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# Optimalization of Buck-Boost converter for automotive

Juraj Tvarozek[1], Michal Prazenica[1], Tomas Paulec[1]

*1 University of Žilina, 01026 Žilina, Slovakia*

## INTRODUCTION

The batteries themselves have the disadvantage that their voltage is not constant and varies according to the battery's charge level. For this reason, manufacturers try to cope with voltage variations by reducing them using voltage regulators or pulse converters.

For on-board appliances with high power and a requirement for a constant supply voltage, reducing the supply voltage is not advantageous because of the increasing currents.

The paper discusses reducing inverter losses by changing the control algorithm when using hard switching mode for low-power automotive applications (10-250W).

## MATERIALS, METHODS & IMPLEMENTATION

A buck converter can have different connections; we can describe two. The first option is to use an inverting circuit with one transistor. Another option is to use a complete bridge circuit interposed as two converters (buck and boost) in series (Figure 1.). Choi et. al. (2024). This wiring gives us several extra options. In addition, when using switches with very low Rdson and optimized inductance and PCB design, this wiring will be more efficient in power scales up to 250 W.

If we need to reduce the voltage, we can start the Buck converter (T1+T2) and shut down the Boost converter by permanently opening the transistor T3. For the opposite case, i.e., the need for voltage boosting, it is possible to open transistor T2 and only operate the Boost converter (T3+T4). These operating states are shown in Figure 2. However, operating the converter designed in this way is significantly disadvantageous because it requires long-term opening of the transistors, which requires a floating driving source.

## RESULTS

The results of the simulations are shown in the Figure 3. For a better interpretation of the results, we also show the curve of the same converter when controlled by permanently opening the transistors in the converter that is not currently in use.
It now remains to investigate the effectiveness for different variations of performance. In Figure 1. We can see the efficiency graph for different output powers for an input supply voltage of 13.4V. The output voltage is a constant 12V. In the range of 30-100W, we can see the minimum difference in efficiency. After that, there is a drop, but it is not very dramatic.

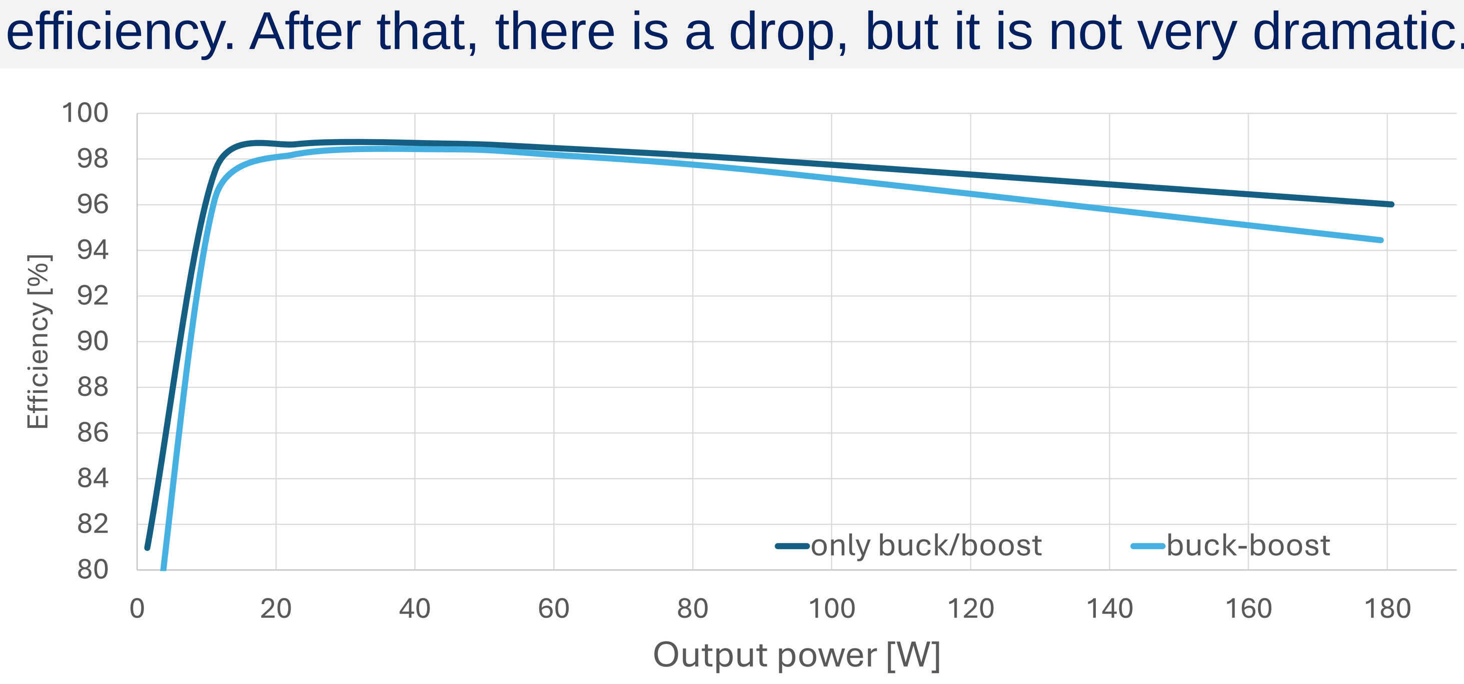


*Fig. 1. Graph of efficiency between two operating mods at input voltage 13.4V for different output power.*

