Student Paper

BOARD EMBEDMENT OF ACTIVE AND PASSIVE DEVICES FOR HIGHER PERFORMANCE COMPETITIVE POWER TECHNOLOGY

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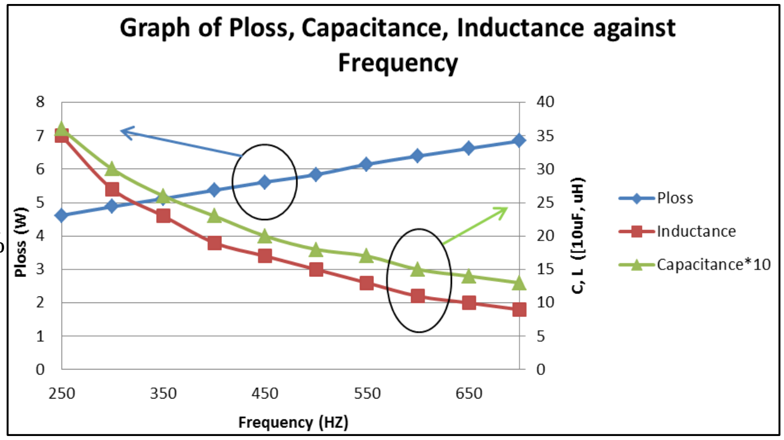
Integration of switching devices with their filters and control circuitry would great benefit the applications with severe size restrictions like automotive and avionic applications. This study features an in depth design of package for a high frequency, 42V/14V, 140W buck converter for automotive application. The devices are integrated in the form of low-cost, insulated and efficient building block where Printed Circuit Boards (PCB) is used for embedment of bare die devices.

Pspice simulation is done to determine the operating frequency and power losses distribution of the devices in an asynchronous buck converter. Figure 1 shows the power loss of the converter is 2.2W (1.57% efficiency drop) when converter is driven up from 250kHz to 700kHz while size of passive components are reduced by factor of 4.



The efficiency of converter does not show significant drop when it is driven up to 700 kHz when considering the loss on inductor and diode as shown in table 1. Thus, switching frequency of 700 kHz with 20% of ΔI_{out} and 2% ΔV_{out} is selected as targeted specification for further analysis.

F (kHz)	Temperature (ºC)	Inductor (W)	Capacitor (uW)	Mosfet (W)	Diode (W)	Gate Driver (mW)	Efficiency (%)
500	30	3.99	384.27	2.76	3.21	552.17	93.25
	30*	3.53	856.24	2.75	3.20	-	93.61
	70	4.46	382.70	2.97	2.92	557.40	92.97
	70*	3.86	866.74	2.93	2.97	-	93.42
700	30	3.34	431.14	3.78	3.19	773.32	93.06
	30*	2.81	1388.60	3.77	3.20	-	93.40
	70	3.34	428.09	4.00	2.95	780.36	93.08
	70*	3.06	1384.30	3.97	2.96	-	93.24

Table 1 Losses distribution among the components in the buck converter with 10% ΔI_{out}, 1% ΔV_{out} (*Note: *=20% ΔI_{out}, 2% ΔV_{out}*)

A thermal modelling of the buck converter is designed using Abaqus. The idea is to place diode and Mosfet on each side of PCB and attach them to oppossite side of PCB using bumps as shown in figure 2. This helps in improving the cooling efficiency of the package by having double sided cooling.

Thorugh hole copper via are designed under the devices to remove heat efficiently. They are used to connect the imput and output of the converter to source and load. This reduces the distance of current conducting, results less parasitic losses and improve the power efficiency of circuit.

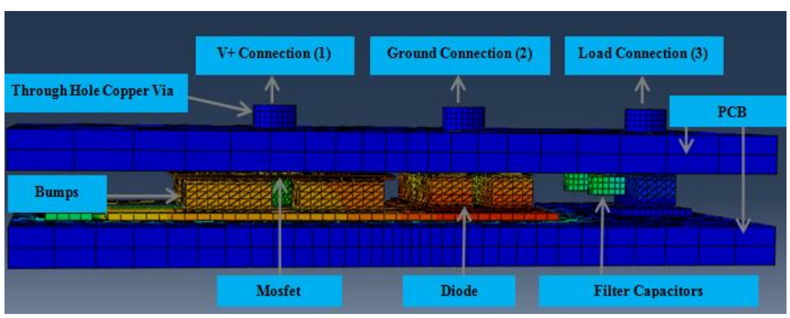


Figure 2 Front view of the designed buck converter model

Figure 3 shows the simulation results of the model. The temperature distribution and heat flux vector results show that through hole via has significant contribution for heat remove.

