National Semiconductor

July 1999

LM341/LM78MXX Series
3-Terminal Positive Voltage Regulators

General Description

The LM341 and LM78MXX series of three-terminal positive voltage regulators employ built-in current limiting, thermal shutdown, and safe-operating area protection which makes them virtually immune to damage from output overloads.

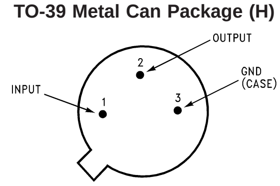
With adequate heatsinking, they can deliver in excess of 0.5A output current. Typical applications would include local (on-card) regulators which can eliminate the noise and degraded performance associated with single-point regulation.

Features

- Output current in excess of 0.5A
- No external components
- Internal thermal overload protection
- Internal short circuit current-limiting
- Output transistor safe-area compensation
- Available in TO-220, TO-39, and TO-252 D-PAK packages
- Output voltages of 5V, 12V, and 15V

Connection Diagrams

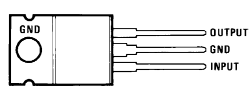
TO-39 Metal Can Package (H)



DS010484-5

Bottom View
Order Number LM78M05CH, LM78M12CH or LM78M15CH
See NS Package Number H03A

TO-220 Power Package (T)



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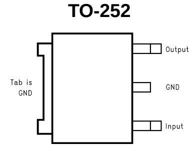
Top View
Order Number LM341T-5.0, LM341T-12, LM341T-15, LM78M05CT, LM78M12CT or LM78M15CT
See NS Package Number T03B

TO-252



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Top View
Order Number LM78M05CDT
See NS Package Number TD03B

 DS010484

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Lead Temperature (Soldering, 10 seconds)

TO-39 Package (H)	300˚C
TO-220 Package (T)	260˚C
Storage Temperature Range	−65˚C to +150˚C
Operating Junction Temperature Range	−40˚C to +125˚C
Power Dissipation (Note 2)	Internally Limited
Input Voltage	
$5V \le V_O \le 15V$	35V
ESD Susceptibility	TBD

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the −40˚C to +125˚C operating temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

LM341-5.0, LM78M05C

Unless otherwise specified: V_{IN} = 10V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L= 500 mA		4.8	5.0	5.2	V
		$5 mA \le I_L \le 500 mA$ $P_D \le 7.5W$, $7.5V \le V_{IN} \le 20V$		**4.75**	**5.0**	**5.25**	
$V_{R\ LINE}$	Line Regulation	$7.2V \le V_{IN} \le 25V$	I_L = 100 mA			50	mV
			I_L = 500 mA			100	
$V_{R\ LOAD}$	Load Regulation	$5 mA \le I_L \le 500 mA$				100	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	$5 mA \le I_L \le 500 mA$				0.5	
		$7.5V \le V_{IN} \le 25V$, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			40		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			78		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		7.2			V
ΔV_O	Long Term Stability	I_L = 500 mA				**20**	mV/khrs

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the −40˚C to +125˚C operating temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. (Continued)

LM341-12, LM78M12C

Unless otherwise specified: V_{IN} = 19V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L = 500 mA		11.5	12	12.5	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 14.8V ≤ V_{IN} ≤ 27V		**11.4**	**12**	**12.6**	
$V_{R\ LINE}$	Line Regulation	14.5V ≤ V_{IN} ≤ 30V	I_L = 100 mA			120	mV
			I_L = 500 mA			240	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				240	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_L ≤ 500 mA				0.5	
		14.8V ≤ V_{IN} ≤ 30V, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			75		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			71		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		14.5			V
ΔV_O	Long Term Stability	I_L = 500 mA				**48**	mV/khrs

