IMPACT OF PRINTED CIRCUIT BOARD LAYOUT ON DEVICE TEMPERATURE IN 3-PHASE INVERTERS USING BRIDGESWITCH™

BridgeSwitch allows building compact, high-voltage brushless DC motors drives without having to use a physical heatsink; the half-bridge architecture makes it ideally suited for 3-phase inverters. Each package handles only a third of the total losses occurring in the inverter while facilitating heat transfer to the printed circuit board through exposed pads. Optimizing the PCB layout concerning device arrangement, inter device distance, and copper clad area play an important role in the thermal performance of the three devices.

WHITEPAPER

motor drivers

STEFAN BAEURLE, MARK CALDERON

Introduction

BridgeSwitch is a half-bridge motor driver, which incorporates two high-voltage N-channel power FREDFETs with low and high-side drivers in an InSOP-24C surface mount package [1]. The half-bridge architecture makes BridgeSwitch ideal for 3-phase inverters driving brushless DC motors. Each package handles a third of the total inverter losses. The distribution of the heat to three devices allows the construction of a motor drive that does not require a metal heatsink. Two exposed pads facilitate heat transfer from the power switch to the printed circuit board (PCB). They are marked HD and HB as shown in Figure 1.

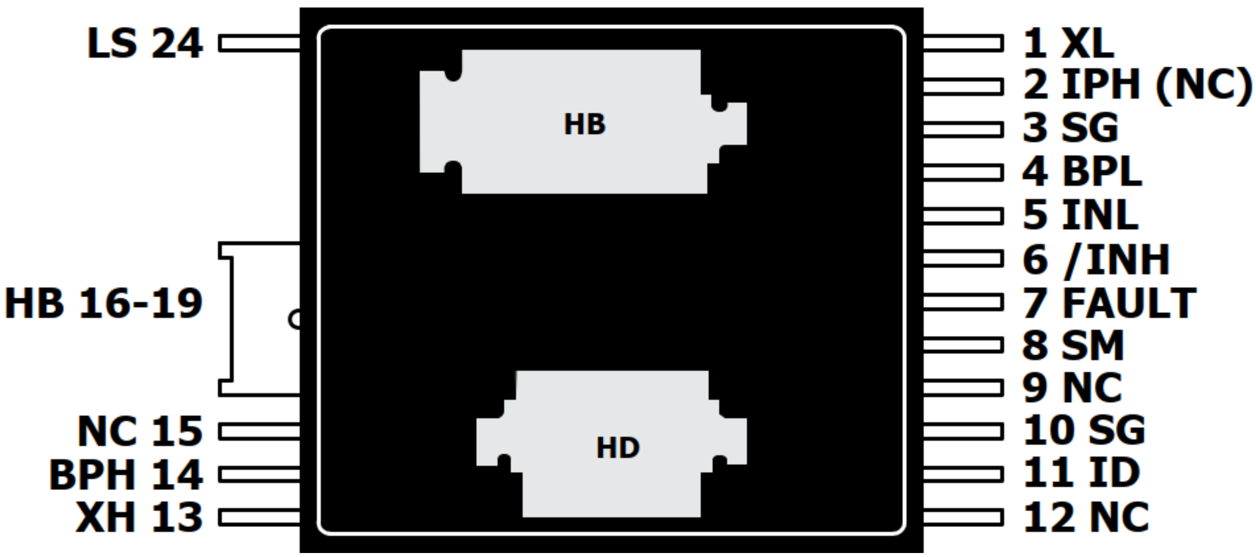


Figure 1 BridgeSwitch InSOP-24C Bottom View

PCB layout plays an important role in the thermal performance of each BridgeSwitch device. The configuration of the three devices and distance between each, the area of the PCB copper connected to the exposed pads, and thickness of that copper all effect thermal performance. The following study compares the effect of mounting configurations, copper areas and device distances on device temperature rise.

Test Setup

Figure 2 depicts the schematic of the test setup used to determine the thermal performance of each layout.

