diff} = 40V, I_L = 10mA to 100mA		-5.0	5.0	µA	2, 3

LM117H & LM117WG Electrical Characteristics DC Parameters (continued)

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, I_L = 8mA

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
ΔI_{Adj} / Line	Adjustment Current Change	3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	1
		3.3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	2, 3
I_{OS}	Short Circuit Current	V_{Diff} = 10V		0.45	1.6	A	1
θ_R	Thermal Regulation	T_A = 25°C, t = 20mS, V_{Diff} = 40V, I_L = 150mA		-6.0	6.0	mV	1
I_{CL}	Current Limit	V_{Diff} ≤ 15V	See (1)	0.5		A	1, 2, 3
		V_{Diff} = 40V	See (1)	0.15		A	1

(1) Specified parameter, not tested.

LM117H & LM117WG Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	V_I = +6.25V, $V_O = V_{Ref}$, f= 120Hz, $e_I = 1V_{RMS}$, I_L = 125mA	See (1)	66		dB	4, 5, 6

(1) Tested @ 25°C; specified, but not tested @ 125°C & −55°C

LM117K Electrical Characteristi DC Parameters

The following conditions apply, unless otherwise specified.$V_{Diff} = (V_I - V_O)$, I_L = 10mA

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
I_{Adj}	Adjustment Pin Current	V_{Diff} = 3V			100	µA	1
		V_{Diff} = 3.3V			100	µA	2, 3
		V_{Diff} = 40V			100	µA	1, 2, 3
I_Q	Minimum Load Current	V_{Diff} = 3V, V_O = 1.7V			5.0	mA	1
		V_{Diff} = 3.3V, V_O = 1.7V			5.0	mA	2, 3
		V_{Diff} = 40V, V_O = 1.7V			5.0	mA	1, 2, 3
V_{Ref}	Reference Voltage	V_{Diff} = 3V		1.2	1.3	V	1
		V_{Diff} = 3.3V		1.2	1.3	V	2, 3
		V_{Diff} = 40V		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-8.9	8.9	mV	1
		3.3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-22.2	22.2	mV	2, 3
V_{RLoad}	Load Regulation	V_{Diff}= 3V, I_L = 10mA to 1.5A		-15	15	mV	1
		V_{Diff}= 3.3V, I_L = 10mA to 1.5A		-15	15	mV	2, 3
		V_{Diff}= 40V, I_L = 10mA to 300mA		-15	15	mV	1
		V_{Diff}= 40V, I_L = 10mA to 195mA		-15	15	mV	2, 3

LM117K Electrical Characteristi DC Parameters (continued)

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, I_L = 10mA

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
ΔI_{Adj} / Load	Adjustment Current Change	V_{Diff} = 3V, I_L = 10mA to 1.5A		-5.0	5.0	µA	1
		V_{Diff} = 3.3V, I_L = 10mA to 1.5A		-5.0	5.0	µA	2, 3
		V_{Diff} = 40V, I_L = 10mA to 300mA		-5.0	5.0	µA	1
		V_{Diff} = 40V, I_L = 10mA to 195mA		-5.0	5.0	µA	2, 3
ΔI_{Adj} / Line	Adjustment Current Change	3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	1
		3.3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	2, 3
I_{OS}	Short Circuit Current	V_{Diff} = 10V		1.6	3.4	A	1
θ_R	Thermal Regulation	T_A = 25°C, t = 20mS, V_{Diff} = 40V, I_L = 300mA		-10.5	10.5	mV	1
I_{CL}	Current Limit	V_{Diff} ≤ 15V	See (1)	1.5		A	1, 2, 3
		V_{Diff} = 40V	See (1)	0.3		A	1

(1) Specified parameter, not tested.

LM117K Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	V_I = +6.25V, $V_O = V_{Ref}$, f = 120Hz, e_I = 1V_{RMS}, I_L = 0.5A	See (1)	66		dB	4, 5, 6

(1) Tested @ 25°C; specified, but not tested @ 125°C & −55°C

LM117E Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, I_L = 8mA, P_D ≤ 1.5W

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
I_{Adj}	Adjustment Pin Current	V_{Diff} = 3V			100	µA	1
		V_{Diff} = 3.3V			100	µA	2, 3
		V_{Diff} = 40V			100	µA	1, 2, 3
I_Q	Minimum Load Current	V_{Diff} = 3V, V_O = 1.7V			5.0	mA	1
		V_{Diff} = 3.3V, V_O = 1.7V			5.0	mA	2, 3
		V_{Diff} = 40V, V_O = 1.7V			5.0	mA	1, 2, 3
V_{Ref}	Reference Voltage	V_{Diff} = 3V		1.2	1.3	V	1
		V_{Diff} = 3.3V		1.2	1.3	V	2, 3
		V_{Diff} = 40V		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-8.9	8.9	mV	1
		3.3V ≤ V_{Diff} ≤ 40V, V_O = 1.2V		-22.2	22.2	mV	2, 3

LM117E Electrical Characteristics DC Parameters (continued)

The following conditions apply, unless otherwise specified. $V_{Diff} = (V_I - V_O)$, I_L = 8mA, $P_D \le$ 1.5W

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{RLoad}	Load Regulation	V_{Diff}= 3V, I_L = 10mA to 100mA		-15	15	mV	1
		V_{Diff}= 3.3V, I_L = 10mA to 100mA		-15	15	mV	2, 3
		V_{Diff}= 40V, I_L = 10mA to 100mA		-15	15	mV	1,2
				−25	25	mV	3
		V_{Diff}= 3V, I_L = 10mA to 500mA		-15	15	mV	1
		V_{Diff}= 3.3V, I_L = 10mA to 500mA		-15	15	mV	2, 3
ΔI_{Adj} / Load	Adjustment Current Change	V_{Diff} = 3V, I_L = 10mA to 500mA		-5.0	5.0	µA	1
		V_{Diff} = 3.3V, I_L = 10mA to 500mA		-5.0	5.0	µA	2, 3
		V_{Diff} = 40V, I_L = 10mA to 100mA		-5.0	5.0	µA	1, 2, 3
ΔI_{Adj} / Line	Adjustment Current Change	3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	1
		3.3V ≤ V_{Diff} ≤ 40V		-5.0	5.0	µA	2, 3
I_{OS}	Short Circuit Current	V_{Diff} = 10V		0.45	1.6	A	1
θ_R	Thermal Regulation	T_A = 25°C, t = 20mS, V_{Diff} = 40V, I_L = 75mA		-6.0	6.0	mV	1
I_{CL}	Current Limit	V_{Diff} ≤ 15V	See [1]	0.5		A	1, 2, 3
		V_{Diff} = 40V	See [1]	0.15		A	1

(1) Specified parameter, not tested.

LM117E Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	V_I = +6.25V, $V_O = V_{Ref}$, f = 120Hz, e_I = 1V_{RMS}, I_L = 100mA, C_{Adj} = 10µf	See [1]	66		dB	4, 5, 6

(1) Tested @ 25°C; specified, but not tested @ 125°C & −55°C

LM117H & LM117WG RH Electrical Characteristics DC Parameters[1][2]

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 4.25V, I_L = -500mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -50mA		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-9.0	9.0	mV	1
				-23	23	mV	2,3

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the “Post Radiation Limits” table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.
(2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

