

LM3940 1A Low Dropout Regulator for 5V to 3.3V Conversion

Check for Samples: [LM3940](#)

FEATURES

- Output voltage specified over temperature
- Excellent load regulation
- Guaranteed 1A output current
- Requires only one external component
- Built-in protection against excess temperature

- Short circuit protected

APPLICATIONS

- Laptop/Desktop Computers
- Logic Systems

DESCRIPTION

The LM3940 is a 1A low dropout regulator designed to provide 3.3V from a 5V supply.

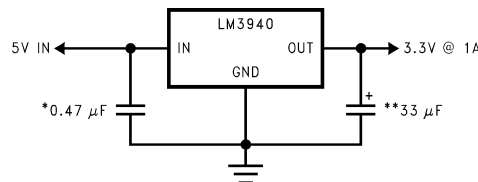
The LM3940 is ideally suited for systems which contain both 5V and 3.3V logic, with prime power provided from a 5V bus.

Because the LM3940 is a true low dropout regulator, it can hold its 3.3V output in regulation with input voltages as low as 4.5V.

The T0-220 package of the LM3940 means that in most applications the full 1A of load current can be delivered without using an additional heatsink.

The surface mount TO-263 package uses minimum board space, and gives excellent power dissipation capability when soldered to a copper plane on the PC board.

Typical Application



*Required if regulator is located more than 1" from the power supply filter capacitor or if battery power is used.

**See [Application Hints](#).

Connection Diagram/Ordering Information

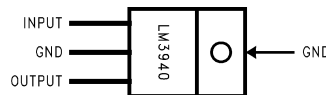


Figure 1. 3-Lead TO-220 Package(Front View)
Order Part Number **LM3940IT-3.3**
NSC Drawing Number **TO3B**

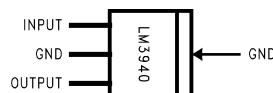
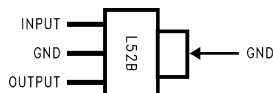


Figure 2. 3-Lead TO-263 Package (Front View)
Order Part Number **LM3940IS-3.3**
NSC Drawing Number **TS3B**

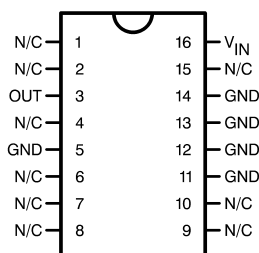


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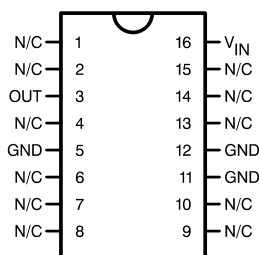
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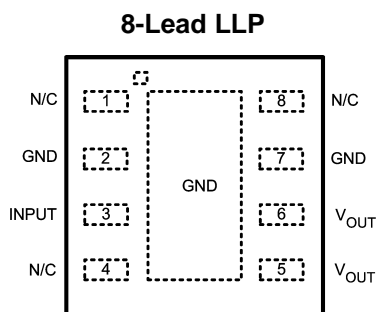
**Figure 3. 3-Lead SOT-223
(Front View)**
Order Part Number LM3940IMP-3.3
Package Marked L52B
NSC Drawing Number MP04A



**Figure 4. 16-Lead Ceramic Dual-in-Line Package
(Top View)**
Order Part Number LM3940J-3.3-QML
5962-9688401QEA
NSC Drawing Number J16A



**Figure 5. 16-Lead Ceramic Surface-Mount Package
(Top View)**
Order Part Number LM3940WG-3.3-QML
5962-9688401QXA
NSC Drawing Number WG16A



- A. Pin 2 and pin 7 are fused to center DAP.
- B. Pin 5 and 6 need to be tied together on PCB board.

Figure 6. (Top View)^{(A)(B)}
Order Part Number LM3940LD-3.3
NSC Drawing Number LDC08A



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⁾

Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 5 seconds)	260°C
Power Dissipation ⁽²⁾	Internally Limited
Input Supply Voltage	7.5V
ESD Rating ⁽³⁾	2 kV

- (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) The maximum allowable power dissipation is a function of the maximum junction temperature, T_J , the junction-to-ambient thermal resistance, θ_{JA} , and the ambient temperature, T_A . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. The value of θ_{JA} (for devices in still air with no heatsink) is 60°C/W for the TO-220 package, 80°C/W for the TO-263 package, and 174°C/W for the SOT-223 package. The effective value of θ_{JA} can be reduced by using a heatsink (see [Application Hints](#) for specific information on heatsinking). The value of θ_{JA} for the LLP package is specifically dependant on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the LLP package, refer to Application Note AN-1187. The θ_{JA} rating for the LLP is with a JESD51-7 test board having 6 thermal vias under the exposed pad.
- (3) ESD rating is based on the human body model: 100 pF discharged through 1.5 k Ω .

