Thermal Management of *GaNFast*™ Power ICs

Introduction

GaNFast™ Power ICs deliver ultra-low capacitance, excellent switching characteristics, and a low $R_{DS(ON)}$ in a small low-profile QFN package. These features make this device ideal for operating at high frequencies and enable high-density power supply designs. In order to take full advantage of these system benefits, the thermal management of GaNFast Power ICs must be designed properly. This includes PCB board design as well as thermal interfacing and heatsinking.

This application note includes correct PCB layout guidelines and power supply examples to help designers correctly design for correct thermal management. These guidelines must be followed as early as possible in the design cycle as possible in order to avoid excessive component temperatures, low efficiency, excessive housing temperatures, component failures and long design cycle times.

Overview

Navitas GaNFast Power ICs are available in a 5x6 mm PQFN package. The IC pinout includes a Drain pad (D), a Source pad (S), and 4 control pins. The control pins manage the gate drive supply and on/off control of the GaN power FET, and the switching currents of the external power conversion circuit flow from the Drain pad to the Source pad during each on-time period. The IC is mounted internally on the Source pad and then over-molded with plastic molding compound. All of the exposed package pads and pins on the bottom side of the package are then soldered down to the PCB. Since the IC is mounted directly on the Source pad (S), the heat from the GaNFast IC ***must be*** taken out through the bottom of the GaNFast IC, to the Source pad (S), and through the solder to the PCB board. Thermal vias are then used to transfer the heat to the opposite side of the PCB where it can then be cooled.

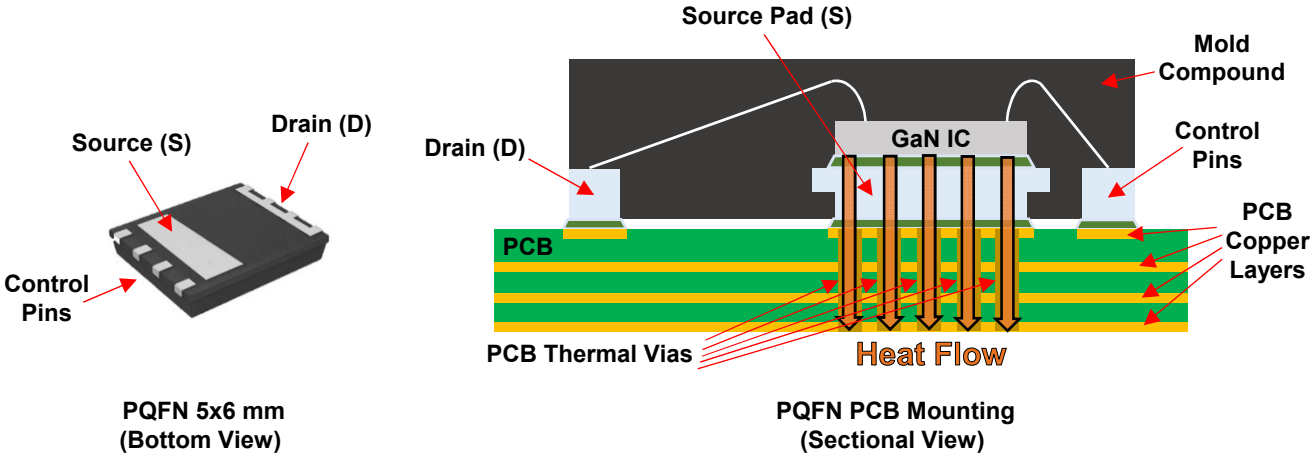
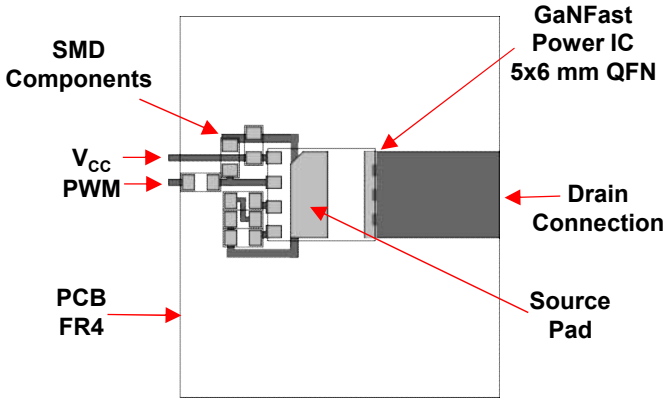