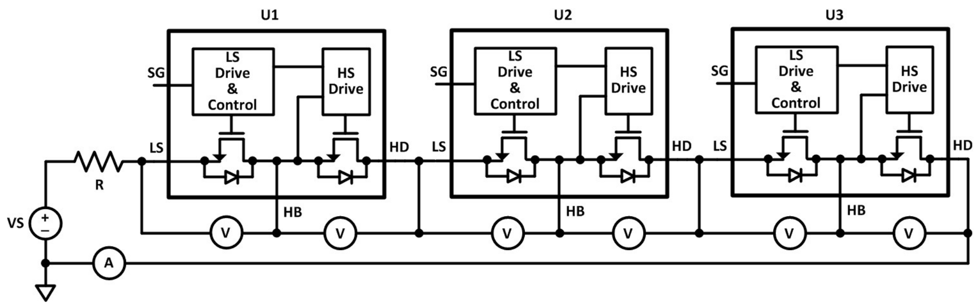


Figure 2 Test Setup Circuit Diagram

The three BridgeSwitch BRD1265C devices U1, U2, and U3 were connected in series and DC voltage source VS induced a DC current to flow through the resulting chain of body diodes. Resistor R limited the current such that the dissipation per body diode is (V) x (A) = 0.75 W, resulting in a well-defined total dissipation per package of 1.5 W.

For the thermal performance study, tests were performed PCBs mounting the BridgeSwitch devices into two triangular configurations and a linear configuration as depicted in Figure 3. Triangular configurations included an equilateral triangle (Triangular A) or an isosceles triangle (Triangular B). Additionally device distance D varied between 17 mm and 25 mm; area A of the copper was varied between 150 mm^2, 300 mm^2, and 600 mm^2. The PCB was a dual layer board with copper cladding of area A on both sides, connected by thermal vias. The effective total copper clad area was 2 x A for each exposed pad. The thermal vias resided directly under the exposed pads of the InSOP-24C package and had an outer diameter of 0.8 mm and an inner diameter of 0.5 mm. The printed board used FR4 laminate with a copper thickness of 70 µm (610 g/m^2).

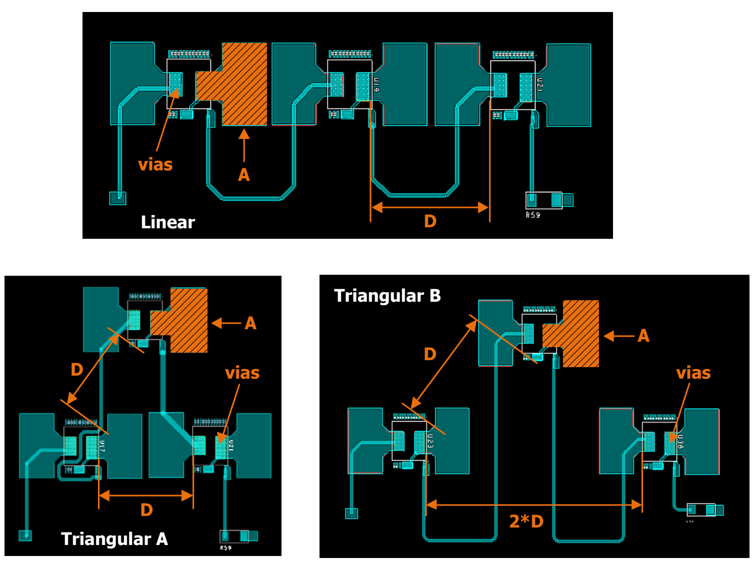


Figure 3 Linear and Triangle A / B Device Configurations (Bottom Layer)

Test Results

Figure 4 plots the measured average rise of device temperature above ambient temperature at 1.5 W package dissipation over copper clad area A per layer at different device distances D for the two triangular configurations and for the linear configuration.