LM117H & LM117WG RH Electrical Characteristics DC Parameters[1][2] (continued)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{RLoad}	Load Regulation	V_I = 6.25V, -500mA ≤ I_L ≤ -5mA		-12	12	mV	1, 2, 3
		V_I = 41.25V, -50mA ≤ I_L ≤ -5mA		-12	12	mV	1, 2, 3
V_{RTh}	Thermal Regulation	V_I = 14.6V, I_L = -500mA		-12	12	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
		V_I = 41.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
ΔI_{Adj}/ Line	Adjust Pin Current Change	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-5.0	5.0	µA	1, 2, 3
ΔI_{Adj} / Load	Adjust Pin Current Change	V_I = 6.25V, -500mA ≤ I_L ≤ -5mA		-5.0	5.0	µA	1, 2, 3
I_Q	Minimum Load Current	V_I = 4.25V, Forced V_O = 1.4V		-3.0	-0.5	mA	1, 2, 3
		V_I = 14.25V, Forced V_O = 1.4V		-3.0	-0.5	mA	1, 2, 3
		V_I = 41.25V, Forced V_O = 1.4V		-5.0	-1.0	mA	1, 2, 3
I_{OS}	Output Short Circuit Current	V_I = 4.25V		-1.8	-0.5	A	1, 2, 3
		V_I = 40V		-0.5	-0.05	A	1, 2, 3
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 2.5Ω, C_L = 20µF		1.2	1.3	V	1, 2, 3
		V_I = 40V, R_L = 250Ω		1.2	1.3	V	1, 2, 3
V_O	Output Voltage	V_I = 6.25V, I_L = -5mA	See[3]	1.2	1.3	V	2
V_{Start}	Voltage Start-Up	V_I = 4.25V, R_L = 2.5Ω, C_L = 20µF, I_L = -500mA		1.2	1.3	V	1, 2, 3

(3) Tested @ T_A = 125°C, correlated to T_A = 150°C

LM117H & LM117WG RH Electrical Characteristics AC Parameters[1][2]

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub - groups
V_{NO}	Output Noise Voltage	V_I = 6.25V, I_L = -50mA			120	μV_{RMS}	7
ΔV_O / ΔV_I	Line Transient Response	V_I = 6.25V, ΔV_I = 3V, I_L = -10mA			6.0	mV/V	7
ΔV_O / ΔI_L	Load Transient Response	V_I = 6.25V, ΔI_L = -200mA, I_L = -50mA			0.6	mV/mA	7
ΔV_I / ΔV_O	Ripple Rejection	V_I = 6.25V, I_L = -125mA, E_I = 1V_{RMS} at f = 2400Hz		65		dB	4

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the “Post Radiation Limits” table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.
(2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

LM117H & LM117WG RH Electrical Characteristics DC Drift Parameters

The following conditions apply, unless otherwise specified.
Deltas performed on QMLV devices at Group B, Subgroup 5, only.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 4.25V, I_L = -500mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -50mA		-0.01	0.01	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-4.0	4.0	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-10	10	µA	1
		V_I = 41.25V, I_L = -5mA		-10	10	µA	1
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 2.5Ω, C_L = 20µf		-0.01	0.01	V	1
		V_I = 40V, R_L = 250Ω		-0.01	0.01	V	1

LM117H & LM117WG RH Electrical Characteristics AC/DC Post Radiation Limits @ +25°C[(1)(2)]

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.350	V	1
		V_I = 4.25V, I_L = -500mA		1.2	1.350	V	1
		V_I = 41.25V, I_L = -5mA		1.2	1.350	V	1
		V_I = 41.25V, I_L = -50mA		1.2	1.350	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-25	25	mV	1
$\Delta V_I / \Delta V_O$	Ripple Rejection	V_I = 6.25V, I_L = -125mA E_I = 1V_{RMS} at f = 2400Hz		60		dB	4
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 2.5Ω, C_L = 20µf		1.20	1.350	V	1
		V_I = 40V, R_L = 250Ω		1.20	1.350	V	1

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the "Post Radiation Limits" table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.
(2) Low dose rate testing has been performed on a wafer-by-wafer basis, per test method 1019 condition D of MIL-STD-883, with no enhanced low dose rate sensitivity (ELDRS) effect.

LM117K RH Electrical Characteristics
DC Parameters[(1)]

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 4.25V, I_L = -1.5A		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -200mA		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-9.0	9.0	mV	1
				-23	23	mV	2,3
V_{RLoad}	Load Regulation	V_I = 6.25V, -1.5A ≤ I_L ≤ -5mA		-3.5	3.5	mV	1
				-12	12	mV	2, 3
		V_I = 41.25V, -200mA ≤ I_L ≤ -5mA		-3.5	3.5	mV	1
				-12	12	mV	2, 3
V_{RTh}	Thermal Regulation	V_I = 14.6V, I_L = -1.5A		-12	12	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
		V_I = 41.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
ΔI_{Adj}/ Line	Adjust Pin Current Change	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-5.0	5.0	µA	1, 2, 3
ΔI_{Adj} / Load	Adjust Pin Current Change	V_I = 6.25V, -1.5A ≤ I_L ≤ -5mA		-5.0	5.0	µA	1, 2, 3
I_Q	Minimum Load Current	V_I = 4.25V, Forced V_O = 1.4V		-3.0	-0.2	mA	1, 2, 3
		V_I = 14.25V, Forced V_O = 1.4V		-3.0	-0.2	mA	1, 2, 3
		V_I = 41.25V, Forced V_O = 1.4V		-5.0	-0.2	mA	1, 2, 3
I_{OS}	Output Short Circuit Current	V_I = 4.25V		-3.5	-1.5	A	1, 2, 3
		V_I = 40V		-1.0	-0.18	A	1, 2, 3
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 0.833Ω, C_L = 20µF		1.2	1.3	V	1, 2, 3
		V_I = 40V, R_L = 250Ω		1.2	1.3	V	1, 2, 3
V_O	Output Voltage	V_I = 6.25V, I_L = -5mA	See[(2)]	1.2	1.3	V	2
V_{Start}	Voltage Start-Up	V_I = 4.25V, R_L = 0.833Ω, C_L = 20µF, I_L = -1.5A		1.2	1.3	V	1, 2, 3

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the “Post Radiation Limits” table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.
(2) Tested @ T_A = 125°C, correlated to T_A = 150°C

LM117K RH Electrical Characteristics AC Parameters(1)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{NO}	Output Noise Voltage	V_I = 6.25V, I_L = -100mA			120	μV_{RMS}	7
$\Delta V_O / \Delta V_I$	Line Transient Response	V_I = 6.25V, ΔV_I = 3V, I_L = -10mA	See(2)		18	mV	7
$\Delta V_O / \Delta I_L$	Load Transient Response	V_I = 6.25V, ΔI_L = -400mA, I_L = -100mA	See(3)		120	mV	7
$\Delta V_I / \Delta V_O$	Ripple Rejection	V_I = 6.25V, I_L = -500mA, E_I = 1V_{RMS} at f = 2400Hz		65		dB	4

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the “Post Radiation Limits” table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.
(2) SMD limit of 6mV/V is equivalent to 18mV
(3) SMD limit of 0.3mV/V is equivalent to 120mV

LM117K RH Electrical Characteristics DC Drift Parameters

The following conditions apply, unless otherwise specified.
Deltas performed on QMLV devices at Group B, Subgroup 5, only.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 4.25V, I_L = -1.5A		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -200mA		-0.01	0.01	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-4.0	4.0	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-10	10	µA	1
		V_I = 41.25V, I_L = -5mA		-10	10	µA	1
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 0.833Ω, C_L = 20µS		-0.01	0.01	V	1
		V_I = 40V, R_L = 250Ω		-0.01	0.01	V	1

LM117K RH Electrical Characteristics AC/DC Post Radiation Limits @ +25°C(1)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.35 0	V	1
		V_I = 4.25V, I_L = -1.5A		1.2	1.35 0	V	1
		V_I = 41.25V, I_L = -5mA		1.2	1.35 0	V	1
		V_I = 41.25V, I_L = -200mA		1.2	1.35 0	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-25	25	mV	1

(1) Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the “Post Radiation Limits” table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.