LM341-15, LM78M15C

Unless otherwise specified: V_{IN} = 23V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L = 500 mA		14.4	15	15.6	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 18V ≤ V_{IN} ≤ 30V		**14.25**	**15**	**15.75**	
$V_{R\ LINE}$	Line Regulation	17.6V ≤ V_{IN} ≤ 30V	I_L = 100 mA			150	mV
			I_L = 500 mA			300	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				300	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_L ≤ 500 mA				0.5	
		18V ≤ V_{IN} ≤ 30V, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			90		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			69		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		17.6			V
ΔV_O	Long Term Stability	I_L = 500 mA				**60**	mV/khrs

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

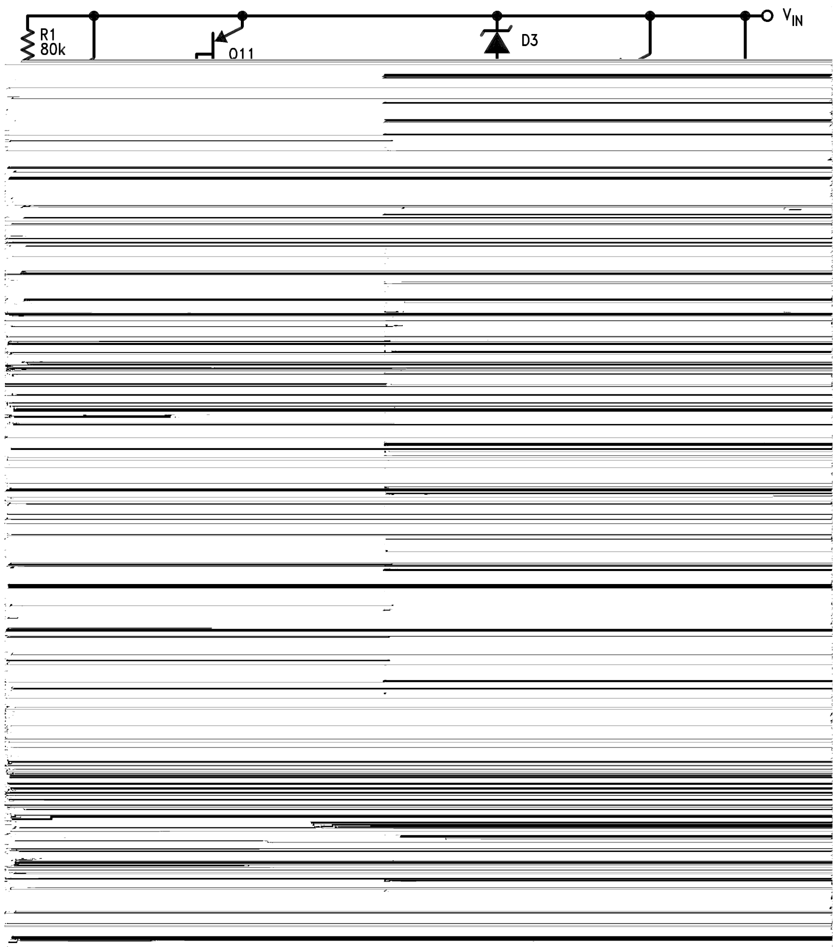
Note 2: The typical thermal resistance of the three package types is:

T (TO-220) package: $\theta_{(JA)}$ = 60 ˚C/W, $\theta_{(JC)}$ = 5 ˚C/W

H (TO-39) package: $\theta_{(JA)}$ = 120 ˚C/W, $\theta_{(JC)}$ = 18 ˚C/W

DT (TO-252) package: $\theta_{(JA)}$ = 92 ˚C/W, $\theta_{(JC)}$ = 10 ˚C/W

Schematic Diagram



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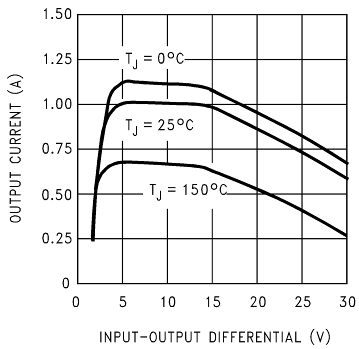
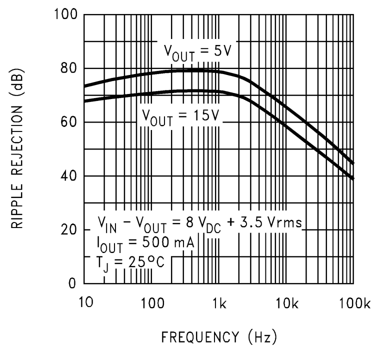
Typical Performance Characteristics