Fig 1. GaNFast Power IC package and PCB mounting

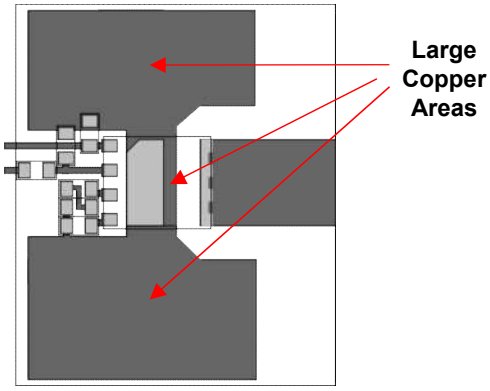
PCB Guidelines

When designing the PCB layout for the GaNFast Power ICs, several guidelines must be followed in order to achieve acceptable device temperatures. Thermal vias must be used to conduct the heat from the top layer IC Source landing pad to the bottom layer and large copper areas are used for PCB heatsinking. The following layout steps and instructions illustrate best layout practices for optimal IC thermal performance.

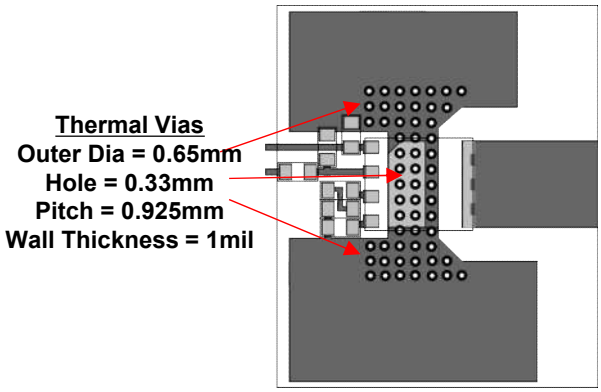
1) Place the GaNFast IC 5x6 mm PQFN footprint on the PCB top layer.
2) Place the additional SMD components required for the control pins on the top layer (CV_{CC}, CV_{DD}, R_{DD}, D_Z). ***Place the SMD components as close as possible to the IC pins!***
3) Route the connections for the SMD components, control pins, and Drain and Source pad all on the top layer.
4) Place large copper areas on the top layer at both sides and connecting to the Source pad.
5) Place thermal vias inside the Source pad and at both sides of the Source pad.
6) Place large copper areas on all other layers (bottom, mid1, mid2).



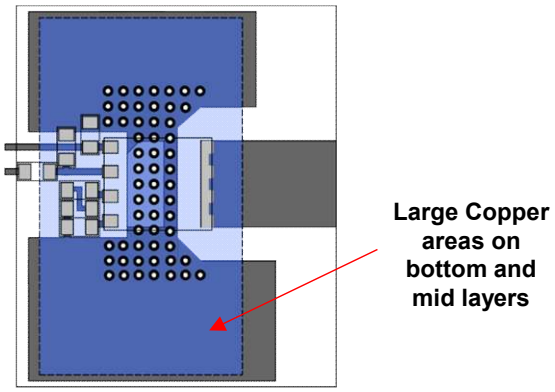
(a) Place and route GaN IC and SMD on Top layer



(b) Place large copper area at Source pad and sides



(c) Place thermal vias inside Source pad and sides



(d) Place large copper areas on Bottom and Mid layers

Fig 2. GaNFast IC PCB layout steps

PCB Layout Example (Single Low-side Switch Configuration)

The following example (Figure 3) shows correct layout practices implemented on actual power supply PCB designs. Components and traces are all on top layer. Bottom and mid layers are for copper areas and thermal vias only.

