LM317L 3-Terminal Adjustable Regulator

Check for Samples: LM317L-N

FEATURES

- **Adjustable output down to 1.2V**
- **Guaranteed 100mA output current**
- **Line regulation typically 0.01%V**
- **Load regulation typically 0.1%**
- **Current limit constant with temperature**
- **Eliminates the need to stock many voltages**
- **Standard 3-lead transistor package**
- **80dB ripple rejection**
- **Available in TO-92, SO-8, or 6-Bump micro SMD package**
- **Output is short circuit protected**
- **See AN-1112 for micro SMD considerations**

DESCRIPTION

The LM317L is an adjustable 3-terminal positive voltage regulator capable of supplying 100mA over a 1.2V to 37V output range. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM317L is available packaged in a standard TO-92 transistor package which is easy to use.

In addition to higher performance than fixed regulators, the LM317L offers full overload protection. 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 LM317L 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.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317L 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.

The LM317L is available in a standard TO-92 transistor package, the SO-8 package, and 6-Bump micro SMD package. The LM317L is rated for operation over a −40°C to 125°C range.

Connection Diagram

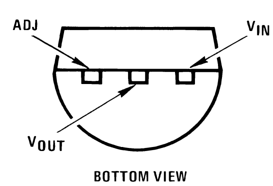


Figure 1. TO-92 Plastic package

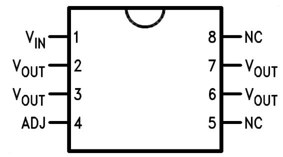
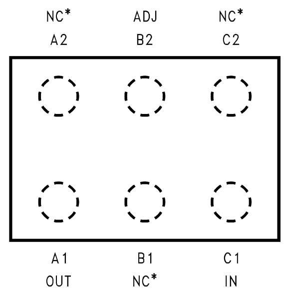


Figure 2. 8-Pin SOIC - Top View



*NC = Not Internally connected.

Figure 3. 6-Bump micro SMD - Top View (Bump Side Down)

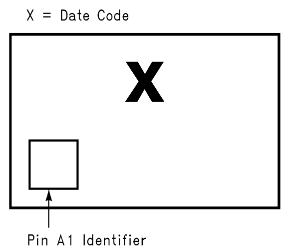


Figure 4. micro SMD Laser Mark

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	Internally Limited
Input-Output Voltage Differential	40V
Operating Junction Temperature Range	−40°C to +125°C
Storage Temperature	−55°C to +150°C
Lead Temperature (Soldering, 4 seconds)	260°C
Output is Short Circuit Protected	
ESD Susceptibility	
Human Body Model (2)	2kV

(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 guarantee specific performance limits.
(2) The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

Electrical Characteristics [(1)]

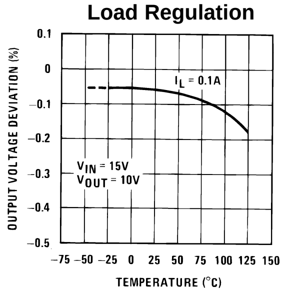
Parameter	Conditions	Min	Typ	Max	Units
Line Regulation	T_J = 25°C, 3V ≤ (V_{IN} − V_{OUT}) ≤ 40V, I_L ≤ 20mA [(2)]		0.01	0.04	%/V
Load Regulation	T_J = 25°C, 5mA ≤ I_{OUT} ≤ I_{MAX}, [(2)]		0.1	0.5	%
Thermal Regulation	T_J = 25°C, 10ms Pulse		0.04	0.2	%/W
Adjustment Pin Current			50	100	μA
Adjustment Pin Current	5mA ≤ I_L ≤ 100mA		0.2	5	μA
Change	3V ≤ (V_{IN} − V_{OUT}) ≤ 40V, P ≤ 625mW				
Reference Voltage	3V ≤ (V_{IN} − V_{OUT}) ≤ 40V, [(3)]	1.20	1.25	1.30	V
	5mA ≤ I_{OUT} ≤ 100mA, P ≤ 625mW				
Line Regulation	3V ≤ (V_{IN} − V_{OUT}) ≤ 40V, I_L ≤ 20mA [(2)]		0.02	0.07	%/V
Load Regulation	5mA ≤ I_{OUT} ≤ 100mA, [(2)]		0.3	1.5	%
Temperature Stability	T_{MIN} ≤ T_J ≤ T_{Max}		0.65		%
Minimum Load Current	(V_{IN} − V_{OUT}) ≤ 40V		3.5	5	mA
	3V ≤ (V_{IN} − V_{OUT}) ≤ 15V		1.5	2.5	
Current Limit	3V ≤ (V_{IN} − V_{OUT}) ≤ 13V	100	200	300	mA
	(V_{IN} − V_{OUT}) = 40V	25	50	150	mA
Rms Output Noise, % of V_{OUT}	T_J = 25°C, 10Hz ≤ f ≤ 10kHz		0.003		%
Ripple Rejection Ratio	V_{OUT} = 10V, f = 120Hz, C_{ADJ} = 0		65		dB
	C_{ADJ} = 10μF	66	80		dB
Long-Term Stability	T_J = 125°C, 1000 Hours		0.3	1	%
Thermal Resistance	Z Package 0.4″ Leads		180		°C/W
Junction to Ambient	Z Package 0.125 Leads		160		°C/W
	SO-8 Package		165		°C/W
	6-Bump micro SMD		290		°C/W

(1) Unless otherwise noted, these specifications apply: −25°C ≤ T_j ≤ 125°C for the LM317L; V_{IN} − V_{OUT} = 5V and I_{OUT} = 40mA. Although power dissipation is internally limited, these specifications are applicable for power dissipations up to 625mW. I_{MAX} is 100mA.
(2) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.
(3) Thermal resistance of the TO-92 package is 180°C/W junction to ambient with 0.4″ leads from a PC board and 160°C/W junction to ambient with 0.125″ lead length to PC board.

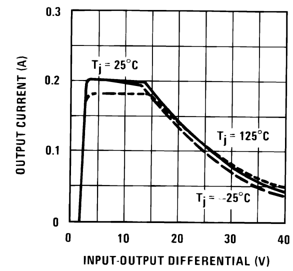
Typical Performance Characteristics

(Output capacitor = 0μF unless otherwise noted.)

