LM341/LM78MXX Series 3-Terminal Positive Voltage Regulators

Check for Samples: LM341/LM78MXX

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, and PFM D-PAK Packages**
- **Output Voltages of 5V, 12V, and 15V**

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.

Connection Diagram

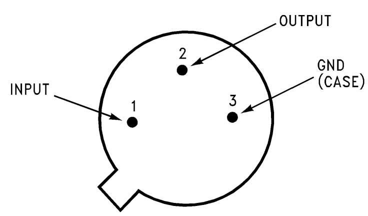


Figure 1. TO Metal Can Package (NDT) - Bottom View
See Package Number NDT0003A

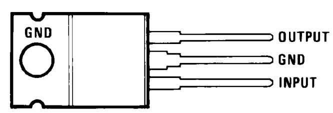


Figure 2. TO-220 Power Package (NDE) - Top View
See Package Number NDE0003B

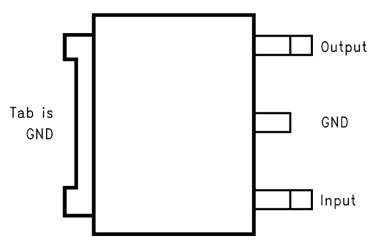


Figure 3. PFM - Top View
See Package Number NDP0003B

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)(2)

Lead Temperature (Soldering, 10 seconds)	TO Package (NDT)	300°C
	TO-220 Package (NDE)	260°C
Storage Temperature Range		−65°C to +150°C
Operating Junction Temperature Range		−40°C to +125°C
Power Dissipation(3)		Internally Limited
Input Voltage 5V ≤ V_O ≤ 15V		35V
ESD Susceptibility		TBD

(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.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(3) The typical thermal resistance of the three package types is: **NDE** (TO-220) package: $\theta_{(JA)}$ = 60 °C/W, $\theta_{(JC)}$ = 5 °C/W **NDT** (TO) package: $\theta_{(JA)}$ = 120 °C/W, $\theta_{(JC)}$ = 18 °C/W **NDP** (PFM) package: $\theta_{(JA)}$ = 92 °C/W, $\theta_{(JC)}$ = 10 °C/W

LM341-5.0, LM78M05C ELECTRICAL CHARACTERISTICS

Unless otherwise specified: V_{IN} = 10V, C_{IN} = 0.33 μF, C_O = 0.1 μF
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 specified by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L= 500 mA		4.8	5.0	5.2	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 7.5V ≤ V_{IN} ≤ 20V		**4.75**	**5.0**	**5.25**	
$V_{R\ LINE}$	Line Regulation	7.2V ≤ V_{IN} ≤ 25V	I_L = 100 mA			50	mV
			I_L = 500 mA			100	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				100	
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	
		7.5V ≤ V_{IN} ≤ 25V, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			40		μV
$\Delta V_{IN}/\Delta V_O$	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

LM341-12, LM78M12C ELECTRICAL CHARACTERISTICS

Unless otherwise specified: V_{IN} = 19V, C_{IN} = 0.33 µF, C_O = 0.1 µF
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 specified by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

