Application Note

How to Achieve Improved Thermal Performance on TPS56x242-7 with SOT563 Package

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ABSTRACT

A signal pin is always placed with a typical width of 10-mil or 20-mil in power part. This application note introduces that an enlarged signal pin area can help heat quickly transfer to ambient which is helpful for power-part thermal performance. This application note introduces the heat path and is confirmed by simulation and test result on board. Finally, this application note shows TPS566242, TPS565242, and TPS564242 thermal performance.

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1 Introduction

With the development of end equipment (EE), there is a strong trend of smaller size, multifunction, and easy-carry. So high density is more and more important, especially for power. TI released a high-power density part TPS566242/7 which can support 6-A continues current with SOT563 package. SOT563 package body size is only 1.6 × 1.2 mm. Up to now, it is the highest power density part of 16-V/6-A. The challenge of high-power density is thermal performance. This application note introduces how TPS566242/7 solve thermal problems from the device itself and the customer's board.

2 Improve Thermal Performance from IC Independently

First, from TPS566242/7 independently, it optimizes pin-out definition. Figure 2-1 shows pin-out. The device integrates BST pin and add one AGND for PIN4. This pin-out makes layout very easy on board. Figure 2-1 shows suggested layout. In top layer, it places nearly all line, especially power line as Figure 2-2. It is recommended to connect GND and AGND together to increase GND area to improve thermal performance. FB line goes through on bottom layer to avoid to be affected by switching noise Figure 2-3.