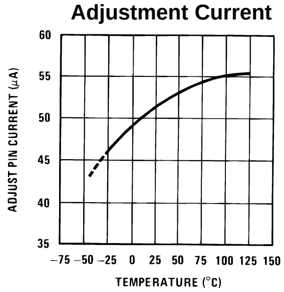
Load Regulation



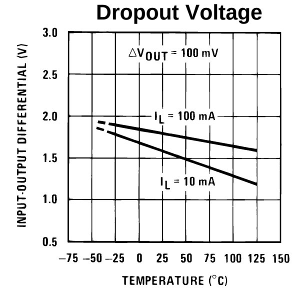
Current Limit



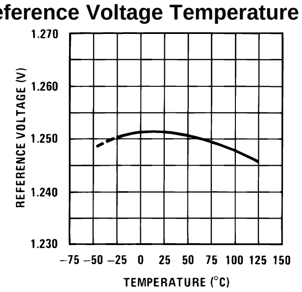
Adjustment Current



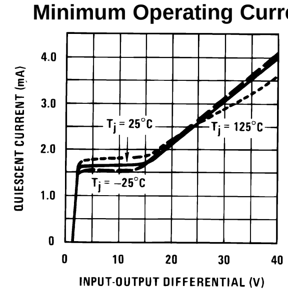
Dropout Voltage



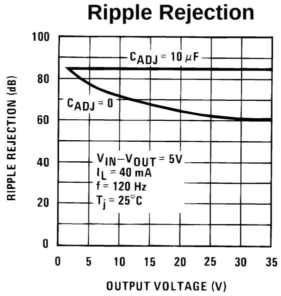
Reference Voltage Temperature Stability



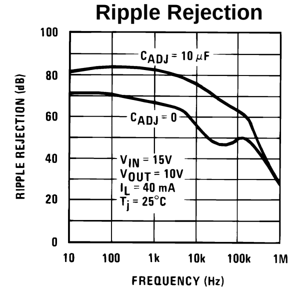
Minimum Operating Current



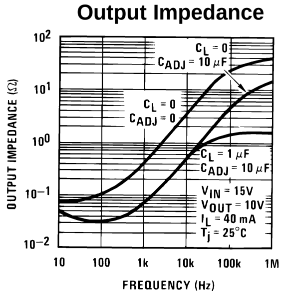
Ripple Rejection



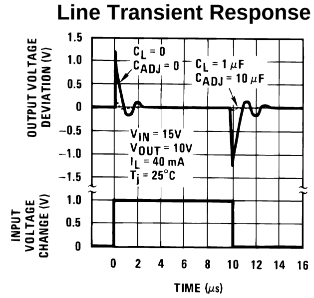
Ripple Rejection



Output Impedance



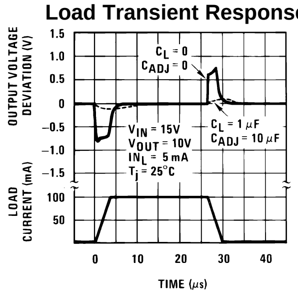
Line Transient Response



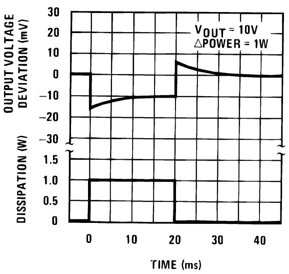
Typical Performance Characteristics (continued)

(Output capacitor = 0µF unless otherwise noted.)

Load Transient Response



Thermal Regulation

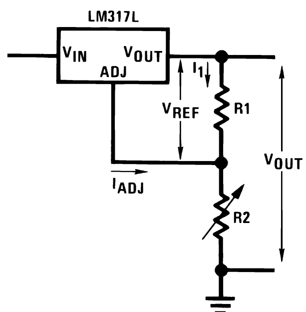


Application Hints

In operation, the LM317L 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 LM317L 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 in case the regulator is more than 6 inches away from the usual large filter capacitor. 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 LM317L to improve ripple rejection and noise. This bypass capacitor prevents ripple and noise 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, a 0.01µF disc may seem to work better than a 0.1µF disc as a bypass.

Although the LM317L is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500pF and 5000pF. A 1µF solid tantalum (or 25µF aluminum electrolytic) on the output swamps this effect and insures stability.

LOAD REGULATION

The LM317L 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 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 5 shows the effect of resistance between the regulator and 240Ω set resistor.

With the TO-92 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the output pin. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

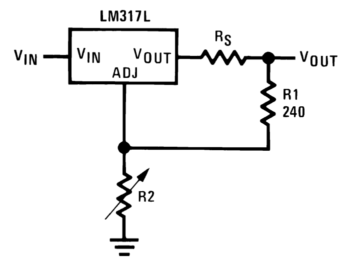


Figure 5. Regulator with Line Resistance in Output Lead

THERMAL REGULATION

When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large. Thermal regulation is the effect of these temperature gradients on output voltage (in percentage output change) per watt of power change in a specified time. Thermal regulation error is independent of electrical regulation or temperature coefficient, and occurs within 5ms to 50ms after a change in power dissipation. Thermal regulation depends on IC layout as well as electrical design. The thermal regulation of a voltage regulator is defined as the percentage change of V_{OUT}, per watt, within the first 10ms after a step of power is applied. The LM317L specification is 0.2%/W, maximum.

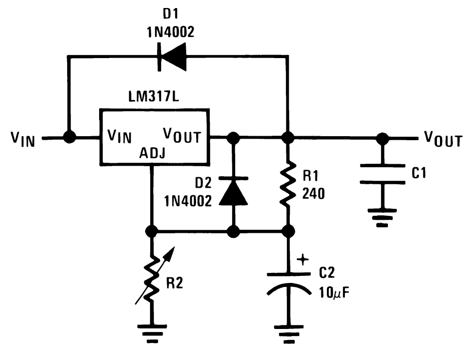
In the Thermal Regulation curve at the bottom of the Typical Performance Characteristics page, a typical LM317L's output changes only 7mV (or 0.07% of V_{OUT} = −10V) when a 1W pulse is applied for 10ms. This performance is thus well inside the specification limit of 0.2%/W × 1W = 0.2% maximum. When the 1W pulse is ended, the thermal regulation again shows a 7mV change as the gradients across the LM317L chip die out. Note that the load regulation error of about 14mV (0.14%) is additional to the thermal regulation error.

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 LM317L, this discharge path is through a large junction that is able to sustain a 2A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25 µF or less, the LM317L's ballast resistors and output structure limit the peak current to a low enough level so that there is no need to use a protection diode.

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 LM317L 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 6 shows an LM317L with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



