PCB Design and Simulation of a Power Distribution Board

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Background

UVic's centre for aerospace research (CfAR) has requested an alternative power distribution board (PDB) for their unmanned aircraft. The PDB must house all the circuitry required to lower the voltage from a 12V DC input to 8V, 5V, and 3.3V.

Goals

- 3 stackable buck converters
  - Input: 12V
  - Output: 8V at 14A, 5V at 6A, 3.3V at 2A
- PCB layouts that reduce EMI and trace impedance
- Non electrically-interconnected modular design
- Target converter efficiency of 90%

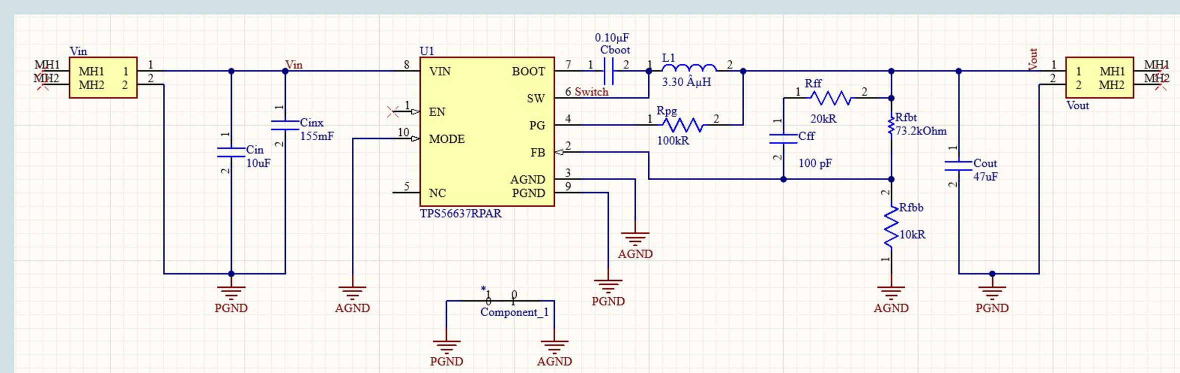
Methodology

Design Process :

- Choosing a switching device → Si MOSFET
- Choosing device topology → non isolated synchronous buck converter
- Heat sink consideration → not needed
- Schematic design
- Schematic simulations
- PCB design - design considerations for EMI reduction & heat dissipation:
  - Implementing 4 layer PCB for higher current ratings
  - Copper island under the switching voltage (Vsw island)
  - Solid ground plane under Vsw island
  - Thermal vias incorporated
  - Avoiding 90 degree traces, corners are band at 45 degrees