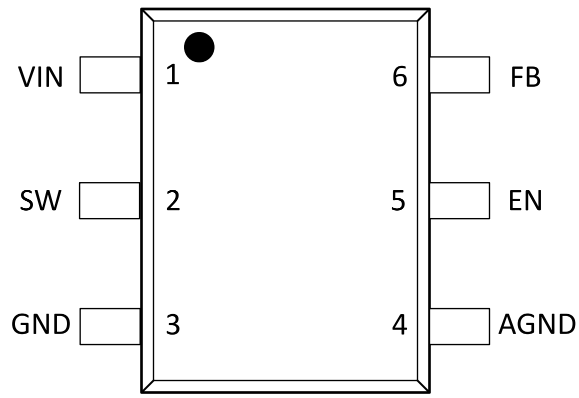

Figure 2-1. TPS566242/7 Pin Out

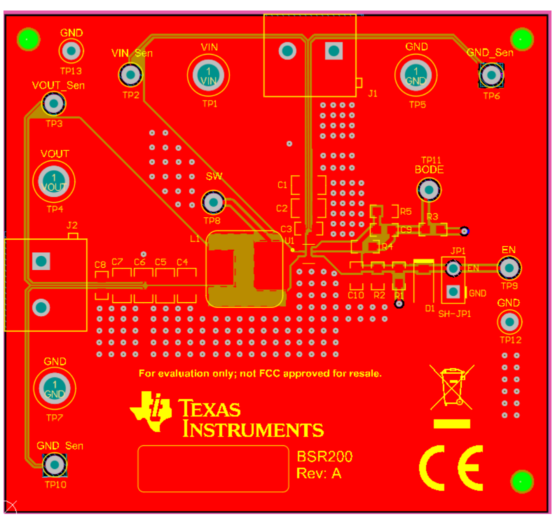

Figure 2-2. EVM TOP Layer

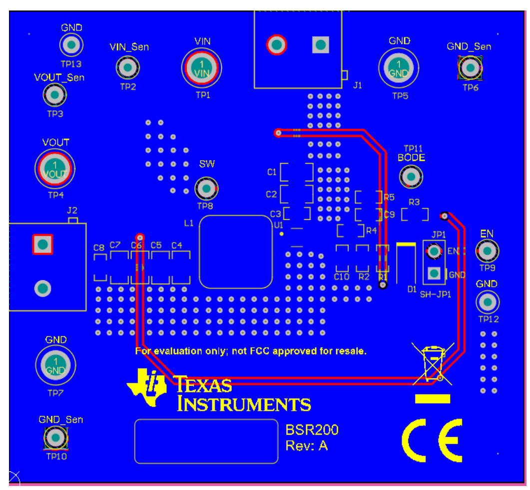

Figure 2-3. EVM Bottom Layer

TPS566242/7 integrates small R_{dson} of 27.7 mohm for high side and 14.8 mohm low side. Small R_{dson} will cause small conducting loss which will be helpful for high efficiency. And it also increases driving slew rate to reduce switching loss. Below Figure 2-4 and Figure 2-5 show the TPS566242 SW waveform at 12-V Vin to 5-V Vout at 6-A loading. For the rising edge, the slew rate could get 4.25-V/ns. At the same time, this part uses special driver design to decrease switching ring voltage. For the falling edge, the slew rate could get 7.35-V/ns. This fast switching slew rate decreases switching loss which is also helpful for high efficiency.

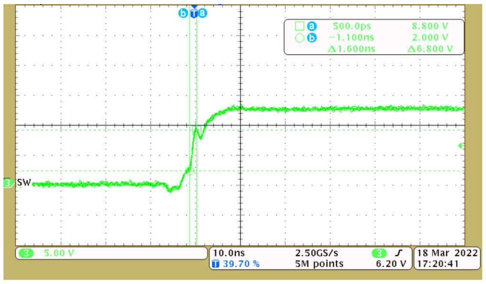

Figure 2-4. TPS566242 Rising Edge

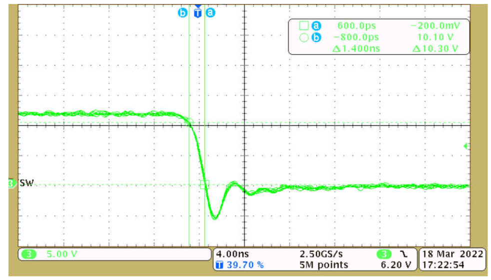

Figure 2-5. TPS566242 Falling Edge

3 Improve Thermal Performance from PCB Board

From a customer's board point, this application note introduces an idea by optimizing layout to improve thermal performance for a small SOT563 package.

PIN 1, 2, and 3 are power pin. It is absolutely important to place large copper area for power line. PIN 4, 5, and 6 are signal pin. Originally signal pin is not necessary to place large copper area. Because it does not go through high current. But for SOT563 package, signal pin is also helpful for heat loss. So large copper area for signal pin is also very helpful for thermal performance. It is recommended to place large copper area for signal pin. Because SOT563 package is small and die size is also small. There is thermal radiation path from FETs area to the signal area because the path is very shot short, so the thermal is able to be dissipated to the signal pins. And TPS566242/7 uses FCOL(Flip Chip On Lead) technology. The copper bump is very helpful for heat conduction from die to pin. Large signal pin copper area can quickly make thermal transfer to PCB board and ambient. The biggest part of thermal is still transferred from FET area. Figure 3-1 shows thermal transfer path.

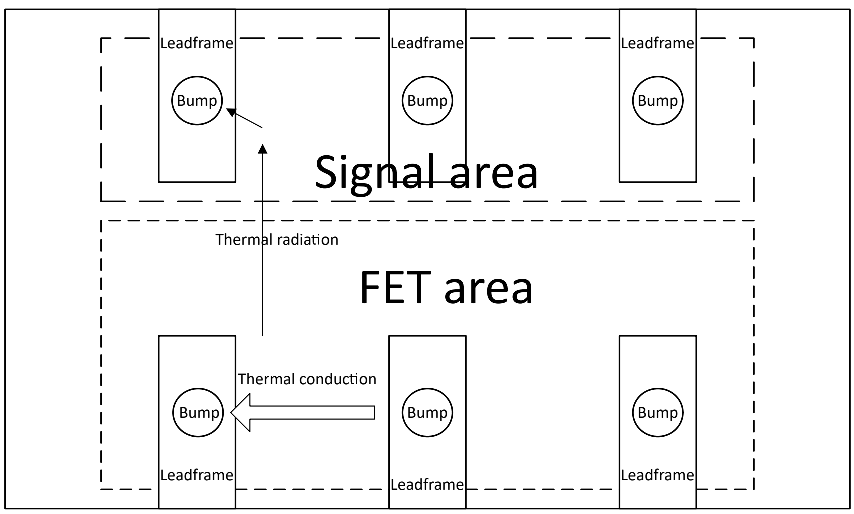

Figure 3-1. Thermal Transfer Direction

Following are two types of EVM boards which are made to compare the thermal performance. Figure 3-2 version 1 shows one EVM layout in which signal line is normal width with 20-mil. Version 2 shows another EVM layout in which signal line is large copper area.