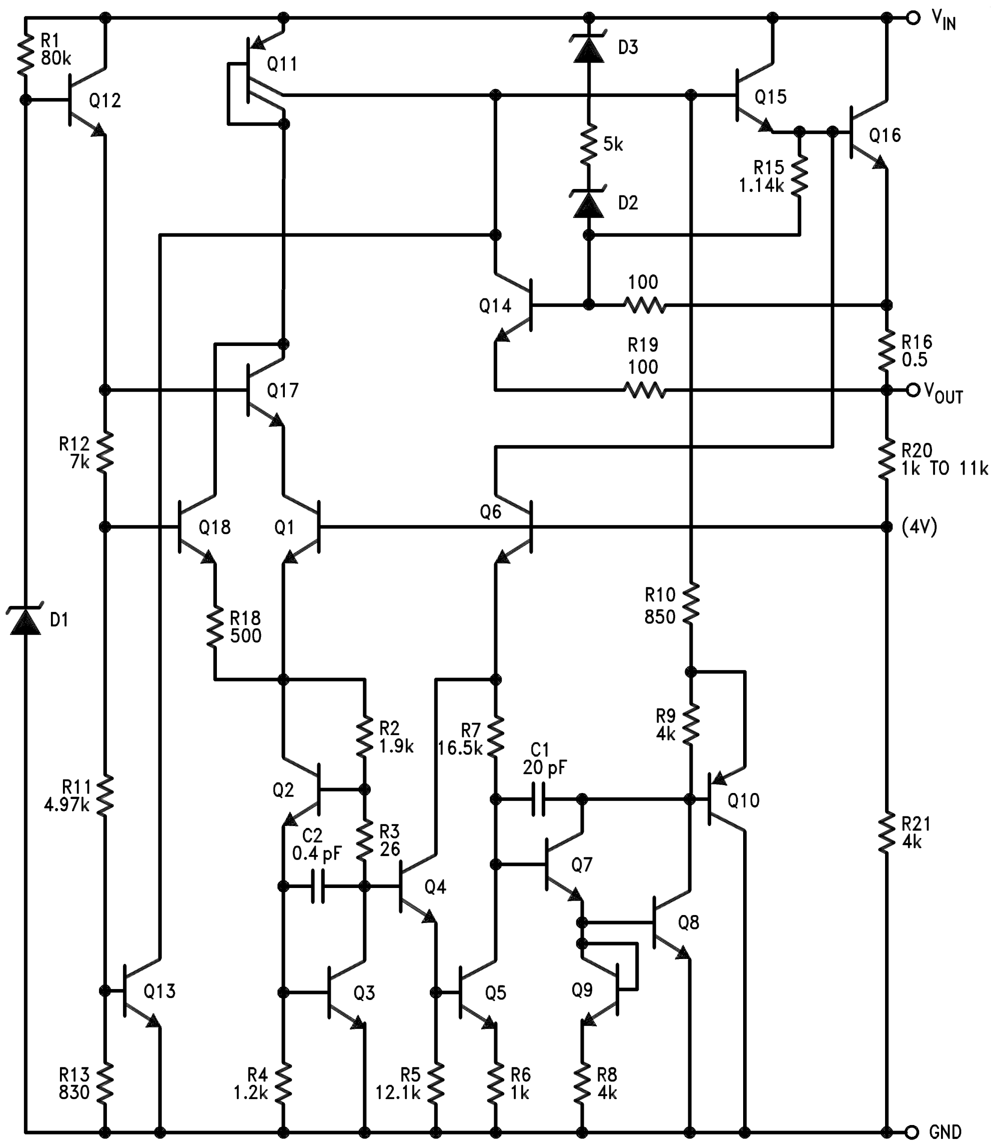
Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L= 500 mA		11.5	12	12.5	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 14.8V ≤ V_{IN} ≤ 27V		**11.4**	**12**	**12.6**	
$V_{R\ LINE}$	Line Regulation	14.5V ≤ V_{IN} ≤ 30V	I_L = 100 mA			120	mV
			I_L = 500 mA			240	
$V_{R\ LOAD}$	Load Regulation	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
$\Delta V_{IN}/\Delta V_O$	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 ELECTRICAL CHARACTERISTICS

Unless otherwise specified: V_{IN} = 23V, C_{IN} = 0.33 µF, C_O = 0.1 µF
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 specified by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

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
$\Delta V_{IN}/\Delta V_O$	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

SCHEMATIC DIAGRAM



TYPICAL PERFORMANCE CHARACTERISTICS

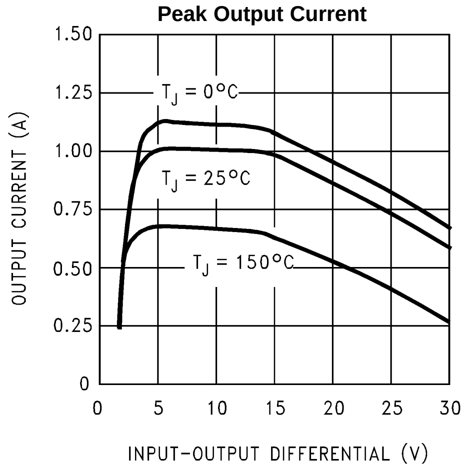


Figure 4.

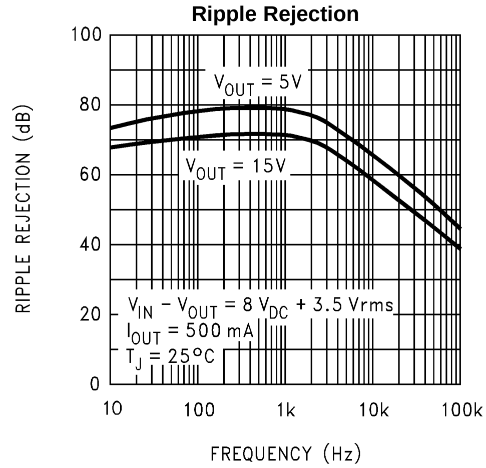


Figure 5.

