

National Semiconductor is now part of
Texas Instruments.

Search <http://www.ti.com/> for the latest technical
information and details on our current products and services.

LM117QML

3-Terminal Adjustable Regulator

General 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.

Features

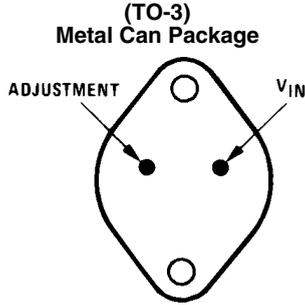
- Available with Radiation Guarantee
 - High Dose Rate 100 krad(Si)
 - ELDRS Free 100 krad(Si)
- Guaranteed max. 0.3% load regulation (LM117)
- Guaranteed 0.5A or 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- 80 dB ripple rejection
- Output is short-circuit protected

Ordering Information

NS Part Number	SMD Part Number	NS Package Number	Package Description
LM117E/883		E20A	20LD LCC
LM117H/883		H03A	3LD T0-39 Metal Can
LM117HRQMLV (Note 12)	5962R9951703VXA 100 krad(Si)	H03A	3LD T0-39 Metal Can
LM117HRLQMLV (Note 13) ELDRS Free	5962R9951705VXA 100 krad(Si)	H03A	3LD T0-39 Metal Can
LM117K/883		K02C	2LD T0-3 Metal Can
LM117KRQMLV (Note 12)	5962R9951704VYA 100 krad(Si)	K02C	2LD T0-3 Metal Can
LM117WGRQMLV (Note 12)	5962R9951703VZA 100 krad(Si)	WG16A	16LD Ceramic SOIC
LM117WGRLQMLV (Note 13) ELDRS Free	5962R9951705VZA 100 krad(Si)	WG16A	16LD Ceramic SOIC
LM117GWRQMLV (Note 12)	5962R9951706VZA 100 krad(Si)	WG16A	16LD Ceramic SOIC
LM117GWRLQMLV (Note 13) ELDRS Free	5962R9951707VZA 100 krad(Si)	WG16A	16LD Ceramic SOIC
LM117H MDE (Note 13) ELDRS Free	5962R9951705V9A 100 krad(Si)	(Note 1)	Bare Die
LM117H MDR (Note 12)	5962R9951703V9A 100 krad(Si)	(Note 1)	Bare Die
LM117H MD8		(Note 1)	Bare Die
LM117KG MD8		(Note 1)	Bare Die

Note 1: FOR ADDITIONAL DIE INFORMATION, PLEASE VISIT THE HI REL WEB SITE AT: www.national.com/analog/space/level_die

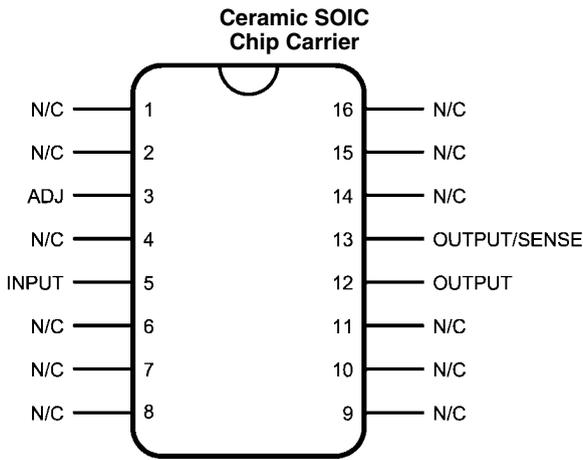
Connection Diagrams



CASE IS OUTPUT

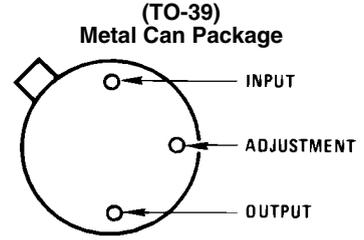
20143630

Bottom View
Steel Package
NS Package Number K02C



Top View
NS Package Number WG16A
(Note 5)

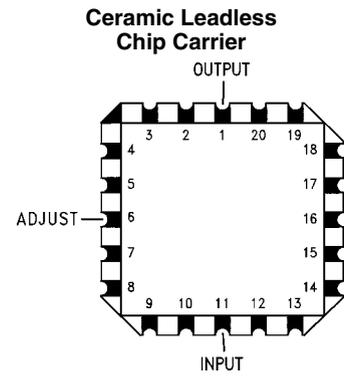
20143667



CASE IS OUTPUT

20143631

Bottom View
NS Package Number H03A



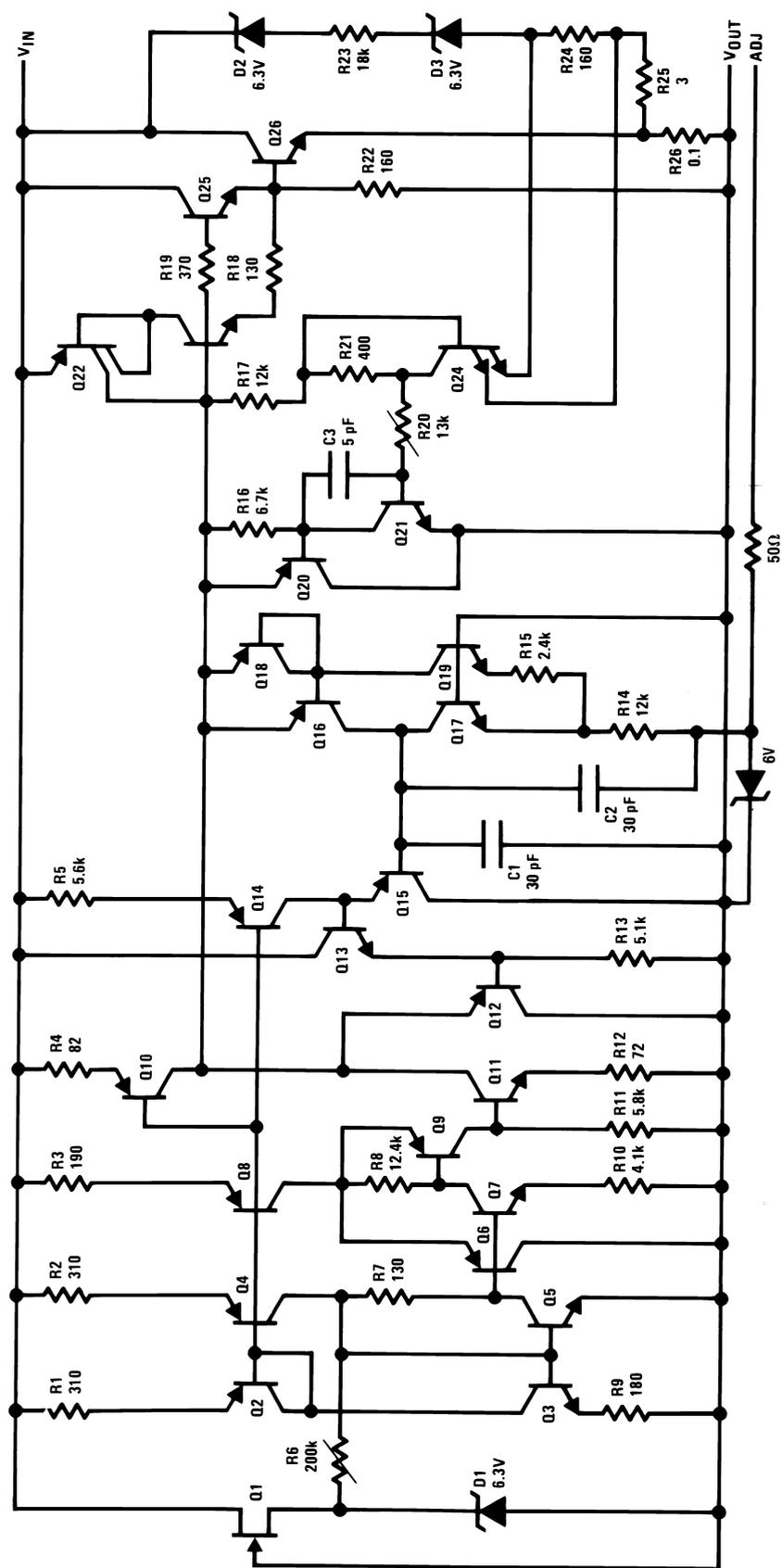
Top View
NS Package Number E20A

20143634

LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO-3	1.5A
H	TO-39	0.5A
WG, GW	Ceramic SOIC	0.5A
E	LCC	0.5A