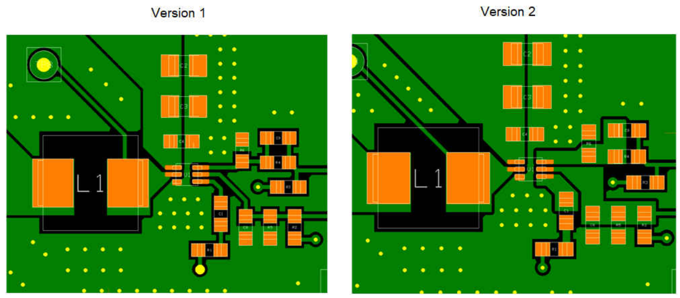

Figure 3-2. PCB Board with Two Version Types

First thermal information is simulated by Ansys software. Figure 3-3 shows the simulation result at same simulation conditions. The highest temp is lower than in version 2. And compare signal pin temperature, the version 1 temperature is higher than second figure which means heat could not quickly transfer to ambient. In version 2, the signal pin area is lower because large signal copper area can make heat quickly transfer to PCB board and ambient.

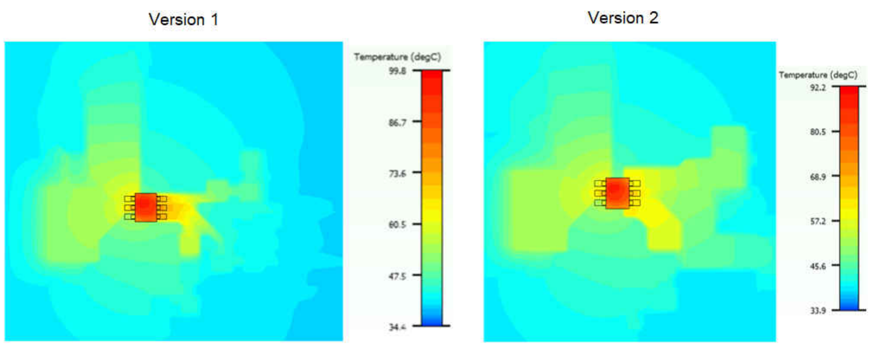

Figure 3-3. Simulation Result with Two Versions

Test result with same conditions on PCB board by camera is shown in Figure 3-4. From test results, the thermal of version 1 is higher than version 2. And the signal pin area of version 1 is also higher than version 2.

