Application Note

BUF634A and BUF634 Thermal Performance Comparison

ABSTRACT

The Texas Instruments BUF634A high-speed-buffer is a newer version of the existing BUF634 device. The BUF634A features equivalent or improved performance along with a lower power consumption, but is not available in the same TO-220 or TO-263 heat-sink packages as the original device. This application note shows that with proper thermal design and equivalent board temperatures, the smaller BUF634A packages can achieve equivalent power dissipation to the BUF634 with minimal thermal degradation.

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1 Introduction

The Texas Instrument BUF634 high-speed-buffer device is available in four different package options, an 8-pin SOIC, 8-pin PDIP, 5-pin TO-220, and 5-pin TO-263. The newer version of the device, the BUF634A, is comparatively only available in three packages, an 8-pin SOIC, 8-pin VSON, and 8-pin HSOIC. Figure 1-1 shows examples of the different package footprints. From a thermal perspective, there may be some concern that the newer BUF634A does not include the TO-220 and TO-263 packages that feature large thermal connection areas. However, with proper design techniques, the VSON and HSOIC packages of the BUF634A can achieve similar thermal performance through their bottom-side thermal pad connections.

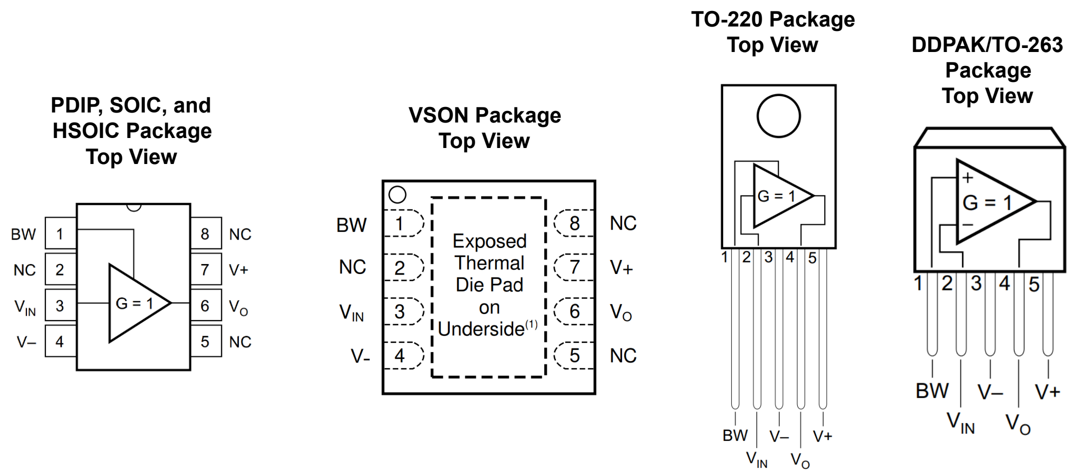

Figure 1-1. BUF634 and BUF634A Packages

2 Theory

To understand the expected thermal performance of different device packages, it is important to understand the various thermal metrics used to quantify the expected behavior from different packages. The Semiconductor and IC Package Thermal Metrics application report is an excellent resource to understand the various package thermal parameters and some common pitfalls of thermal analysis.

Table 2-1 shows the thermal metrics for the BUF634 and BUF634A package options.

Table 2-1. BUF634 and BUF634A Thermal Information

THERMAL METRIC		BUF634				BUF634A			UNIT
		PDIP	SOIC	TO-220	DDPAK-TO-263	SOIC	VSON	HSOIC	
		8 PINS	8 PINS	5 PINS	5 PINS	8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	46.5	103.4	32.1	41.8	122.9	50.5	41.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	34.8	44.2	25.6	45	55.2	60	57.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	23.8	44.5	18.3	24.8	68.4	23.6	17.0	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	12	5.4	8.5	13.1	12.1	1.5	4.6	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	23.6	43.8	17.7	23.8	67.2	23.6	17.0	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	NA	0.7	2.4	NA	6.9	5.3	°C/W

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To predict the thermal performance of the devices, there is no perfect metric that will give exact results because there are far too many variables in an actual measurement. For the comparison of the TO-220, TO-263, VSON, and HSOIC packages, we have chosen to use the ($R_{\theta JC(bot)}$) Junction-to-case (bottom) thermal resistance parameter. $R_{\theta JC(bot)}$ is used in this case because the majority of the thermal dissipation will be through the package heatsinks/thermal pads, making it the dominant factor in estimating junction temperature. Equation 1 was used to perform the analysis.

$$T_J = T_{PCB} + R_{\theta JC(bot)} * (P_{static} + P_{dynamic}) \quad (1)$$

The junction temperature (T_J) is estimated by adding the temperature of the board attached to the thermal pad (T_{PCB}) to the total power dissipated times the junction to case thermal resistance. The total power dissipated by the device consists of both the static power that the part consumes with no output (P_{static}) and the power into the load ($P_{dynamic}$). The static power is calculated by multiplying the quiescent current by the total power supply voltage. The BUF634A has an advantage in static power because it only consumes 8.5 mA of current in wide bandwidth mode compared to the 15 mA of the BUF634. Figure 2-1 shows the junction temperature change as the dynamic power dissipation is increased from 0 to 500 mW with an assumed constant PCB temperature of 40 °C.

