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A New Multiport DC-AC Power Converter for Distributed Energy Applications

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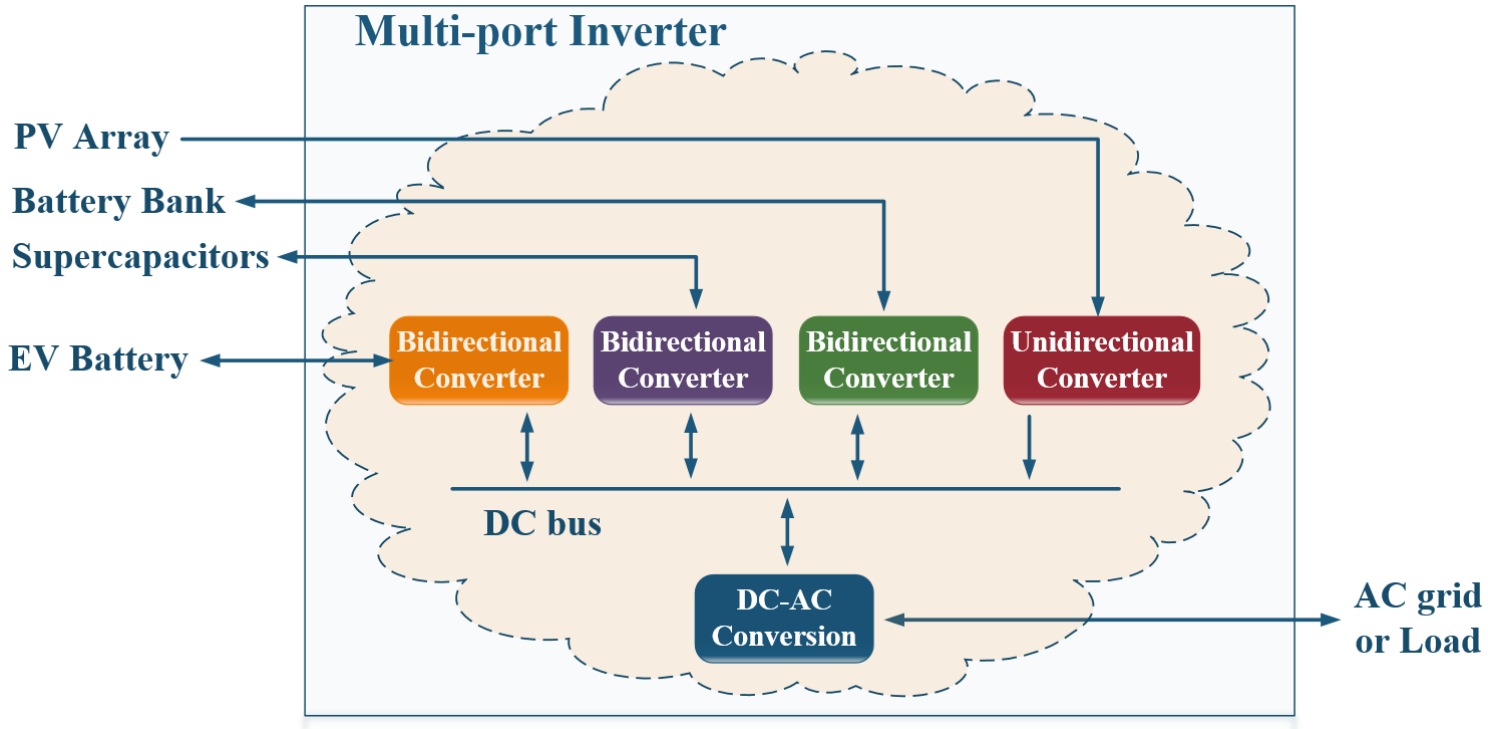
Introduction

- The fact that the majority of the required energy is still produced by burning fossil fuels, along with the worldwide growth in energy demands, has made the use of renewable energy sources (RES) mandatory.
- To increase RES utilization, smaller scale RES connected near to the point of use, known as distributed energy resources (DERs), are implemented.
- DERs can be easily integrated with energy storage systems (ESS) such as battery banks, supercapacitor arrays or electric vehicles.
- To interconnect DERs and ESS units with a load or the electricity grid, multiple power electronic devices are required.