Operating Ratings ⁽¹⁾

Junction Temperature Range, T_J	–40°C to +125°C
Input Supply Voltage, $V_{IN(MIN)}$	$V_O + V_{DO}$

- (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.

Electrical Characteristics

Limits in standard typeface are for $T_J = 25^\circ\text{C}$, and limits in **boldface type** apply over the full operating temperature range.

Unless otherwise specified: $V_{IN} = 5\text{V}$, $I_L = 1\text{A}$, $C_{OUT} = 33\ \mu\text{F}$.

Symbol	Parameter	Conditions	Typical	LM3940 ⁽¹⁾		Units
				min	max	
V_O	Output Voltage	$5\text{ mA} \leq I_L \leq 1\text{ A}$	3.3	3.20 3.13	3.40 3.47	V
$\frac{\Delta V_O}{\Delta V_I}$ (1)	Line Regulation	$I_L = 5\text{ mA}$ $4.5\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	20		40	mV
$\frac{\Delta V_O}{I_L}$ (2)	Load Regulation	$50\text{ mA} \leq I_L \leq 1\text{ A}$	35		50 80	
Z_O	Output Impedance	I_L (DC) = 100 mA I_L (AC) = 20 mA (rms) $f = 120\text{ Hz}$	35			mΩ
I_Q	Quiescent Current	$4.5\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ $I_L = 5\text{ mA}$	10		15 20	mA
		$V_{IN} = 5\text{ V}$ $I_L = 1\text{ A}$	110		200 250	
e_n	Output Noise Voltage	BW = 10 Hz–100 kHz $I_L = 5\text{ mA}$	150			μV (rms)
V_{DO}	Dropout Voltage ⁽²⁾	$I_L = 1\text{ A}$	0.5		0.8 1.0	V
		$I_L = 100\text{ mA}$	110		150 200	mV
$I_L(\text{SC})$	Short Circuit Current	$R_L = 0$	1.7	1.2		A

(1) All limits guaranteed for $T_J = 25^\circ\text{C}$ are 100% tested and are used to calculate Outgoing Quality Levels. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods.

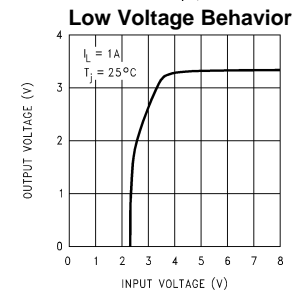
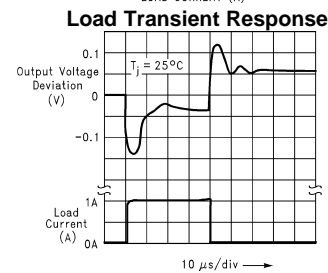
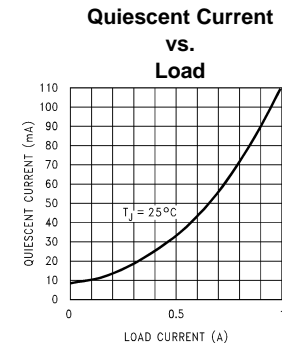
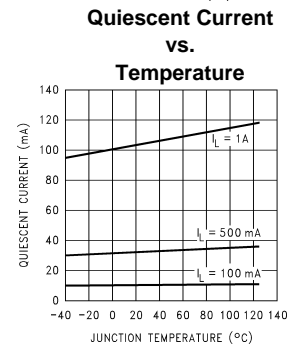
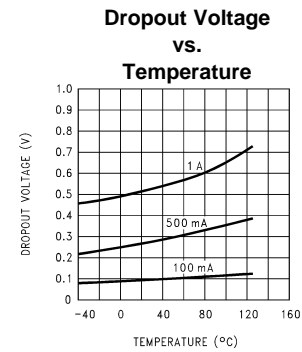
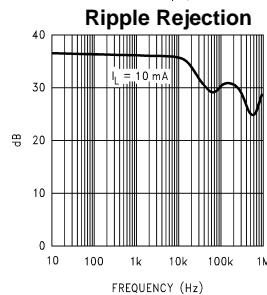
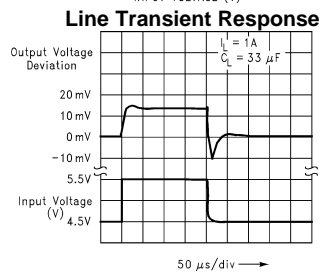
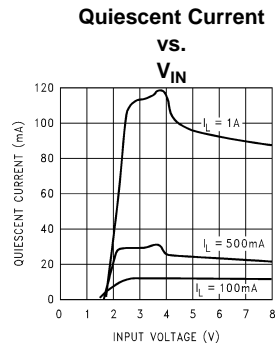
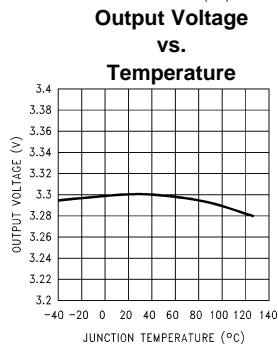
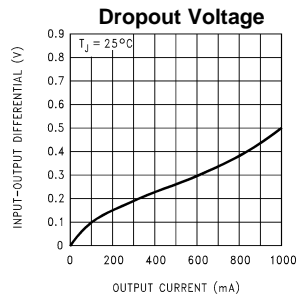
(2) Dropout voltage is defined as the input-output differential voltage where the regulator output drops to a value that is 100 mV below the value that is measured at $V_{IN} = 5\text{V}$.