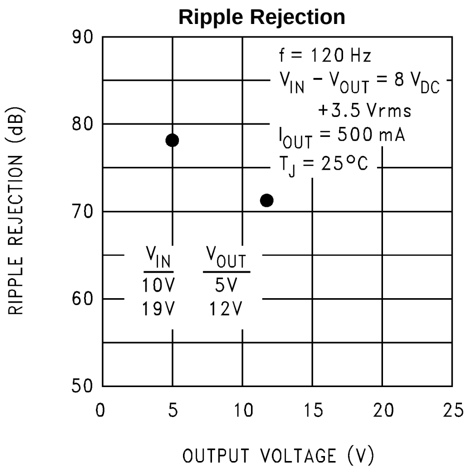
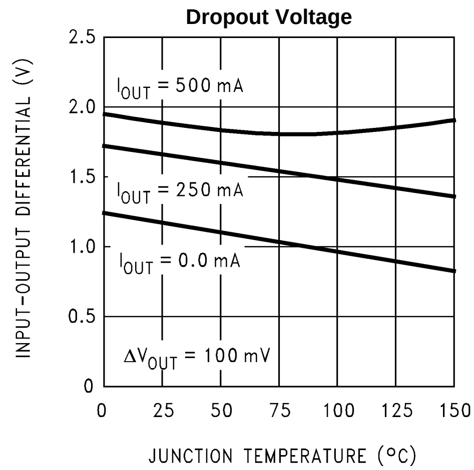


Figure 6.



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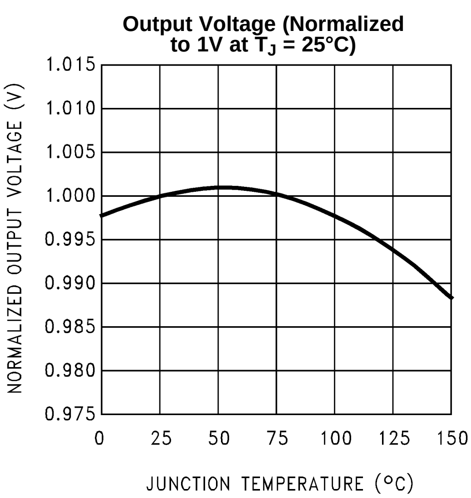

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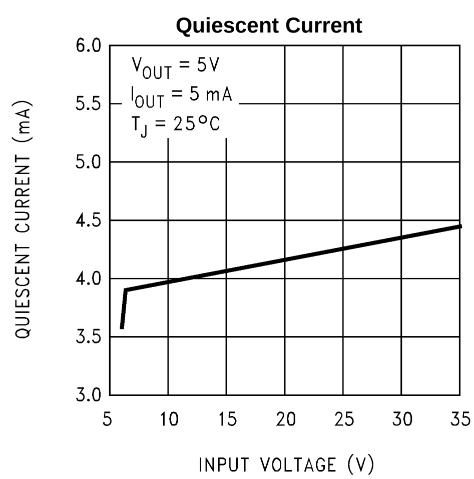


Figure 9.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

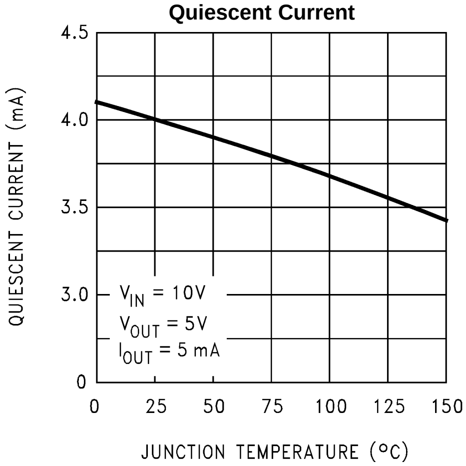


Figure 10.

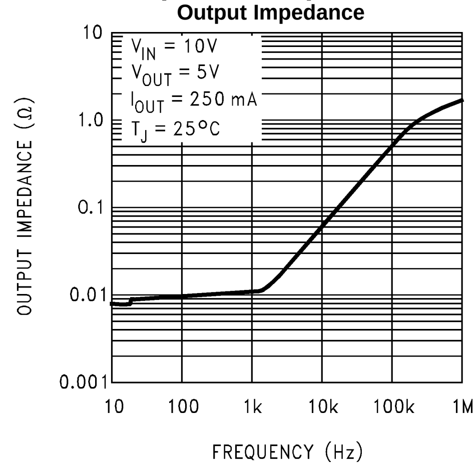


Figure 11.

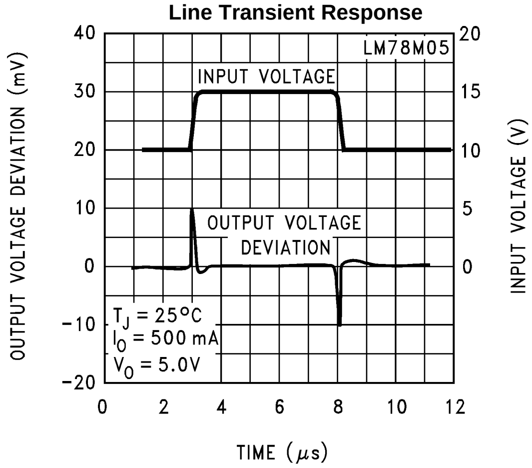


Figure 12.