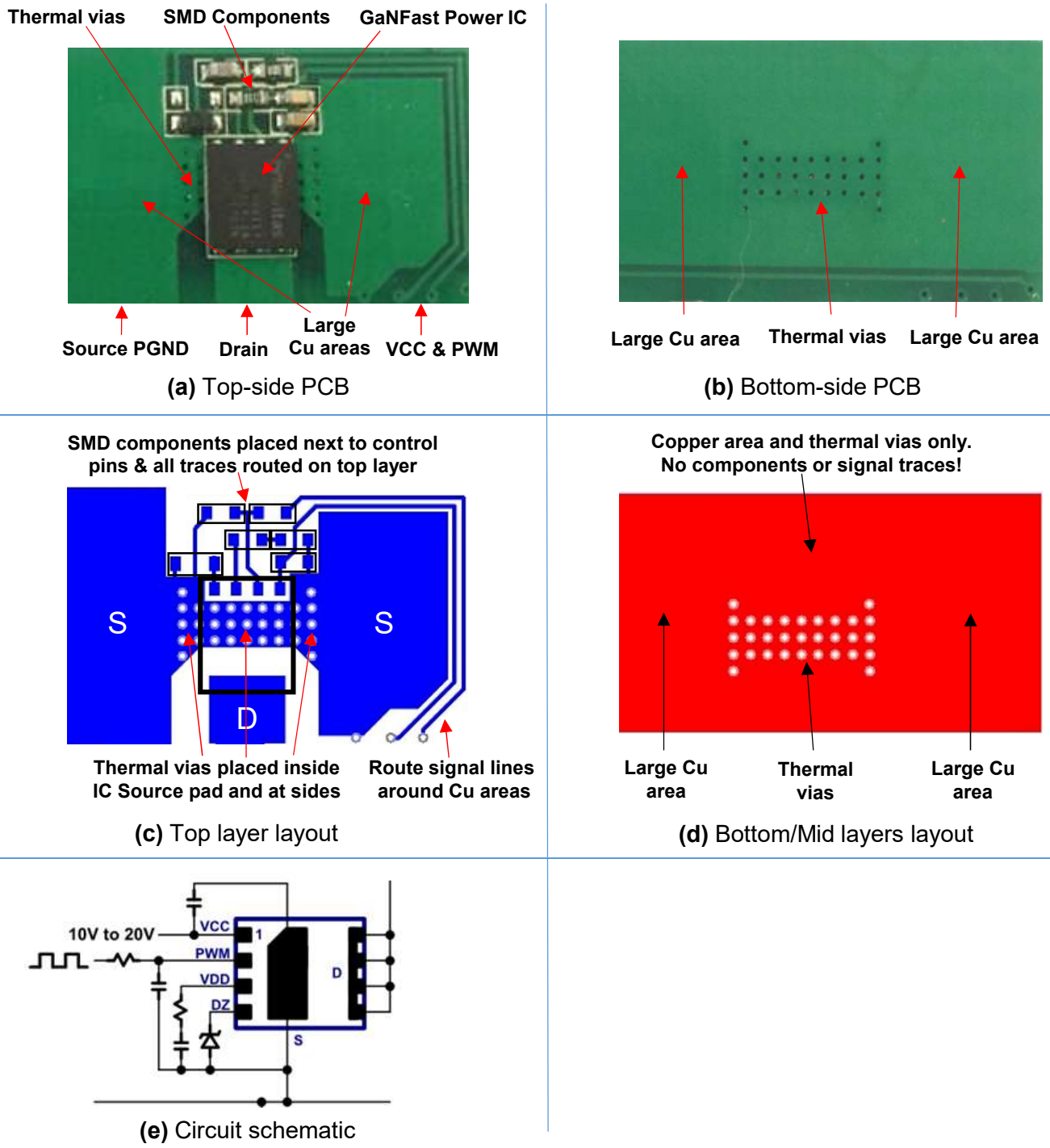
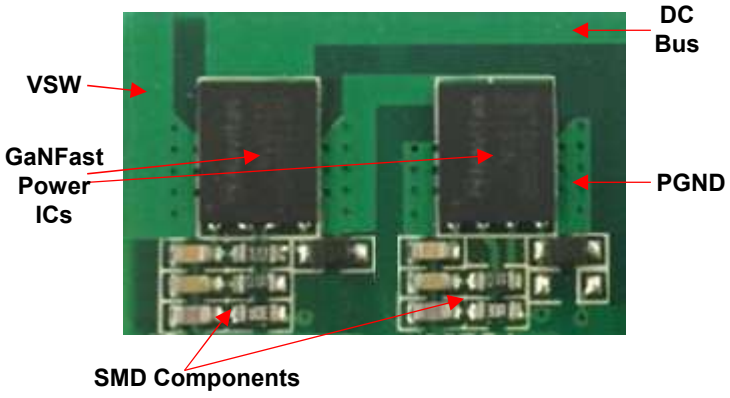


