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MOTOROLA

LM317M, LM317MA

Three-Terminal Adjustable Output Positive Voltage Regulator

MEDIUM CURRENT THREE–TERMINAL ADJUSTABLE POSITIVE VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

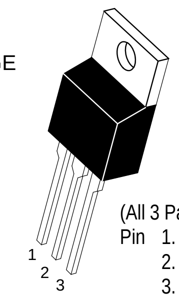
The LM317M is an adjustable three–terminal positive voltage regulator capable of supplying in excess of 500 mA over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow–out proof.

The LM317M serves a wide variety of applications including local, on–card regulation. This device also makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317M can be used as a precision current regulator.

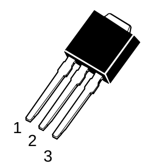
- Output Current in Excess of 500 mA
- Output Adjustable between 1.2 V and 37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe–Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking Many Fixed Voltages

T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface connected to Pin 2

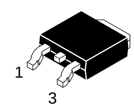


(All 3 Packages)
Pin 1. Adjust
2. V_{out}
3. V_{in}



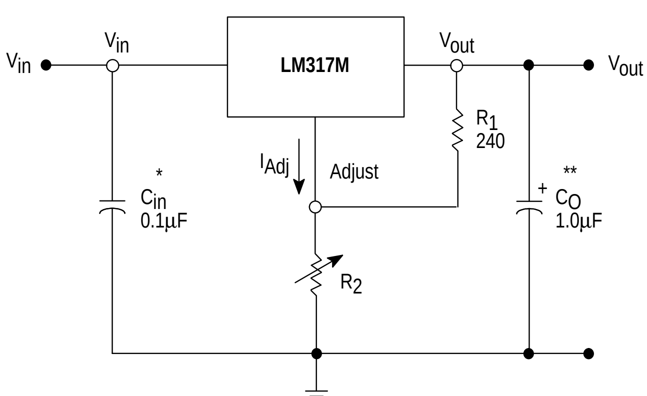
DT–1 SUFFIX
PLASTIC PACKAGE
CASE 369
(DPAK)

DT SUFFIX
PLASTIC PACKAGE
CASE 369A
(DPAK)



Heatsink Surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.

Simplified Application



* = C_{in} is required if regulator is located an appreciable distance from power supply filter.
** = C_O is not needed for stability, however, it does improve transient response.

$$V_{out} = 1.25\ V\left(1 + \frac{R_2}{R_1}\right) + I_{Adj}\,R_2$$

Since I_{Adj} is controlled to less than 100 µA, the error associated with this term is negligible in most applications.

ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM317MT LM317MAT	T_J = 0° to +125°C	Plastic Power
LM317MBT# LM317MABT#	T_J = –40° to +125°C	Plastic Power
LM317MDT LM317MADT LM317MDT–1 LM317MADT–1	T_J = 0° to 125°C	DPAK
LM317MBDT LM317MABDT LM317MBDT–1 LM317MABDT–1	T_J = –40° to 125°C	DPAK

\# Automotive temperature range selections are available with special test conditions and additional tests. Contact your local Motorola sales office for information.

MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Input–Output Voltage Differential	$V_I–V_O$	40	Vdc
Power Dissipation (Package Limitation) (Note 1)			
Plastic Package, T Suffix			
T_A = 25°C	P_D	Internally Limited	
Thermal Resistance, Junction–to–Air	θ_{JA}	70	°C/W
Thermal Resistance, Junction–to–Case	θ_{JC}	5.0	°C/W
Plastic Package, DT Suffix			
T_A = 25°C	P_D	Internally Limited	
Thermal Resistance, Junction–to–Air	θ_{JA}	92	°C/W
Thermal Resistance, Junction–to–Case	θ_{JC}	5.0	°C/W
Operating Junction Temperature Range	T_J	–40 to +125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

NOTE: 1. Figure 23 provides thermal resistance versus pc board pad size.

ELECTRICAL CHARACTERISTICS ($V_I–V_O$ = 5.0 V; I_O = 0.1 A, T_J = T_{low} to T_{high} [Note 1], unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit
Line Regulation (Note 2) T_A = 25°C, 3.0 V ≤ $V_I–V_O$ ≤ 40 V	1	Reg_{line}	–	0.01	0.04	%/V
Load Regulation (Note 2) T_A = 25°C, 10 mA ≤ I_O ≤ 0.5 A V_O ≤ 5.0 V V_O ≥ 5.0 V	2	Reg_{load}	 – –	 5.0 0.1	 25 0.5	 mV % V_O
Adjustment Pin Current	3	I_{Adj}	–	50	100	µA
Adjustment Pin Current Change 2.5 V ≤ $V_I–V_O$ ≤ 40 V, 10 mA ≤ I_L ≤ 0.5 A, P_D ≤ P_{max}	1,2	ΔI_{Adj}	–	0.2	5.0	µA
Reference Voltage LM317M: 3.0 V ≤ $V_I–V_O$ ≤ 40 V, 10 mA ≤ I_O ≤ 0.5 A, P_D ≤ P_{max} LM317MA:	3	V_{ref}	1.200 1.225	1.250 1.250	1.300 1.275	V
Line Regulation (Note 2) 3.0 V ≤ $V_I–V_O$ ≤ 40 V	1	Reg_{line}	–	0.02	0.07	%/V
Load Regulation (Note 2) 10 mA ≤ I_O ≤ 0.5 A V_O ≤ 5.0 V V_O ≥ 5.0 V	2	Reg_{load}	 – –	 20 0.3	 70 1.5	 mV % V_O
Temperature Stability (T_{low} ≤ T_J ≤ T_{high})	3	T_S	–	0.7	–	% V_O
Minimum Load Current to Maintain Regulation ($V_I–V_O$ = 40 V)	3	I_{Lmin}	–	3.5	10	mA
Maximum Output Current $V_I–V_O$ ≤ 15 V, P_D ≤ P_{max} $V_I–V_O$ = 40 V, P_D ≤ P_{max}, T_A = 25°C	3	I_{max}	 0.5 0.15	 0.9 0.25	 – –	A
RMS Noise, % of V_O T_A= 25°C, 10 Hz ≤ f ≤ 10 kHz	–	N	–	0.003	–	% V_O
Ripple Rejection, V_O = 10 V, f = 120 Hz (Note 3) Without C_{Adj} C_{Adj} = 10 µF	4	RR	 – 66	 65 80	 – –	dB
Long–Term Stability, T_J = T_{high} (Note 4) T_A= 25°C for Endpoint Measurements	3	S	–	0.3	1.0	%/1.0 k Hrs.