Peak Output Current



Ripple Rejection



Ripple Rejection

Dropout Voltage

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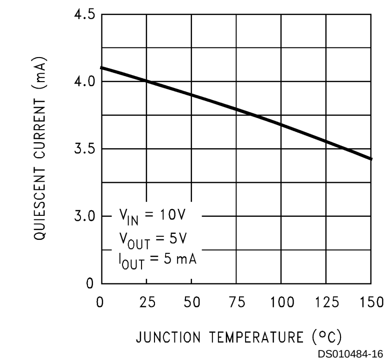
Typical Performance Characteristics (Continued)

Quiescent Current



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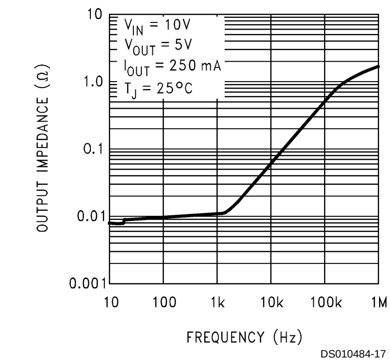
Output Imp



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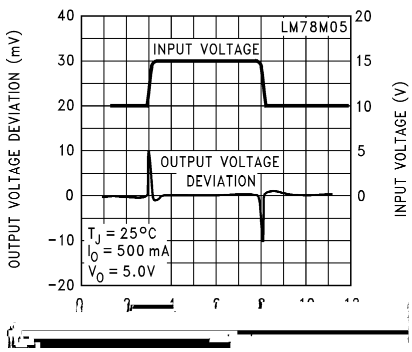
Line Transient Response



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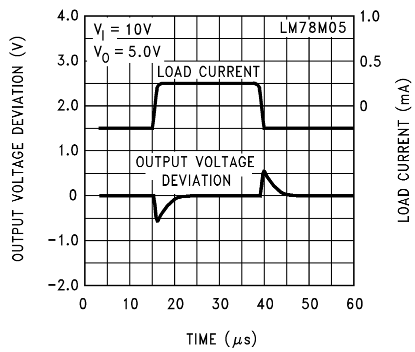
Load Transient Response



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Design Considerations

The LM78MXX/LM341XX fixed voltage regulator series has built-in thermal overload protection which prevents the device from being damaged due to excessive junction tem-

The regulators also contain internal short-circuit protection which limits the maximum output current, and safe-area protection for the pass transistor which reduces the short-circuit current as the voltage across the pass transistor is increased.

Although the internal power dissipation is automatically lim-

be kept below +125˚C in order to meet data sheet sp tions. An adequate heatsink should be provided to assure this limit is not exceeded under worst-case op conditions (maximum input voltage and load current) if reliable p is to be obtained).

When an integrated circuit op with appreciable cur-

quantify its thermal limits in order to achieve acceptable p formance and reliability. This limit is determined by summing the individual parts consisting of a series of temp

ronment. A one-dimension steady-state model of conduction heat transfer is demonstrated in The heat generated at the device junction flows through the die to the die attach pad, through the lead frame to the surrounding case material, to the printed circuit board, and eventually to the ambient environment. Below is a list of variables that may affect the thermal resistance and in turn the need for a heatsink.