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

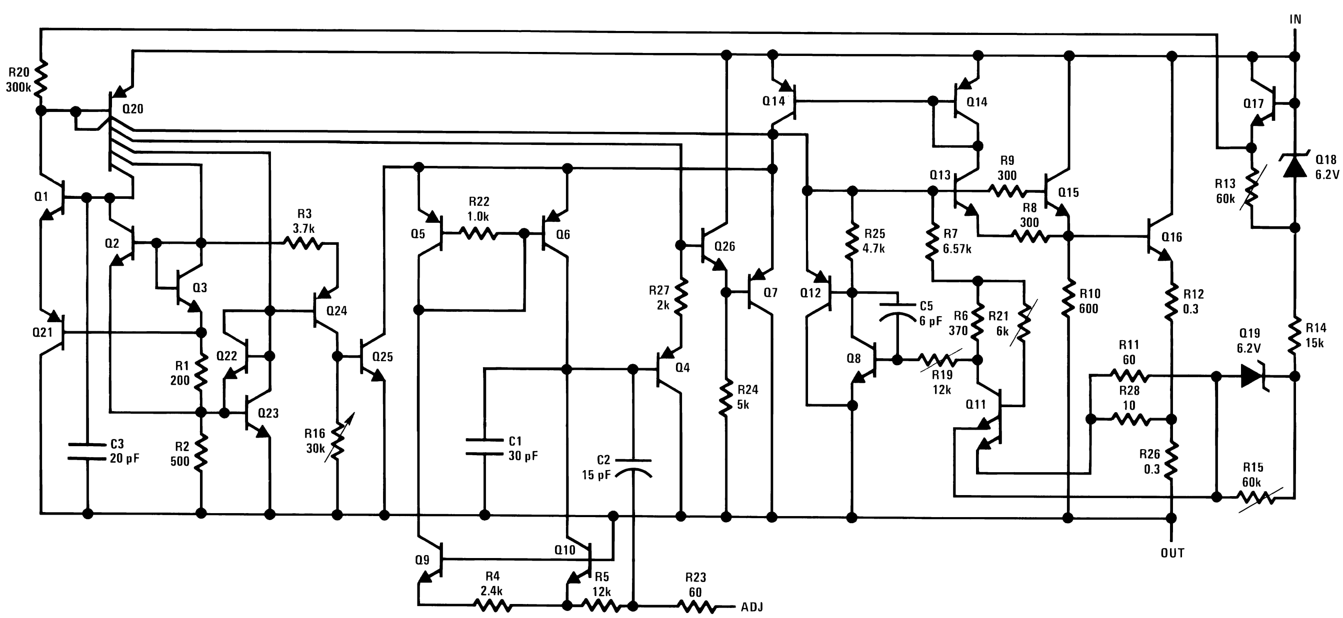
D1 protects against C1
D2 protects against C2

Figure 6. Regulator with Protection Diodes

LM317L micro SMD Light Sensitivity

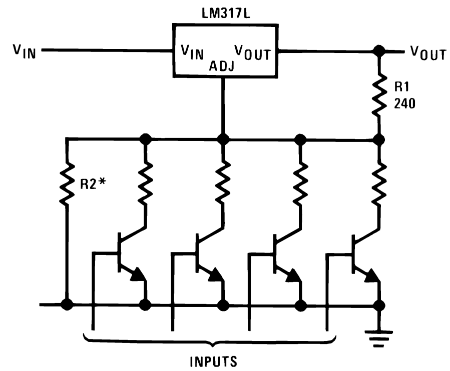
Exposing the LM317L micro SMD package to bright sunlight may cause the V_{REF} to drop. In a normal office environment of fluorescent lighting the output is not affected. The LM317 micro SMD does not sustain permanent damage from light exposure. Removing the light source will cause LM317L's V_{REF} to recover to the proper value.

Schematic Diagram



Typical Applications

Figure 7. Digitally Selected Outputs



*Sets maximum V_{OUT}

Figure 8. High Gain Amplifier

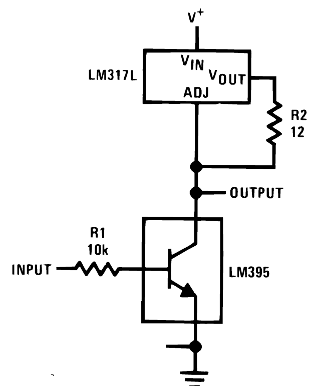
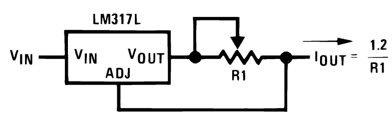


Figure 9. Adjustable Current Limiter



12 ≤ R1 ≤ 240

Figure 10. Precision Current Limiter

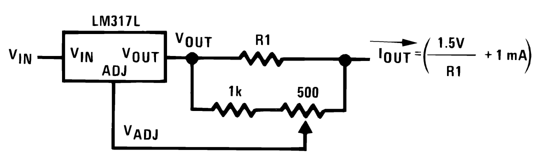


Figure 11. Slow Turn-On 15V Regulator

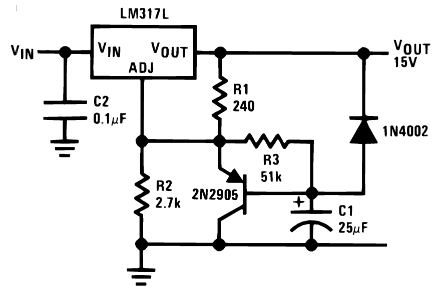
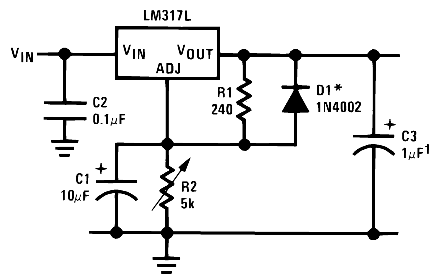


Figure 12. Adjustable Regulator with Improved Ripple Rejection



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

Figure 13. High Stability 10V Regulator

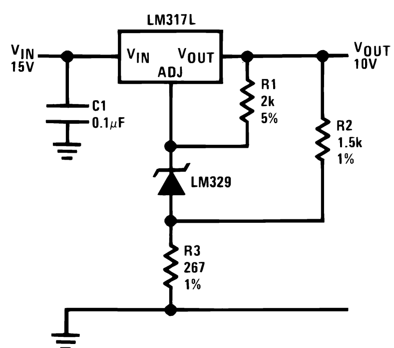
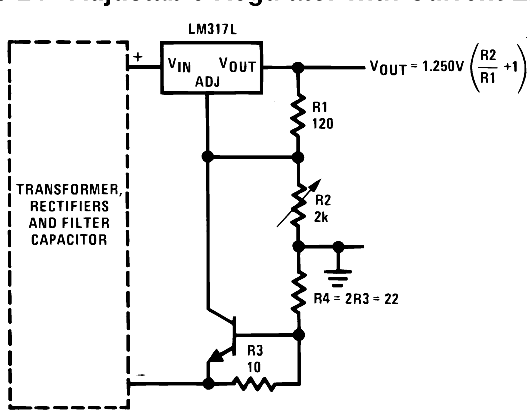
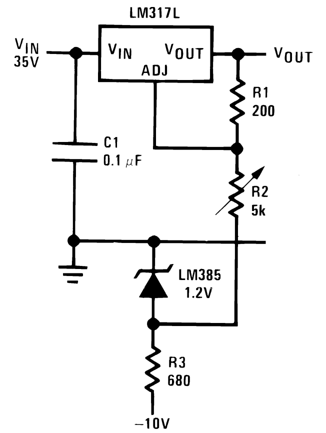


Figure 14. Adjustable Regulator with Current Limiter



Short circuit current is approximately 600 mV/R3, or 60mA (compared to LM317LZ's 200mA current limit).
At 25mA output only 3/4V of drop occurs in R3 and R4.