NOTES: 1. T_{low} to T_{high} = 0° to +125°C for LM317M T_{low} to T_{high} = –40° to +125°C for LM317MB
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
3. C_{Adj}, when used, is connected between the adjustment pin and ground.
4. Since Long–Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.

Representative Schematic Diagram

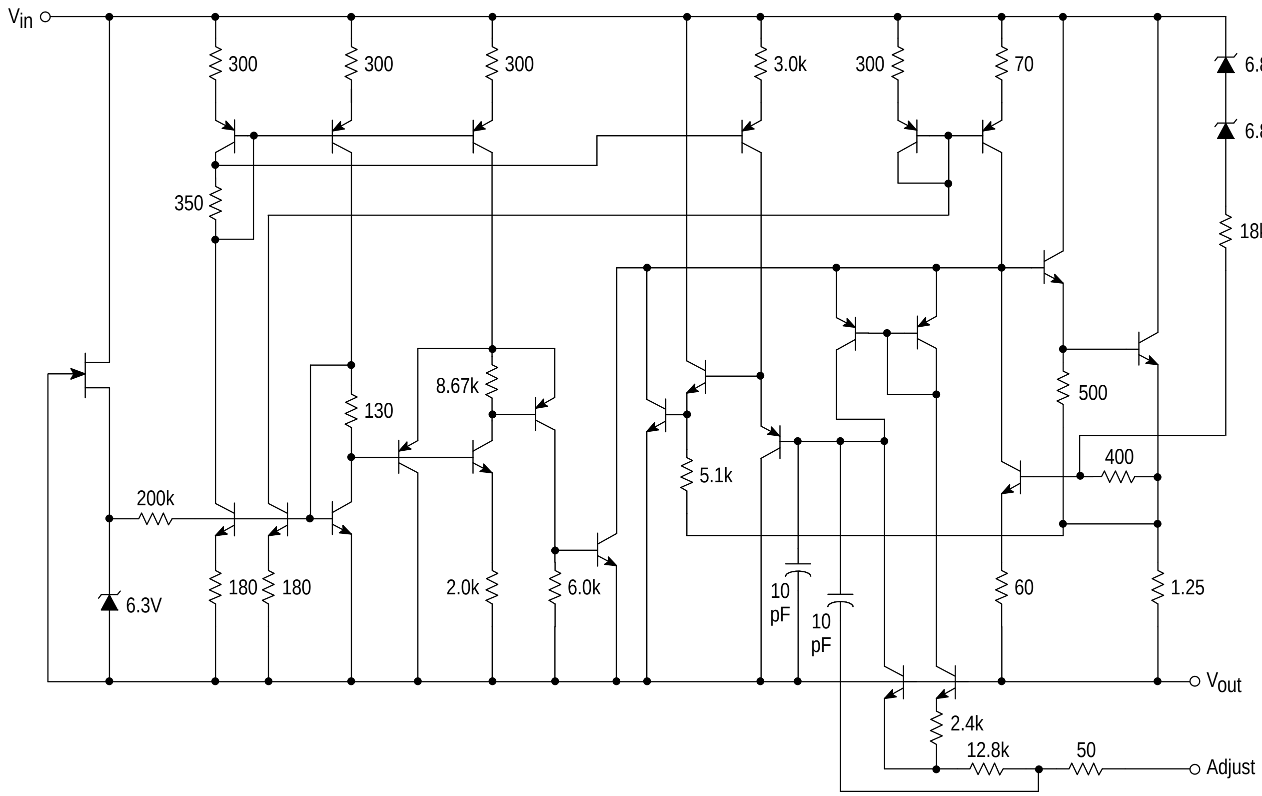


Figure 1. Line Regulation and ΔI_{Adj}/Line Test Circuit