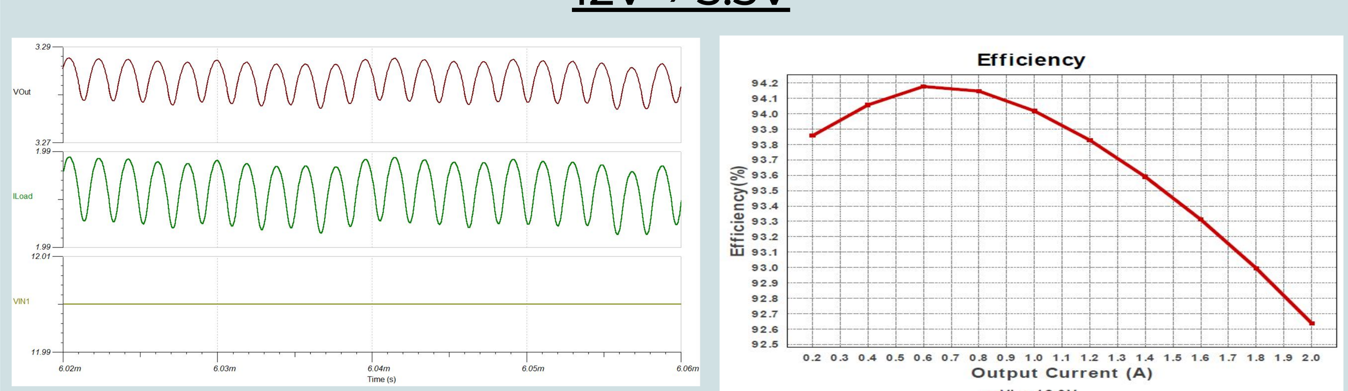
Buck Converters

A buck converter, also known as a step down converter, is a DC-DC converter that efficiently reduces the voltage from an input source to a load.