LM117K RH Electrical Characteristics AC/DC Post Radiation Limits @ +25°C[(1)] (continued)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{RLoad}	Load Regulation	V_I = 6.25V, -1.5A ≤ I_L ≤ -5mA		-7.0	7.0	mV	1
		V_I = 41.25V, -200mA ≤ I_L ≤ -5mA		-7.0	7.0	mV	1
ΔV_I / ΔV_O	Ripple Rejection	V_I = 6.25V, I_L = -500mA E_I = 1V_{RMS} at f = 2400Hz		60		dB	4
V_O (Recov)	Output Voltage Recovery	V_I = 4.25V, R_L = 0.833Ω, C_L = 20µS		1.20	1.350	V	1
		V_I = 40V, R_L = 250Ω		1.20	1.350	V	1

Typical Performance Characteristics

Output Capacitor = 0μF unless otherwise noted

Load Regulation

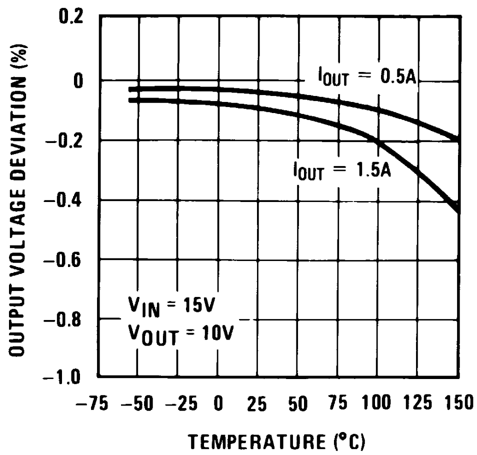


Figure 5.

Current Limit

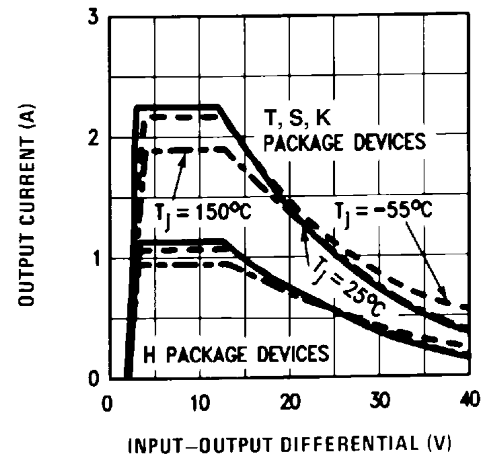


Figure 6.

Adjustment Current

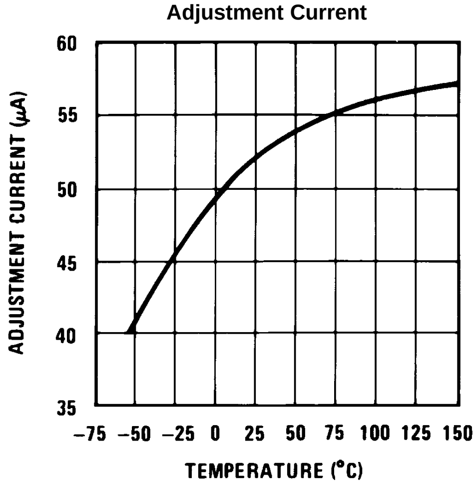


Figure 7.

Dropout Voltage

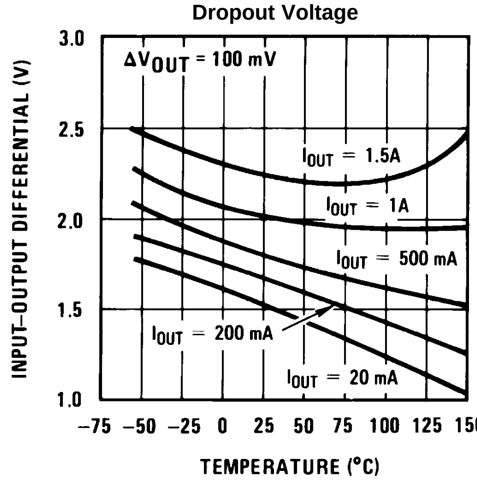


Figure 8.

Temperature Stability

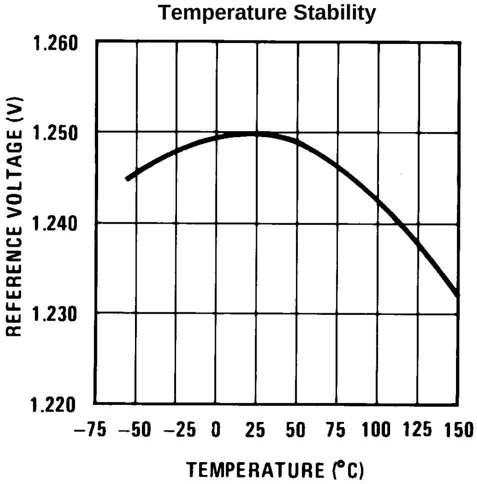


Figure 9.

Minimum Operating Current

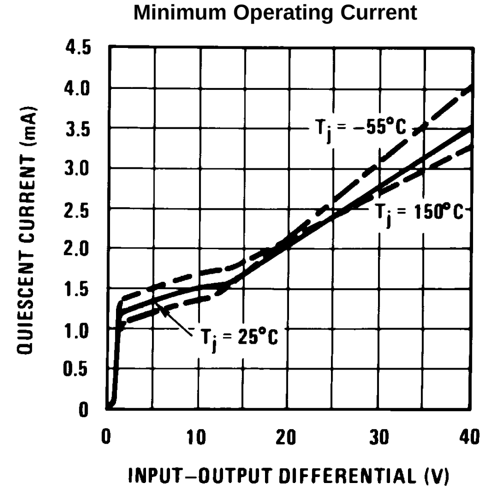


Figure 10.

Typical Performance Characteristics (continued)

Output Capacitor = 0μF unless otherwise noted

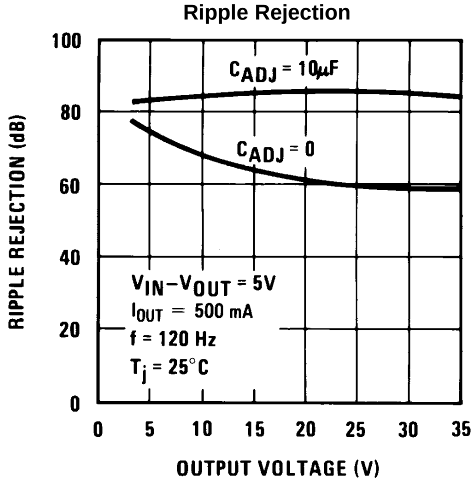


Figure 11.

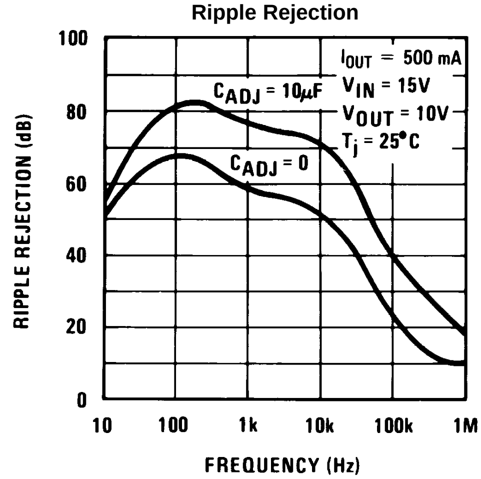


Figure 12.

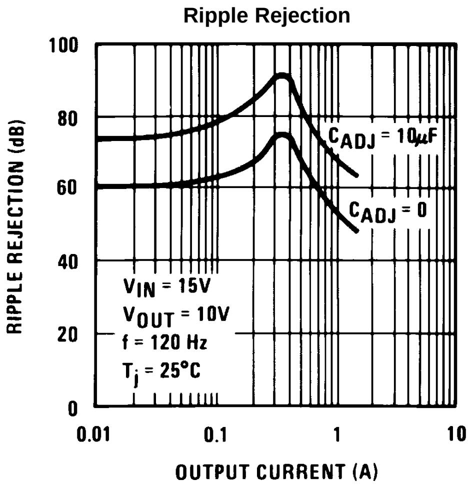


Figure 13.

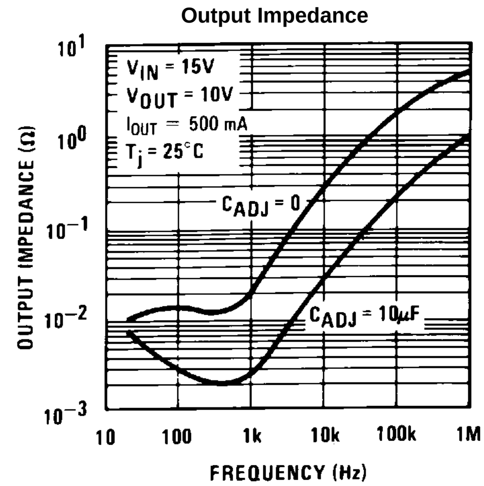


Figure 14.