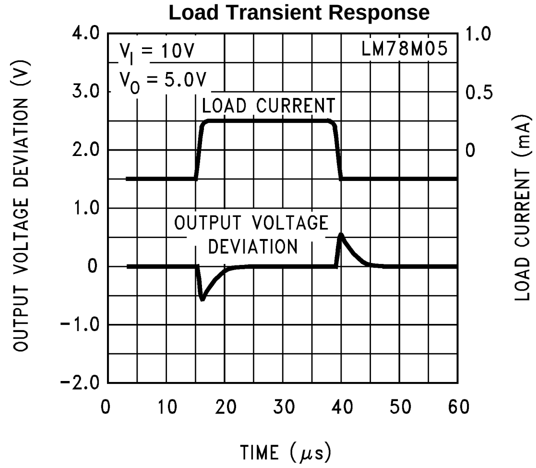


Figure 13.

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 temperature.

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.

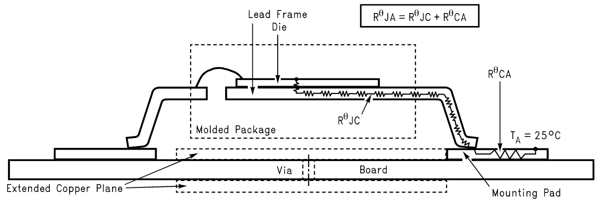
Although the internal power dissipation is automatically limited, the maximum junction temperature of the device must be kept below +125°C in order to meet data sheet specifications. An adequate heatsink should be provided to assure this limit is not exceeded under worst-case operating conditions (maximum input voltage and load current) if reliable performance is to be obtained).

HEATSINK CONSIDERATIONS

When an integrated circuit operates with appreciable current, its junction temperature is elevated. It is important to quantify its thermal limits in order to achieve acceptable performance and reliability. This limit is determined by summing the individual parts consisting of a series of temperature rises from the semiconductor junction to the operating environment. A one-dimension steady-state model of conduction heat transfer is demonstrated in Figure 14 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 Temperature
	Shape of Mounting Pad

APPLICATION INFORMATION



Note that the case temperature is measured at the point where the leads contact with the mounting pad surface

Figure 14. Cross-sectional view of Integrated Circuit Mounted on a printed circuit board.

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:

$$I_{IN} = I_L + I_G \quad (1)$$

$$P_D = (V_{IN}−V_{OUT})\ I_L + V_{IN}I_G \quad (2)$$

Figure 15 shows the voltages and currents which are present in the circuit.

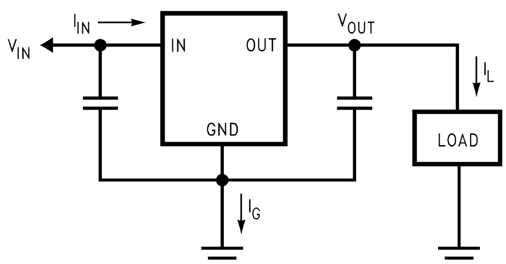


Figure 15. Power Dissipation Diagram

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

$$\theta_{JA} = TR\ (max)/P_D \quad (3)$$

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 PFM 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 PFM 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. Figure 16 reflects the same test results as what are in the Table 1

Figure 17 shows the maximum allowable power dissipation vs. ambient temperature for the TO-252 device. Figure 18 shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN-1028 (SNVA036) 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)[(1)]	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