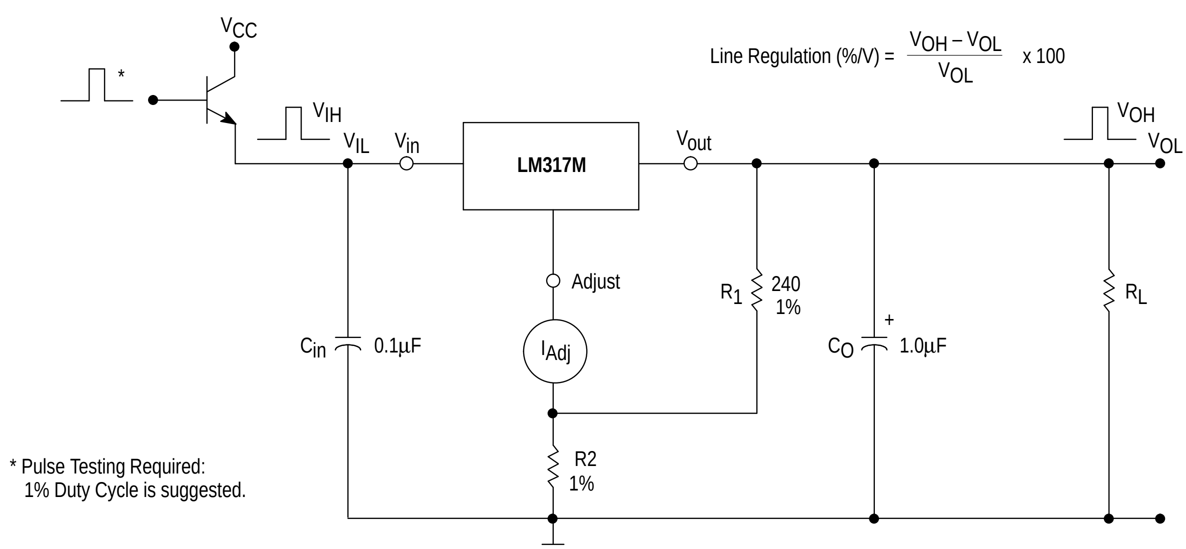
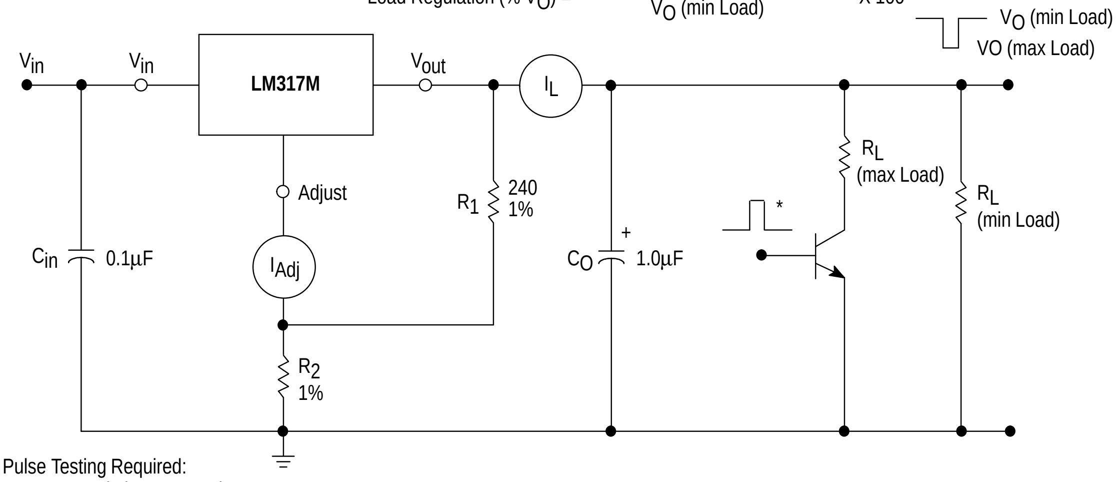


Figure 2. Load Regulation and ΔI_{Adj}/Load Test Circuit

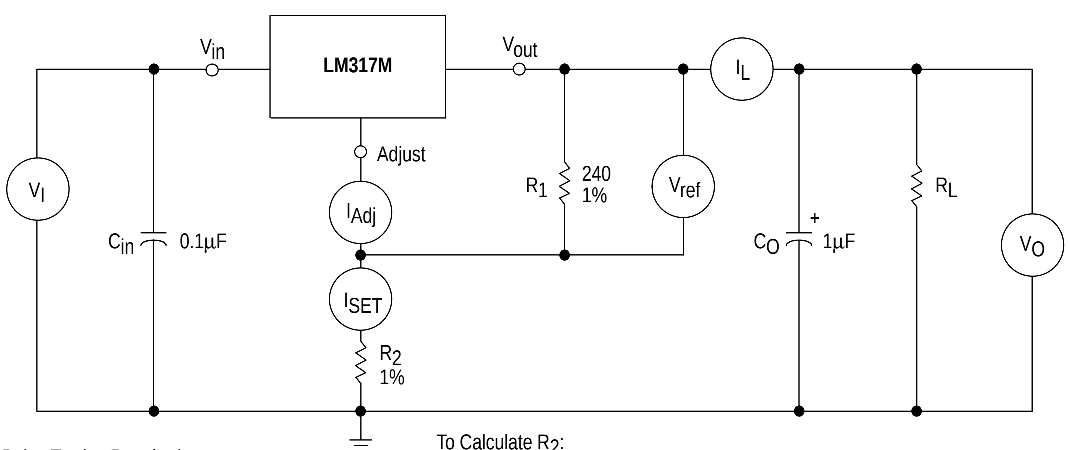
$$\text{Load Regulation (mV)} = V_O \text{ (min Load)} - V_O \text{ (max Load)}$$

$$\text{Load Regulation (\% } V_O) = \frac{V_O \text{ (min Load)} - V_O \text{ (max Load)}}{V_O \text{ (min Load)}} \times 100$$



* Pulse Testing Required:
1% Duty Cycle is suggested.