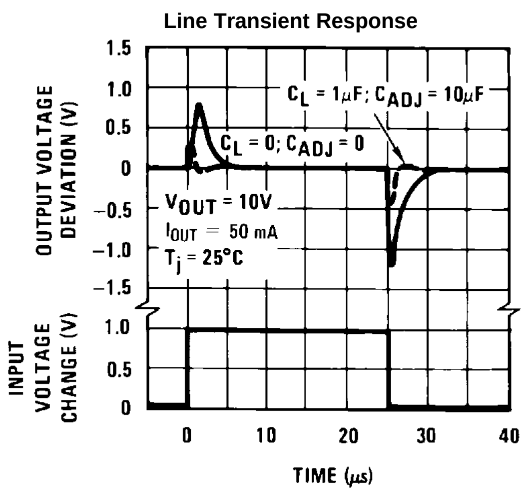


Figure 15.

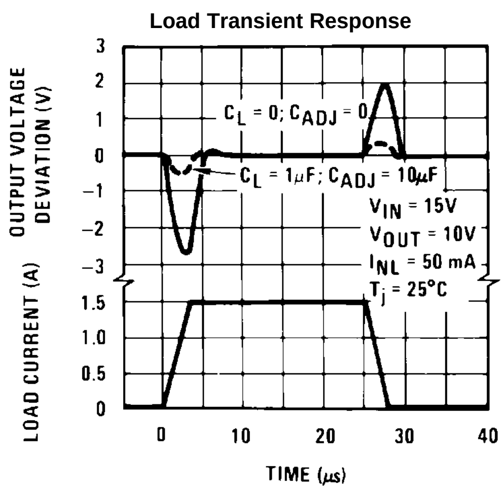
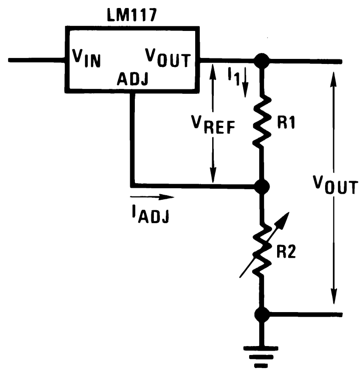


Figure 16.

APPLICATION HINTS

In operation, the LM117 develops a nominal 1.25V reference voltage, V_{REF}, between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2 \quad (1)$$



Since the 100μA current from the adjustment terminal represents an error term, the LM117 was designed to minimize I_{ADJ} and make it very 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.

EXTERNAL CAPACITORS

An input bypass capacitor is recommended. A 0.1μF disc or 1μF 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 eliminate 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 10μF bypass capacitor 80dB ripple rejection is obtainable at any output level. Increases over 10μF do not appreciably improve the ripple rejection at frequencies above 120Hz. 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.

In general, the best type of capacitors to use is solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25μF in aluminum electrolytic to equal 1μF 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 0.5MHz. For this reason, 0.01μF disc may seem to work better than a 0.1μF 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 1μF solid tantalum (or 25μF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10μF will merely improve the loop stability and output impedance.

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 240Ω) 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 15V regulator with 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05Ω × I_L. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 17 shows the effect of resistance between the regulator and 240Ω set resistor.

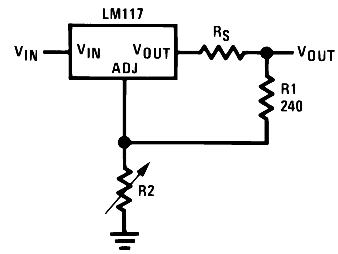


Figure 17. Regulator with Line Resistance in Output Lead

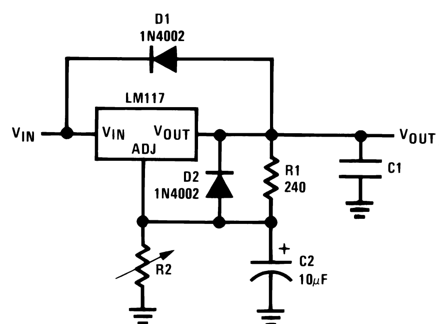
With the TO package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the PFM package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide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

PROTECTION DIODES

When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10μF capacitors have low enough internal series resistance to deliver 20A 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 15A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25μF or less, there is 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 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10μF capacitance. *Figure 18* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

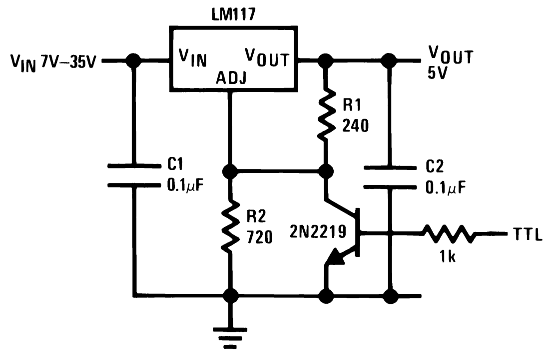
D1 protects against C1
D2 protects against C2

Figure 18. Regulator with Protection Diodes

When a value for $\theta_{(H-A)}$ is found using the equation shown, *a heatsink must be selected that has a value that is less than or equal to this number.*

$\theta_{(H-A)}$ is specified numerically by the heatsink manufacturer in the catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

Typical Applications



*Min. output ≅ 1.2V

Figure 19. 5V Logic Regulator with Electronic Shutdown*

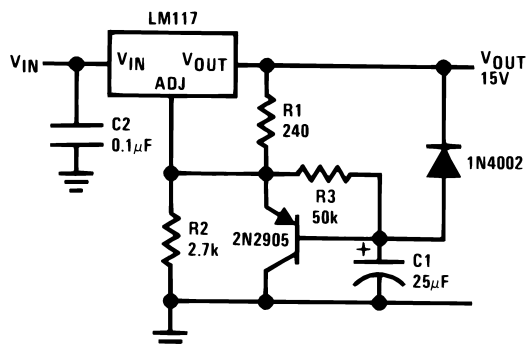
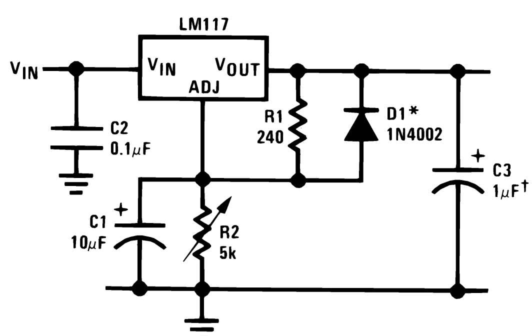