(1) Tab of device attached to topside copper

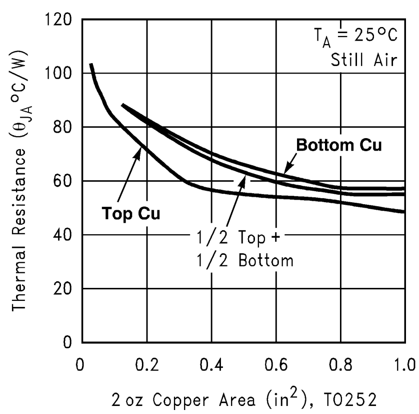


Figure 16. θ_{JA} vs. 2oz Copper Area for TO-252

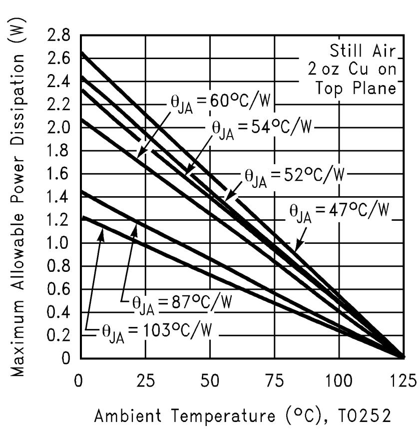


Figure 17. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

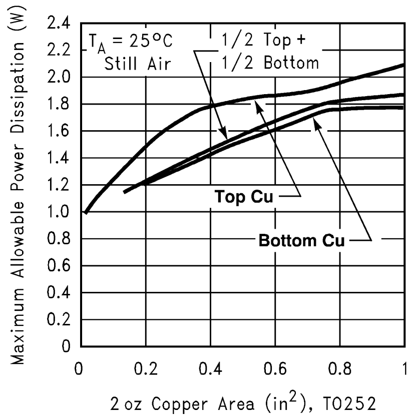
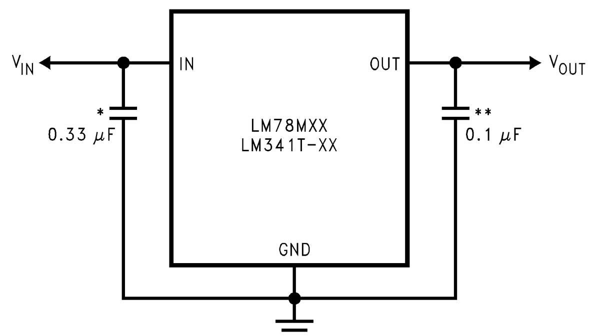


Figure 18. Maximum Allowable Power Dissipation vs. 2oz. Copper Area for TO-252

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.

Figure 19. Typical Application

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM341T-15	NRND	TO-220	NDE	3	45	TBD	Call TI	Call TI	-40 to 125	LM341T-15 LM78M15CT	
LM341T-15/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	-40 to 125	LM341T-15 LM78M15CT	Samples
LM341T-5.0	NRND	TO-220	NDE	3	45	TBD	Call TI	Call TI	-40 to 125	LM341T-5.0 LM78M05CT	
LM341T-5.0/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	-40 to 125	LM341T-5.0 LM78M05CT	Samples
LM78M05CDT	NRND	TO-252	NDP	3	75	TBD	Call TI	Call TI	-40 to 125	LM78M05 CDT	
LM78M05CDT/NOPB	ACTIVE	TO-252	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	LM78M05 CDT	Samples
LM78M05CDTX	NRND	TO-252	NDP	3	2500	TBD	Call TI	Call TI	-40 to 125	LM78M05 CDT	
LM78M05CDTX/NOPB	ACTIVE	TO-252	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	LM78M05 CDT	Samples
LM78M05CH	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-40 to 125	(LM78M05CH ~ LM78M05CH)	Samples
LM78M05CH/NOPB	ACTIVE	TO	NDT	3	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-40 to 125	(LM78M05CH ~ LM78M05CH)	Samples
LM78M05CT	NRND	TO-220	NDE	3	45	TBD	Call TI	Call TI	-40 to 125	LM341T-5.0 LM78M05CT	
LM78M05CT/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	-40 to 125	LM341T-5.0 LM78M05CT	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.

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

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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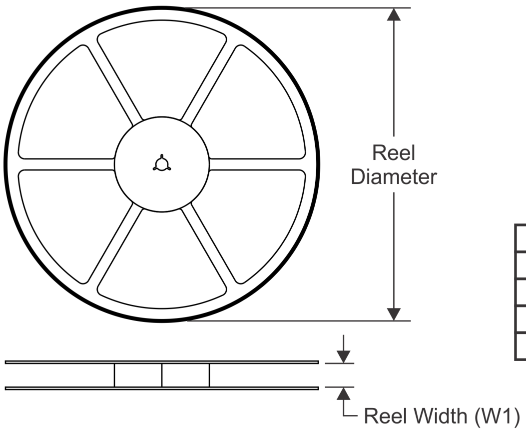
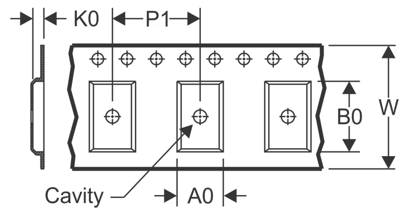
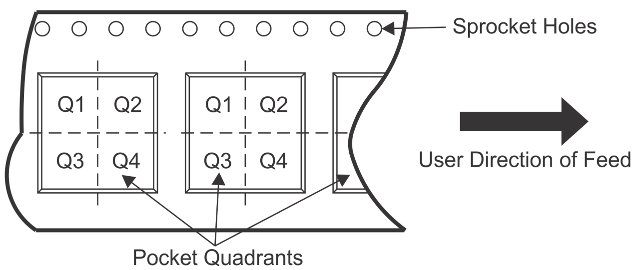
TAPE AND REEL INFORMATION