Schematic Diagram



20143608

Absolute Maximum Ratings *(Note 2)*

Power Dissipation <i>(Note 3)</i>	Internally Limited
Input-Output Voltage Differential	+40V, -0.3V
Storage Temperature	$-65^{\circ}\text{C} \leq T_A \leq +150^{\circ}\text{C}$
Maximum Junction Temperature (T_{Jmax})	+150°C
Lead Temperature Metal Package	300°C
Thermal Resistance	
θ_{JA}	
TO-3 Still Air	39°C/W
TO-3 500LF/Min Air flow	14°C/W
TO-39 Still Air	186°C/W
TO-39 500LF/Min Air flow	64°C/W
Ceramic SOIC Still Air "WG"	115°C/W
Ceramic SOIC 500LF/Min Air flow "WG"	66°C/W
Ceramic SOIC Still Air "GW"	130°C/W
Ceramic SOIC 500LF/Min Air flow "GW"	80°C/W
LCC Still Air	88°C/W
LCC 500LF/Min Air flow	62°C/W
θ_{JC}	
TO-3	1.9°C/W
TO-39 Metal Can	21°C/W
Ceramic SOIC "WG" <i>(Note 6)</i>	3.4°C/W
Ceramic SOIC "GW"	7°C/W
LCC	12°C/W
Package Weight	
TO-39 Metal Can	960mg
SOIC "WG"	365mg
SOIC "GW"	410mg
ESD Tolerance <i>(Note 4)</i>	3KV

Recommended Operating Conditions

Operating Temperature Range	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$
Input Voltage Range	4.25V to 41.25V

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 & WG 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	$3V \leq V_{Diff} \leq 40V,$ $V_O = 1.2V$		-8.9	8.9	mV	1
		$3.3V \leq V_{Diff} \leq 40V,$ $V_O = 1.2V$		-22.2	22.2	mV	2, 3
V_{RLoad}	Load Regulation	$V_{Diff} = 3V,$ $I_L = 10mA \text{ to } 500mA$		-15	15	mV	1
		$V_{Diff} = 3.3V,$ $I_L = 10mA \text{ to } 500mA$		-15	15	mV	2, 3
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 150mA$		-15	15	mV	1
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 100mA$		-15	15	mV	2, 3
$\Delta I_{Adj} / \text{Load}$	Adjustment Current Change	$V_{Diff} = 3V,$ $I_L = 10mA \text{ to } 500mA$		-5.0	5.0	μA	1
		$V_{Diff} = 3.3V,$ $I_L = 10mA \text{ to } 500mA$		-5.0	5.0	μA	2, 3
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 150mA$		-5.0	5.0	μA	1
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 100mA$		-5.0	5.0	μA	2, 3
$\Delta I_{Adj} / \text{Line}$	Adjustment Current Change	$3V \leq V_{Diff} \leq 40V$		-5.0	5.0	μA	1
		$3.3V \leq V_{Diff} \leq 40V$		-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	$T_A = 25^\circ C, t = 20mS, V_{Diff} = 40V,$ $I_L = 150mA$		-6.0	6.0	mV	1
I_{CL}	Current Limit	$V_{Diff} \leq 15V$	(Note 7)	0.5		A	1, 2, 3
		$V_{Diff} = 40V$	(Note 7)	0.15		A	1

AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	$V_I = +6.25V, V_O = V_{Ref},$ $f = 120Hz, e_1 = 1V_{RMS},$ $I_L = 125mA$	(Note 8)	66		dB	4, 5, 6

LM117K Electrical Characteristics

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	$3V \leq V_{Diff} \leq 40V,$ $V_O = 1.2V$		-8.9	8.9	mV	1
		$3.3V \leq V_{Diff} \leq 40V,$ $V_O = 1.2V$		-22.2	22.2	mV	2, 3
V_{RLoad}	Load Regulation	$V_{Diff} = 3V,$ $I_L = 10mA \text{ to } 1.5A$		-15	15	mV	1
		$V_{Diff} = 3.3V,$ $I_L = 10mA \text{ to } 1.5A$		-15	15	mV	2, 3
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 300mA$		-15	15	mV	1
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 195mA$		-15	15	mV	2, 3
$\Delta I_{Adj} / \text{Load}$	Adjustment Current Change	$V_{Diff} = 3V,$ $I_L = 10mA \text{ to } 1.5A$		-5.0	5.0	μA	1
		$V_{Diff} = 3.3V,$ $I_L = 10mA \text{ to } 1.5A$		-5.0	5.0	μA	2, 3
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 300mA$		-5.0	5.0	μA	1
		$V_{Diff} = 40V,$ $I_L = 10mA \text{ to } 195mA$		-5.0	5.0	μA	2, 3
$\Delta I_{Adj} / \text{Line}$	Adjustment Current Change	$3V \leq V_{Diff} \leq 40V$		-5.0	5.0	μA	1
		$3.3V \leq V_{Diff} \leq 40V$		-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	$T_A = 25^\circ C, t = 20mS,$ $V_{Diff} = 40V, I_L = 300mA$		-10.5	10.5	mV	1
I_{CL}	Current Limit	$V_{Diff} \leq 15V$	(Note 7)	1.5		A	1, 2, 3
		$V_{Diff} = 40V$	(Note 7)	0.3		A	1

AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	$V_I = +6.25V, V_O = V_{Ref},$ $f = 120Hz, e_1 = 1V_{RMS},$ $I_L = 0.5A$	(Note 8)	66		dB	4, 5, 6

LM117E Electrical Characteristics

DC Parameters

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

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
I_{Adj}	Adjustment Pin Current	$V_{\text{Diff}} = 3\text{V}$			100	μA	1
		$V_{\text{Diff}} = 3.3\text{V}$			100	μA	2, 3
		$V_{\text{Diff}} = 40\text{V}$			100	μA	1, 2, 3
I_Q	Minimum Load Current	$V_{\text{Diff}} = 3\text{V}$, $V_O = 1.7\text{V}$			5.0	mA	1
		$V_{\text{Diff}} = 3.3\text{V}$, $V_O = 1.7\text{V}$			5.0	mA	2, 3
		$V_{\text{Diff}} = 40\text{V}$, $V_O = 1.7\text{V}$			5.0	mA	1, 2, 3
V_{Ref}	Reference Voltage	$V_{\text{Diff}} = 3\text{V}$		1.2	1.3	V	1
		$V_{\text{Diff}} = 3.3\text{V}$		1.2	1.3	V	2, 3
		$V_{\text{Diff}} = 40\text{V}$		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	$3\text{V} \leq V_{\text{Diff}} \leq 40\text{V}$, $V_O = 1.2\text{V}$		-8.9	8.9	mV	1
		$3.3\text{V} \leq V_{\text{Diff}} \leq 40\text{V}$, $V_O = 1.2\text{V}$		-22.2	22.2	mV	2, 3
V_{RLoad}	Load Regulation	$V_{\text{Diff}} = 3\text{V}$, $I_L = 10\text{mA}$ to 100mA		-15	15	mV	1
		$V_{\text{Diff}} = 3.3\text{V}$, $I_L = 10\text{mA}$ to 100mA		-15	15	mV	2, 3
		$V_{\text{Diff}} = 40\text{V}$, $I_L = 10\text{mA}$ to 100mA		-15	15	mV	1,2
				-25	25	mV	3
		$V_{\text{Diff}} = 3\text{V}$, $I_L = 10\text{mA}$ to 500mA		-15	15	mV	1
$\Delta I_{\text{Adj}} / \text{Load}$	Adjustment Current Change	$V_{\text{Diff}} = 3\text{V}$, $I_L = 10\text{mA}$ to 500mA		-5.0	5.0	μA	1
		$V_{\text{Diff}} = 3.3\text{V}$, $I_L = 10\text{mA}$ to 500mA		-5.0	5.0	μA	2, 3
		$V_{\text{Diff}} = 40\text{V}$, $I_L = 10\text{mA}$ to 100mA		-5.0	5.0	μA	1, 2, 3
$\Delta I_{\text{Adj}} / \text{Line}$	Adjustment Current Change	$3\text{V} \leq V_{\text{Diff}} \leq 40\text{V}$		-5.0	5.0	μA	1
		$3.3\text{V} \leq V_{\text{Diff}} \leq 40\text{V}$		-5.0	5.0	μA	2, 3
I_{OS}	Short Circuit Current	$V_{\text{Diff}} = 10\text{V}$		0.45	1.6	A	1
θ_R	Thermal Regulation	$T_A = 25^\circ\text{C}$, $t = 20\text{mS}$, $V_{\text{Diff}} = 40\text{V}$, $I_L = 75\text{mA}$		-6.0	6.0	mV	1
I_{CL}	Current Limit	$V_{\text{Diff}} \leq 15\text{V}$	(Note 7)	0.5		A	1, 2, 3
		$V_{\text{Diff}} = 40\text{V}$	(Note 7)	0.15		A	1

AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
RR	Ripple Rejection	$V_I = +6.25\text{V}$, $V_O = V_{\text{Ref}}$, $f = 120\text{Hz}$, $e_1 = 1V_{\text{RMS}}$, $I_L = 100\text{mA}$, $C_{\text{Adj}} = 10\mu\text{f}$	(Note 8)	66		dB	4, 5, 6

LM117H & WG RH Electrical Characteristics

DC Parameters (Note 12, Note 13)

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
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	(Note 9)	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

AC Parameters (Note 12, Note 13)

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

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	$4.25V \leq V_I \leq 41.25V,$ $I_L = -5mA$		-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	$V_I = 4.25V, R_L = 2.5\Omega,$ $C_L = 20\mu f$		-0.01	0.01	V	1
		$V_I = 40V, R_L = 250\Omega$		-0.01	0.01	V	1

AC/DC Post Radiation Limits @ +25°C (Note 12, Note 13)

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	$4.25V \leq V_I \leq 41.25V,$ $I_L = -5mA$		-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	$V_I = 4.25V, R_L = 2.5\Omega,$ $C_L = 20\mu f$		1.20	1.350	V	1
		$V_I = 40V, R_L = 250\Omega$		1.20	1.350	V	1

LM117K RH Electrical Characteristics

DC Parameters (Note 12)

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	(Note 9)	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

AC Parameters (Note 12)

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
ΔV _O / ΔV _I	Line Transient Response	V _I = 6.25V, ΔV _I = 3V, I _L = -10mA	(Note 10)		18	mV	7
ΔV _O / ΔI _L	Load Transient Response	V _I = 6.25V, ΔI _L = -400mA, I _L = -100mA	(Note 11)		120	mV	7
ΔV _I / ΔV _O	Ripple Rejection	V _I = 6.25V, I _L = -500mA, E _I = 1V _{RMS} at f = 2400Hz		65		dB	4

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	$4.25V \leq V_I \leq 41.25V,$ $I_L = -5mA$		-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	$V_I = 4.25V, R_L = 0.833\Omega,$ $C_L = 20\mu S$		-0.01	0.01	V	1
		$V_I = 40V, R_L = 250\Omega$		-0.01	0.01	V	1

AC/DC Post Radiation Limits @ +25°C (Note 12)

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
		$V_I = 4.25V, I_L = -1.5A$		1.2	1.350	V	1
		$V_I = 41.25V, I_L = -5mA$		1.2	1.350	V	1
		$V_I = 41.25V, I_L = -200mA$		1.2	1.350	V	1
V_{RLine}	Line Regulation	$4.25V \leq V_I \leq 41.25V,$ $I_L = -5mA$		-25	25	mV	1
V_{RLoad}	Load Regulation	$V_I = 6.25V,$ $-1.5A \leq I_L \leq -5mA$		-7.0	7.0	mV	1
		$V_I = 41.25V,$ $-200mA \leq I_L \leq -5mA$		-7.0	7.0	mV	1
$\Delta V_I / \Delta V_O$	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	$V_I = 4.25V, R_L = 0.833\Omega,$ $C_L = 20\mu S$		1.20	1.350	V	1
		$V_I = 40V, R_L = 250\Omega$		1.20	1.350	V	1

Note 2: 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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 3: 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 TO39, LCC, and ceramic SOIC packages, and 20W for the TO3 package."

Note 4: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Note 5: For the Ceramic SOIC device to function properly, the "Output" and "Output/Sense" pins must be connected on the users printed circuit board.

Note 6: 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.

Note 7: Guaranteed parameter, not tested.

Note 8: Tested @ 25°C; guaranteed, but not tested @ 125°C & -55°C

Note 9: Tested @ $T_A = 125^\circ\text{C}$, correlated to $T_A = 150^\circ\text{C}$

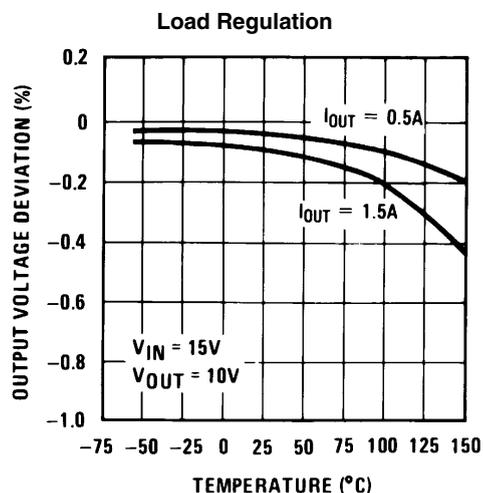
Note 10: SMD limit of 6mV/V is equivalent to 18mV

Note 11: SMD limit of 0.3mV/V is equivalent to 120mV

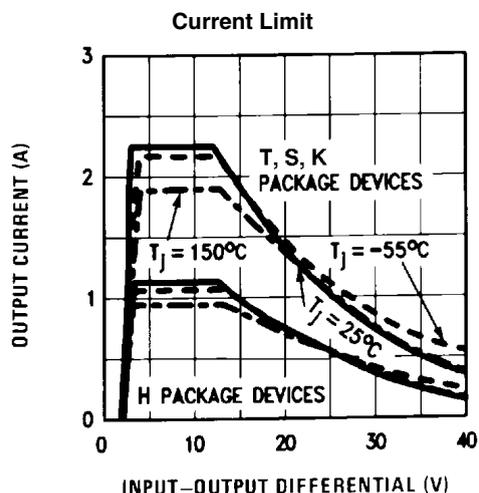
Note 12: Pre and post irradiation limits are identical to those listed under AC and DC electrical characteristics except as listed in the "Post Radiation Limits" table. These parts may be dose rate sensitive in a space environment and demonstrate enhanced low dose rate effect. Radiation end point limits for the noted parameters are guaranteed only for the conditions as specified in Mil-Std-883, Method 1019.5, Condition A.

Note 13: 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.