Multi-port Converters

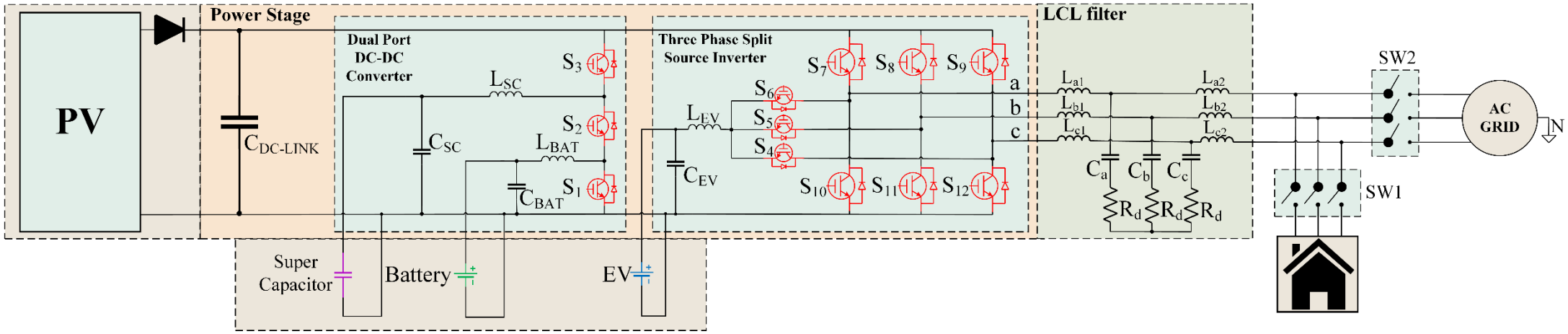
- Conventional architecture consists of multiple single input DC-DC converters connected to the DC bus and a DC-AC converter for the inversion stage.
- Multi-port power converters (MPCs) integrate multiple power converters into a single unit.



MPCs advantages over the two-stage conventional architecture:

- Less passive and active components
- Higher efficiency
- Simplified structure
- Less power stages
- Lower cost
- Reduced size and volume