Figure 15. 0V–30V Regulator



Full output current not available at high input-output voltages

Figure 16. Regulator With 15mA Short Circuit Current

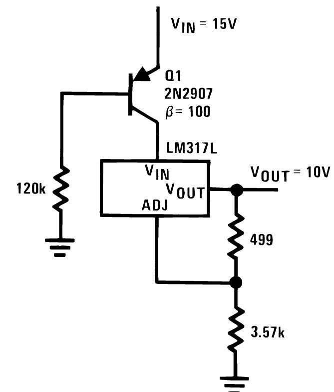


Figure 17. Power Follower

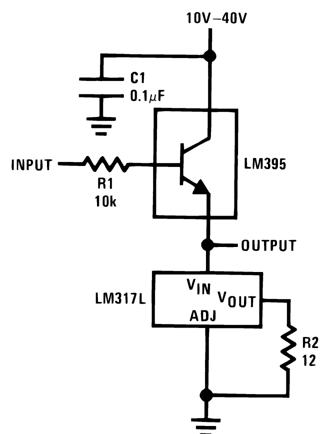
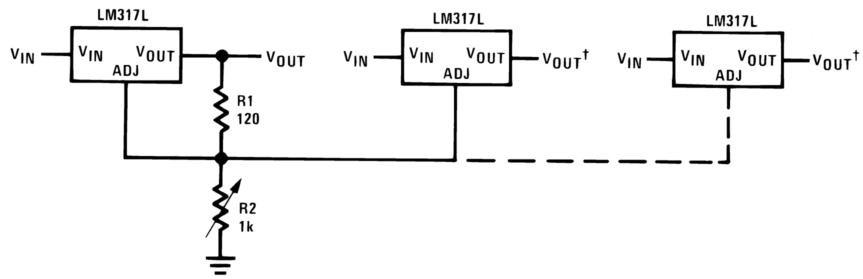


Figure 18. Adjusting Multiple On-Card Regulators with Single Control*



*All outputs within ± 100mV
†Minimum load −5mA

Figure 19. 100mA Current Regulator

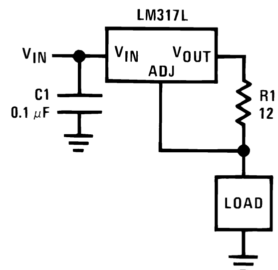
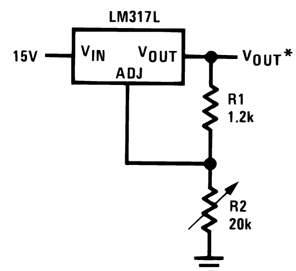


Figure 20. 1.2V–12V Regulator with Minimum Program Current



*Minimum load current ≈ 2 mA

Figure 21. 50mA Constant Current Battery Charger for Nickel-Cadmium Batteries

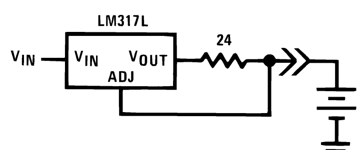
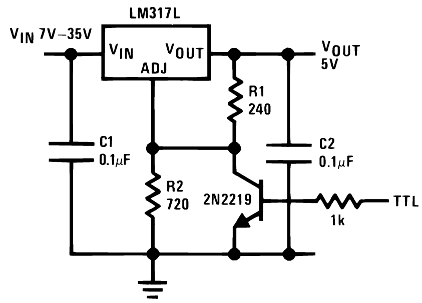
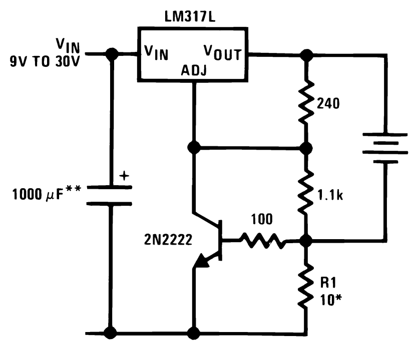


Figure 22. 5V Logic Regulator with Electronic Shutdown*



*Minimum output ≈ 1.2V

Figure 23. Current Limited 6V Charger



*Sets peak current, I_{PEAK} = 0.6V/R1
**1000μF is recommended to filter out any input transients.

Figure 24. Short Circuit Protected 80V Supply

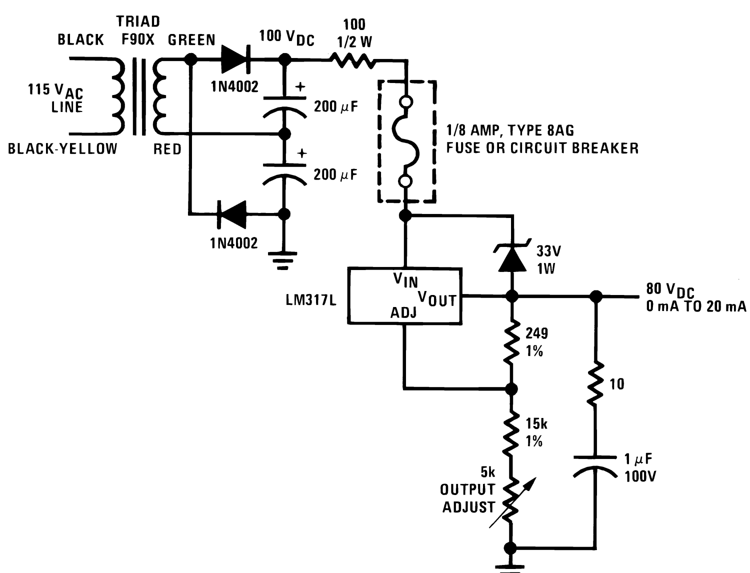
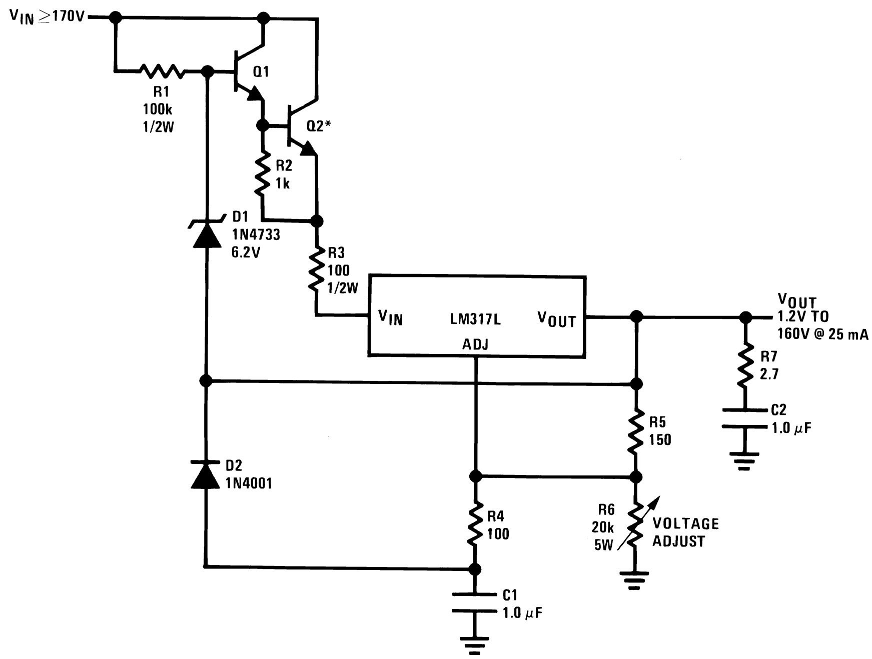
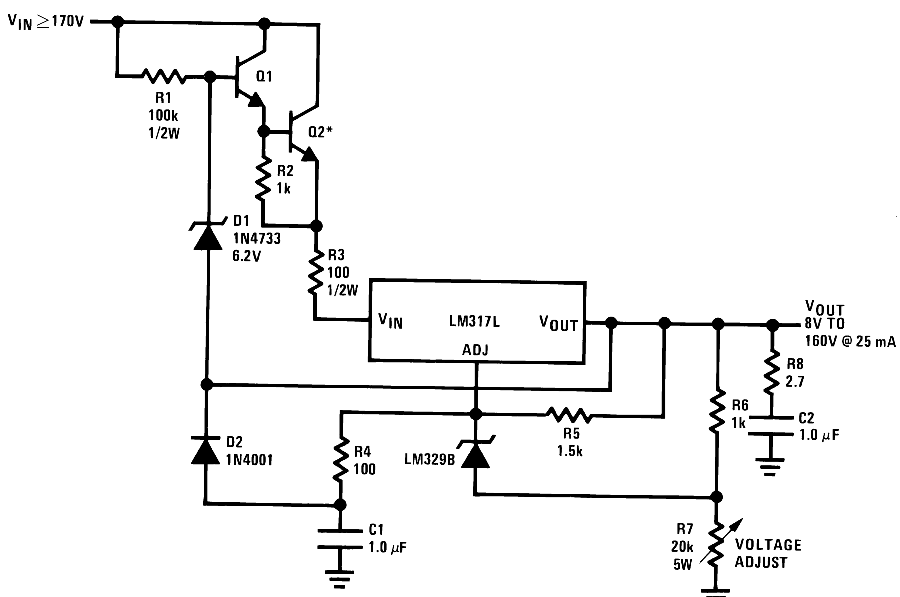