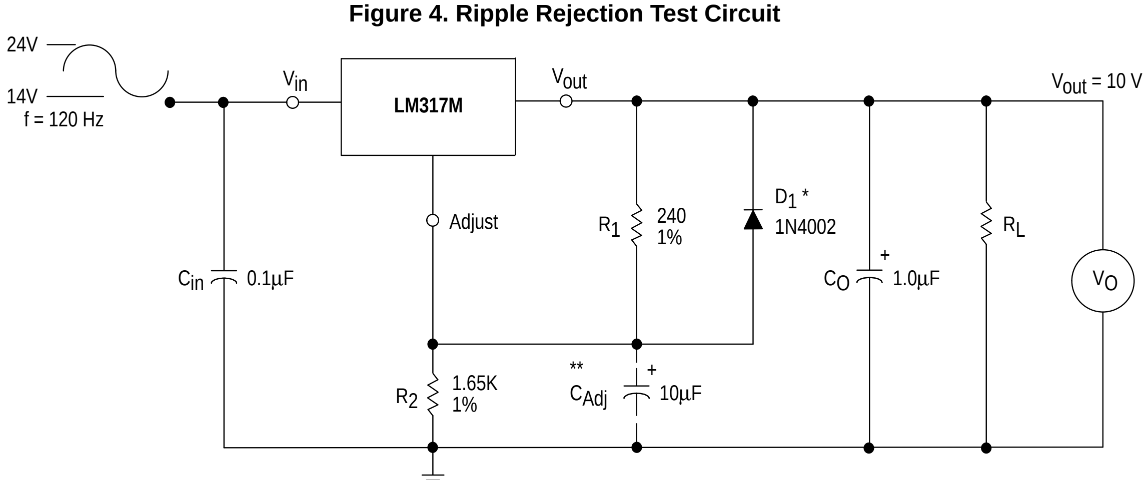
Figure 3. Standard Test Circuit



*Pulse Testing Required:
1% Duty Cycle is suggested.

To Calculate R_2:
$V_{out} = I_{SET} R_2 + 1.250$ V
Assume $I_{SET} = 5.25$ mA

Figure 4. Ripple Rejection Test Circuit



* D_1 Discharges C_{Adj} if Output is Shorted to Ground.
**C_{Adj} provides an AC ground to the adjust pin.