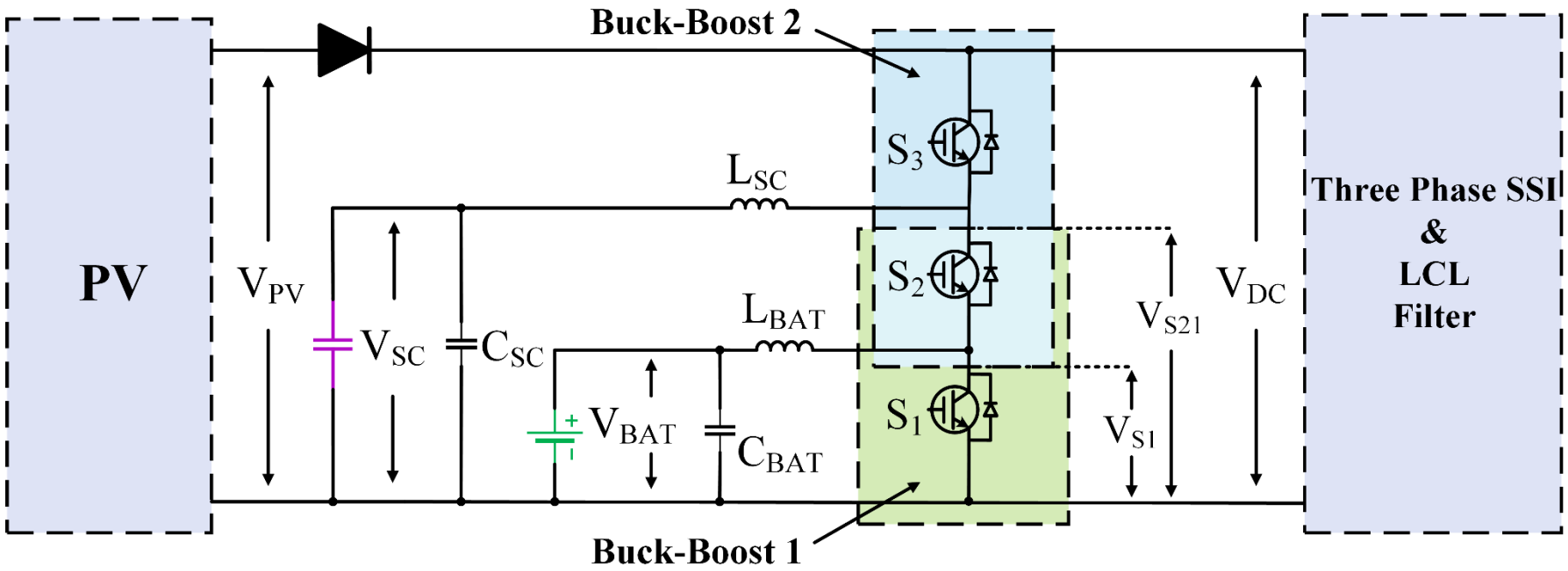
Proposed Circuit Topology



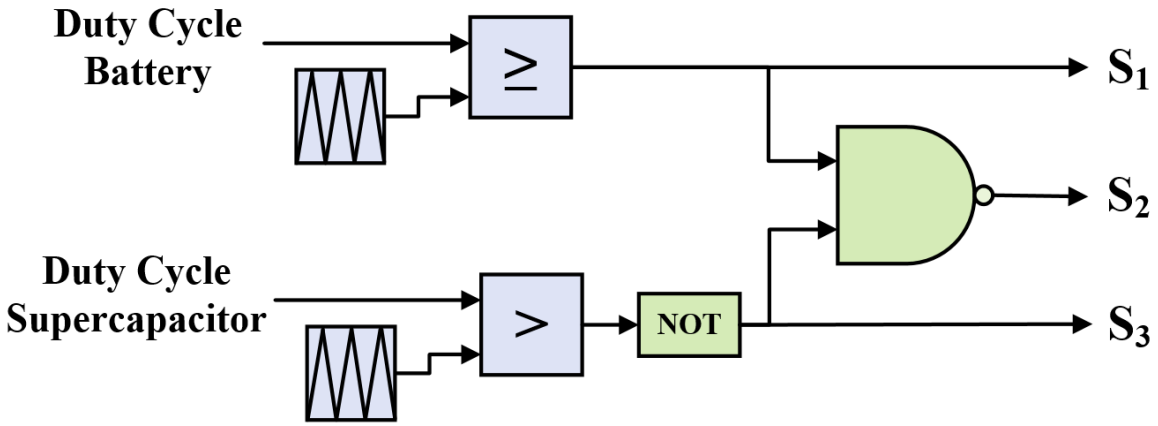
The proposed MPC advantages:

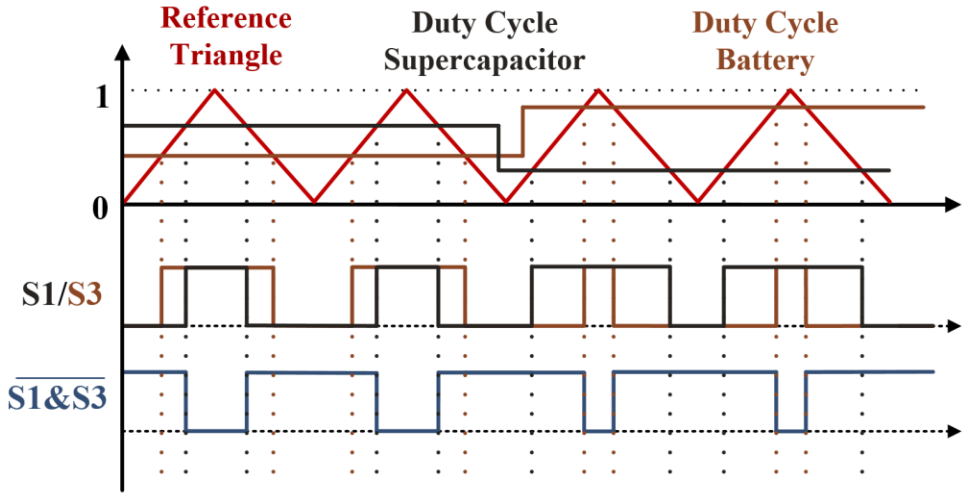
- It is a five-port MPC including four DC ports and a three-phase AC port,
- The number of passive components (inductors and capacitors) is reduced,
- Four of five ports can handle bidirectional power flow,
- The PV array is directly connected to the DC-link. However, the MPPT algorithm can still be performed by regulating the DC-link voltage directly.
- The proposed topology consists of 9 high-switching frequency power switches and 3 low-frequency ones, in contrast to a conventional topology which consists of 13 high-frequency switches for the same number of ports.