$R^{\theta JC}$(Component Variables)	$R^{\theta CA}$(Application Variables)
Leadframe Size & Material	Mounting Pad Size, Material, & Location
No. of Conduction Pins	Placement of Mounting Pad
Die Size	PCB Size & Material
Die Attach Material	Traces Length & Width
Molding Compound Size and Material	Adjacent Heat Sources
	Volume of Air
	Air Flow
	Ambient Temp
	Shap of Mounting Pad

Design Considerations (Continued)

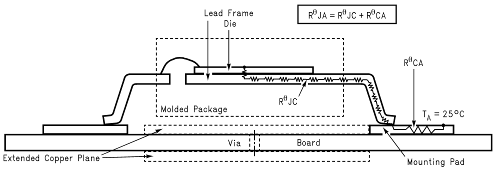

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FIGURE 1. Cross-sectional view of Integrated Circuit Mounted on a printed circuit board. Note that the case temperature is measured at the point where the leads contact with the mounting pad surface

The LM78MXX/LM341XX regulators have internal thermal shutdown to protect the device from over-heating. Under all possible operating conditions, the junction temperature of the LM78MXX/LM341XX must be within the range of 0˚C to 125˚C. A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$I_{IN} = I_L + I_G$

$P_D = (V_{IN}-V_{OUT})\ I_L + V_{IN}I_G$

shows the voltages and currents which are present in the circuit.

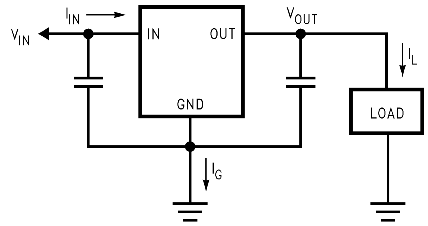

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FIGURE 2. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max):

θ_{JA} = TR (max)/P_D

If the maximum allowable value for θ_{JA}˚C/w is found to be ≥60˚C/W for TO-220 package or ≥92˚C/W for TO-252 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} fall below these limits, a heatsink is required.

As a design aid, *Table 1* shows the value of the θ_{JA} of TO-252 for different heatsink area. The copper patterns that we used to measure these θ_{JA} are shown at the end of the Application Note Section. reflects the same test results as what are in the *Table 1*

shows the maximum allowable power dissipation vs. ambient temperature for theTO-252 device. shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN1028 for power enhancement techniques to be used with TO-252 package.

TABLE 1. θ_{JA} Different Heatsink Area

Layout	Copper Area		Thermal Resistance
	Top Sice (in^2)*	Bottom Side (in^2)	(θ_{JA}, ˚C/W) TO-252
1	0.0123	0	103
2	0.066	0	87
3	0.3	0	60
4	0.53	0	54
5	0.76	0	52
6	1	0	47
7	0	0.2	84
8	0	0.4	70
9	0	0.6	63
10	0	0.8	57
11	0	1	57
12	0.066	0.066	89
13	0.175	0.175	72
14	0.284	0.284	61
15	0.392	0.392	55
16	0.5	0.5	53

*Tab of device attached to topside copper

Design Considerations (Continued)