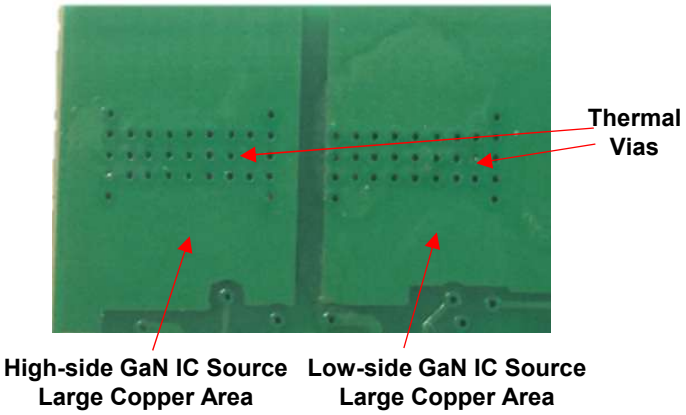
Fig 3. PCB and layout for single GaNFast Power IC.
(a) Top side PCB, (b) Bottom side PCB, (c) Top layout, (d) Bottom/Mid layout, (e) Circuit schematic

PCB Layout Example (Half-Bridge Configuration)

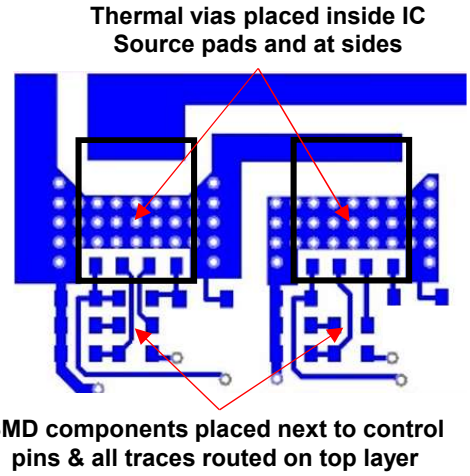
The following example (Figure 4) shows correct layout practices for half-bridge configuration. All components and connections are realized on top layer allowing all other layers to be used only for copper area and thermal vias.