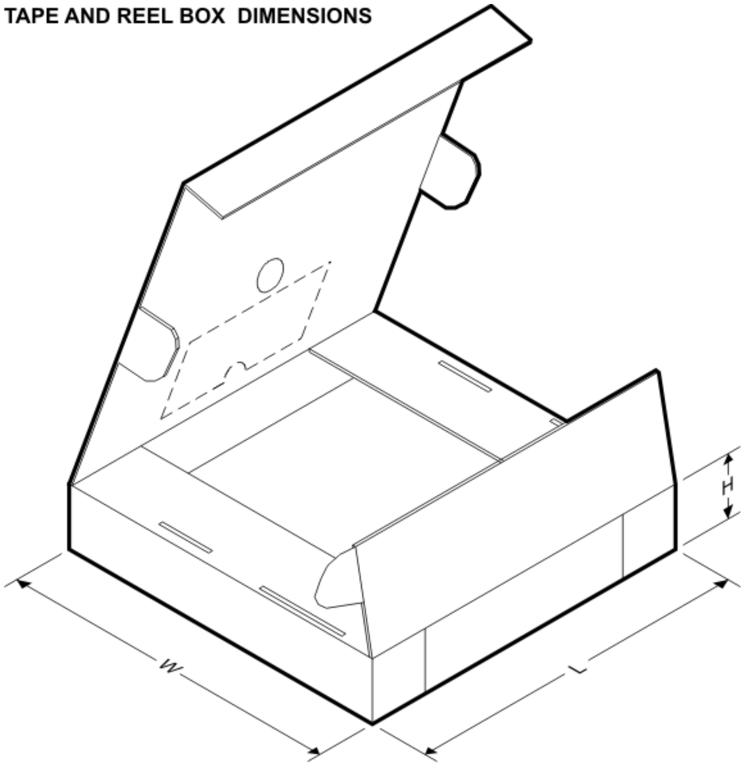
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*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
LM78M05CDTX	TO-252	NDP	3	2500	330.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
LM78M05CDTX/NOPB	TO-252	NDP	3	2500	330.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2