Figure 25. Basic High Voltage Regulator



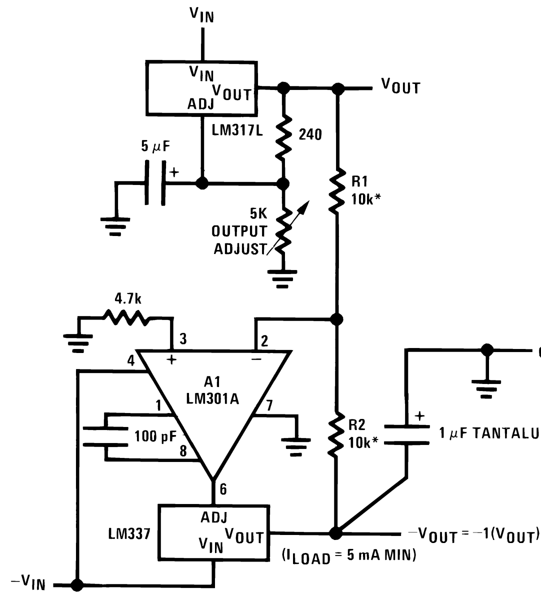
Q1, Q2: NSD134 or similar
C1, C2: 1μF, 200V mylar**
*Heat sink

Figure 26. Precision High Voltage Regulator



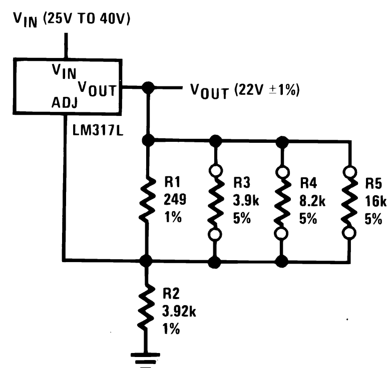
Q1, Q2: NSD134 or similar
C1, C2: 1μF, 200V mylar**
*Heat sink
**Mylar is a registered trademark of DuPont Co.

Figure 27. Tracking Regulator



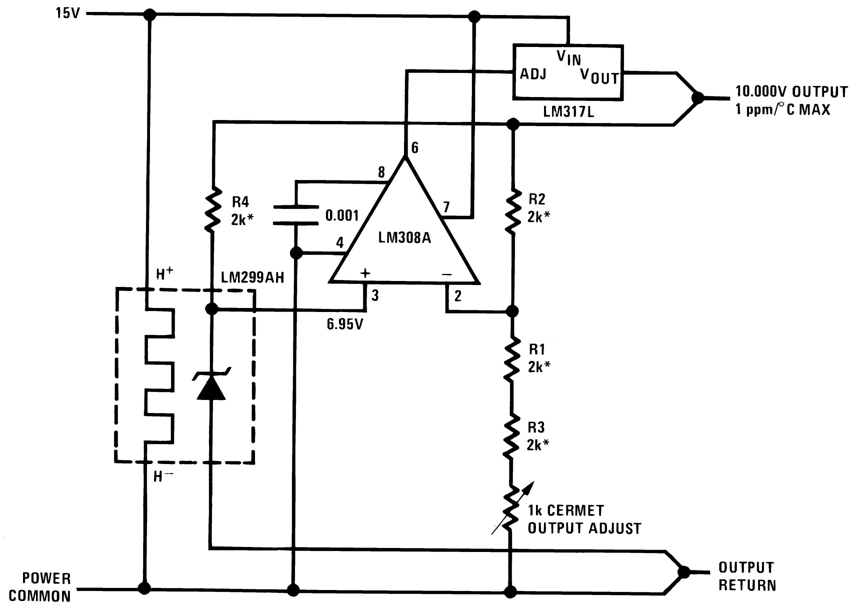
A1 = LM301A, LM307, or LF13741 only
R1, R2 = matched resistors with good TC tracking

Figure 28. Regulator With Trimmable Output Voltage



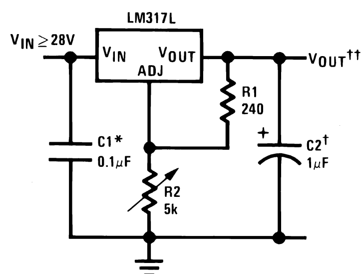
Trim Procedure:
—If V_{OUT} is 23.08V or higher, cut out R3 (if lower, don't cut it out).
—Then if V_{OUT} is 22.47V or higher, cut out R4 (if lower, don't).
—Then if V_{OUT} is 22.16V or higher, cut out R5 (if lower, don't).
This will trim the output to well within ±1% of 22.00 V_{DC}, without any of the expense or uncertainty of a trim pot (see LB-46). Of course, this technique can be used at any output voltage level.