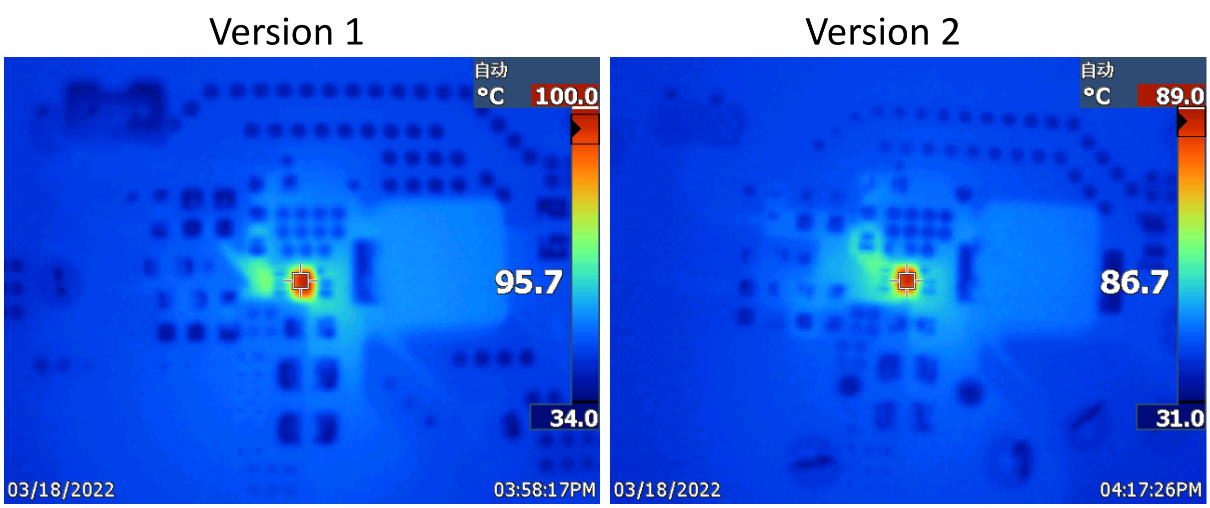

Figure 3-4. Thermal Test Result with Two Versions

4 Thermal Performance

This topic introduces thermal performance of this EVM family.

Figure 4-1, Figure 4-2, and Figure 4-3 show TPS566242 thermal performance at different conditions. TPS566242 public EVM board is used to test. This EVM board has 4-layers which includes 2 internal layers with 1-oz copper and top, bottom layer with 2-oz copper. Test ambient temp is room temp.

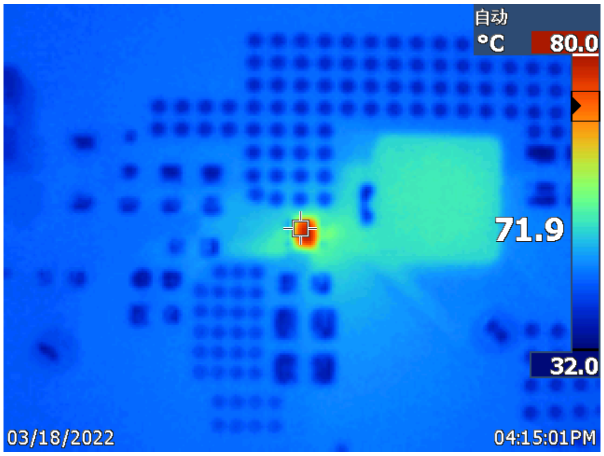

Figure 4-1. TPS566242 12-V Vin to 1.05-V Vout at 6-A

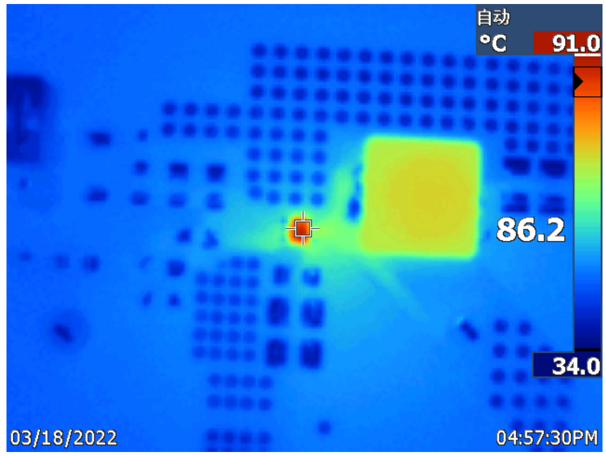

Figure 4-2. TPS566242 12-V Vin to 3.3-V Vout AT 6-A

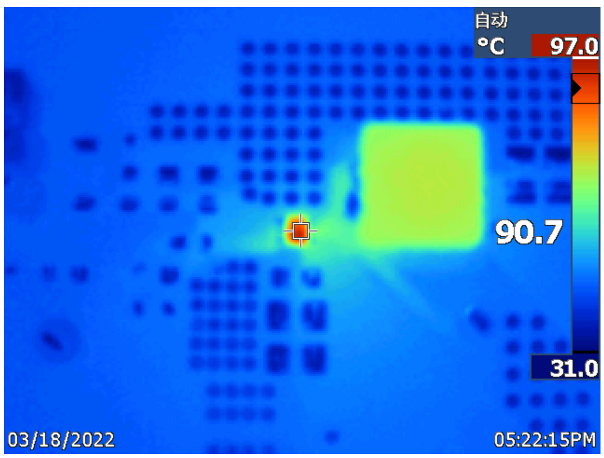

Figure 4-3. TPS566242 12-V Vin to 5-V Vout at 6-A

Figure 4-4, Figure 4-5, and Figure 4-6 show TPS565242 thermal performance at different conditions. TPS565242 public EVM board is used to test. This EVM board has 2-layers in which top and bottom layers are 2-oz copper.