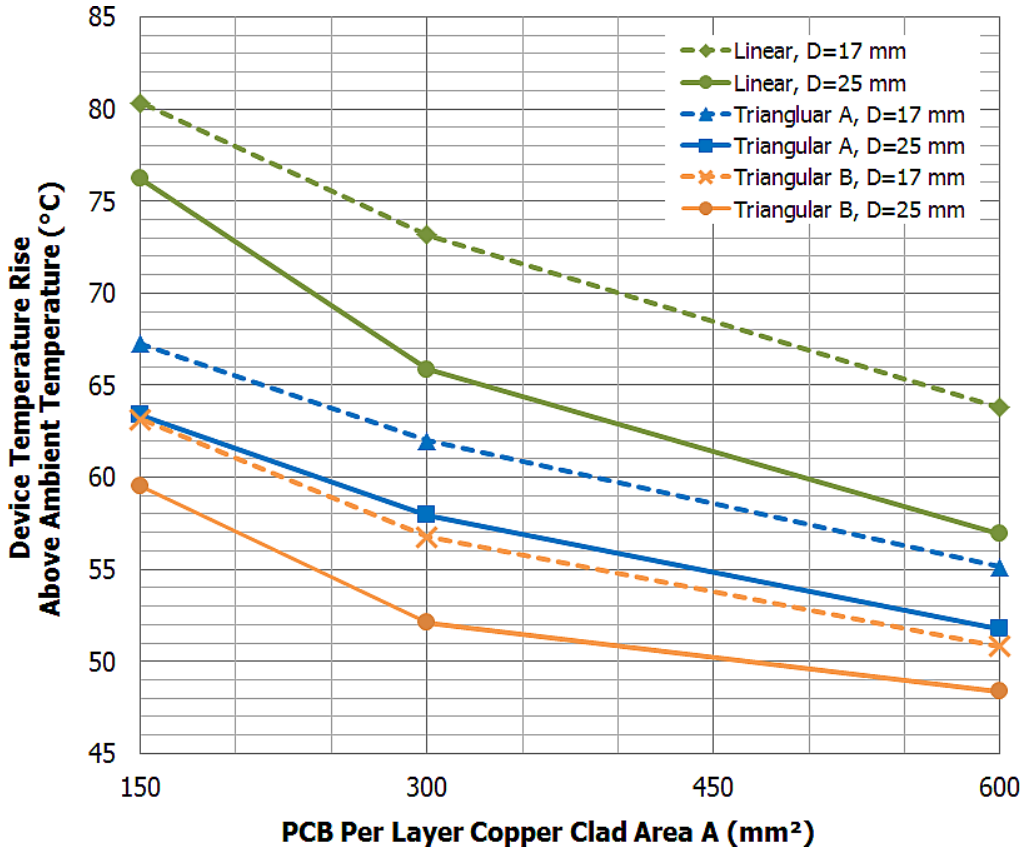


Figure 4 Average Device Temperature Rise vs. Configuration, per Layer Copper Clad Area, and Device Distance

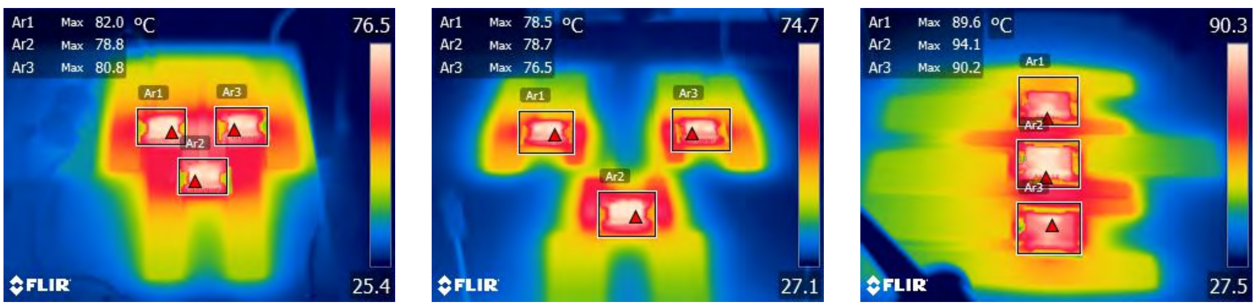
Table 1 summarizes test results with a PCB copper area A = 600 mm² per layer.

Device Distance D	17 mm	25 mm
Average Temperature Rise Triangular A Configuration (A = 600 mm²)	55.1 °C	51.8 °C
Average Temperature Rise Triangular B Configuration (A = 600 mm²)	50.8 °C	48.4 °C
Average Temperature Rise Linear Configuration (A = 600 mm²)	63.8 °C	56.9 °C

Table 1 Average Temperature Rise Above Ambient Temperature with A = 600 mm² per Layer Copper Clad Area

Both triangular configurations significantly reduced average device temperature rise compared to the linear configuration. For a device distance D = 25 mm and copper clad area A = 600 mm^2, Triangular A configuration reduced average device temperature rise by 5.1 °C and Triangular B configuration reduced the average temperature rise by 8.5 °C compared to the linear configuration. For a device distance D = 17 mm and A = 600 mm^2, the average temperature rise was 8.7 °C lower for Triangular A and 13.0 °C lower for Triangular B, respectively, compared to the linear configuration. Note, that both triangular configurations still had lower device temperature rise in a more dense design with D = 17 mm compared to the linear configuration in a less dense design—device distance D = 25 mm.

Figure 5 depicts thermal device scans for triangular configurations and the linear configuration with a PCB per layer copper clad area of A = 600 mm^2 and a device distance D = 17 mm at 1.5 W total dissipation in the package.