Figure 5. Load Regulation

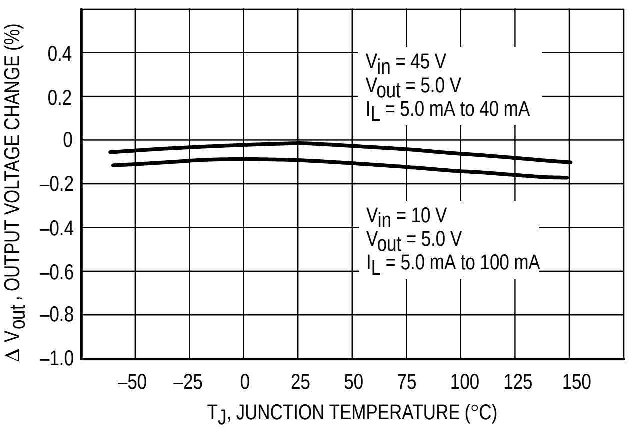


Figure 6. Ripple Rejection

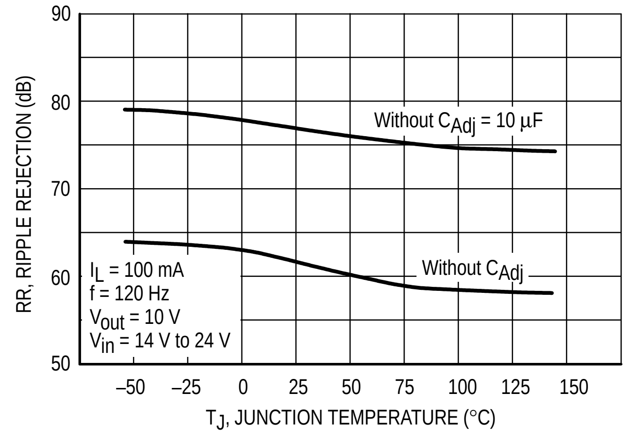


Figure 7. Current Limit

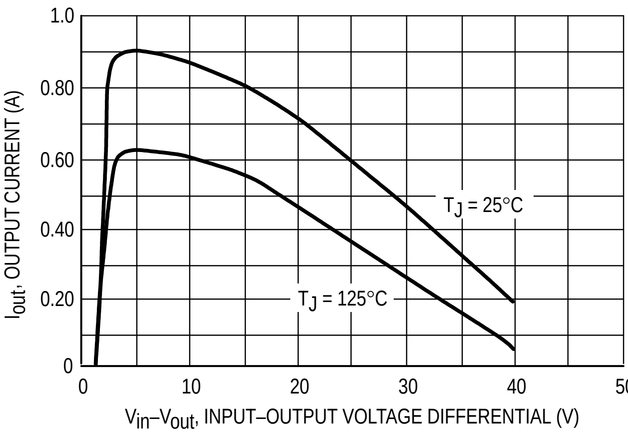


Figure 8. Dropout Voltage

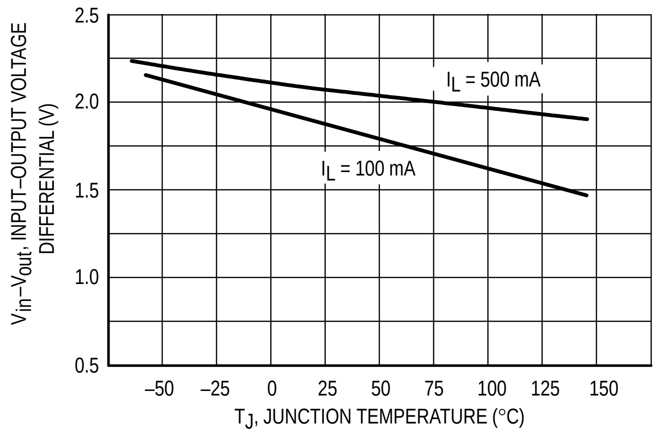


Figure 9. Minimum Operating Current

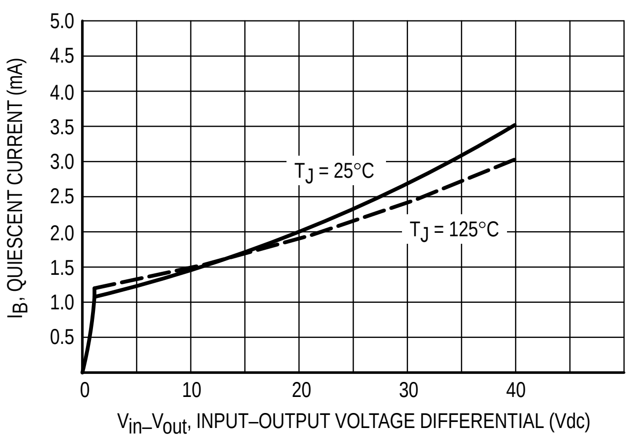


Figure 10. Ripple Rejection versus Frequency

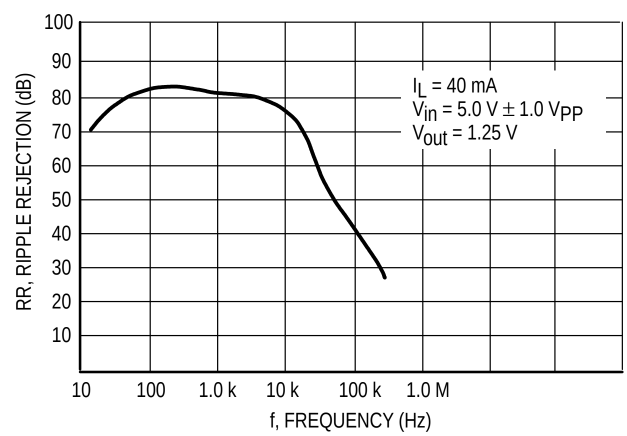


Figure 11. Temperature Stability

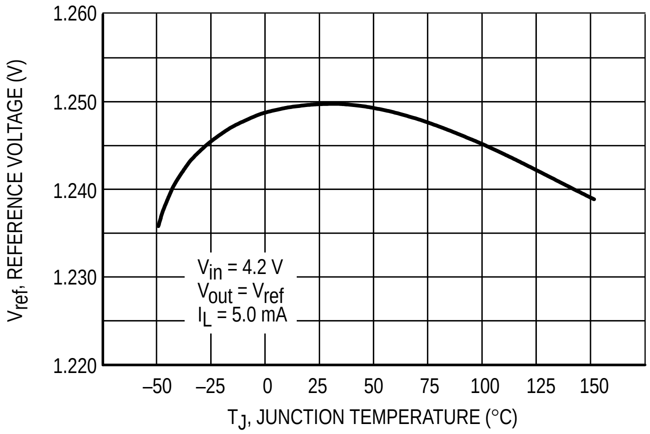


Figure 12. Adjustment Pin Current

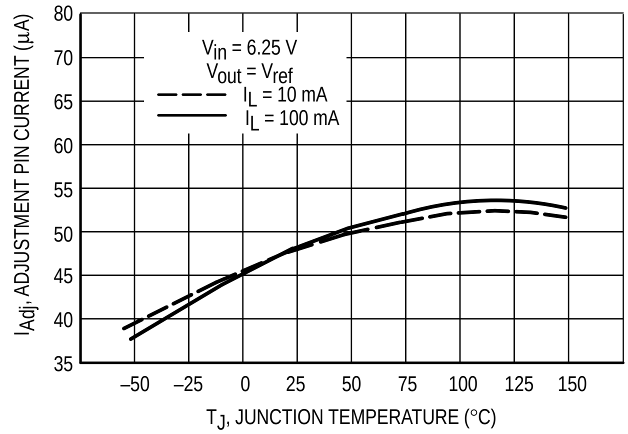


Figure 13. Line Regulation

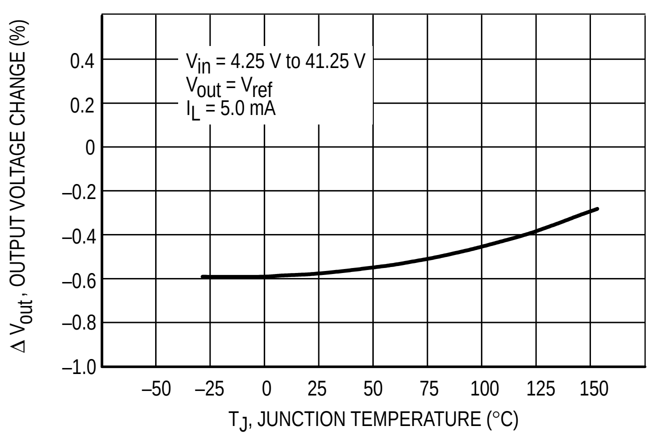


Figure 14. Output Noise

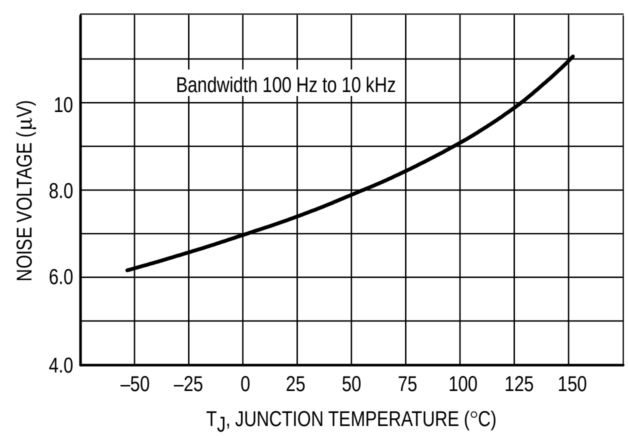


Figure 15. Line Transient Response

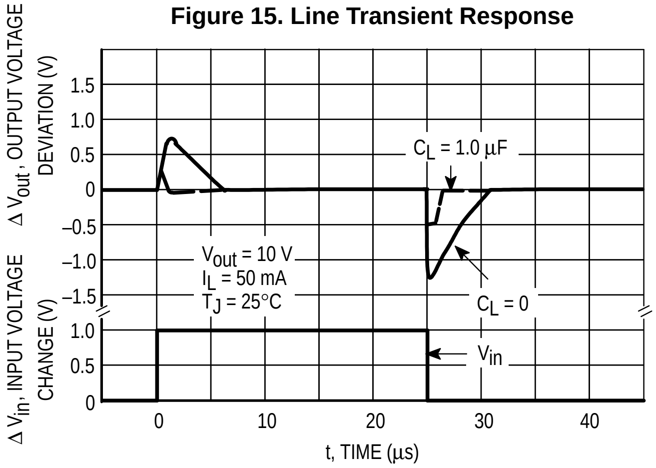
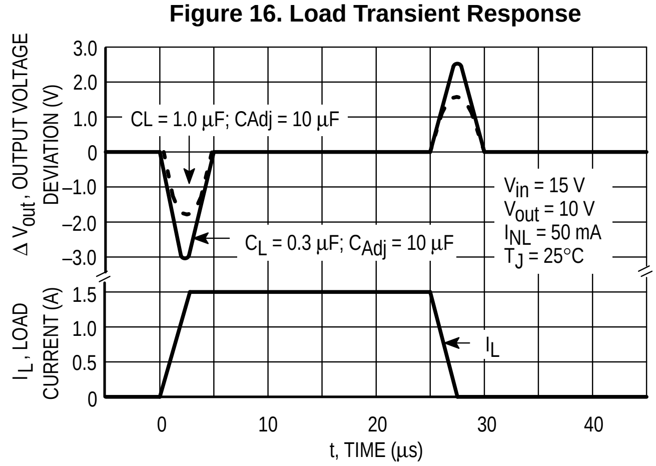


Figure 16. Load Transient Response