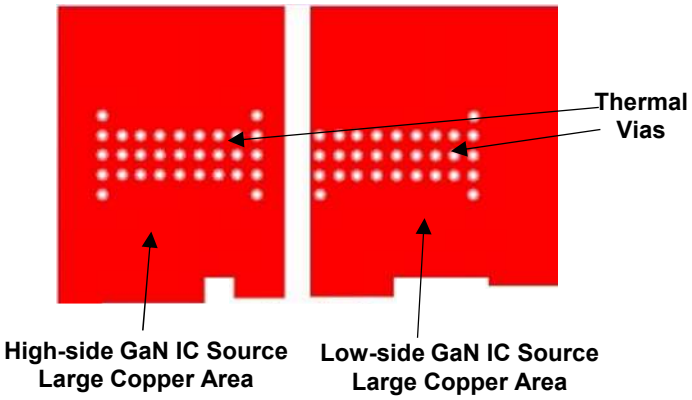
(a) Top-side PCB



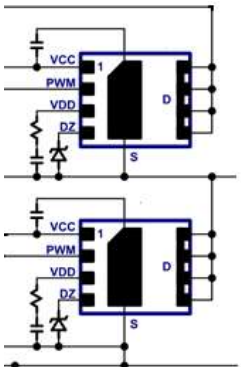
(b) Bottom-side PCB



(c) Top layer layout



(d) Bottom/Mid layers layout

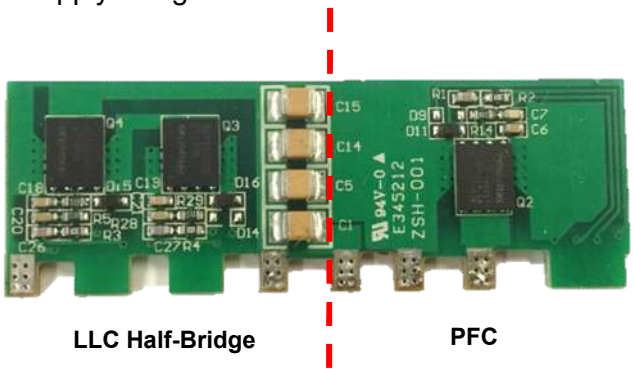


(e) Circuit schematic

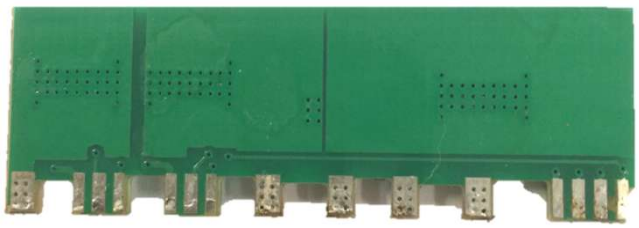
Fig 4. PCB and layout for GaN Power ICs in half-bridge configuration.
(a) Top side PCB, (b) Bottom side PCB, (c) Top layout, (d) Bottom/Mid layout, (e) Circuit schematic

PCB Layout Example (PFC and LLC GaN daughtercard)

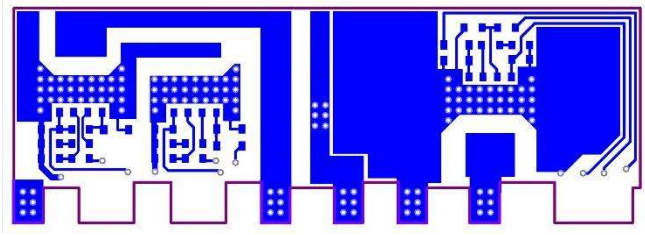
The following example (Figure 5) show correct layout practices implemented on actual power supply designs.