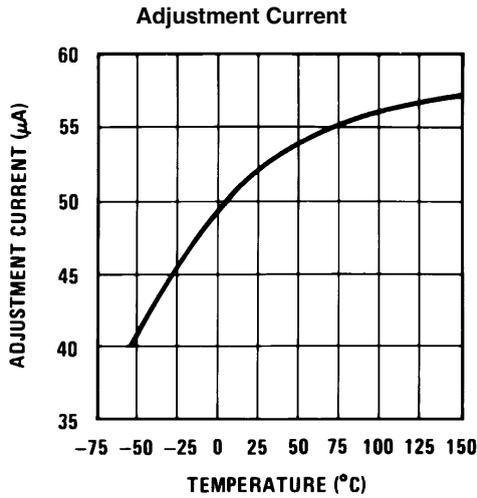
Typical Performance Characteristics Output Capacitor = 0 μ F unless otherwise noted



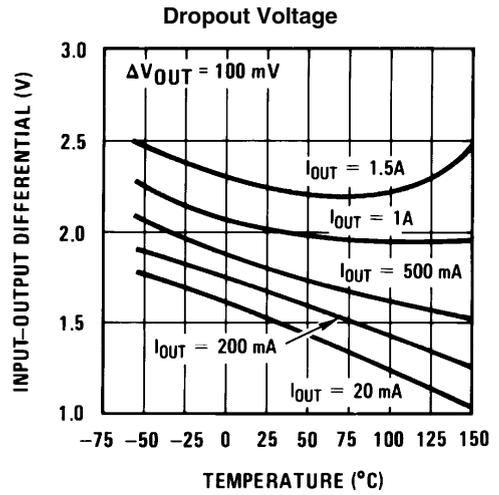
20143637



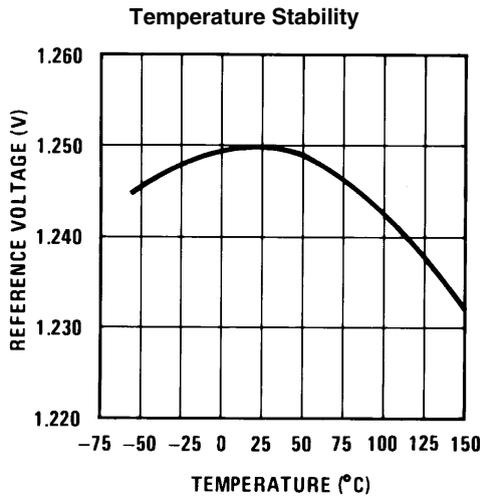
20143638



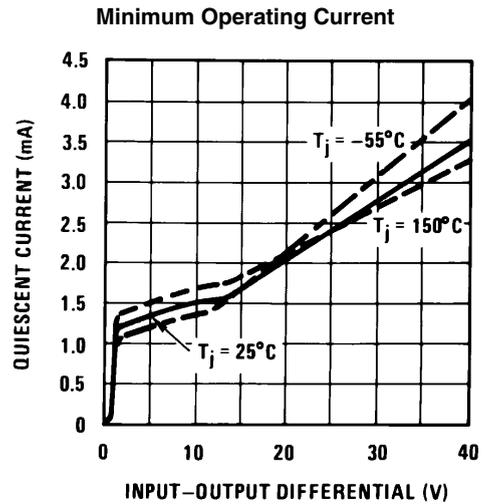
20143639



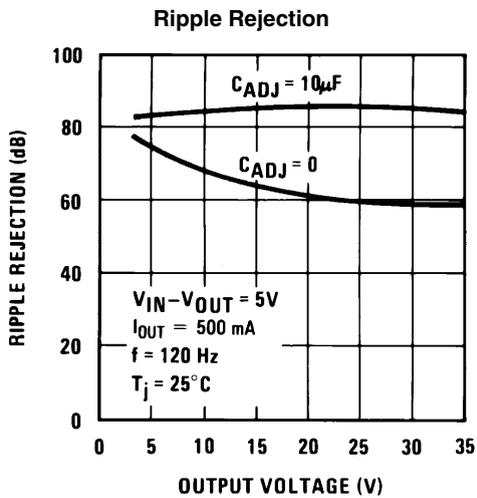
20143640



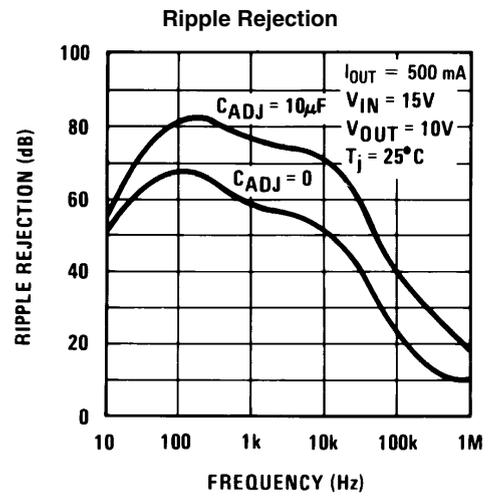
20143641



20143642

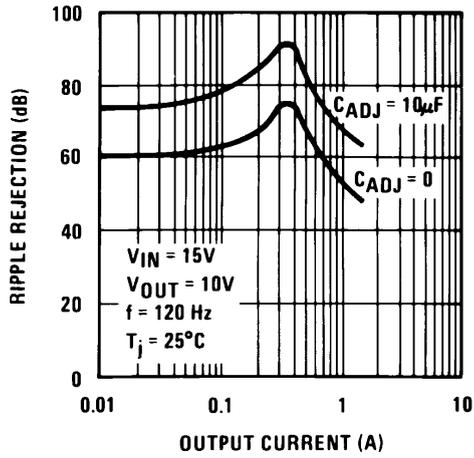


20143643



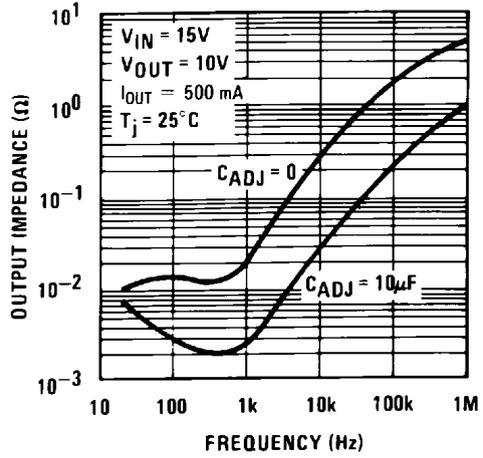
20143644

Ripple Rejection



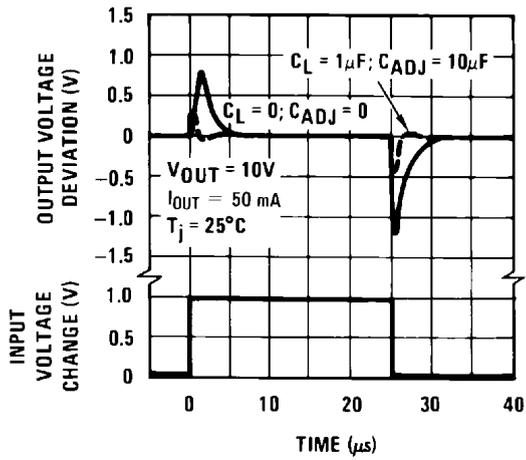
20143645

Output Impedance



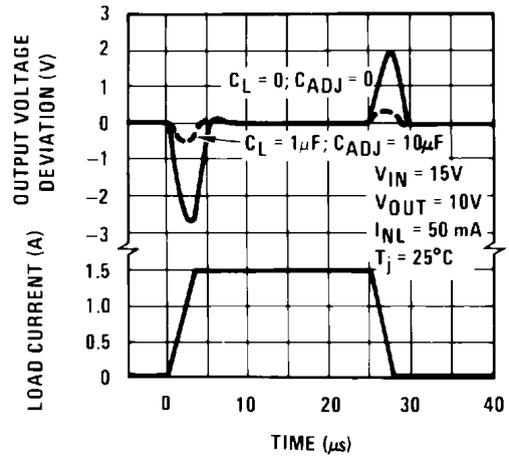
20143646

Line Transient Response



20143647

Load Transient Response



20143648

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

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

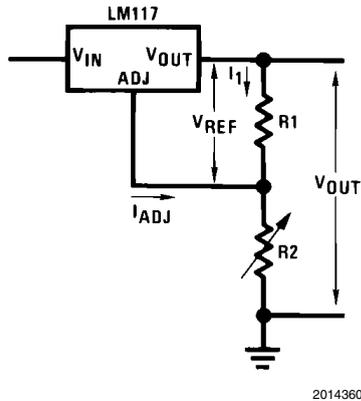


FIGURE 1.