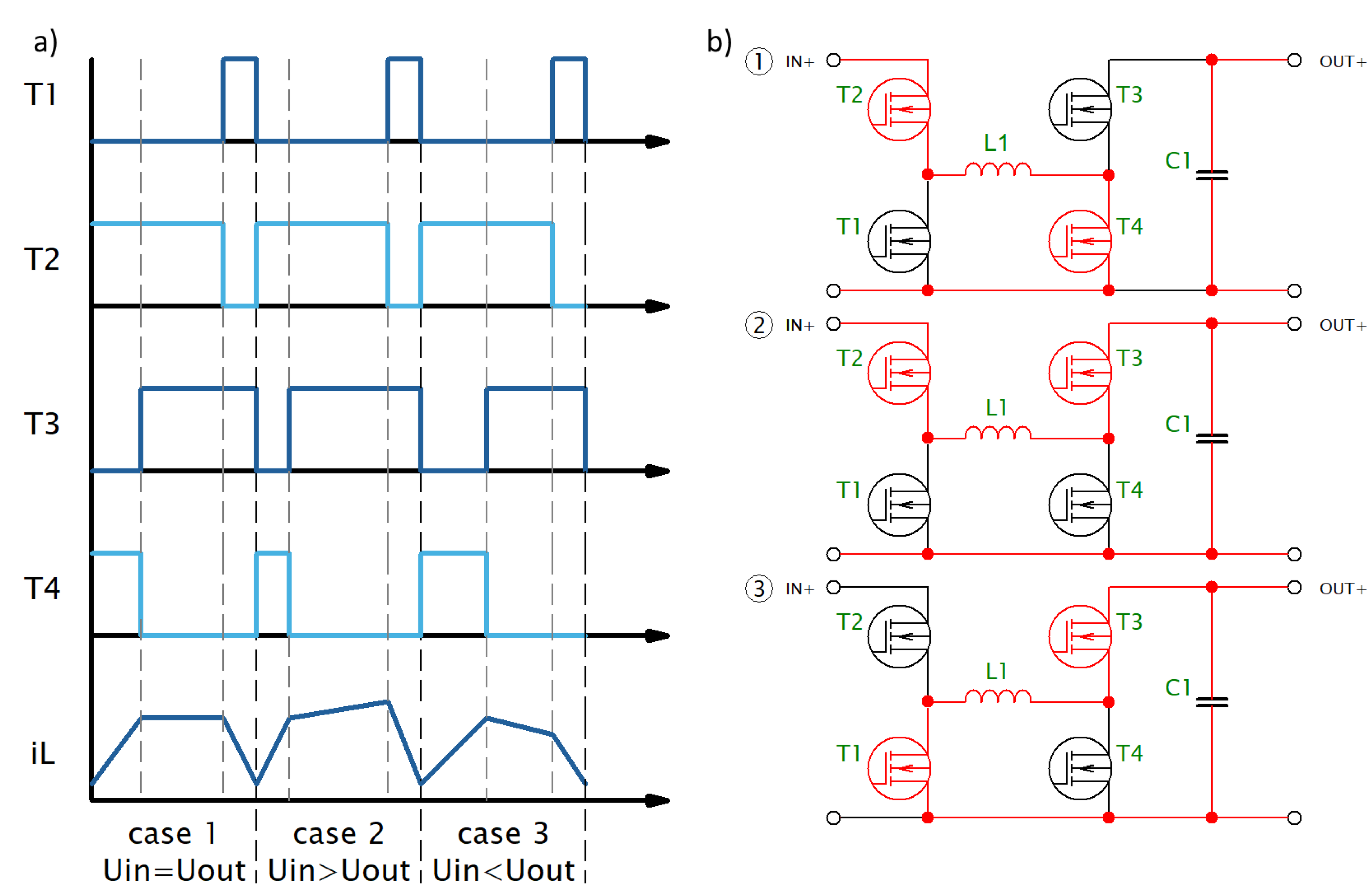


*Fig. 2. (a) PWM signals for transistors switching with current shape; (b) working intervals of the converter.*