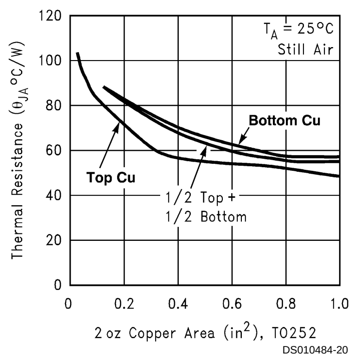


FIGURE 3. θ_{JA} vs. 2oz Copper Area for TO-252

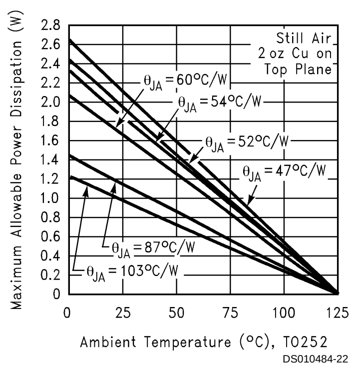


FIGURE 4. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

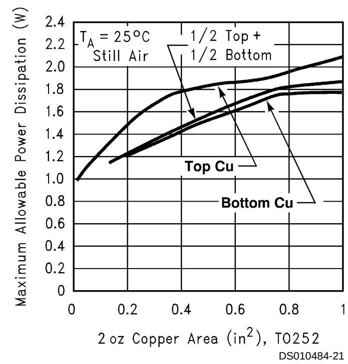
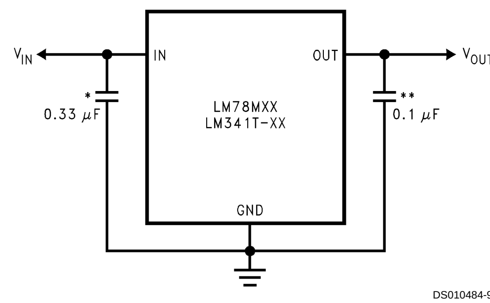


FIGURE 5. Maximum Allowable Power Dissipation vs. 2oz. Copper Area for TO-252

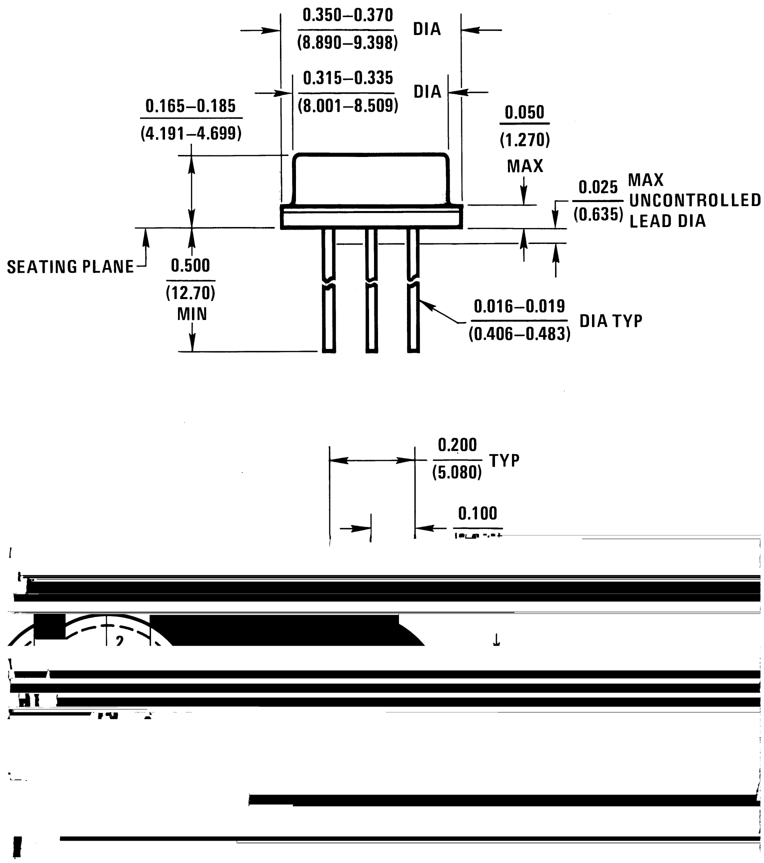
Typical Application



*Required if regulator input is more than 4 inches from input filter capacitor (or if no input filter capacitor is used).

