Automation of Multi-Chip Power Module (MCPM) Layout Optimization

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Degree: Ph.D., May 2018
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Background (general)
• MCPMs are ubiquitous in the transportation and energy sectors. They are high power density and high switching frequency modules but with significant electrical, thermal, mechanical, reliability, and EMI effects. This presents a need for optimization of MCPM layouts.
• Existing optimization tools are limited to doing one simulation at a time. This presents a need for automation.

Innovation
New tool developed can provide a finite solution set of layouts by performing multiple simulations in a few hours or even minutes. The user can then select an appropriately optimized solution for transient thermal test.

Key Results (general)
• Optimized layouts generated 10,000 times faster than FEM models (within 10% accuracy).
• Layouts/Equivalent circuits successfully exported to Q3D, SolidWorks, SPICE.

Key Results (specific to current work)
• Able to improve the fidelity of the thermal model
• Findings published in IEEE COMPEL 2016.

Approach
1. Modeling
• Successive approximation of power dissipation and temperature
2. Software Engineering
• Alternately simulate power dissipation and temperature for fixed time intervals. Output of one simulation becomes input to the next
• Communicate between python and HSPICE
• Final output: temperature over time graph
3. Testing
• To be determined.

Conclusions
PowerSynth (the new tool) addresses a much-needed preliminary optimization of MCPM layouts for the power electronic packaging industry.

Comparison of models to find temperature

<table>
<thead>
<tr>
<th>Function</th>
<th>Estimated number of iterations</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerSynth’s steady-state thermal model</td>
<td>n/a</td>
<td>6-8 ms</td>
</tr>
<tr>
<td>Steady-state successive approximation model</td>
<td>5</td>
<td>20-30 ms</td>
</tr>
<tr>
<td>State space thermal model</td>
<td>300,000</td>
<td>3-4 s</td>
</tr>
<tr>
<td>State space temperature-power loop model</td>
<td>300,000</td>
<td>600-700 s</td>
</tr>
</tbody>
</table>

Next steps
• Test performance against ANSYS Q3D and perform physical validation.