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 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 0.1 μ F disc or 1 μ F 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 10 μ F bypass capacitor 80dB ripple rejection is obtainable at any output level. Increases over 10 μ F 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 25 μ F in aluminum electrolytic to equal 1 μ F 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, 0.01 μ F disc may seem to work better than a 0.1 μ F 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 be-

tween 500 pF and 5000 pF. A 1 μ F solid tantalum (or 25 μ F aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10 μ F 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 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 15V 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 $0.05\Omega (1 + R2/R1)$ or in this case, 11.5 times worse.

Figure 2 shows the effect of resistance between the regulator and 240 Ω set resistor.

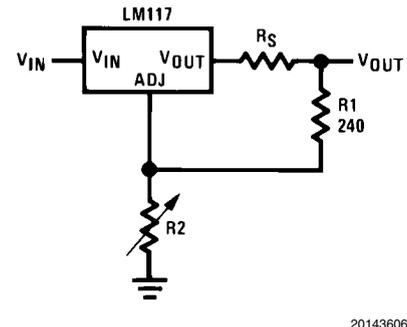


FIGURE 2. Regulator with Line Resistance in Output Lead

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.

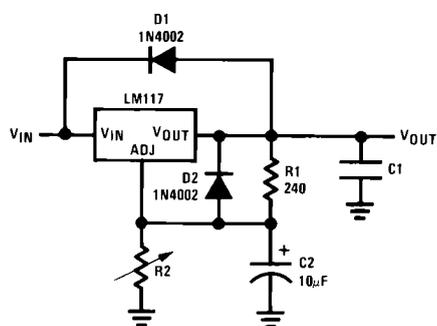
PROTECTION DIODES

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 10 μ F 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 25 μ F 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 50 Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and

10 μ F capacitance. *Figure 3* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



20143607

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

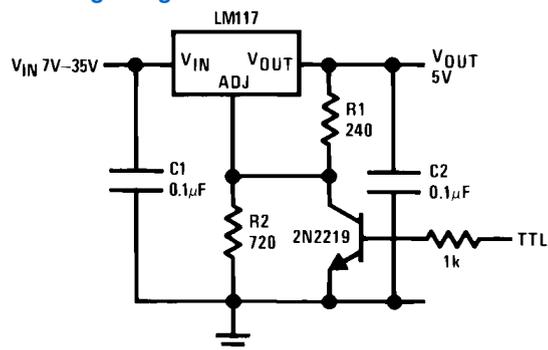
D1 protects against C1

D2 protects against C2

FIGURE 3. Regulator with Protection Diodes

Typical Applications

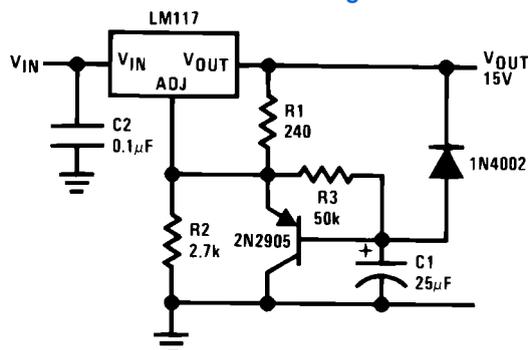
5V Logic Regulator with Electronic Shutdown*