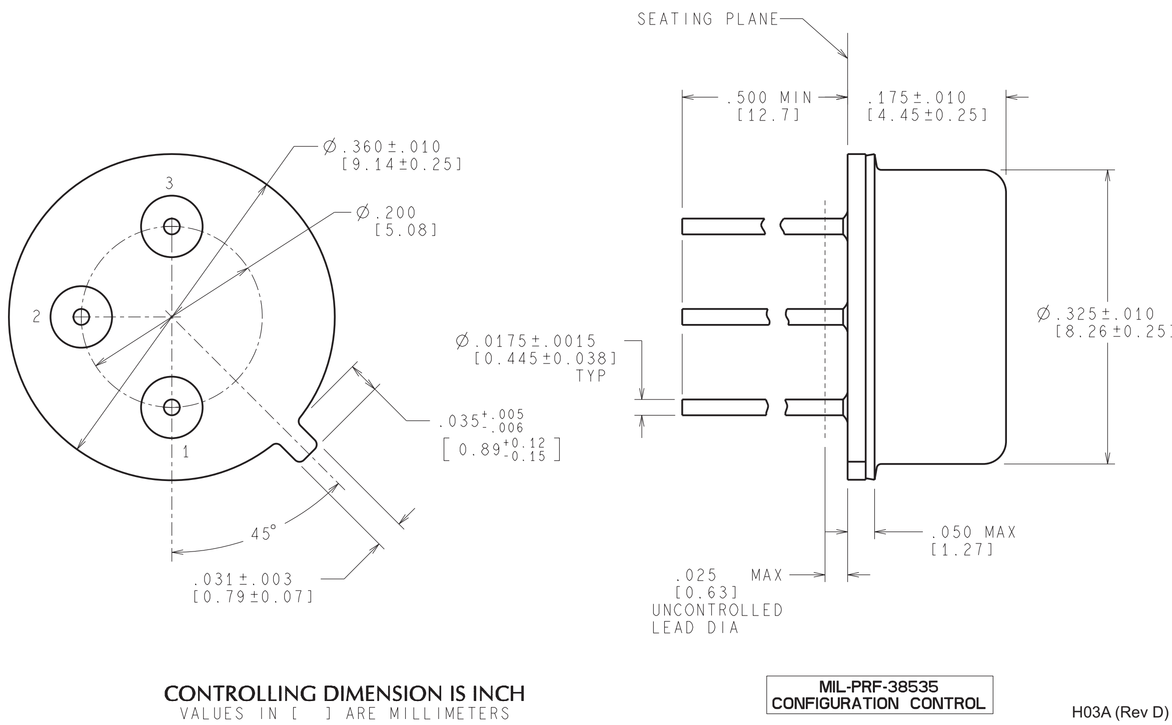
TAPE AND REEL BOX DIMENSIONS



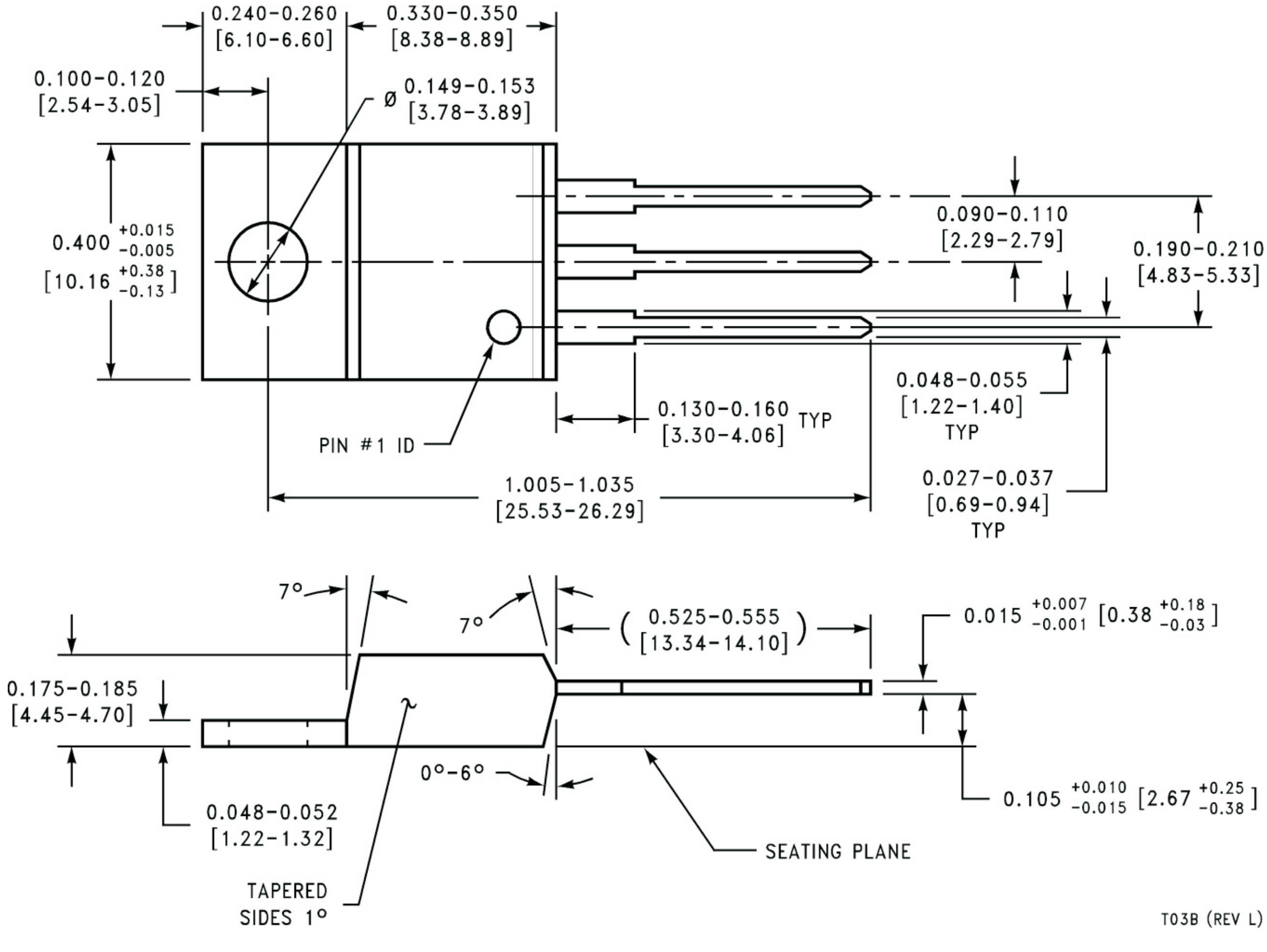
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM78M05CDTX	TO-252	NDP	3	2500	367.0	367.0	35.0
LM78M05CDTX/NOPB	TO-252	NDP	3	2500	367.0	367.0	38.0