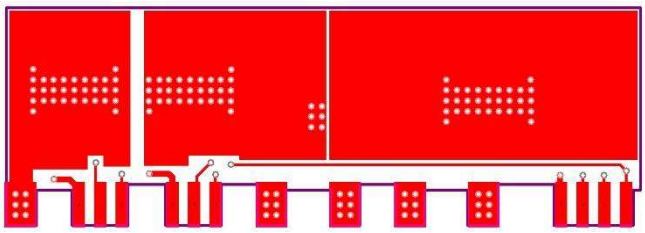
(a) Top-side PCB



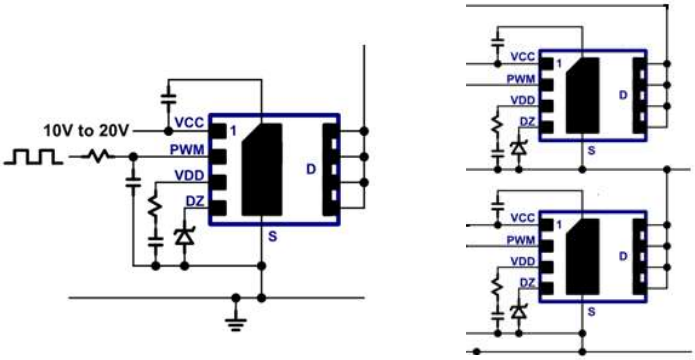
(b) Bottom-side PCB



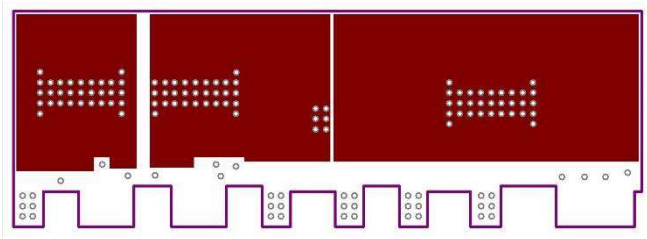
(c) Top layer



(d) Bottom layer



(e) Circuit schematic



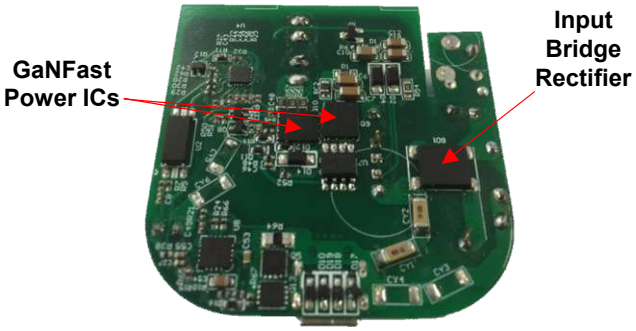
(f) Mid layers

Fig 5. PCB and layout for GaNFast Power ICs in PFC+LLC daughtercard

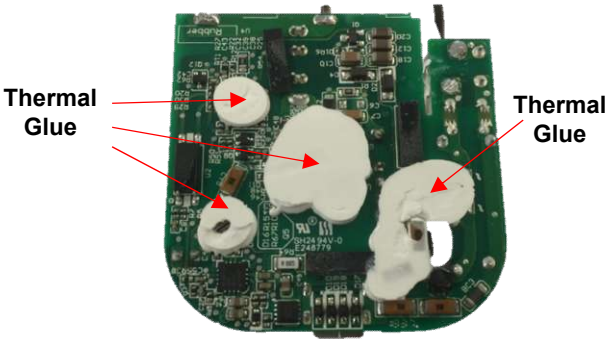
(a) Top side PCB, (b) Bottom side PCB, (c) Top layer, (d) Bottom layer, (e) Circuit schematic, (f) Mid layers

Thermal Management with Case (45 W Charger example)