APPLICATIONS INFORMATION

Basic Circuit Operation

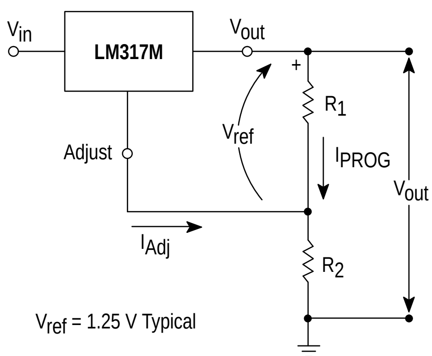
The LM317M is a three–terminal floating regulator. In operation, the LM317M develops and maintains a nominal 1.25 V reference (V_{ref}) between its output and adjustment terminals. This reference voltage is converted to a programming current (I_{PROG}) by R_1 (see Figure 17), and this constant current flows through R_2 to ground. The regulated output voltage is given by:

$$V_{out} = V_{ref}\left(1 + \frac{R_2}{R_1}\right) + I_{Adj}\,R_2$$

Since the current from the terminal (I_{Adj}) represents an error term in the equation, the LM317M was designed to control I_{Adj} to less than 100 µA and keep it constant. To do this, all quiescent operating current is returned to the output terminal. This imposes the requirement for a minimum load current. If the load current is less than this minimum, the output voltage will rise.