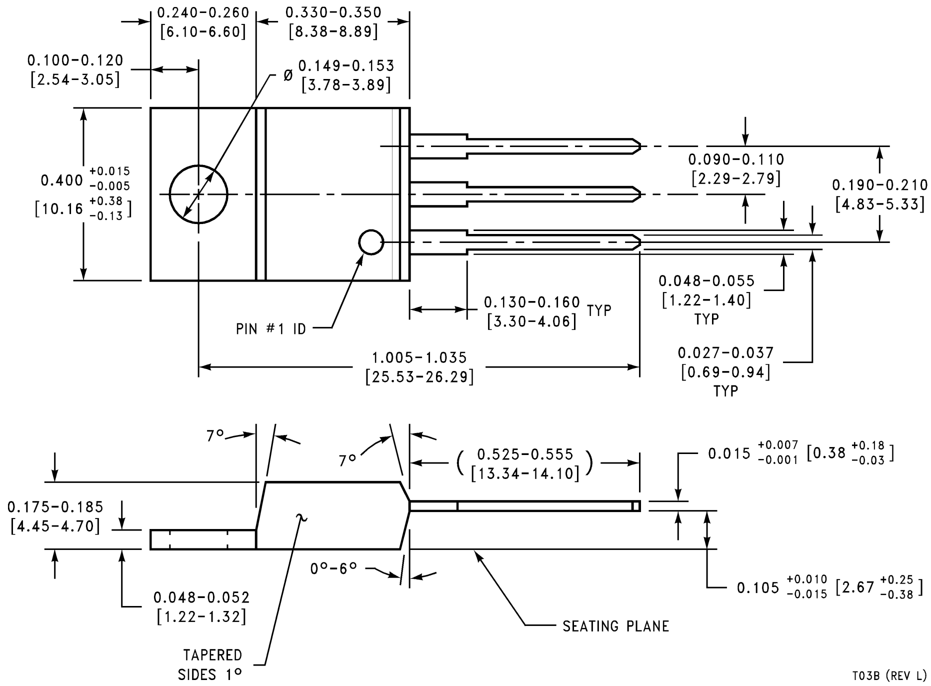
**Optional for improved transient response.

Physical Dimensions inches (millimeters) unless otherwise noted



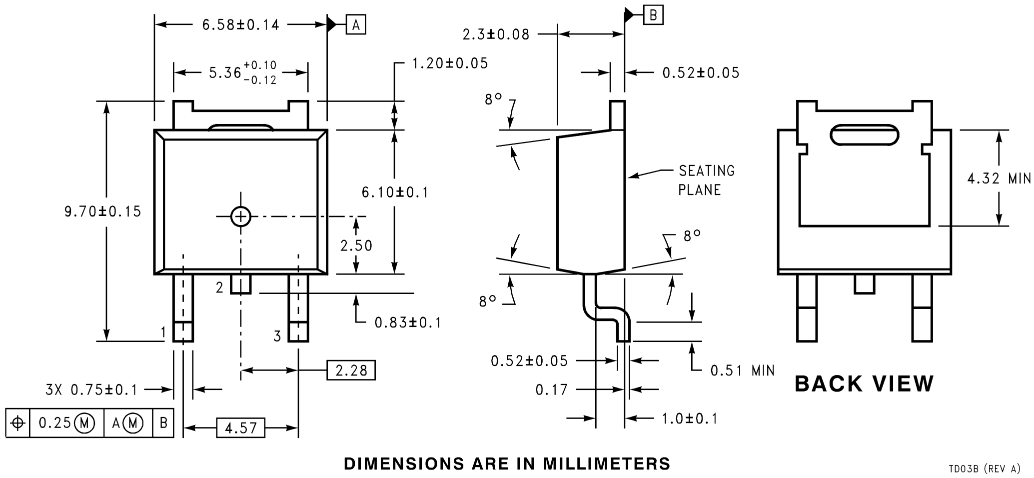
TO-39 Metal Can Package (H)
Order Number LM78M05CH, LM78M12CH or LM78M15CH
NS Package Number H03A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-220 Power Package (T)
Order Number LM341T-5.0, LM341T-12, LM341T-15, LM78M05CT, LM78M12CT or LM78M15CT
NS Package Number T03B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-252
Order Number LM78M05CDT
NS Package Number TD03B

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