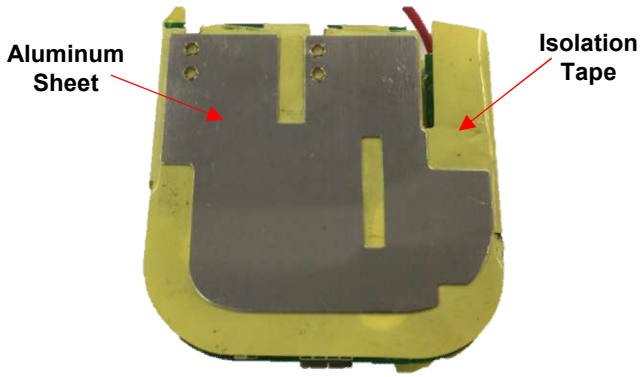
When placing the power supply PCB board into a housing, additional thermal management is required to properly conduct the heat from the PCB to the case. This is necessary to avoid high component temperatures and reduced efficiency. The following 45W phone charger example (Figure 6) uses thermal glue placed on top of the power components, followed by isolation tape and an aluminum sheet for heat spreading. A thermal pad is then used to conduct the heat from aluminum sheet to the plastic case.



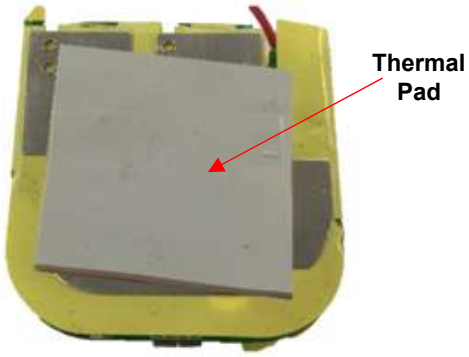
(a) 45 W charger bottom side PCB



(b) Place thermal glue over power devices



(c) Add isolation tape (yellow) and aluminum sheet



(d) Place thermal pad over aluminum sheet

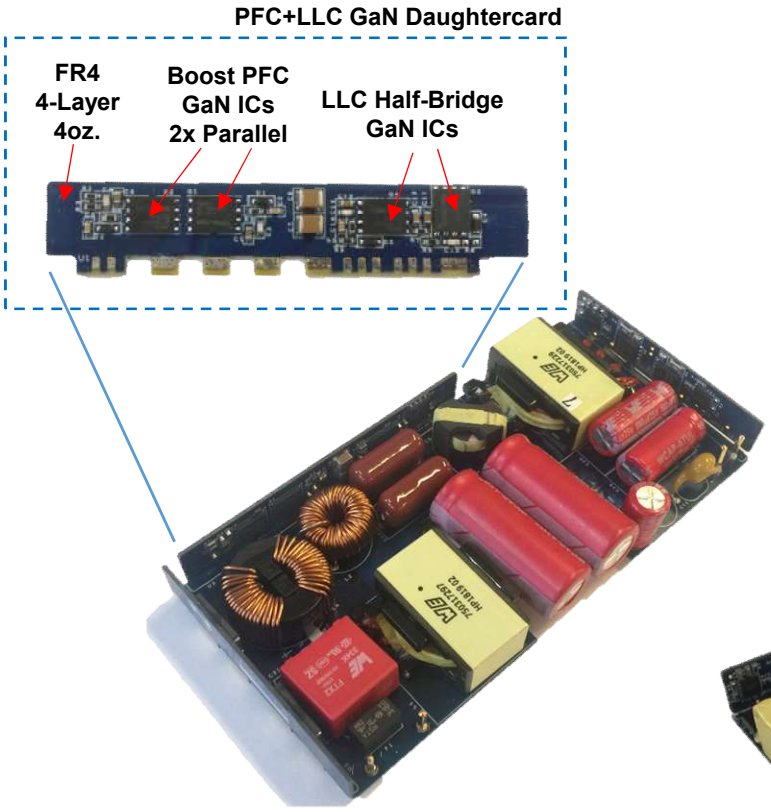
(e) Assemble inside plastic housing

Fig 6. 45 W phone charger thermal management

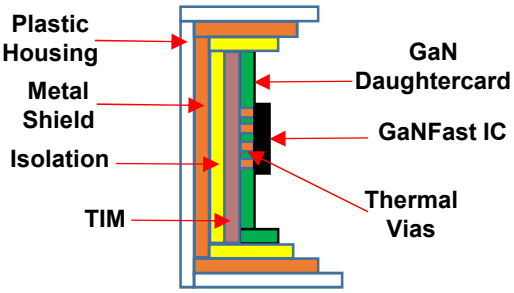
(a) Bottom side PCB, (b) Thermal glue, (c) Isolation tape & aluminum sheet, (d) Thermal pad, (e) Plastic housing