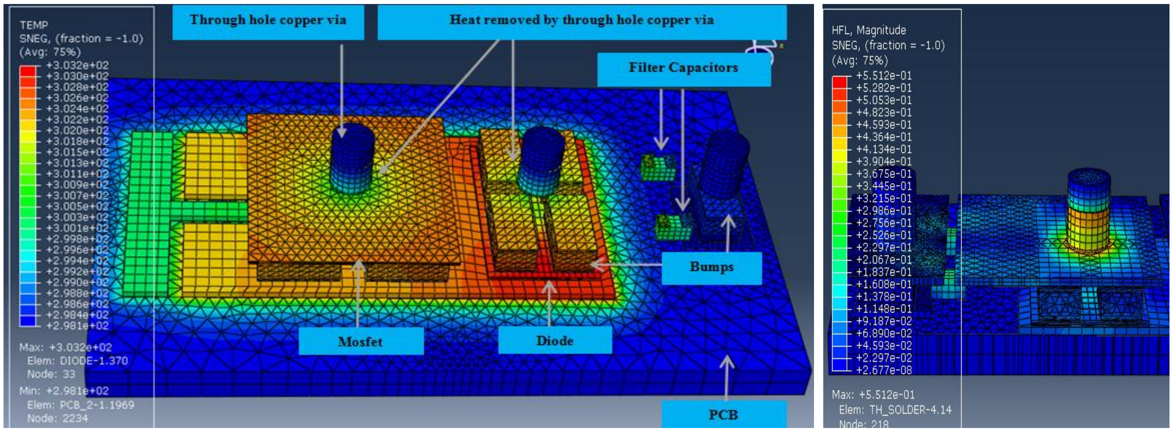


Figure 3 Thermal simulation result (left) and Heat Flux Vector result (HFL) (right) of the package

An experiment is carried out to test the performance of designed packaged with 700kHz operating frequency, 20% ΔI_{out} and 2% ΔV_{out}. A PCB layout with dimension of 28mm x 24mm is designed in eagle software. Pins are planned to replace bumps for cheaper experimental approach. The experiment is on going during the submission of abstract.

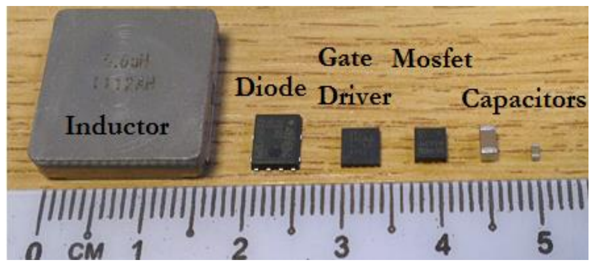


Figure 4 Actual components using in experiment

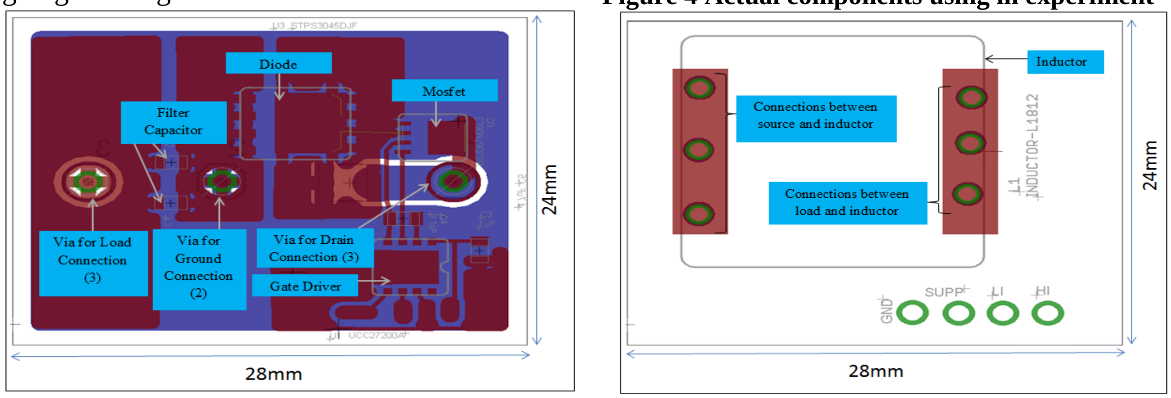


Figure 5 Layout of PCBs for proposed buck converter package (Red-Top Layer, Blue-Bottom Layer)

Future Approaches:

PCB can be custom made to have different thickness of copper layer. Mounted only with thin bare die device (eg. 70um), the thicker copper layer section will touch each other, replacing bump for connection between two PCBs.

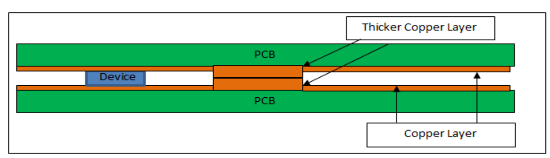


Figure 6 Diagram showing different thickness of copper layer replacing the bump

PCB can be also custom made with 'cut-off' section within it to place the components. This allows thicker component such as surface mounted (SMD) capacitor to be placed between the PCB without affecting the distance between two PCB

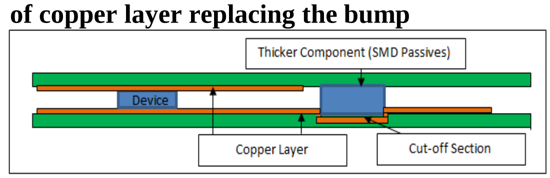


Figure 7 Diagram showing the cut-off section for placing thicker components

With these approaches, thin polyimide film can be used to replace gel to provide insulation between the PCBs. Thus, the distance between the two PCB can be reduced to negligible where the performance of the package is worth to be analysed.