20143603

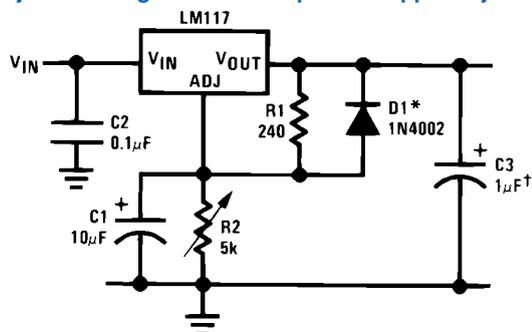
*Min. output \cong 1.2V

Slow Turn-On 15V Regulator



20143609

Adjustable Regulator with Improved Ripple Rejection

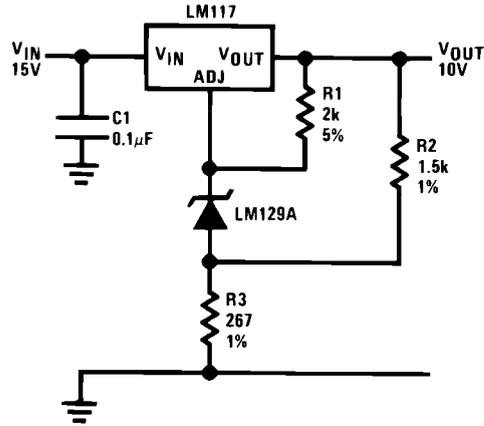


20143610

†Solid tantalum

*Discharges C1 if output is shorted to ground

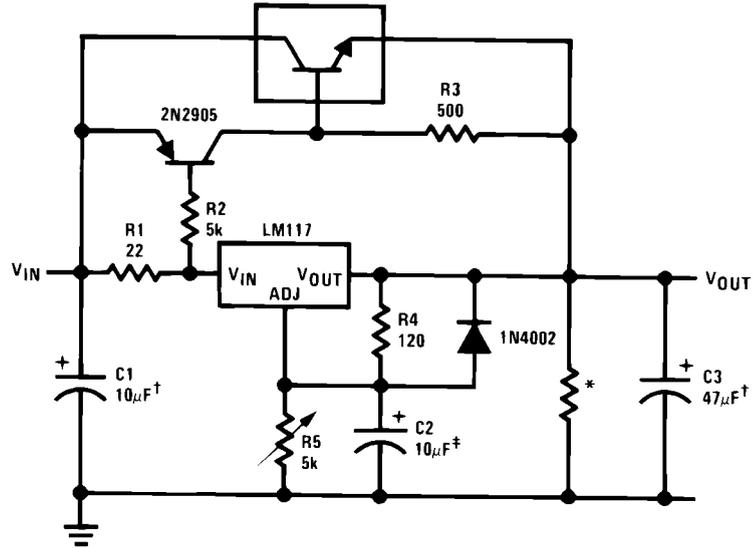
High Stability 10V Regulator



20143611

High Current Adjustable Regulator

3-LM195'S IN PARALLEL



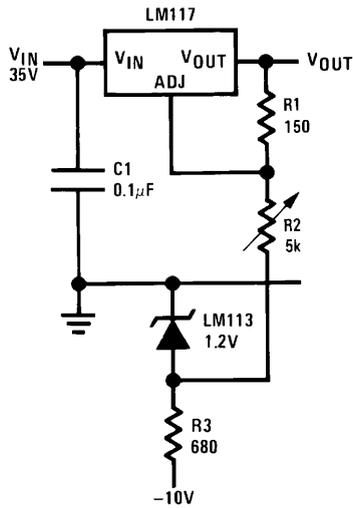
20143612

‡Optional—improves ripple rejection

†Solid tantalum

*Minimum load current = 30 mA

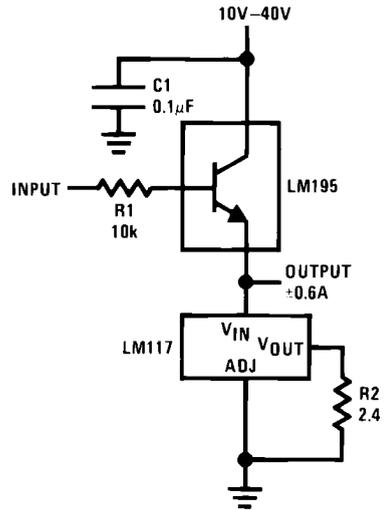
0 to 30V Regulator



20143613

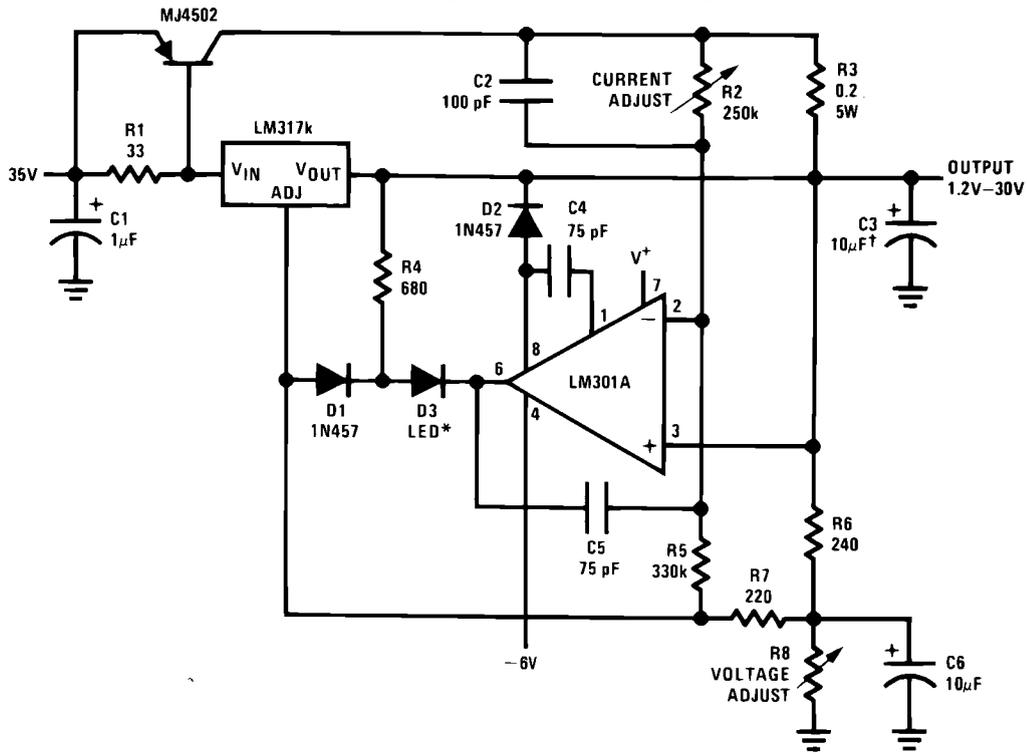
Full output current not available at high input-output voltages

Power Follower



20143614

5A Constant Voltage/Constant Current Regulator

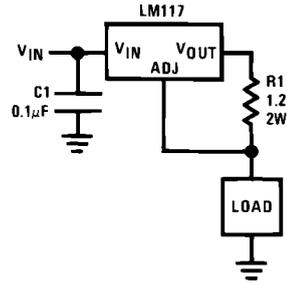


20143615

†Solid tantalum

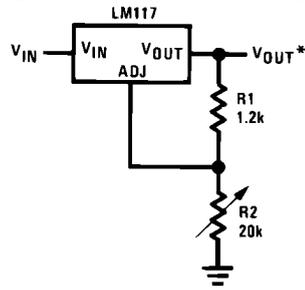
*Lights in constant current mode

1A Current Regulator



20143616

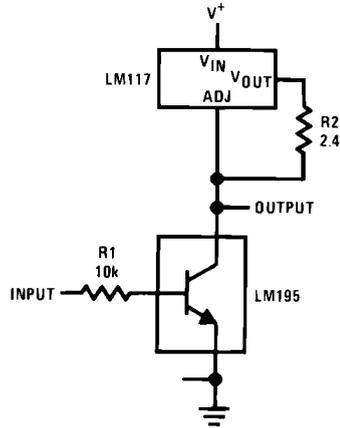
1.2V–20V Regulator with Minimum Program Current