Thermal Performance

Thermal Resistance, Junction-to-Case, θ_{JC}	3-Lead TO-220	4	°C/W
	3-Lead TO-263	4	°C/W
	8-Lead LLP	6	°C/W
Thermal Resistance, Junction-to-Ambient, θ_{JA}	3-Lead TO-220	60	°C/W
	3-Lead TO-263	80	°C/W
	8-Lead LLP ⁽¹⁾	35	°C/W

- (1) The maximum allowable power dissipation is a function of the maximum junction temperature, T_J , the junction-to-ambient thermal resistance, θ_{JA} , and the ambient temperature, T_A . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. The value of θ_{JA} (for devices in still air with no heatsink) is 60°C/W for the TO-220 package, 80°C/W for the TO-263 package, and 174°C/W for the SOT-223 package. The effective value of θ_{JA} can be reduced by using a heatsink (see [Application Hints](#) for specific information on heatsinking). The value of θ_{JA} for the LLP package is specifically dependant on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the LLP package, refer to Application Note AN-1187. The θ_{JA} rating for the LLP is with a JESD51-7 test board having 6 thermal vias under the exposed pad.

Typical Performance Characteristics



Typical Performance Characteristics (continued)



Application Hints

EXTERNAL CAPACITORS

The output capacitor is critical to maintaining regulator stability, and must meet the required conditions for both ESR (Equivalent Series Resistance) and minimum amount of capacitance.

MINIMUM CAPACITANCE:

The minimum output capacitance required to maintain stability is 33 μF (this value may be increased without limit). Larger values of output capacitance will give improved transient response.

ESR LIMITS:

The ESR of the output capacitor will cause loop instability if it is too high or too low. The acceptable range of ESR plotted versus load current is shown in [Figure 7](#). ***It is essential that the output capacitor meet these requirements, or oscillations can result.***

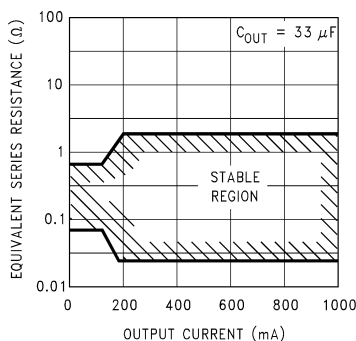


Figure 7. ESR Limits

It is important to note that for most capacitors, ESR is specified only at room temperature. However, the designer must ensure that the ESR will stay inside the limits shown over the entire operating temperature range for the design.

For aluminum electrolytic capacitors, ESR will increase by about 30X as the temperature is reduced from 25°C to -40°C. This type of capacitor is not well-suited for low temperature operation.