Since the LM317M is a floating regulator, it is only the voltage differential across the circuit which is important to performance, and operation at high voltages with respect to ground is possible.

Figure 17. Basic Circuit Configuration



Load Regulation

The LM317M is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor (R_1) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of R_2 can be returned near the load ground to provide remote ground sensing and improve load regulation.

External Capacitors

A 0.1 µF disc or 1.0 µF tantalum input bypass capacitor (C_{in}) is recommended to reduce the sensitivity to input line impedance.

The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor (C_{Adj}) prevents ripple from being amplified as the output voltage is increased. A 10 µF capacitor should improve ripple rejection about 15 dB at 120 Hz in a 10 V application.

Although the LM317M is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output capacitance (C_O) in the form of a 1.0 µF tantalum or 25 µF aluminum electrolytic capacitor on the output swamps this effect and insures stability.

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.

Figure 18 shows the LM317M with the recommended protection diodes for output voltages in excess of 25 V or high capacitance values (C_O > 25 µF, C_{Adj} > 5.0 µF). Diode D_1 prevents C_O from discharging thru the IC during an input short circuit. Diode D_2 protects against capacitor C_{Adj} discharging through the IC during an output short circuit. The combination of diodes D_1 and D_2 prevents C_{Adj} from discharging through the IC during an input short circuit.

Figure 18. Voltage Regulator with Protection Diodes

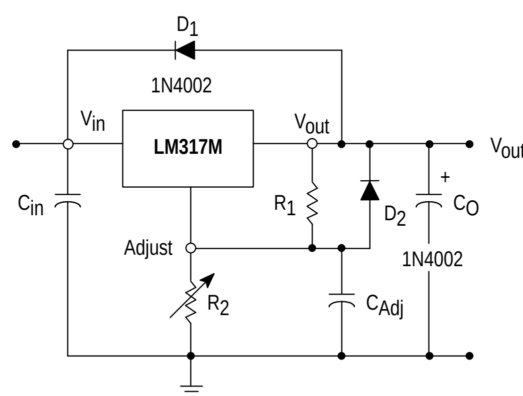


Figure 19. Adjustable Current Limiter

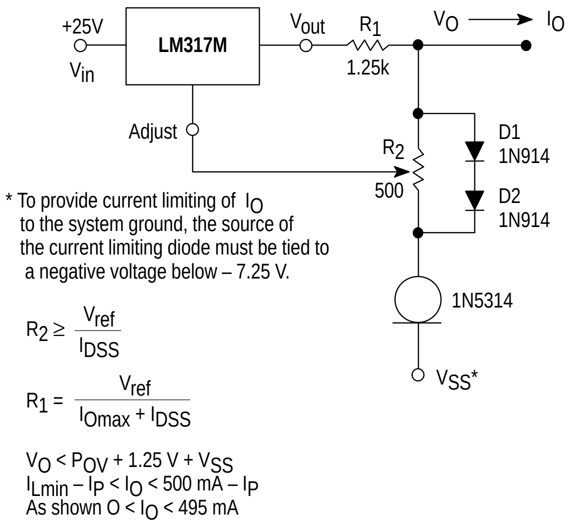
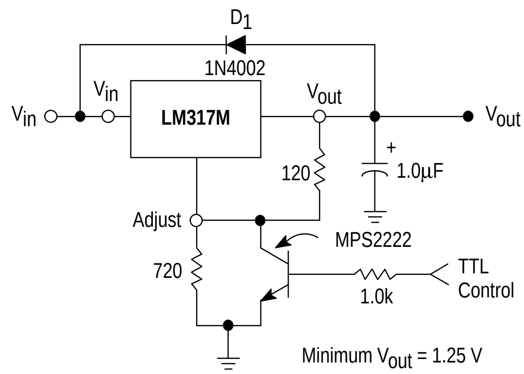


Figure 20. 5 V Electronic Shutdown Regulator



D_1 protects the device during an input short circuit.

Figure 21. Slow Turn–On Regulator

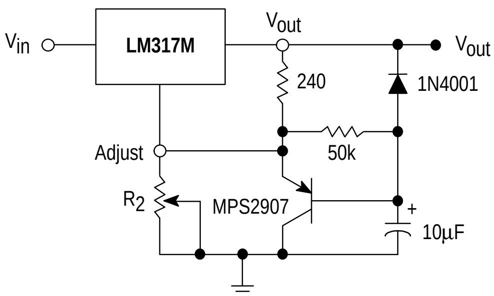
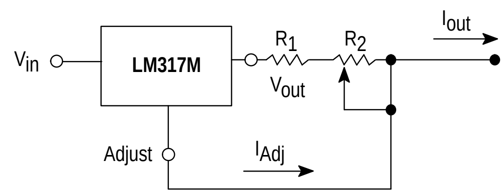