20143617

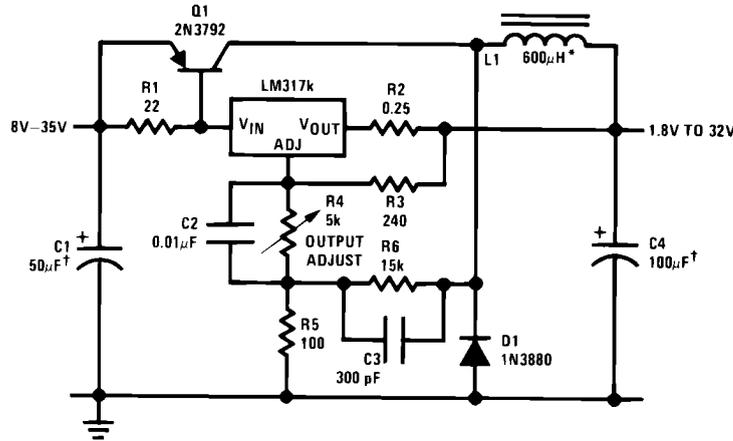
*Minimum load current \cong 4 mA

High Gain Amplifier



20143618

Low Cost 3A Switching Regulator

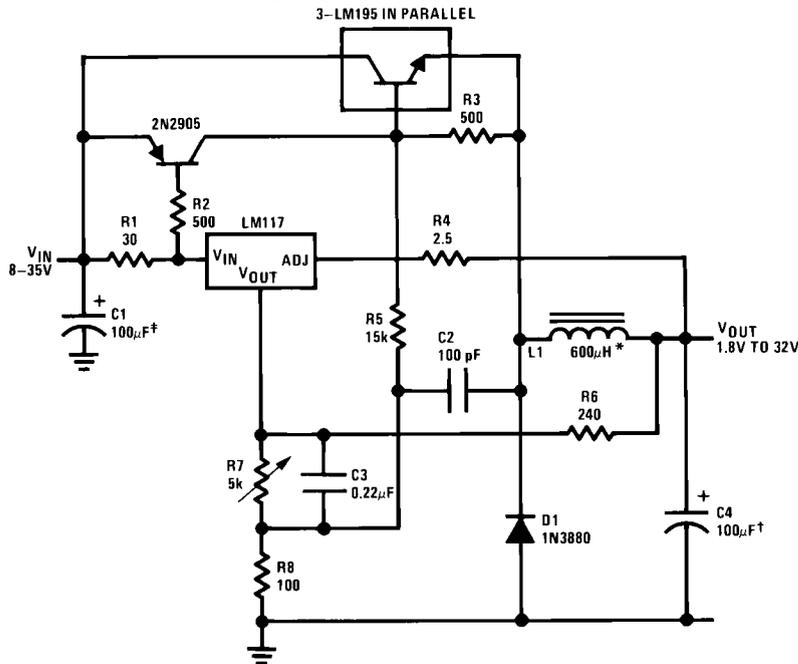


20143619

†Solid tantalum

*Core—Arnold A-254168-2 60 turns

4A Switching Regulator with Overload Protection

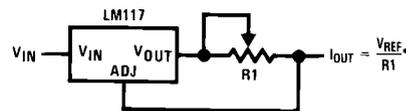


20143620

†Solid tantalum

*Core—Arnold A-254168-2 60 turns

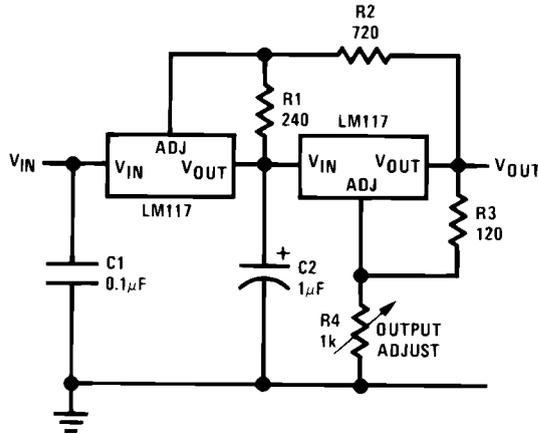
Precision Current Limiter



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

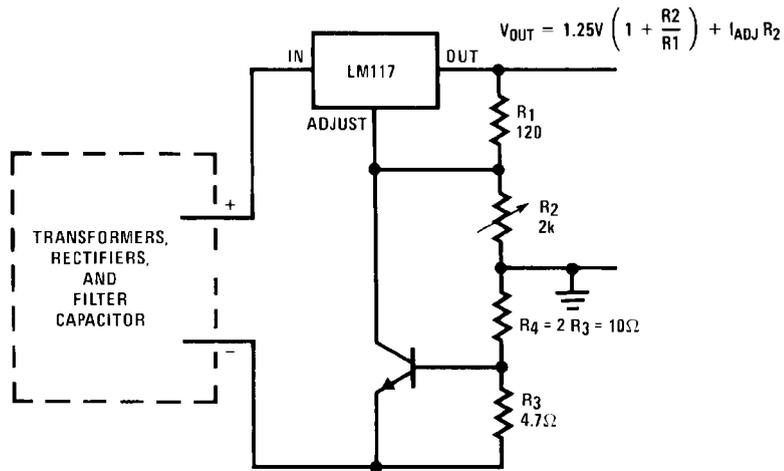
20143621

Tracking Preregulator



20143622

Current Limited Voltage Regulator



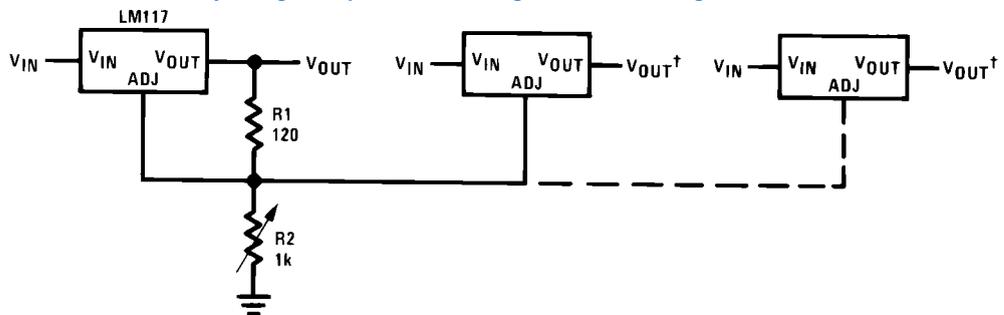
20143623

— Short circuit current is approximately $\frac{600 \text{ mV}}{R_3}$, or 120 mA

(Compared to LM117's higher current limit)

—At 50 mA output only ¼ volt of drop occurs in R_3 and R_4

Adjusting Multiple On-Card Regulators with Single Control*

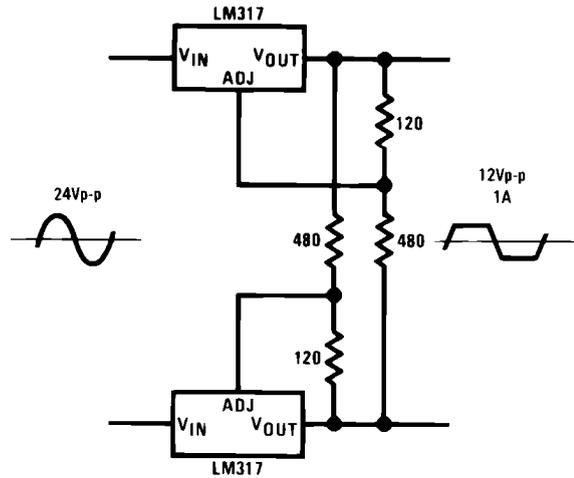


20143624

*All outputs within $\pm 100 \text{ mV}$

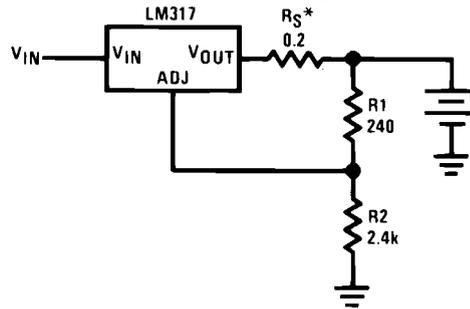
†Minimum load—10 mA

AC Voltage Regulator



20143625

12V Battery Charger

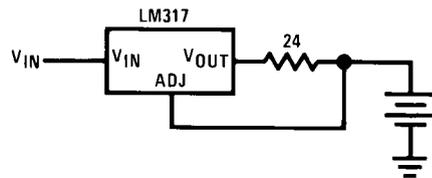


20143626

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

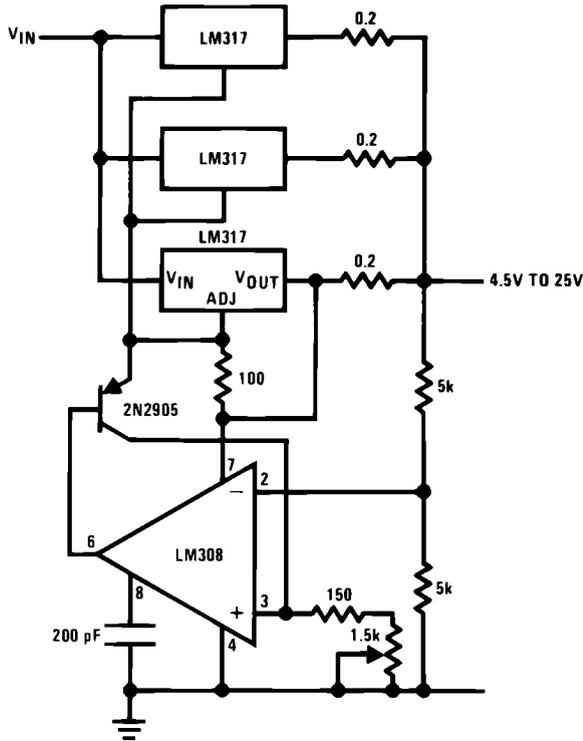
Use of R_S allows low charging rates with fully charged battery.

50mA Constant Current Battery Charger



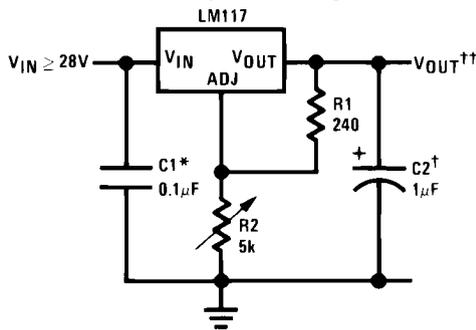
20143627

Adjustable 4A Regulator



20143628

1.2V–25V Adjustable Regulator



20143601

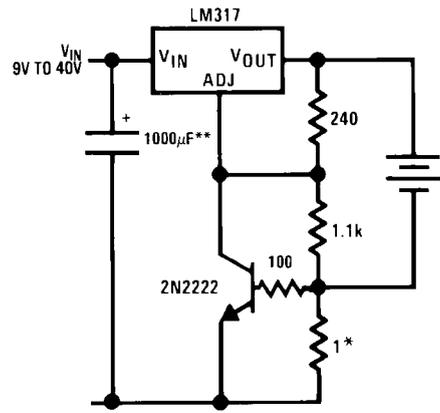
Full output current not available at high input-output voltages

*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.

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

Current Limited 6V Charger

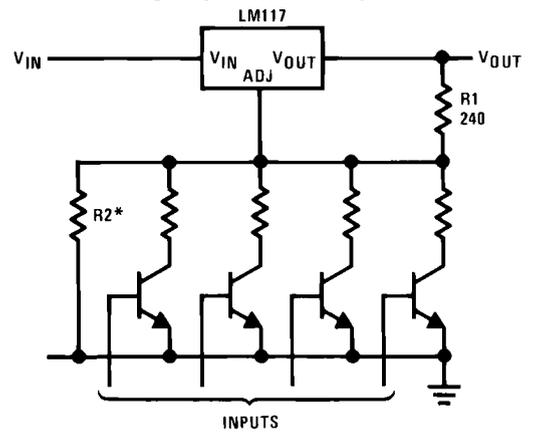


20143629

*Sets peak current (0.6A for 1Ω)

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

Digitally Selected Outputs



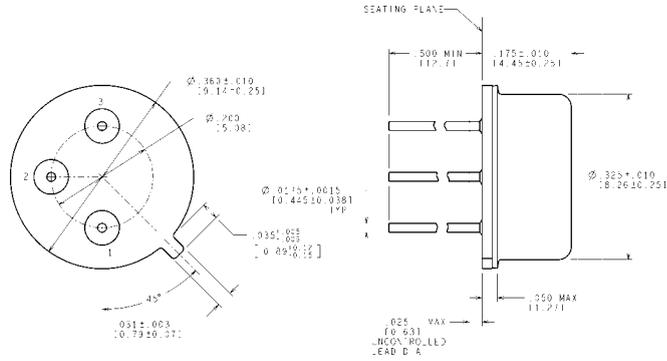
20143602

*Sets maximum V_{OUT}

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 H and WG 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 H and WG 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, V_o (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.