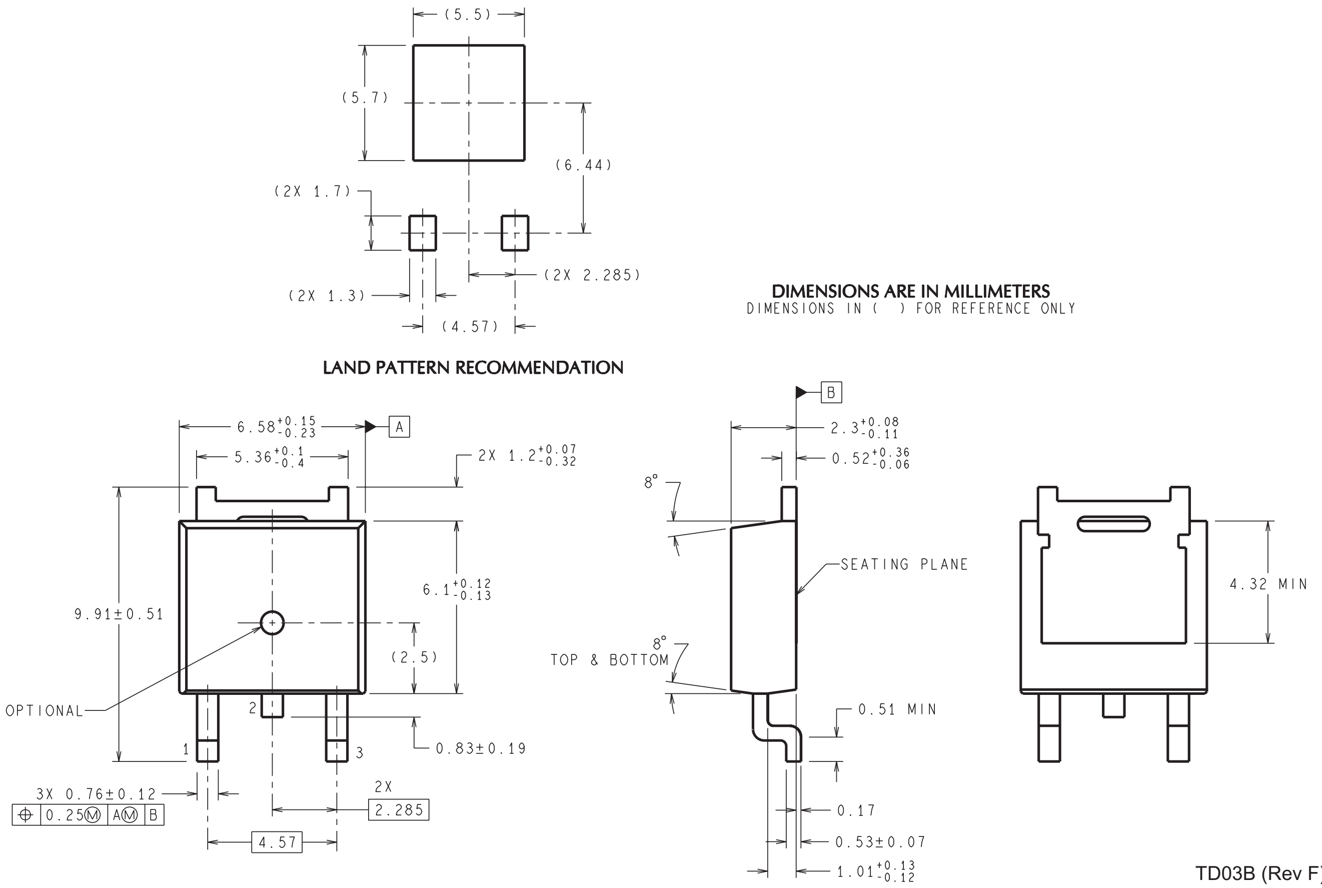
NDT0003A


SEATING PLANE
.500 MIN
[12.7]
.175±.010
[4.45±0.25]
Ø.360±.010
[9.14±0.25]
Ø.200
[5.08]
3
2
1
Ø.0175±.0015
[0.445±0.038]
TYP
.035+.005 -.006
[0.89+0.12 -0.15]
Ø.325±.010
[8.26±0.25]
45°
.031±.003
[0.79±0.07]
.050 MAX
[1.27]
.025 MAX
[0.63]
UNCONTROLLED
LEAD DIA
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
MIL-PRF-38535
CONFIGURATION CONTROL
H03A (Rev D)

NDE0003B



0.240–0.260
[6.10–6.60]
0.330–0.350
[8.38–8.89]
0.100–0.120
[2.54–3.05]
Ø 0.149–0.153
[3.78–3.89]
0.400 +0.015 −0.005
[10.16 +0.38 −0.13]
0.090–0.110
[2.29–2.79]
0.190–0.210
[4.83–5.33]
0.048–0.055
[1.22–1.40]
TYP
0.130–0.160 TYP
[3.30–4.06]
PIN #1 ID
1.005–1.035
[25.53–26.29]
0.027–0.037
[0.69–0.94]
TYP
7°
7°
(0.525–0.555)
[13.34–14.10]
0.015 +0.007 −0.001 [0.38 +0.18 −0.03]
0.175–0.185
[4.45–4.70]
0°–6°
0.105 +0.010 −0.015 [2.67 +0.25 −0.38]
0.048–0.052
[1.22–1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)


(5.5)
(5.7)
(6.44)
(2X 1.7)
(2X 2.285)
(2X 1.3)
(4.57)
LAND PATTERN RECOMMENDATION
DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY
6.58 +0.15 -0.23
A
5.36 +0.1 -0.4
2X 1.2 +0.07 -0.32
9.91±0.51
6.1 +0.12 -0.13
(2.5)
OPTIONAL
0.83±0.19
1
2
3
3X 0.76±0.12
0.25 M A M B
2X
2.285
4.57
B
2.3 +0.08 -0.11
0.52 +0.36 -0.06
8°
SEATING PLANE
8°
TOP & BOTTOM
0.51 MIN
0.17
0.53±0.07
1.01 +0.13 -0.12
4.32 MIN

TD03B (Rev F)

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