Figure 20. Slow Turn-On 15V Regulator



†Solid tantalum
*Discharges C1 if output is shorted to ground

Figure 21. Adjustable Regulator with Improved Ripple Rejection

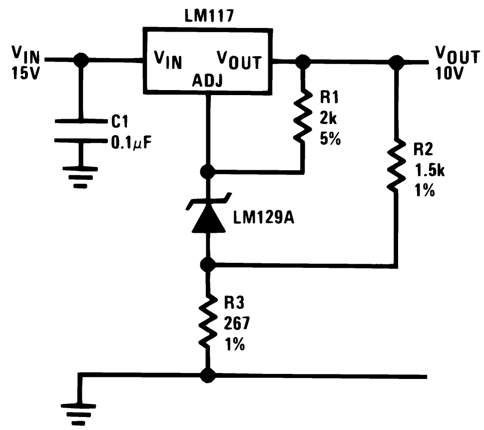
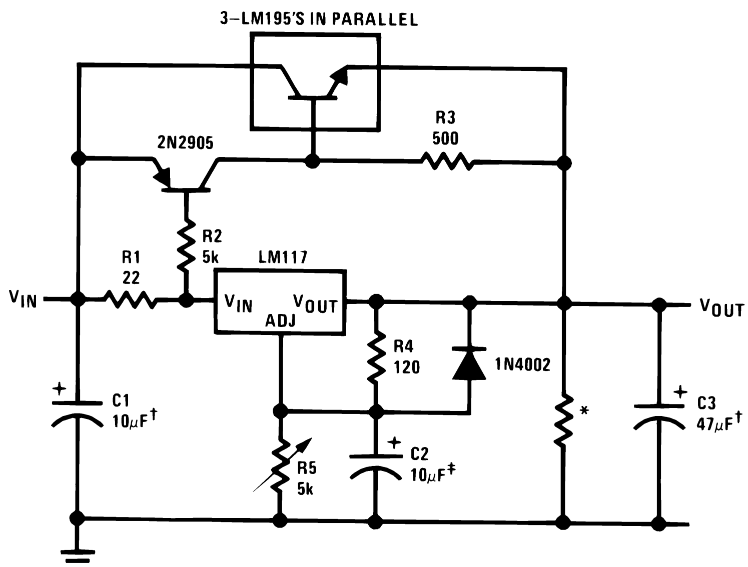
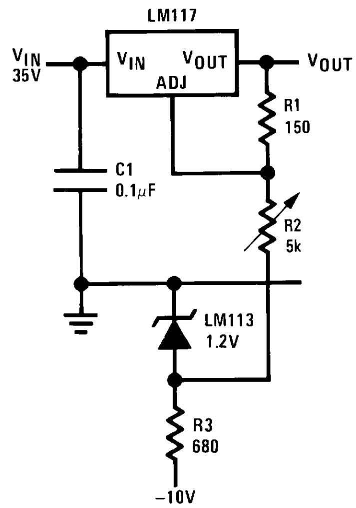


Figure 22. High Stability 10V Regulator



‡Optional—improves ripple rejection
†Solid tantalum
*Minimum load current = 30 mA

Figure 23. High Current Adjustable Regulator



Full output current not available at high input-output voltages

Figure 24. 0 to 30V Regulator

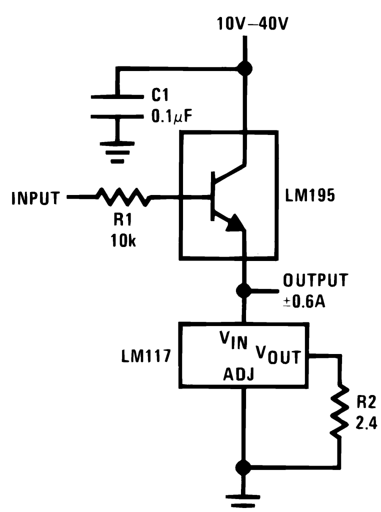
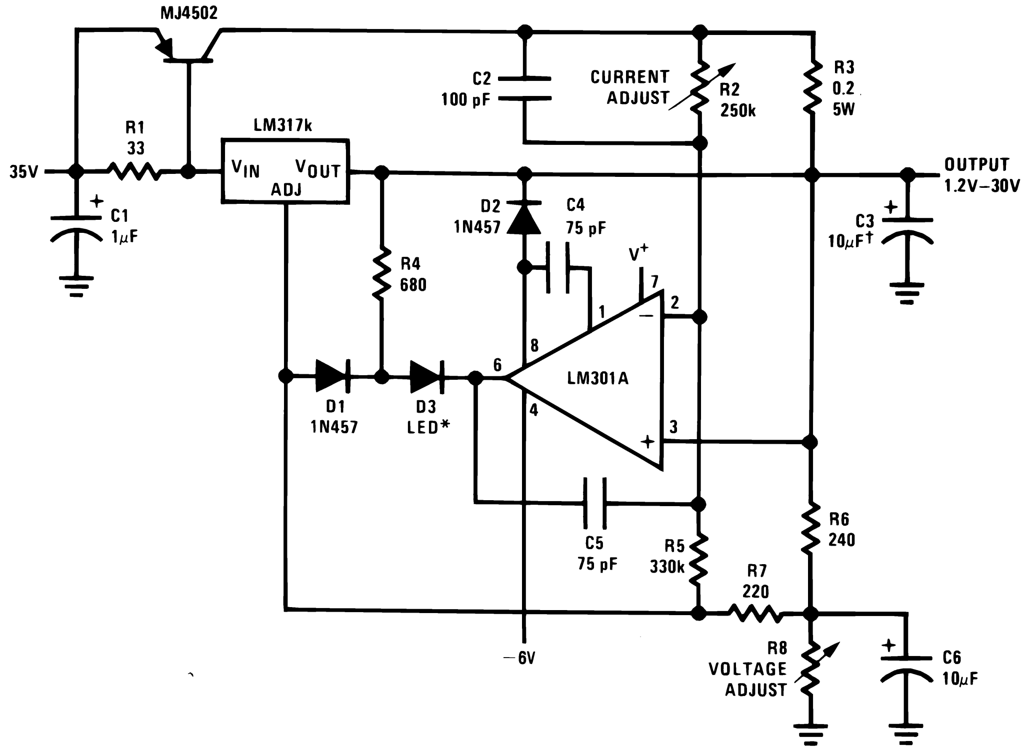


Figure 25. Power Follower



†Solid tantalum
*Lights in constant current mode

Figure 26. 5A Constant Voltage/Constant Current Regulator

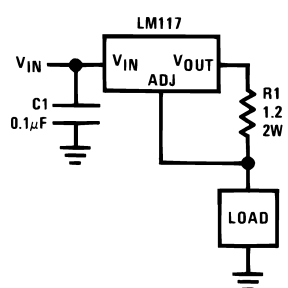
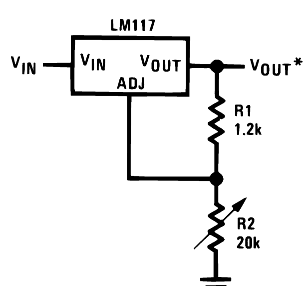


Figure 27. 1A Current Regulator



*Minimum load current ≅ 4 mA

Figure 28. 1.2V–20V Regulator with Minimum Program Current

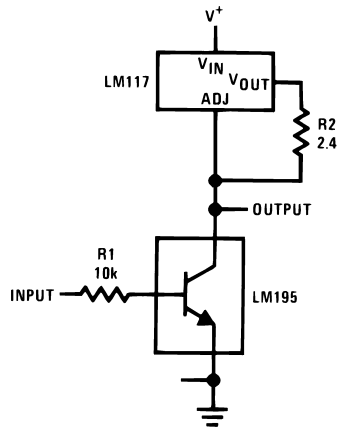
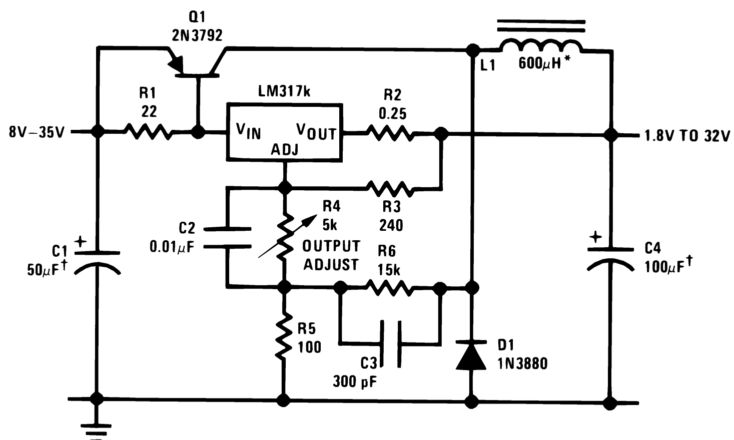