Solid tantalum capacitors have a more stable ESR over temperature, but are more expensive than aluminum electrolytics. A cost-effective approach sometimes used is to parallel an aluminum electrolytic with a solid Tantalum, with the total capacitance split about 75/25% with the Aluminum being the larger value.

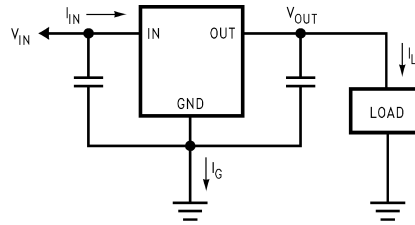
If two capacitors are paralleled, the effective ESR is the parallel of the two individual values. The “flatter” ESR of the Tantalum will keep the effective ESR from rising as quickly at low temperatures.

HEATSINKING

A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under [Absolute Maximum Ratings](#).

To determine if a heatsink is required, the power dissipated by the regulator, P_D , must be calculated.

Figure 8 shows the voltages and currents which are present in the circuit, as well as the formula for calculating the power dissipated in the regulator:



$$I_{IN} = I_L + I_G$$

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

Figure 8. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R (max). This is calculated by using the formula:

$$T_R \text{ (max)} = T_J \text{ (max)} - T_A \text{ (max)}$$

Where: T_J (max) is the maximum allowable junction temperature, which is 125°C for commercial grade parts.

T_A (max) is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for T_R (max) and P_D , the maximum allowable value for the junction-to-ambient thermal resistance, θ_{JA} , can now be found:

$$\theta_{JA} = T_R \text{ (max)} / P_D$$

IMPORTANT: If the maximum allowable value for θ_{JA} is found to be $\geq 60^\circ\text{C/W}$ for the TO-220 package, $\geq 80^\circ\text{C/W}$ for the TO-263 package, or $\geq 174^\circ\text{C/W}$ for the SOT-223 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements.

If the calculated value for θ_{JA} falls below these limits, a heatsink is required.

HEATSINKING TO-220 PACKAGE PARTS

The TO-220 can be attached to a typical heatsink, or secured to a copper plane on a PC board. If a copper plane is to be used, the values of θ_{JA} will be the same as shown in the [HEATSINKING TO-263](#) section for the TO-263.

If a manufactured heatsink is to be selected, the value of heatsink-to-ambient thermal resistance, $\theta_{(H-A)}$, must first be calculated:

$$\theta_{(H-A)} = \theta_{JA} - \theta_{(C-H)} - \theta_{(J-C)}$$

Where: $\theta_{(J-C)}$ is defined as the thermal resistance from the junction to the surface of the case. A value of 4°C/W can be assumed for $\theta_{(J-C)}$ for this calculation.

$\theta_{(C-H)}$ is defined as the thermal resistance between the case and the surface of the heatsink. The value of $\theta_{(C-H)}$ will vary from about 1.5°C/W to about 2.5°C/W (depending on method of attachment, insulator, etc.). If the exact value is unknown, 2°C/W should be assumed for $\theta_{(C-H)}$.

When a value for $\theta_{(H-A)}$ is found using the equation shown above, a *heatsink must be selected that has a value that is less than or equal to this number.*

$\theta_{(H-A)}$ is specified numerically by the heatsink manufacturer in the catalog, or shown in a curve that plots temperature rise vs. power dissipation for the heatsink.

HEATSINKING TO-263 AND SOT-223 PACKAGE PARTS

Both the TO-263 ("S") and SOT-223 ("MP") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

Figure 9 shows for the TO-263 the measured values of θ_{JA} for different copper area sizes using a typical PCB with 1 ounce copper and no solder mask over the copper area used for heatsinking.

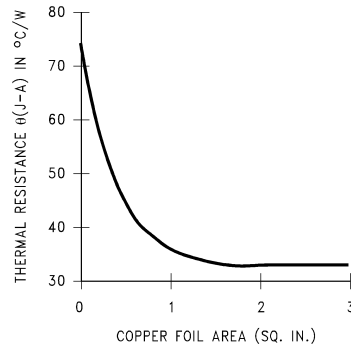


Figure 9. $\theta_{(JA)}$ vs. Copper (1 ounce) Area for the TO-263 Package

As shown in [Figure 9](#), increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(JA)}$ for the TO-263 package mounted to a PCB is 32°C/W.