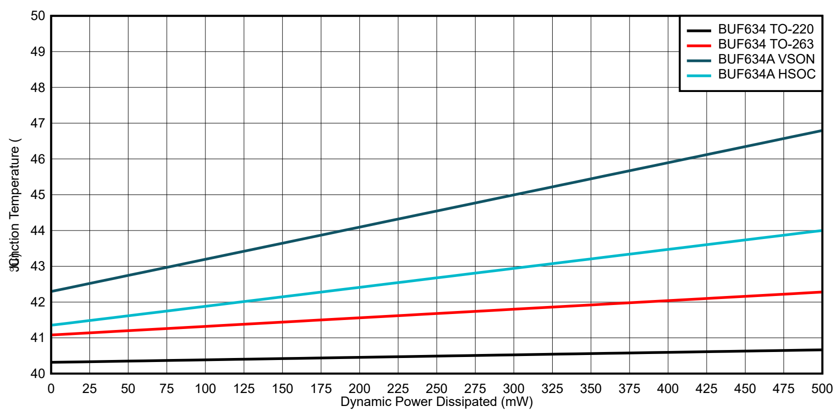

Figure 2-1. TO-220, TO-263, VSON, HSOIC0 Junction Temperature Comparison for 40 °C Board Temperature

From the analysis in Figure 2-1, the junction temperature difference at 500mW is only 3.3 °C between the best performing BUF634 TO-220 package and the best performance BUF634A HSOIC package. This comparison shows that the difference in junction temperature rise is minimal even given the large package size difference between the HSOIC and TO-220 packages. The smaller VSON package is only 6.1 °C worse than the TO-220 at 500 mW of power dissipation.

PCB Considerations

From the above analysis we can see that the BUF634A packages thermal performance difference is minimal and will likely not have a significant impact on most designs. However, there is a key assumption that all four packages have a constant and equivalent board temperature. For most designs, the board temperature will significantly depend on the board design and any additional thermal mitigation. For example, a board where the thermal pad of the HSOIC package is connected to a 1-oz copper plane though only a handful of vias is going to have much worse thermal performance than a board connected to multiple thick copper planes with many parallel vias and an additional bottom side board heat sink. For these reasons, it is very important to have good thermal PCB design to make sure that the device package is the limiting thermal path and not the PCB board. Additionally the board will likely heat up in a local area around the device, which will cause the total junction temperature to rise. Therefore it is important to include additional guard band in thermal analysis or use more complex tools to more accurately estimate the exact temperature.

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Special Case: TO-220 External Heat Sink

One thing to consider in comparing thermal performance, is the case of the TO-220 package soldered to an external heat sink. The configuration of the TO-220 package allows the bottom of the package case to be connected to an external heat sink that may be at a lower temperature than the PCB. In this configuration the TO-220 package does have a thermal advantage compared to the other packages, but it does require a separate heat sink design and connection.

Packages without Thermal Pads

It is also possible to try and compare the thermal performance of the BUF634 and BUF634A packages that do not have thermal pad connections. In this case, it is best to use the junction-to-board thermal resistance ($R_{\theta JB}$) or junction-to-board characterization parameter (Ψ_{JB}) as the board should still be the primary thermal sink for the package despite there being no thermal pad connections. However, without a thermal pad, the devices do not have as strong of a thermal dissipation path and therefore will be greater effected by other parameters such as ambient temperature. Figure 2-2 shows a similar junction temperature estimation for the packages without thermal pads. It is apparent from the analysis that these packages have significantly worse thermal performance and should not be used for thermally stressful designs.

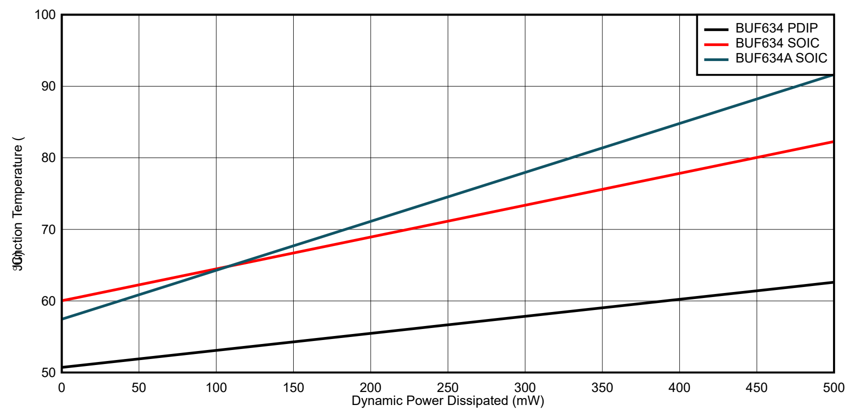

Figure 2-2. BUF634 PDIP, SOIC and BUF634A SOIC Thermal Comparison for 40 °C Board Temperature

3 Summary

The thermal analysis comparison between the BUF634 and BUF634A packages has shown that with proper PCB design, the thermal differences between the large BUF634 packages and smaller BUF634A packages can be mostly mitigated. In the special case of the TO-220 package with an external heatsink, it might not be possible to match equivalent performance with the BUF634A, but the smaller BUF634A packages could be used in a parallel configuration or the board designed with a backside heatsink.

4 References

- Texas Instruments, BUF634A 36-V, 210-MHz, 250-mA Output, High-Speed Buffer data sheet.
- Texas Instruments, BUF634250-mA High-Speed Buffer data sheet.
- Texas Instruments, Semiconductor and IC Package Thermal Metrics application report.

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