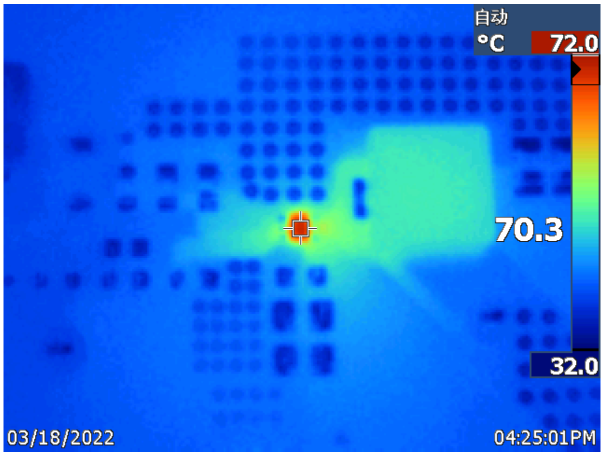

Figure 4-4. TPS565242 12-V Vin to 1.05-V Vout at 5-A

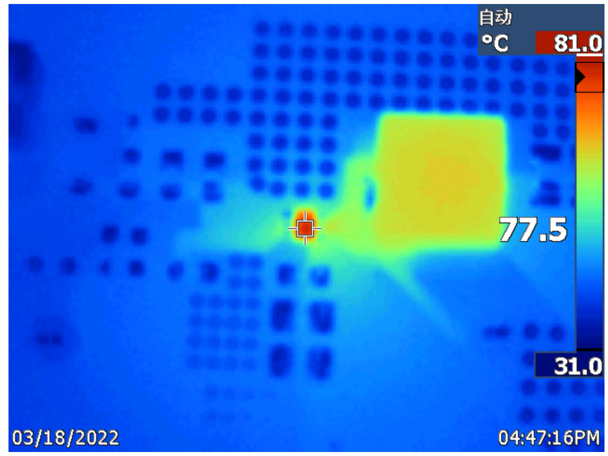

Figure 4-5. TPS565242 12-V Vin to 3.3-V Vout at 5-A

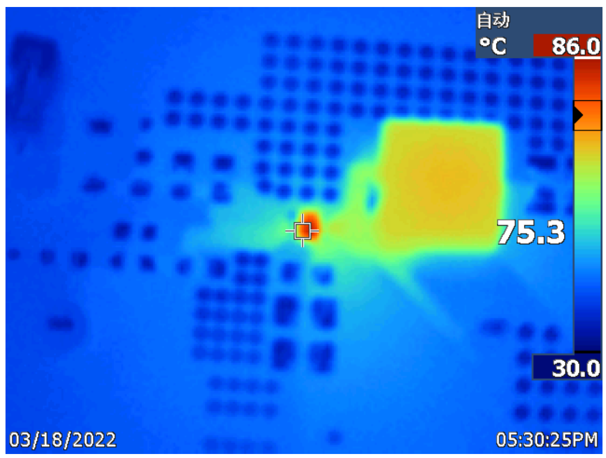

Figure 4-6. TPS565242 12-V Vin to 5-V Vout at 5-A

Figure 4-7, Figure 4-8, and Figure 4-9 show TPS564242 thermal performance at different conditions. TPS564242 public EVM board is used to test. This EVM board has 2-layesr in which top and bottom layers are 2-oz copper.