As a design aid, [Figure 10](#) shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming $\theta_{(JA)}$ is 35°C/W and the maximum junction temperature is 125°C).

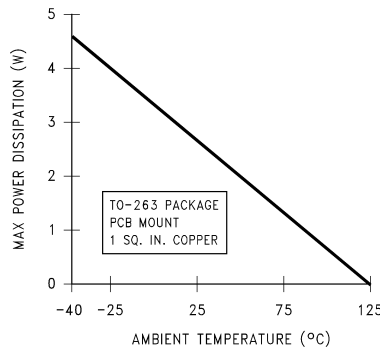


Figure 10. Maximum Power Dissipation vs. T_{AMB} for the TO-263 Package

[Figure 11](#) and [Figure 12](#) show the information for the SOT-223 package. [Figure 12](#) assumes a $\theta_{(JA)}$ of 74°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C.

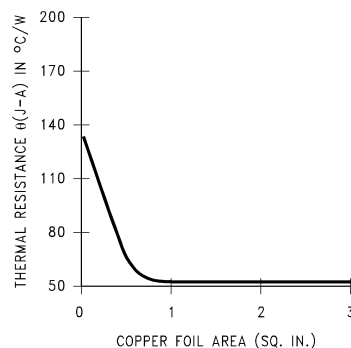


Figure 11. $\theta_{(JA)}$ vs. Copper (2 ounce) Area for the SOT-223 Package

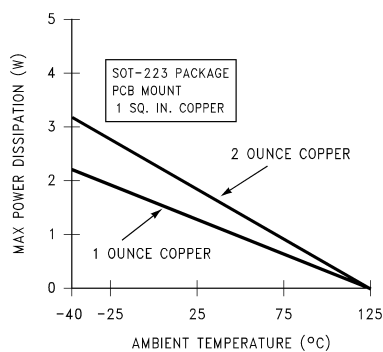


Figure 12. Maximum Power Dissipation vs. T_{AMB} for the SOT-223 Package

Please see AN1028 for power enhancement techniques to be used with the SOT-223 package.



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)
LM3940IMP-3.3	ACTIVE	SOT-223	DCY	4	1000	TBD	CU SNPB	Level-1-260C-UNLIM	
LM3940IMP-3.3/NOPB	ACTIVE	SOT-223	DCY	4	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	
LM3940IMPX-3.3	ACTIVE	SOT-223	DCY	4	2000	TBD	CU SNPB	Level-1-260C-UNLIM	
LM3940IMPX-3.3/NOPB	ACTIVE	SOT-223	DCY	4	2000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	
LM3940IS-3.3	ACTIVE	DDPAK/ TO-263	KT	3	45	TBD	CU SNPB	Level-3-235C-168 HR	
LM3940IS-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KT	3	45	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	
LM3940ISX-3.3	ACTIVE	DDPAK/ TO-263	KT	3	500	TBD	CU SNPB	Level-3-235C-168 HR	
LM3940ISX-3.3/NOPB	ACTIVE	DDPAK/ TO-263	KT	3	500	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	
LM3940IT-3.3	ACTIVE	TO-220	NDE	3	45	TBD	CU SNPB	Level-1-NA-UNLIM	
LM3940IT-3.3/NOPB	ACTIVE	TO-220	NDE	3	45	Green (RoHS & no Sb/Br)	CU SN	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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TAPE AND REEL INFORMATION


*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
LM3940IMP-3.3	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM3940IMP-3.3/NOPB	SOT-223	DCY	4	1000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM3940IMPX-3.3	SOT-223	DCY	4	2000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM3940IMPX-3.3/NOPB	SOT-223	DCY	4	2000	330.0	16.4	7.0	7.5	2.2	12.0	16.0	Q3
LM3940ISX-3.3	DDPAK/TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2
LM3940ISX-3.3/NOPB	DDPAK/TO-263	KTT	3	500	330.0	24.4	10.75	14.85	5.0	16.0	24.0	Q2