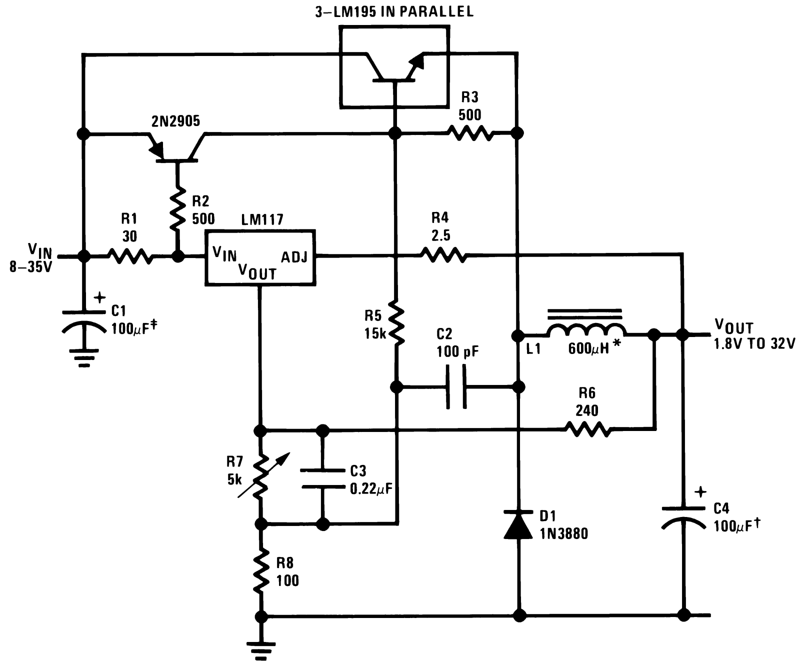
Figure 29. High Gain Amplifier



†Solid tantalum

*Core—Arnold A-254168-2 60 turns

Figure 30. Low Cost 3A Switching Regulator



†Solid tantalum
*Core—Arnold A-254168-2 60 turns

Figure 31. 4A Switching Regulator with Overload Protection

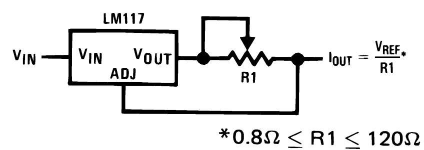


Figure 32. Precision Current Limiter

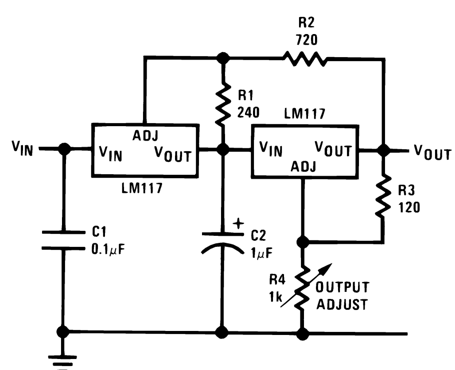
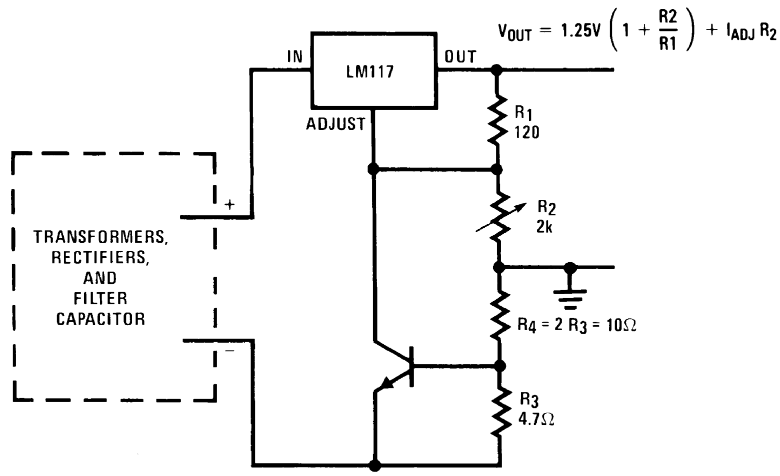


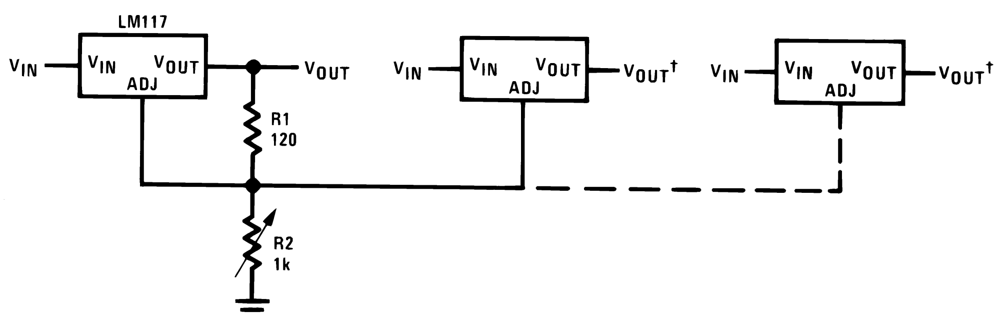
Figure 33. Tracking Preregulator



—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 ¾ volt of drop occurs in R_3 and R_4

Figure 34. Current Limited Voltage Regulator



*All outputs within ±100 mV
†Minimum load—10 mA

Figure 35. Adjusting Multiple On-Card Regulators with Single Control*

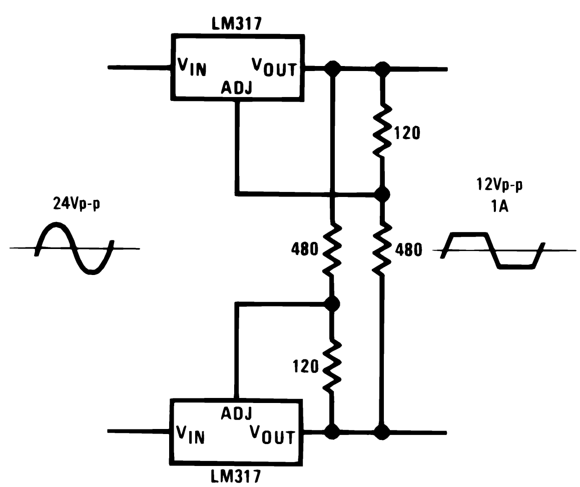
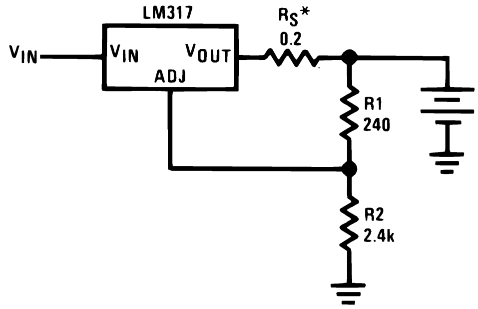


Figure 36. AC Voltage Regulator



*R_S—sets output impedance of charger: $Z_{OUT} = R_S \left(1 + \frac{R2}{R1}\right)$

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

Figure 37. 12V Battery Charger

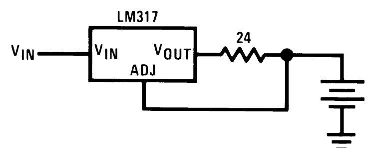


Figure 38. 50mA Constant Current Battery Charger

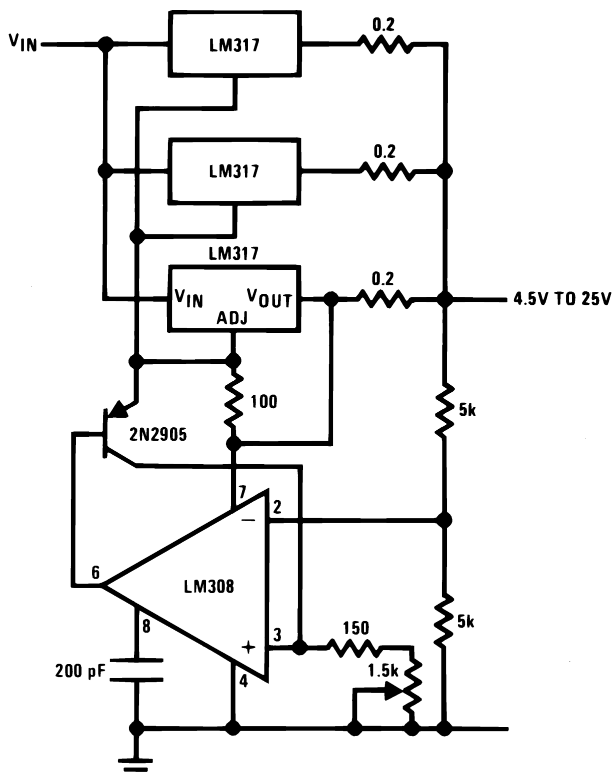
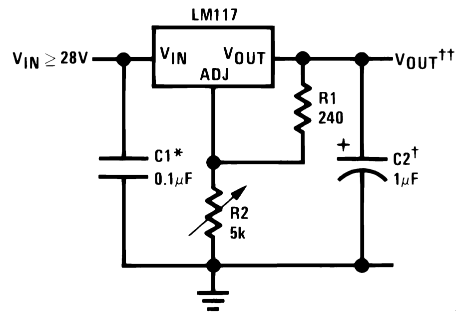