Physical Dimensions inches (millimeters) unless otherwise noted

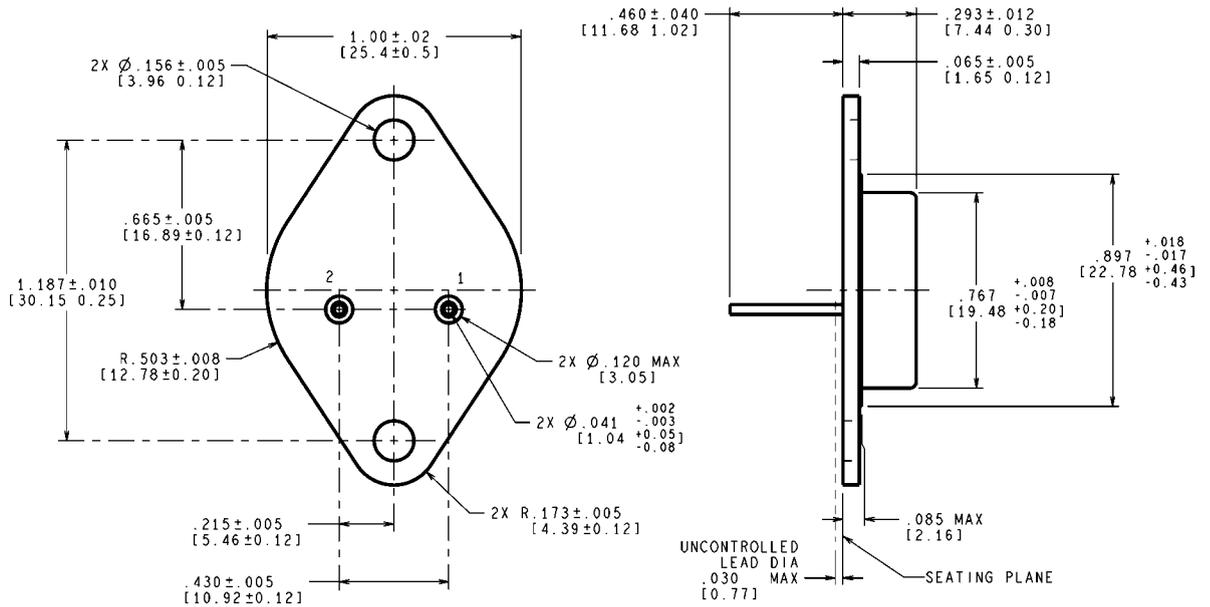


CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

(TO-39) Metal Can Package
NS Package Number H03A

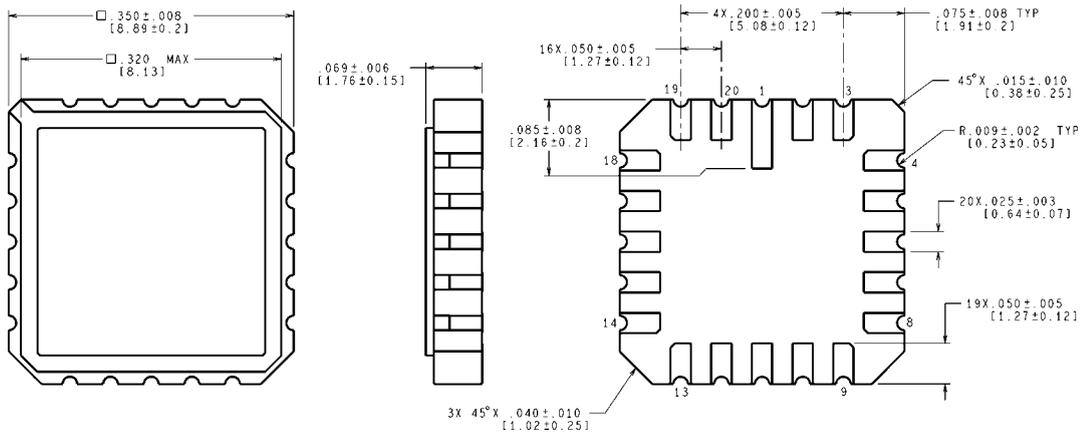


CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MIL-PRF-38535
CONFIGURATION CONTROL

TO-3 Metal Can Package (K)
NS Package Number K02C

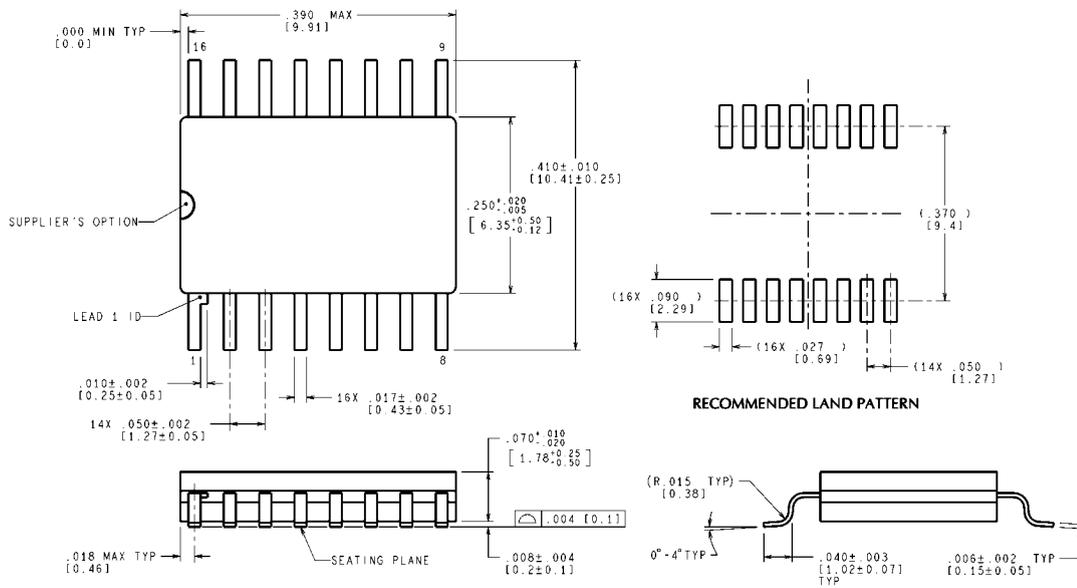
K02C (Rev E)



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

E20A (Rev F)

**Ceramic Leadless Chip Carrier
NS Package Number E20A**



MIL-PRF-38535
CONFIGURATION CONTROL

CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS
DIMENSIONS IN () FOR REFERENCE ONLY

WG16A (Rev E)

**Ceramic SOIC
NS Package Number WG16A**

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:
www.national.com

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adc	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempensors	SolarMagic™	www.national.com/solarmagic
PLL/VCO	www.national.com/wireless	PowerWise® Design University	www.national.com/training

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2011 National Semiconductor Corporation

For the most current product information visit us at www.national.com



**National Semiconductor
Americas Technical
Support Center**
Email: support@nsc.com
Tel: 1-800-272-9959

**National Semiconductor Europe
Technical Support Center**
Email: europe.support@nsc.com

**National Semiconductor Asia
Pacific Technical Support Center**
Email: ap.support@nsc.com

**National Semiconductor Japan
Technical Support Center**
Email: jpn.feedback@nsc.com