TAPE AND REEL BOX DIMENSIONS



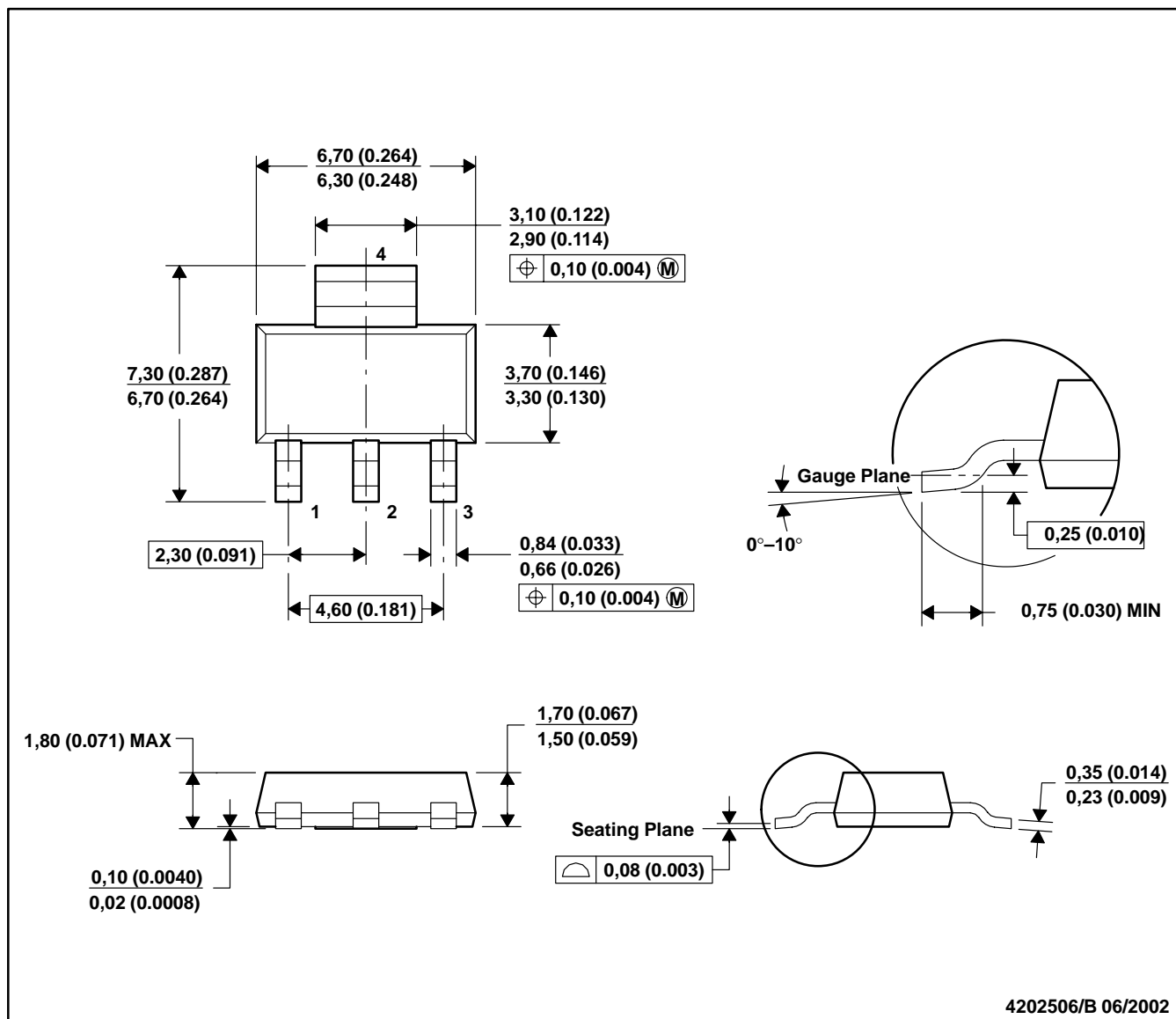
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM3940IMP-3.3	SOT-223	DCY	4	1000	349.0	337.0	45.0
LM3940IMP-3.3/NOPB	SOT-223	DCY	4	1000	349.0	337.0	45.0
LM3940IMPX-3.3	SOT-223	DCY	4	2000	354.0	340.0	35.0
LM3940IMPX-3.3/NOPB	SOT-223	DCY	4	2000	354.0	340.0	35.0
LM3940ISX-3.3	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0
LM3940ISX-3.3/NOPB	DDPAK/TO-263	KTT	3	500	358.0	343.0	63.0



DCY (R-PDSO-G4)

PLASTIC SMALL-OUTLINE



- NOTES:
- All linear dimensions are in millimeters (inches).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion.
 - Falls within JEDEC TO-261 Variation AA.

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