Figure 39. Adjustable 4A Regulator



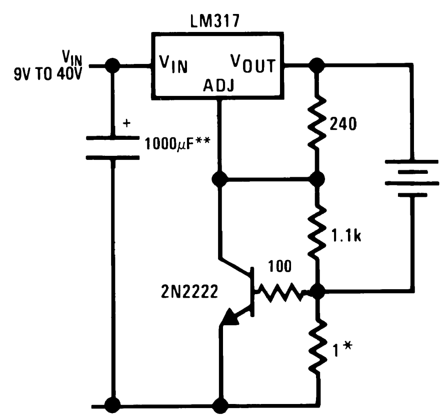
Full output current not available at high input-output voltages

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

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

$$\dagger\dagger V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}(R_2)$$

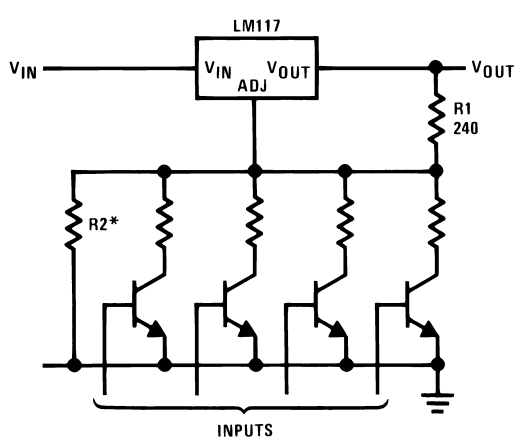
Figure 40. 1.2V–25V Adjustable Regulator



*Sets peak current (0.6A for 1Ω)

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

Figure 41. Current Limited 6V Charger



*Sets maximum V_{OUT}

Figure 42. Digitally Selected Outputs

REVISION HISTORY

Date Released	Revision	Section	Changes
03/17/06	A	New Release to corporate format	5 MDS data sheets were consolidated into one corporate data sheet format. Clarified ΔI_{Adj}/ Line versus ΔI_{Adj}/ Load by separating the parameters in all of the tables. MNLM117–K Rev 1C1, MNLM117–X Rev 0A0, MNLM117–E Rev 0B1, MRLM117–X-RH Rev 2A0, MRLM117–K-RH Rev 3A0 will be archived.
06/29/06	B	Features, Ordering Information Table, Rad Hard Electrical Section for PFM and CLGA packages and Notes	Deleted NSID LM117WGRQML, no longer available. Added Available with Radiation Guarantee, Low Dose NSID's to table 5962R9951705VXA LM117HRLQMLV, 5962R9951705VZA LM117WGRLQMLV, and reference to Note 11 and 12. Note 12 to Rad Hard Electrical Heading for PFM and CLGA packages. Note 12 to Notes. Archive Revision A.
11/30/2010	C	Features, Ordering Table, Absolute Ratings, LM117H, WG and K RH Drift Electrical Table	Added radiation info., Update with current device information and format, T0–39 Pkg weight, Vo (Recov). Revision B will be Archived.
09/06/2011	D	Ordering Information, Absolute Ratings	Order Info: Added 'GW' NSIDS and SMD numbers. Abs Max Ratings: Added 'GW' Theta JA and Theta JC along with 'GW' weight. Revision C will be Archived. Deleted Ordering Information table.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
5962R9951703V9A	ACTIVE	DIESALE	Y	0	42	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
5962R9951703VXA	ACTIVE	TO	NDT	3	20	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117HRQMLV 5962R9951703VXA Q ACO 5962R9951703VXA Q >T	Samples
5962R9951704VYA	ACTIVE	TO	K	2	50	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117KRQMLV 5962R99517 04VYA Q ACO 04VYA Q >T	Samples
5962R9951705V9A	ACTIVE	DIESALE	Y	0	42	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
5962R9951705VXA	ACTIVE	TO	NDT	3	20	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117HRLQMLV 5962R9951705VXA Q ACO 5962R9951705VXA Q >T	Samples
5962R9951706VZA	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	-55 to 125	LM117GWR QMLV Q 5962R99517 06VZA ACO 06VZA >T	Samples
5962R9951707VZA	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	-55 to 125	LM117GWRL QMLV Q 5962R99517 07VZA ACO 07VZA >T	Samples
LM117E/883	ACTIVE	LCCC	NAJ	20	50	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117E /883 Q ACO /883 Q >T	Samples
LM117GWRLQMLV	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	-55 to 125	LM117GWRL QMLV Q 5962R99517 07VZA ACO 07VZA >T	Samples
LM117GWRQMLV	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	-55 to 125	LM117GWR QMLV Q 5962R99517 06VZA ACO 06VZA >T	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM117H MDE	ACTIVE	DIESALE	Y	0	42	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
LM117H MDR	ACTIVE	DIESALE	Y	0	42	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125		Samples
LM117H/883	ACTIVE	TO	NDT	3	20	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117H/883 Q ACO LM117H/883 Q >T	Samples
LM117HRLQMLV	ACTIVE	TO	NDT	3	20	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117HRLQMLV 5962R9951705VXA Q ACO 5962R9951705VXA Q >T	Samples
LM117HRQMLV	ACTIVE	TO	NDT	3	20	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117HRQMLV 5962R9951703VXA Q ACO 5962R9951703VXA Q >T	Samples
LM117K/883	ACTIVE	TO	K	2	50	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117K /883 Q ACO /883 Q >T	Samples
LM117KRQMLV	ACTIVE	TO	K	2	50	TBD	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM117KRQMLV 5962R99517 04VYA Q ACO 04VYA Q >T	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.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

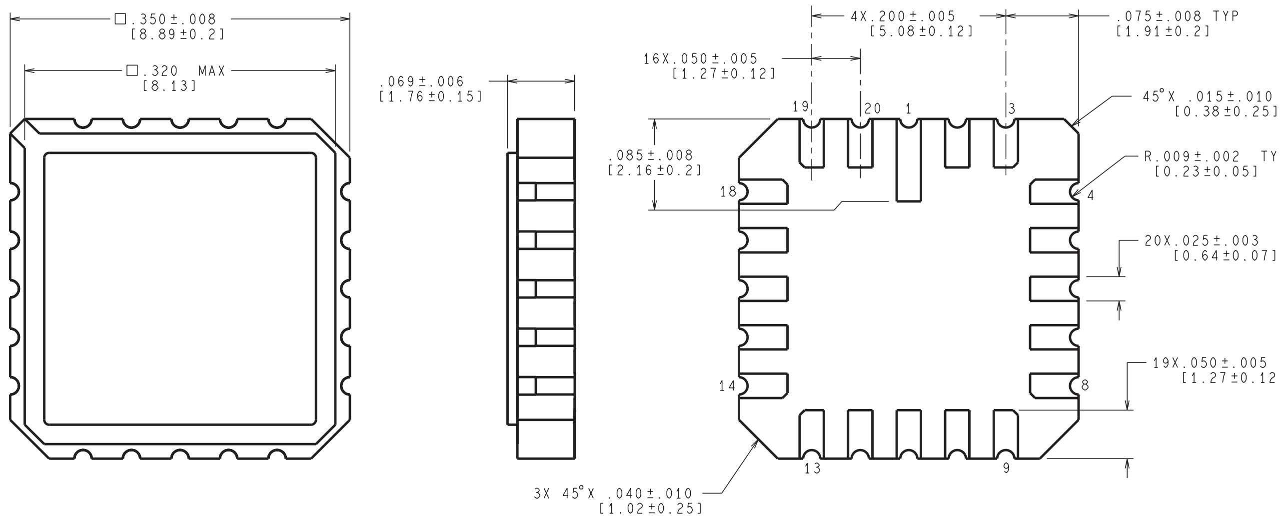
OTHER QUALIFIED VERSIONS OF LM117QML, LM117QML-SP :