Triangular A Configuration, D = 17 mm, A = 600 mm^2

Triangular B Configuration, D = 17 mm, A = 600 mm^2

Linear Configuration, D = 17 mm, A = 600 mm^2

Figure 5 Thermal Device Scans of Triangular vs. Linear Configurations and a 1.5 W Package Dissipation

Both triangular configurations resulted in a more equal temperature match between the three BridgeSwitch devices compared to the linear configuration. For Triangle B, the temperature difference between all three devices was only 2.2 °C. This compared to 4.5 °C temperature difference between all devices in the linear configuration with the center device operating at the highest temperature.

Conclusion

PCB layout plays a key role on the package temperature in a 3-phase inverter using BridgeSwitch. The test results showed that triangular configurations lowered device temperature significantly compared to a linear configuration and reduced temperature variation between devices. The advantage of the triangular configuration becomes even more prominent in denser designs.

References

[1] "BridgeSwitch Family Datasheet", Power Integrations, Inc., 2019

Return to Previous Page

WORLDWIDE SALES SUPPORT LOCATIONS

WORLD HEADQUARTERS

5245 Hellyer Avenue
San Jose, CA 95138 USA

Phone +1 408 414 9200
Fax +1 408 414 9201

Customer Service

Phone +1 408 414 9520
Email usasales@power.com

AMERICAS - EAST

7360 McGinnis Ferry Road, Suite 225
Suwanee, GA 30024 USA

Phone +1 678 957 0724
Email usasales@power.com

AMERICAS - CENTRAL

3100 Dundee Road, Suite 204
Northbrook, IL 60062 USA

Phone +1 847 721 6293
Email usasales@power.com

CHINA (SHANGHAI)

Room 1601-1603, Charity Plaza
No. 88 North Caoxi Road
Shanghai, China 200030

Phone +86 021 6354 6323
Email chinasales@power.com

CHINA (SHENZHEN)

17/F, Hivac Building, #2
Keji South 8th Road, Nanshan District
Shenzhen, China 518057

Phone +86 755 8672 8689
Email chinasales@power.com

GERMANY (AC-DC / LED SALES)

Einsteinring 24
85609 Dornach / Aschheim
Germany

Phone +49 89 5527 39100
Email eurosales@power.com

GERMANY (GATE DRIVERS SALES)

HellwegForum 1
59469 Ense
Germany

Phone +49 29 3864 39990
Email gate-drivers.sales@power.com

INDIA (BANGALORE)

Bangalore 560052 India

Phone 1 +91 80 4113 8020
Phone 2 +91 80 4113 8028
Email indiasales@power.com

INDIA (MUMBAI)

Unit 106-107, Sagar Tech Plaza-B
Sakinaka, Andheri Kurla Road
Mumbai-400072, Maharashtra, India

Phone 1 +91 22 4003 3700
Phone 2 +91 22 4003 3600
Email indiasales@power.com

INDIA (NEW DELHI)

#45, Top Floor
Okhla Industrial Area, Phase-III
New Delhi, India
Pin-110020

Phone 1 +91 11 4055 2351
Phone 2 +91 11 4055 2353
Email indiasales@power.com

ITALY

Via Milanese 20
20099 Sesto San Giovanni (MI)
Italy

Phone +39 02 4550 8708
Email eurosales@power.com

JAPAN

Yusen Shin-Yokohama 1-chome Building
1-7-9, Shin-Yokohama, Kohoku-ku,
Yokohama-shi, Kanagawa
Japan 222-0033

Phone +81 45 471 1021
Email japansales@power.com

KOREA

Room 602, 6th Floor, #22
Teheran-ro 87-gil, Gangnam-gu
Seoul 06164, Korea

Phone + 82 2 2016 6610
Email koreasales@power.com

SINGAPORE

51 Newton Road
#20-01/03 Goldhill Plaza
Singapore 308900

Phone +65 6358 2160

Customer Service

Phone +65 6356 4480
Email singaporesales@power.com

SWITZERLAND

Johann-Renfer-Strasse 15
2504 Biel/Bienne, Switzerland

Phone +41 32 344 47 47
Email gate-drivers.sales@power.com

TAIWAN

5F, #318, NeiHu Road, Section 1
Neihu District
Taipei, Taiwan 114, ROC

Phone +886 2 26594570
Email taiwansales@power.com

UNITED KINGDOM

Building 5, Suite 21
The Westbrook Centre
Milton Road, Cambridge CB4 1YG

Phone +44 7823 557484
Email eurosales@power.com

ac-dc converters led drivers gate drivers motor drivers