Figure 29. Precision Reference with Short-Circuit Proof Output



*R1–R4 from thin-film network,
Beckman 694-3-R2K-D or similar

Figure 30. 1.2V-25 Adjustable Regulator



Full output current not available at high input-output voltages
†Optional—improves transient response
*Needed if device is more than 6 inches from filter capacitors

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

Figure 31. Fully Protected (Bulletproof) Lamp Driver

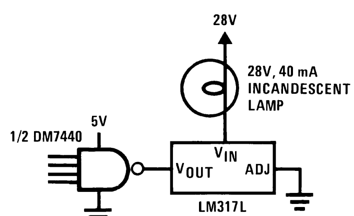
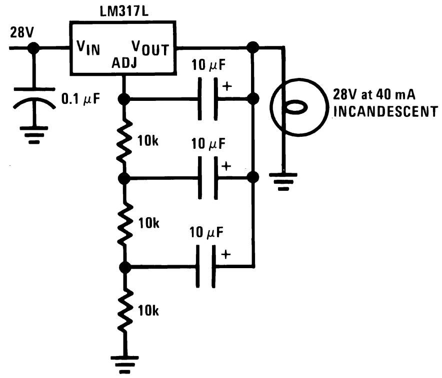


Figure 32. Lamp Flasher



Output rate—4 flashes per second at 10% duty cycle

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
LM317LITP/NOPB	ACTIVE	DSBGA	YPB	6	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	
LM317LITPX/NOPB	ACTIVE	DSBGA	YPB	6	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	
LM317LM/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	
LM317LMX	ACTIVE	SOIC	D	8	2500	TBD	CU SNPB	Level-1-235C-UNLIM	
LM317LMX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	
LM317LZ/LFT1	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	
LM317LZ/LFT2	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	
LM317LZ/LFT3	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	
LM317LZ/LFT4	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	
LM317LZ/LFT7	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	
LM317LZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	

(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.

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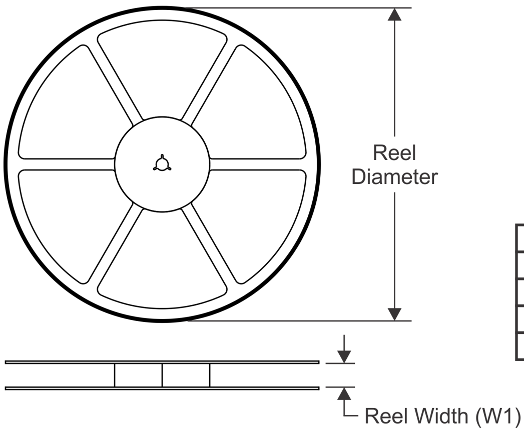
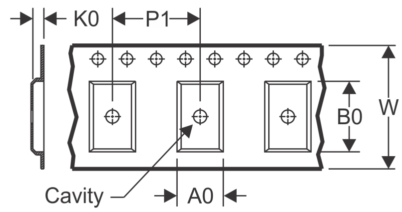
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

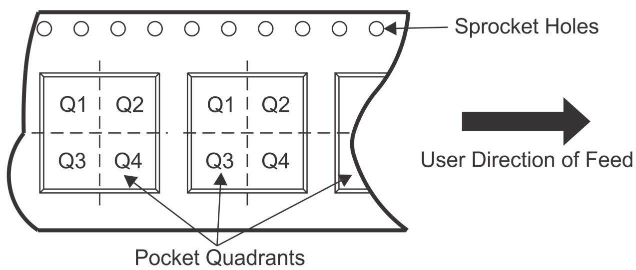


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

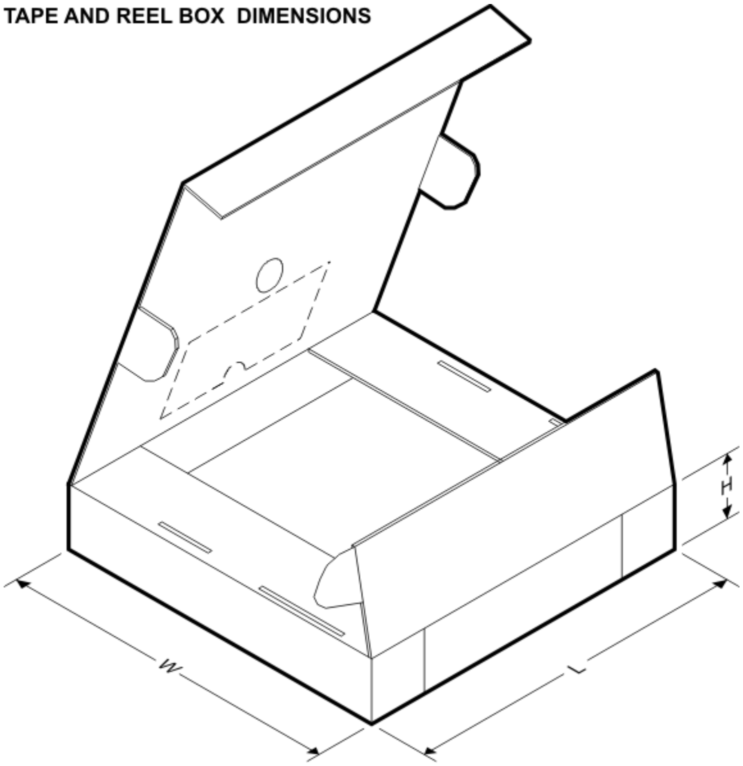
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM317LITP/NOPB	DSBGA	YPB	6	250	178.0	8.4	1.09	1.75	0.66	4.0	8.0	Q1
LM317LITPX/NOPB	DSBGA	YPB	6	3000	178.0	8.4	1.09	1.75	0.66	4.0	8.0	Q1
LM317LMX	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM317LMX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