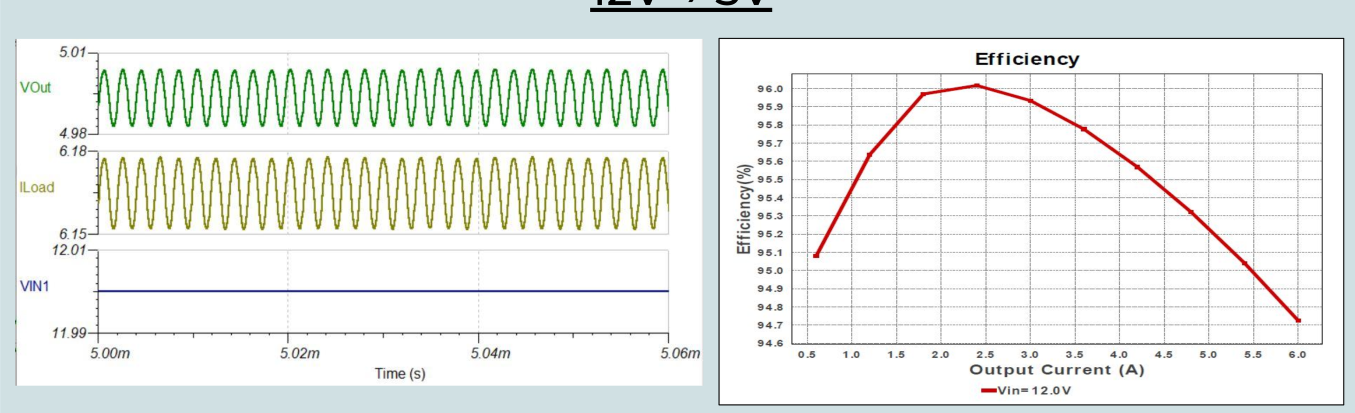


Simulations

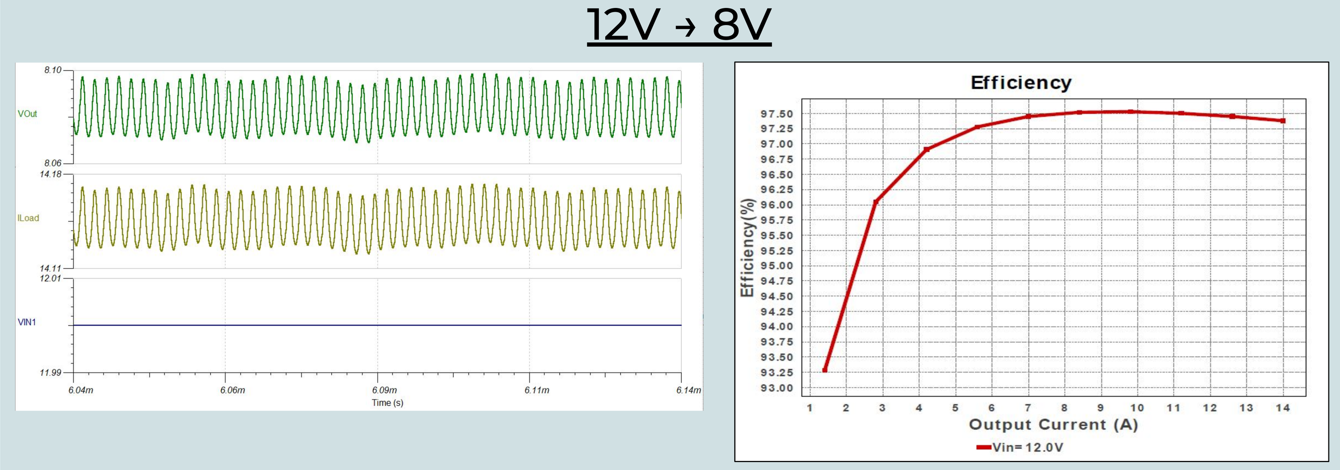
12V → 3.3V



12V → 5V

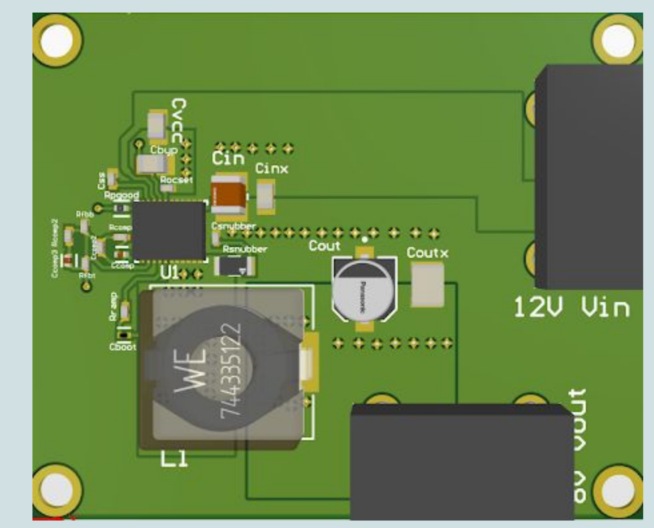


12V → 8V

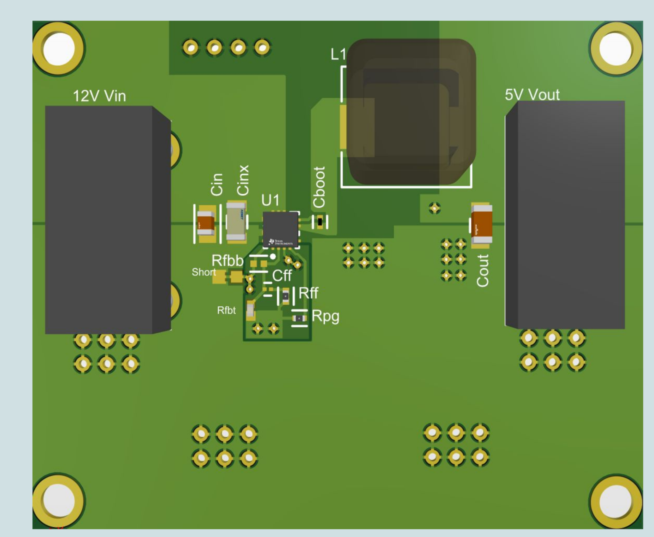


Results

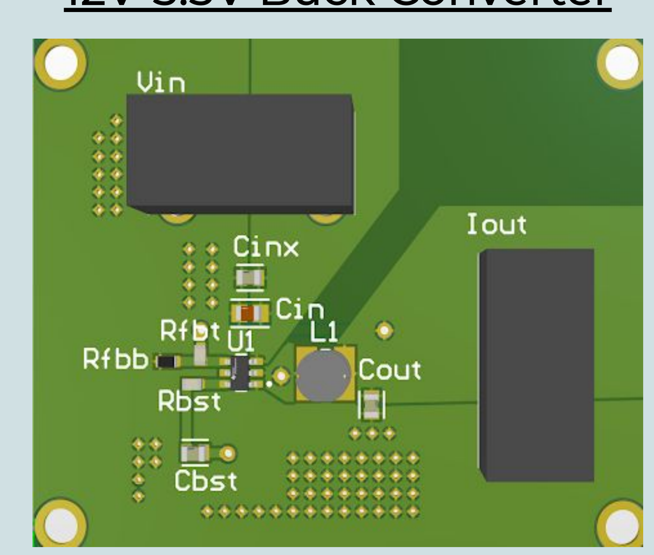
12V-8V Buck Converter



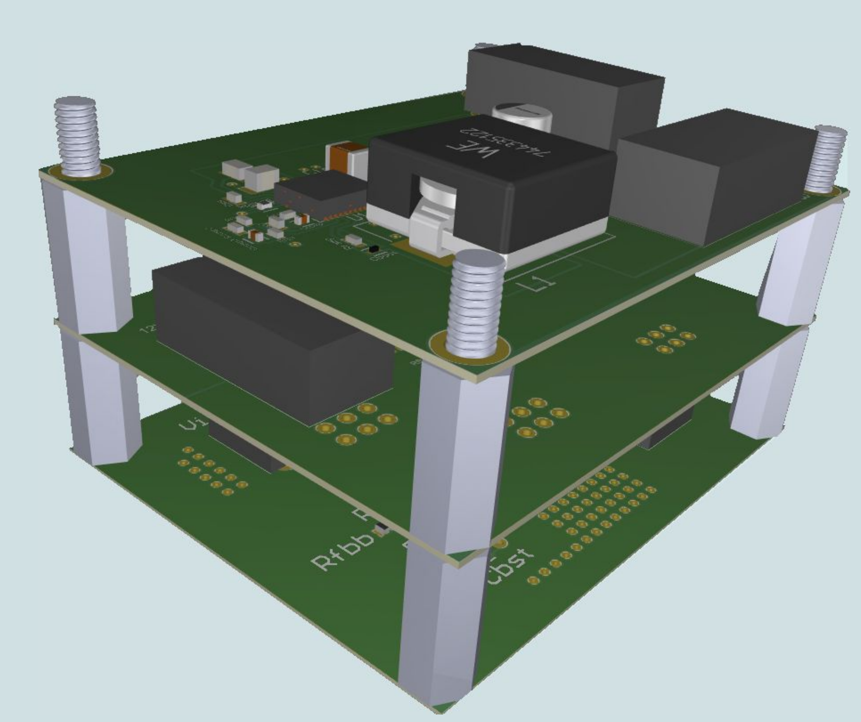
12V-5V Buck Converter



12V-3.3V Buck Converter



Modular Buck Converters Design



Conclusion

Each of the three buck converters are able to convert 12V DC to the require voltages of 8V, 5V and 3.3V respectively at high efficiency.

	Efficiency	Cost
12V-8V	97.0%	$95.24
12V-5V	94.7%	$91.89
12V-3.3V	92.6%	$85.19

References

[1] "Partie 6 - Alimentation en energie solaire", Four Solaire. [Online]. Available: https://tribu.phm.education.gouv.fr/toutatice-portail-cms-nuxeo/binary/Four+Solaire-Alimentation.pdf [Accessed. 30-Mar-2021]

[2] S. Park, H. A. Huynh and S. Kim, "Analysis of EMI reduction methods of DC-DC buck converter," 2015 10th International Workshop on the Electromagnetic Compatibility of Integrated Circuits (EMC Compo), Edinburgh, UK, 2015, pp. 92-96, doi: 10.1109/EMCCompo.2015.7358337.

[3] K. Koo, J. Kim, M. Kim and J. Kim, "Impact of PCB design on switching noise and EMI of synchronous DC-DC buck converter," 2010 IEEE International Symposium on Electromagnetic Compatibility, Fort Lauderdale, FL, USA, 2010, pp. 67-71, doi: 10.1109/ISEMC.2010.5711249.

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