Thermal Management with Shielding

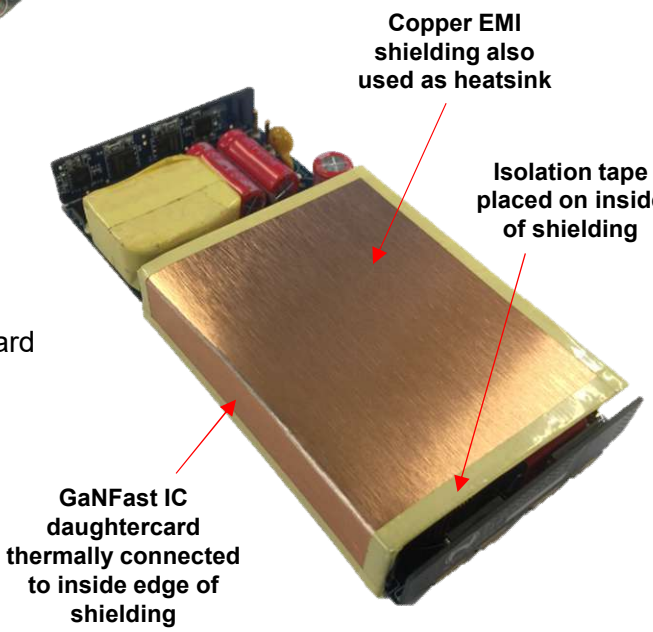
For larger power supply designs, a daughtercard with the GaNFast ICs can be inserted into the main power board along the edge. This allows for the heat from the GaNFast ICs to transfer through the thermal vias of the daughtercard to the backside copper planes. From the copper planes, a heatsink or airflow can then be attached for cooling. The following 150 W AC/DC adapter example (Figure 7) uses a thermal interface material (TIM) to conduct heat from the back of the daughtercard to the copper shielding of the adapter. The internal adapter shielding is already necessary for EMI so it can also be used as a heatsink. The heat will then conduct from the shielding to the outside surface of the surrounding plastic housing.



(a) 150 W AC/DC adapter with GaNFast IC daughtercard



(b) Thermal stack-up



(c) Using copper shield as heatsink

Fig 7. 150 W AC/DC adapter thermal management

(a) GaN IC daughtercard, (b) Thermal stack-up, (c) Copper shield heatsink

Thermal Management with Shielding (cont.)

Materials commonly used for shielding include copper or aluminum. Steel can be also be used for improved EMI shielding and is typically tin-plated to prevent rusting or corrosion. Some available thermal stack-up and shielding materials are summarized in the table below (Figure 8).

Thermal Interface (TIM)			
MATERIAL	MANUFACTURER	PART NUMBER	THERMAL CONDUCTIVITY
Thermal Pad	PMP	PMP-P-300	4.0 W/mK
Isolation Material			
MATERIAL	MANUFACTURER	PART NUMBER	THERMAL CONDUCTIVITY
Mylar	Formex	PC-ITW N3-8	0.14 W/mK
Metal Shielding			
MATERIAL	MANUFACTURER	PART NUMBER	THERMAL CONDUCTIVITY
Copper	Various	Various	399 W/mK
Aluminum	Various	Various	235 W/mK
Steel	Various	Various	14 W/mK
Plastic Case			
MATERIAL	MANUFACTURER	PART NUMBER	THERMAL CONDUCTIVITY
Polycarbonate Resin	Sabic Plastics	PC Sabic 945	0.20 W/mK

Fig 8. Thermal stack-up and shielding materials summary table.

Additional Information

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