- Military: LM117QML
- Space: LM117QML-SP

NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

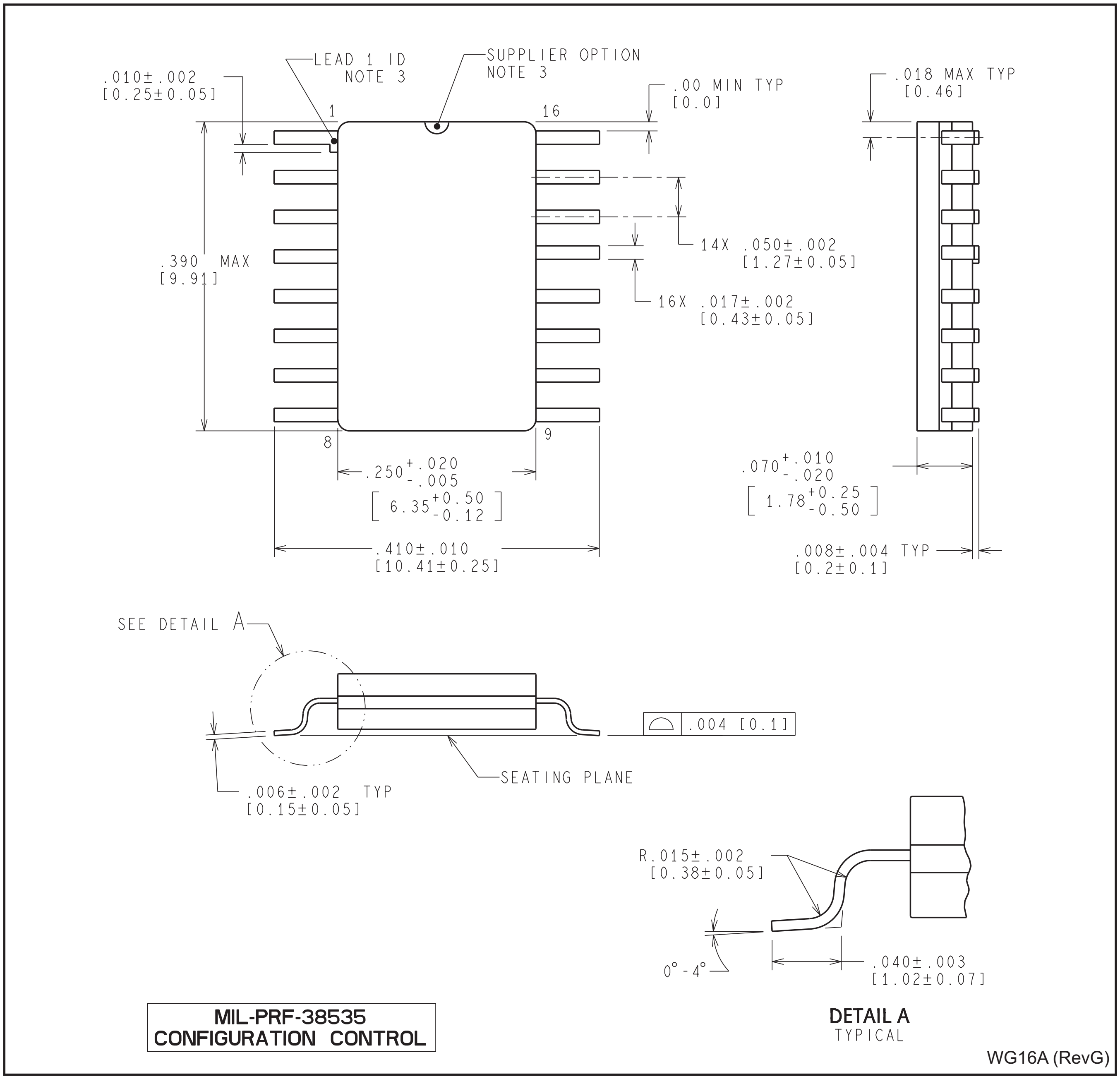
NAJ0020A



CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

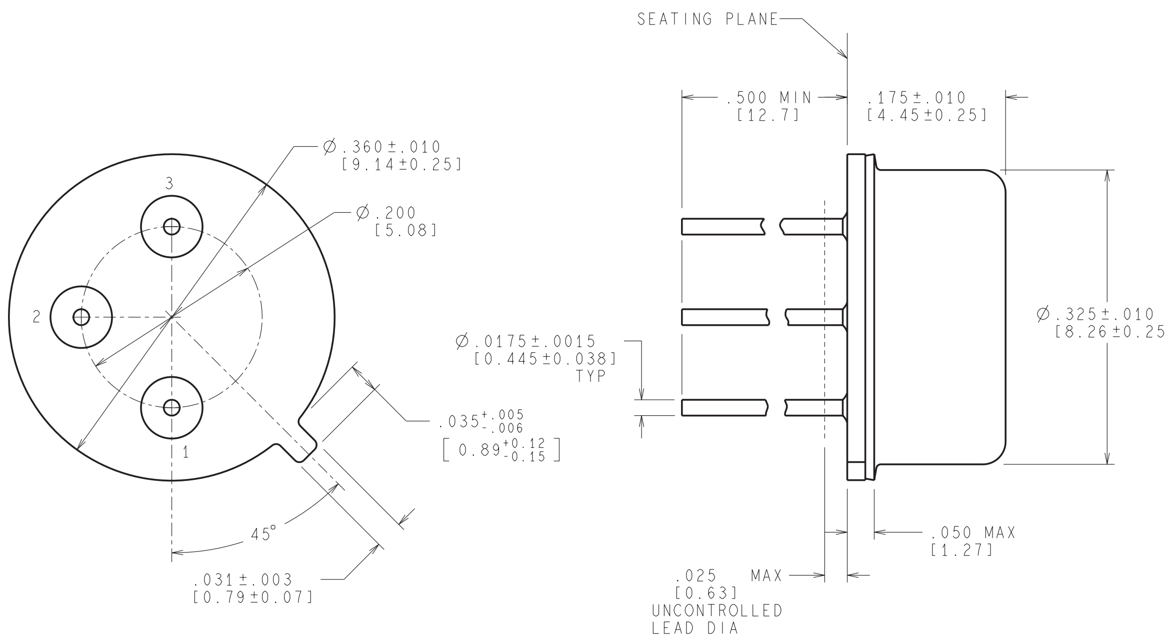
E20A (Rev F)

NAC0016A



LEAD 1 ID
NOTE 3
SUPPLIER OPTION
NOTE 3
.010±.002
[0.25±0.05]
1
16
.00 MIN TYP
[0.0]
.018 MAX TYP
[0.46]
14X .050±.002
[1.27±0.05]
.390 MAX
[9.91]
16X .017±.002
[0.43±0.05]
8
9
.250 +.020 -.005
[6.35 +0.50 -0.12]
.070 +.010 -.020
[1.78 +0.25 -0.50]
.410±.010
[10.41±0.25]
.008±.004 TYP
[0.2±0.1]
SEE DETAIL A
.004 [0.1]
SEATING PLANE
.006±.002 TYP
[0.15±0.05]
R.015±.002
[0.38±0.05]
0°-4°
.040±.003
[1.02±0.07]
MIL-PRF-38535
CONFIGURATION CONTROL
DETAIL A
TYPICAL
WG16A (RevG)

NDT0003A



CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265