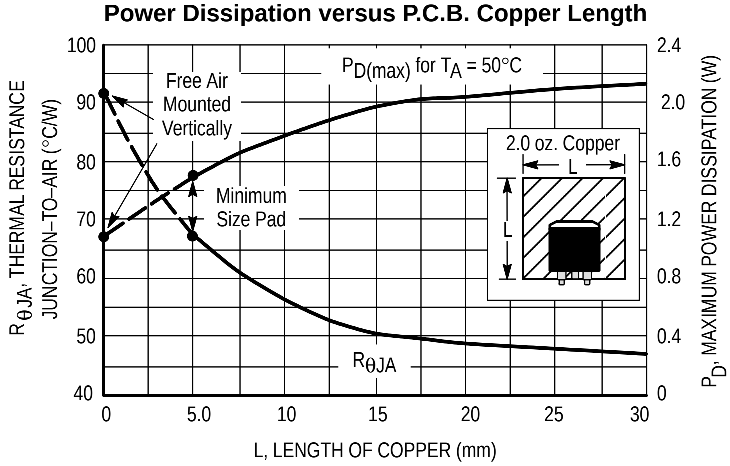
Figure 22. Current Regulator



$$I_{outmax} = \left(\frac{V_{ref}}{R_1 + R_2}\right) + I_{Adj} \cong \frac{1.25\ V}{R_1 + R_2}$$

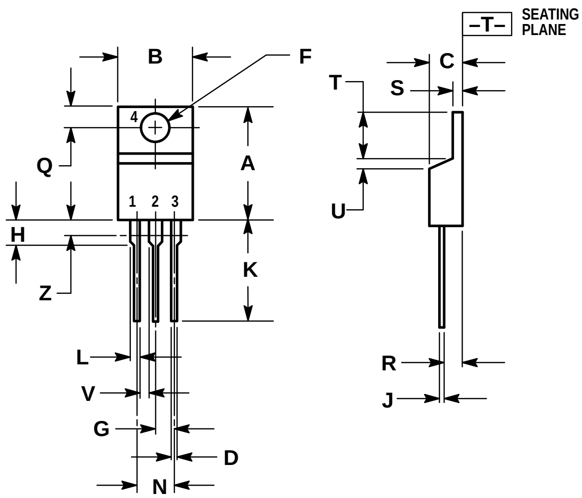
$5.0\ mA < I_{out} < 100\ mA$

Figure 23. DPAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length



OUTLINE DIMENSIONS

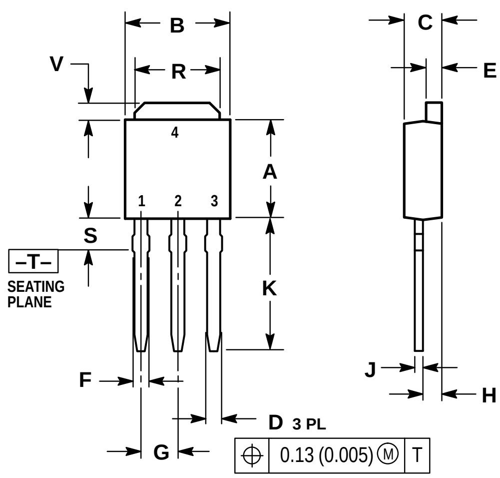
T SUFFIX
PLASTIC PACKAGE
CASE 221A–06
ISSUE Y



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	—	1.15	—
Z	—	0.080	—	2.04

DT–1 SUFFIX
PLASTIC PACKAGE
CASE 369–07
(DPAK)
ISSUE K



NOTES:
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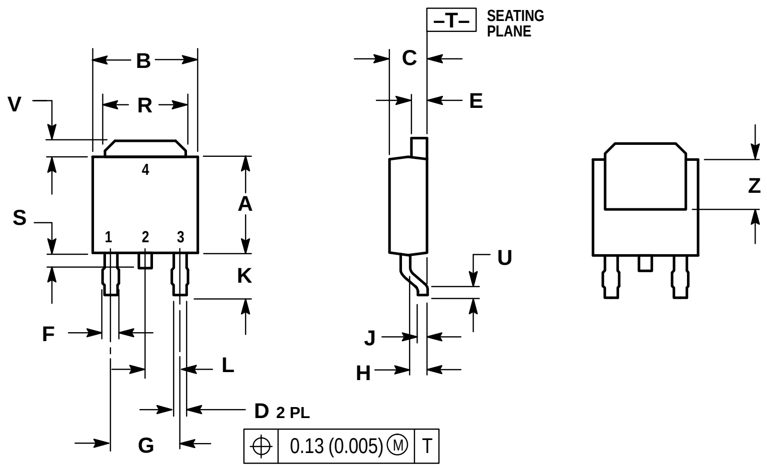
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.090 BSC		2.29 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.350	0.380	8.89	9.65
R	0.175	0.215	4.45	5.46
S	0.050	0.090	1.27	2.28
V	0.030	0.050	0.77	1.27

OUTLINE DIMENSIONS

DT SUFFIX
PLASTIC PACKAGE
CASE 369A–13
(DPAK)
ISSUE Y



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.175	0.215	4.45	5.46
S	0.020	0.050	0.51	1.27
U	0.020	—	0.51	—
V	0.030	0.050	0.77	1.27
Z	0.138	—	3.51	—

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