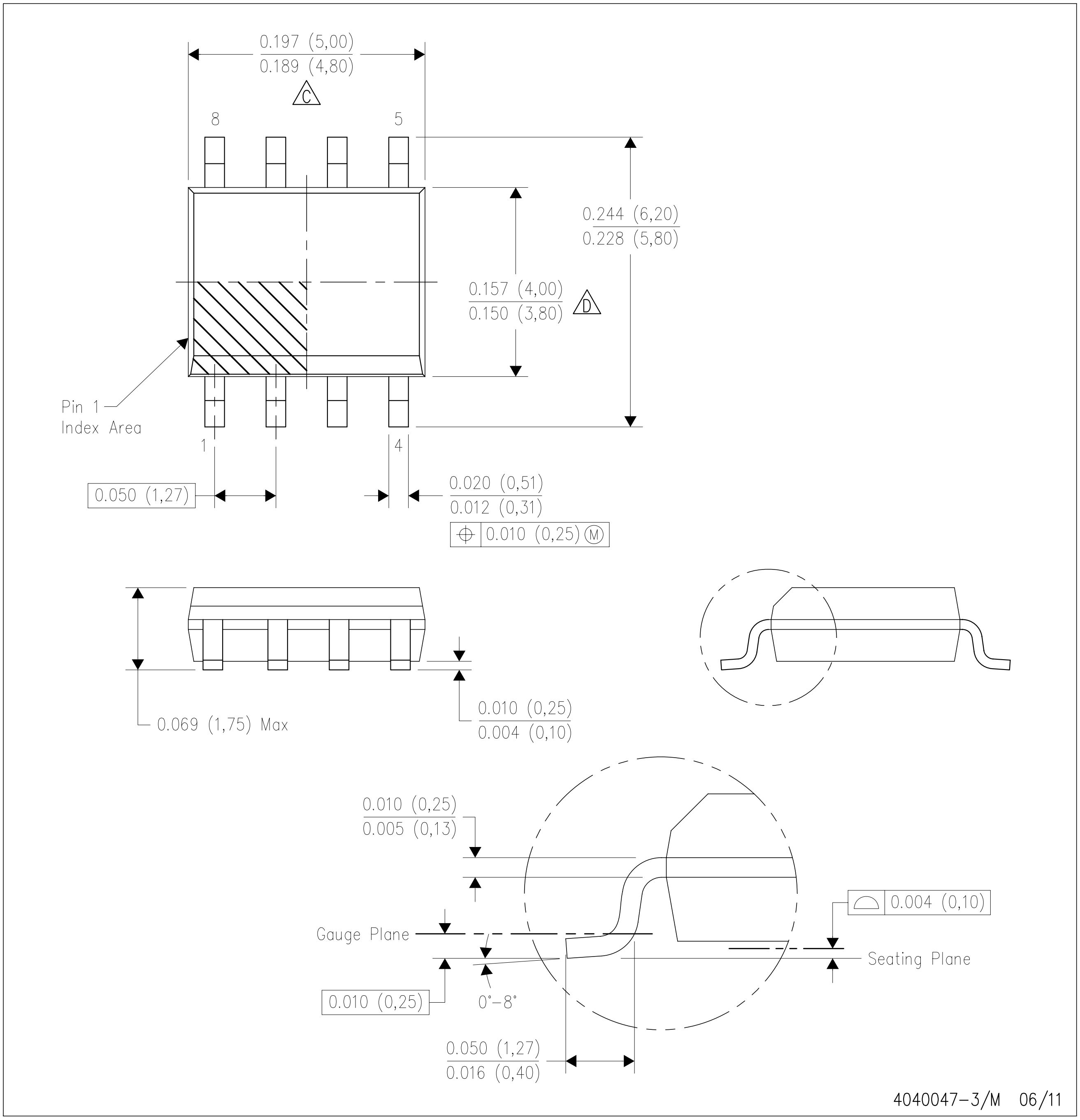
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

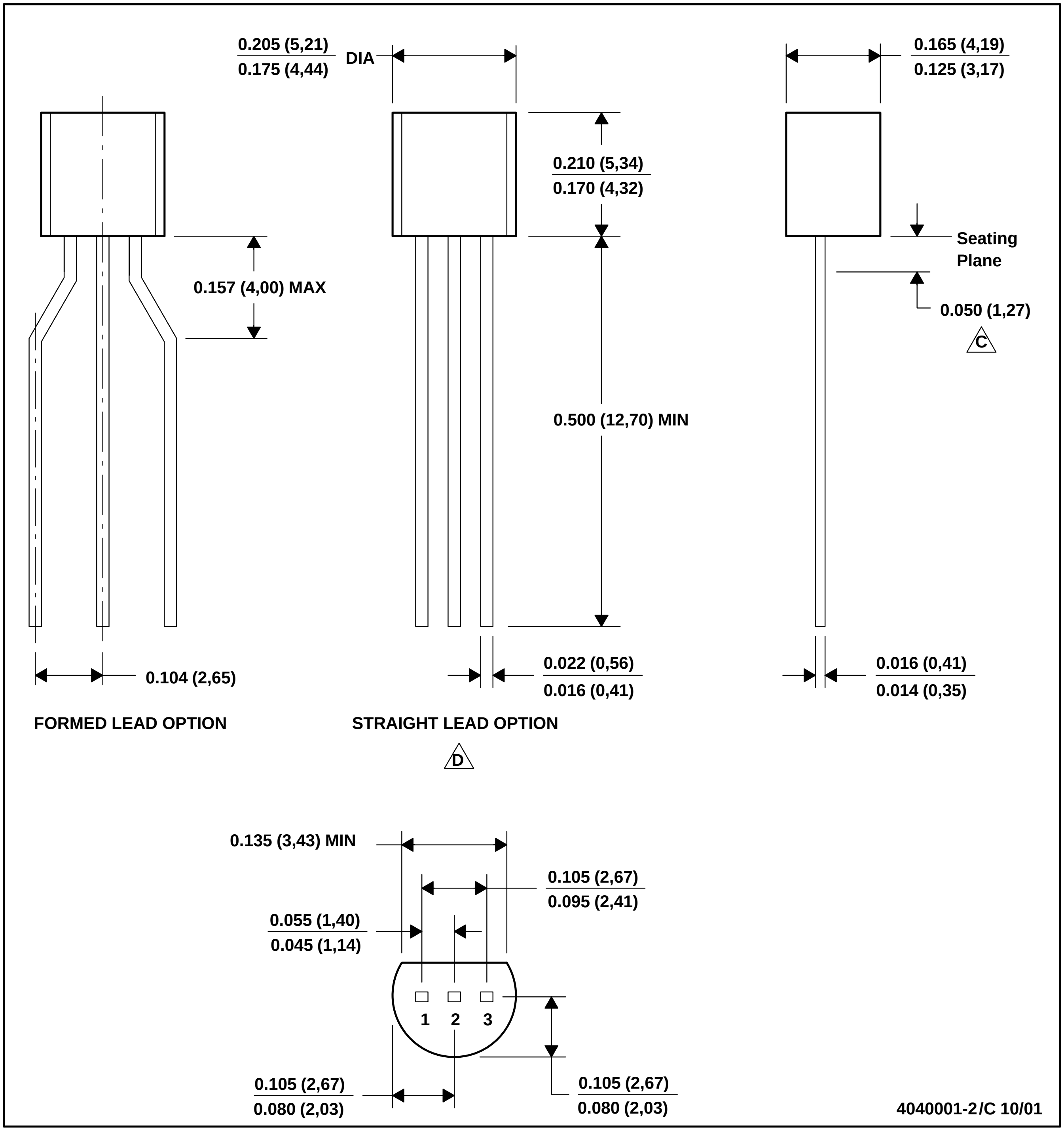
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM317LITP/NOPB	DSBGA	YPB	6	250	203.0	190.0	41.0
LM317LITPX/NOPB	DSBGA	YPB	6	3000	206.0	191.0	90.0
LM317LMX	SOIC	D	8	2500	349.0	337.0	45.0
LM317LMX/NOPB	SOIC	D	8	2500	349.0	337.0	45.0