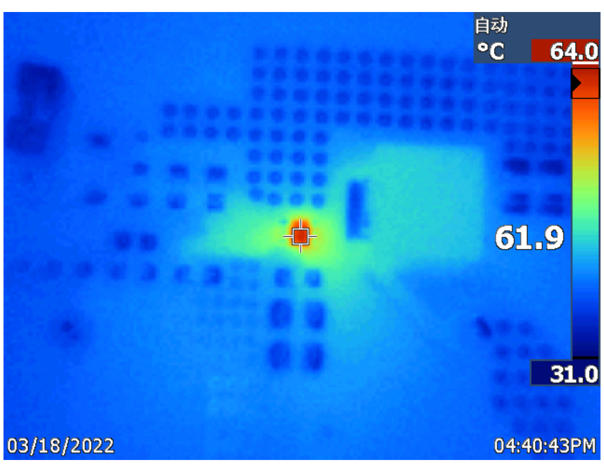

Figure 4-7. TPS564242 12-V Vin to 1.05-V Vout at 4-A

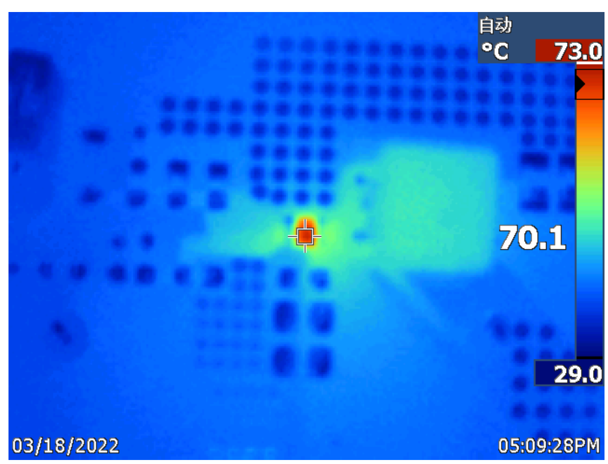

Figure 4-8. TPS564242 12-V Vin to 3.3-V Vout at 4-A

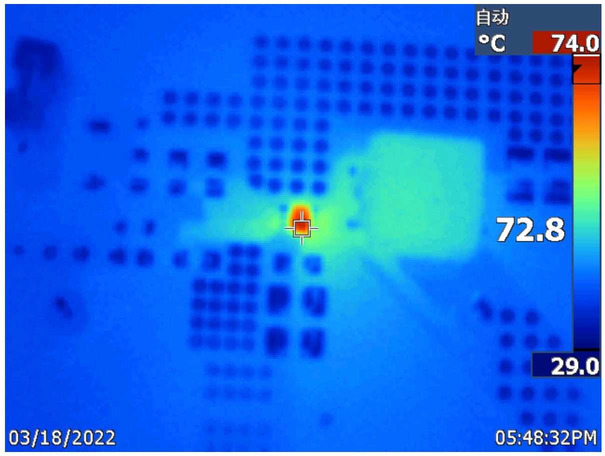

Figure 4-9. TPS564242 12-V Vin to 5-V Vout at 4-A

Table 4-1 shows a summary of this efficiency and thermal performance.

Table 4-1. Efficiency and Thermal Performance

Part number	Vin/V	Vout/V	Iout/A	Efficiency	Temperature
TPS566242	12	1.05	6	82.38%	80
TPS566242	12	3.3	6	91.67%	91
TPS566242	12	5	6	93.75%	97
TPS565242	12	1.05	5	83.94%	72
TPS565247	12	3.3	5	92.86%	81
TPS565247	12	5	5	94.63%	86
TPS564242	12	1.05	4	83.61%	64
TPS564242	12	3.3	4	93.50%	73
TPS564242	12	5	4	95.41%	75

5 Summary

This application note introduces how TPS566242 improves thermal performance independently and customer's PCB board. The application note introduces an idea of enlarging signal area to improve thermal performance. And also gives simulation result and test result. Finally, the application note shows the thermal performance and efficiency of this family of parts.

6 References

- Texas Instruments, *3-V to 16-V Input Voltage, 6-A ECO Mode, Synchronous Buck Converter in SOT-563 Package* data sheet.
- Texas Instruments, *3-V to 16-V Input Voltage, 5-A ECO Mode, Synchronous Buck Converter in SOT-563 Package* data sheet.
- Texas Instruments, *3-V to 16-V Input Voltage, 4-A ECO Mode, Synchronous Buck Converter in SOT-563 Package* data sheet.

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