## CONCLUSION & IMPLEMENTATION PATH

We achieved a cost and dimensionally advantageous model by changing the control algorithm. Since the necessity of using isolated voltages for most drivers is eliminated, we can use inexpensive drivers based on the bootstrap driver method. Such an inverter is advantageous for use in a precise voltage range. An ideal example is automotive use since the car battery is most often in the range of 12-14 during regular operation, not in fault mode. 4, thus, the inverter operates in a favorable combination of cycles (buck 80% and boost 1-10% ). Also, during deep battery discharge or fault conditions, this inverter can still deliver a constant 12V voltage even if the battery voltage is well below 12V. It reaches a theoretical efficiency of up to 97% in regular use. In the power range, 20-150W. In fault mode, the efficiency of such a transmission is around 93-96%, which is still within the usable range, considering the price and size of the design.

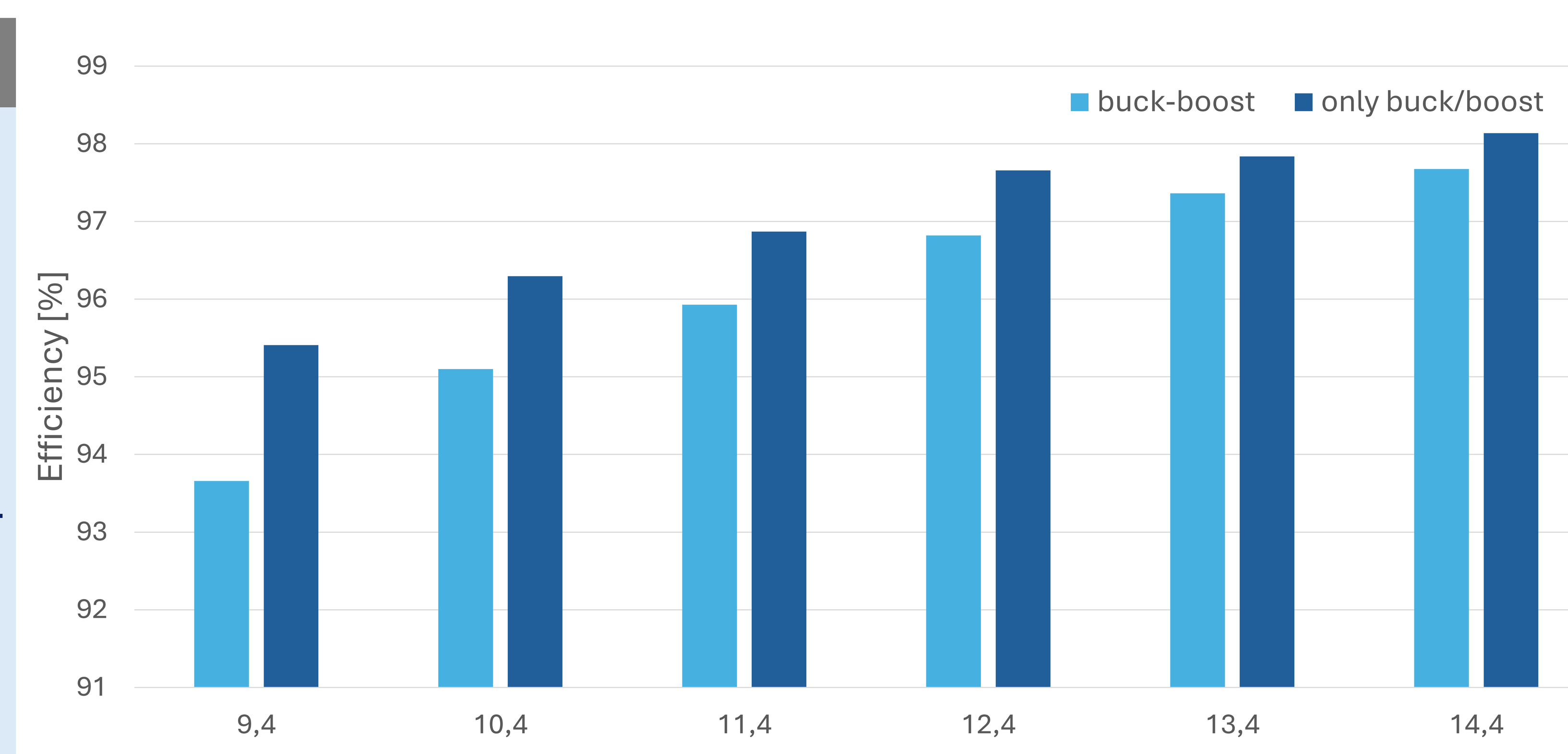


*Fig. 3. Graph of efficiencies of different modes of operations for various input voltages. Simulating for output power of 100 W and output voltage of 12V*

## ACKNOWLEDGEMENTS

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