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



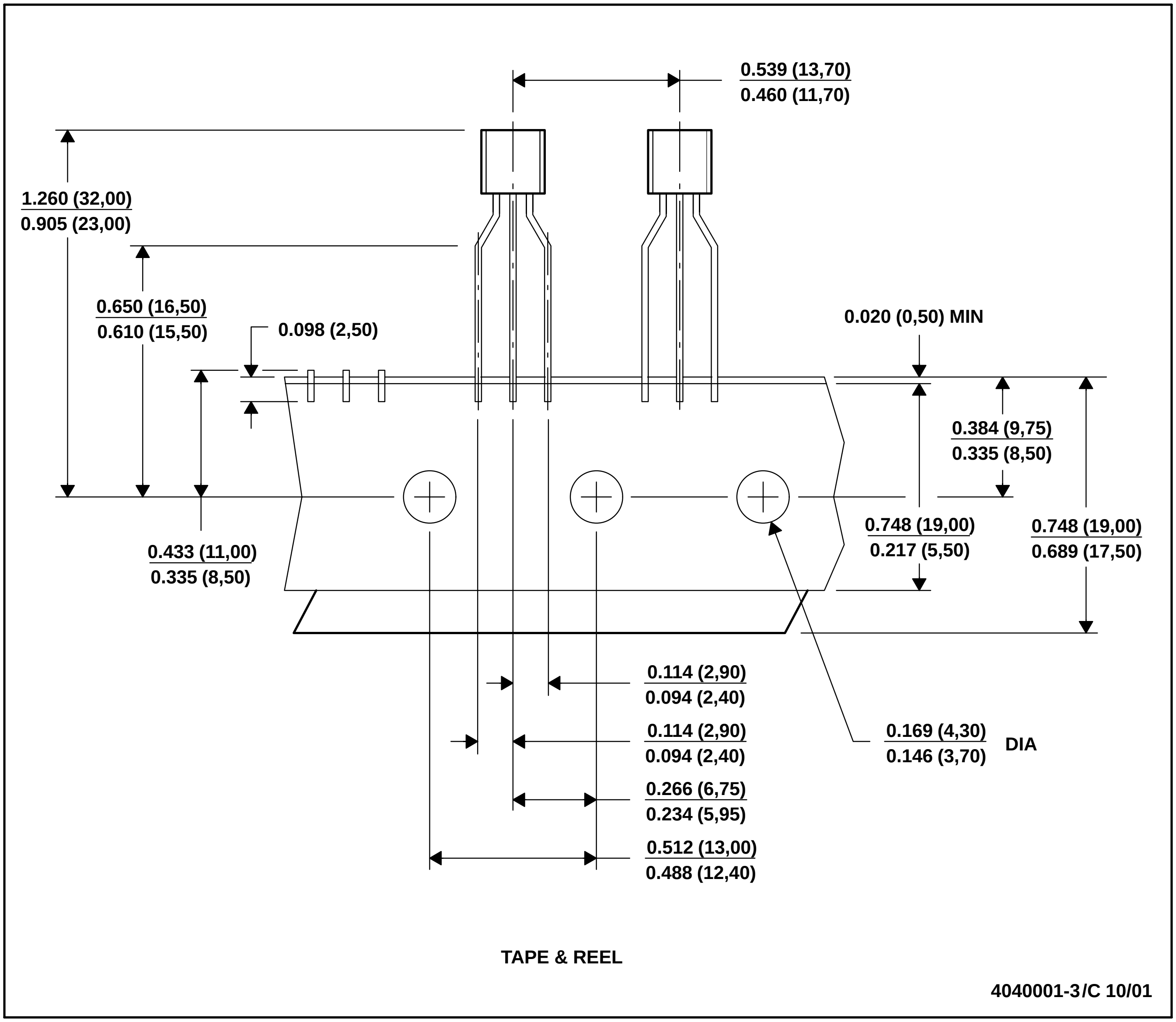
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.

LP (O-PBCY-W3) **PLASTIC CYLINDRICAL PACKAGE**

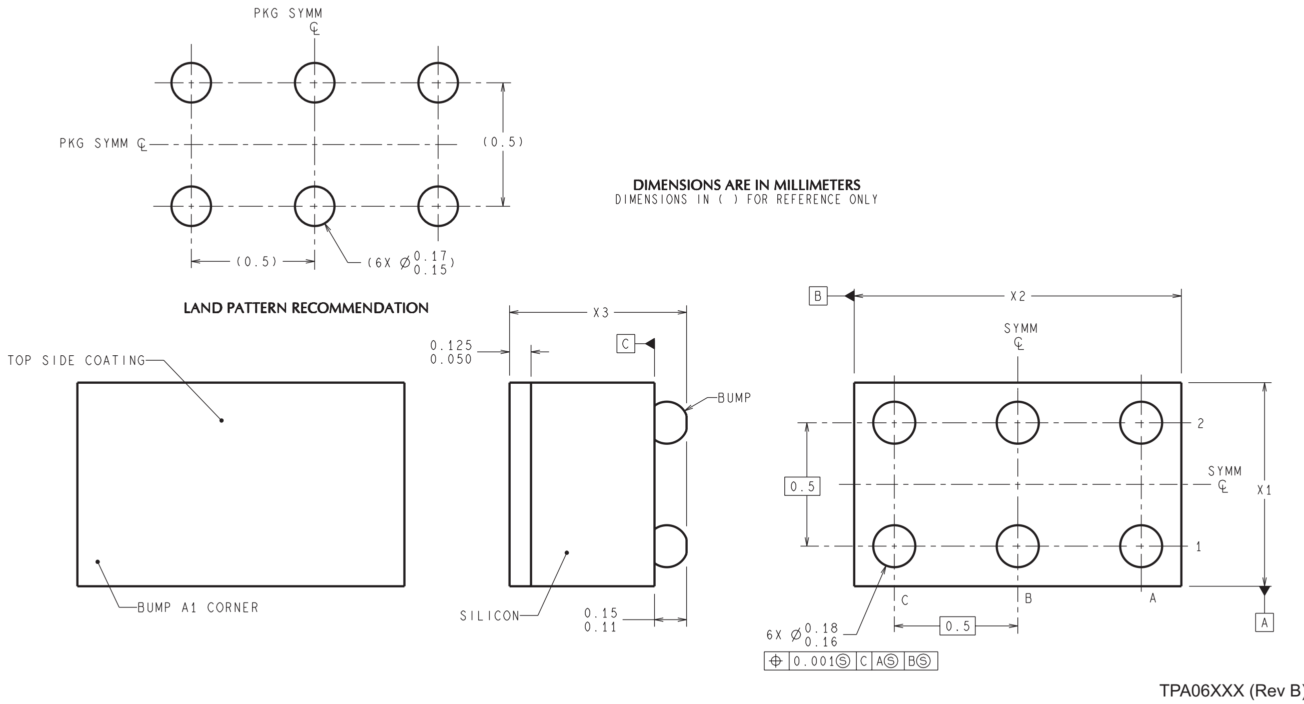


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Lead dimensions are not controlled within this area
D. FAlls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92)
E. Shipping Method:
Straight lead option available in bulk pack only.
Formed lead option available in tape & reel or ammo pack.

LP (O-PBCY-W3) **PLASTIC CYLINDRICAL PACKAGE**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Tape and Reel information for the Format Lead Option package.



X: Max = 1.7 mm, Min = 1.599 mm

Y: Max = 1.039 mm, Min =0.938 mm