Two-input DC-DC Converter Circuit Topology

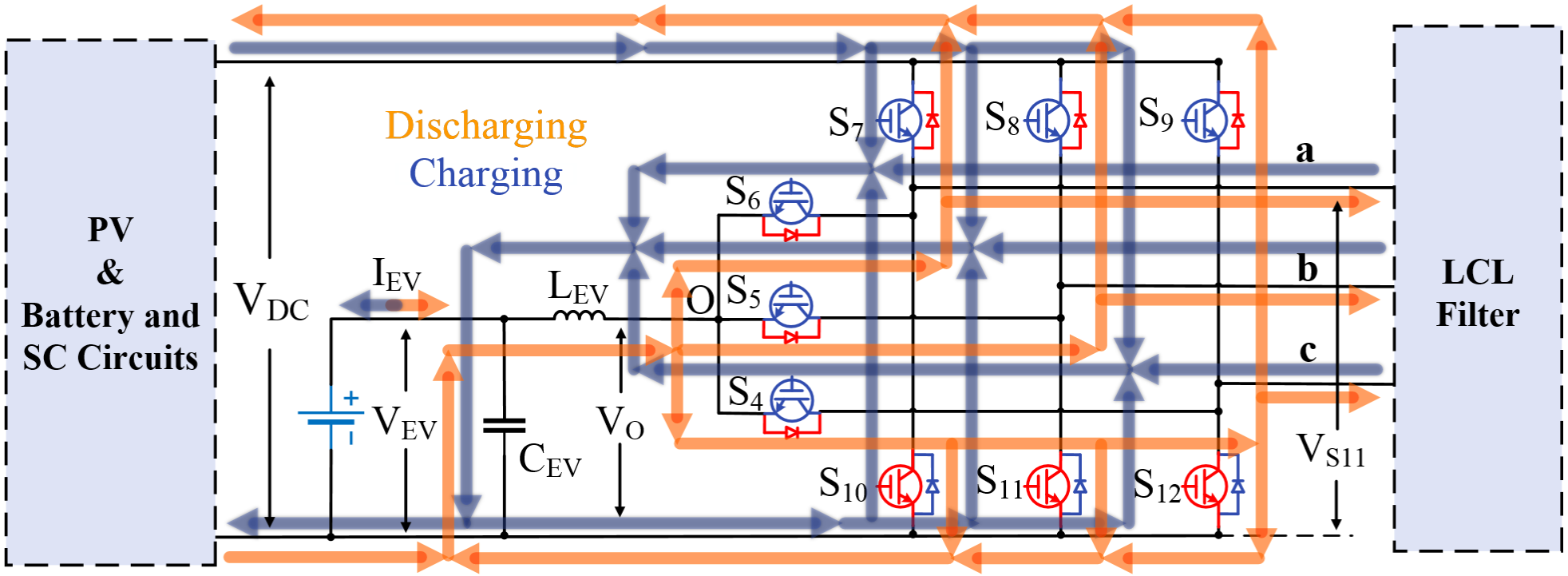


Driving Pulses for Battery and Supercapacitor ports

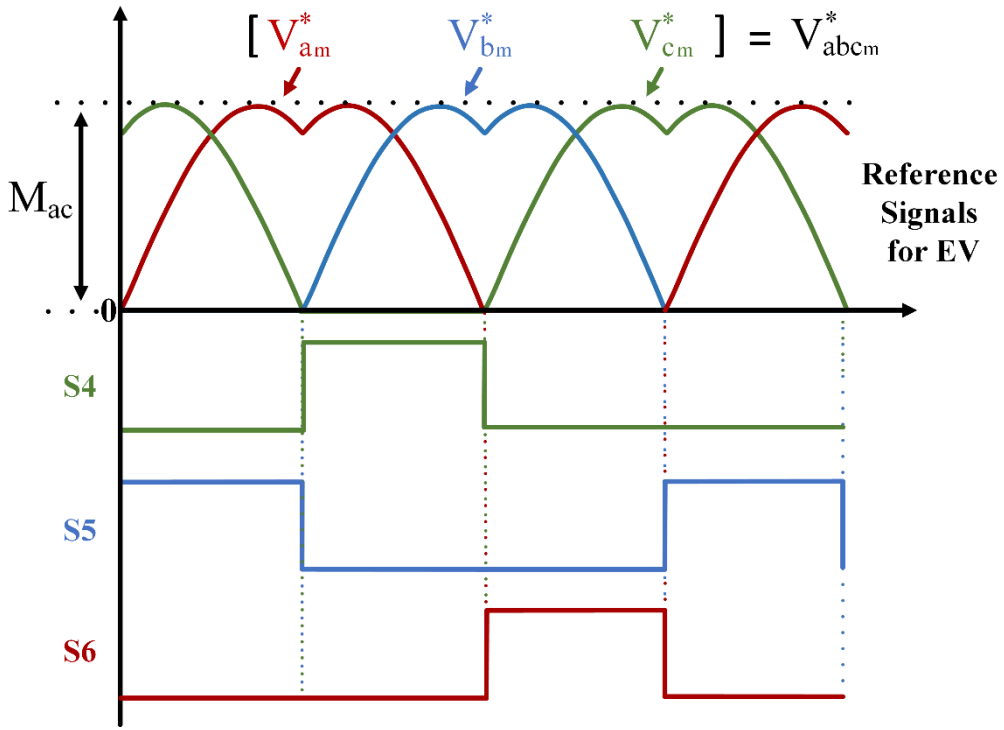


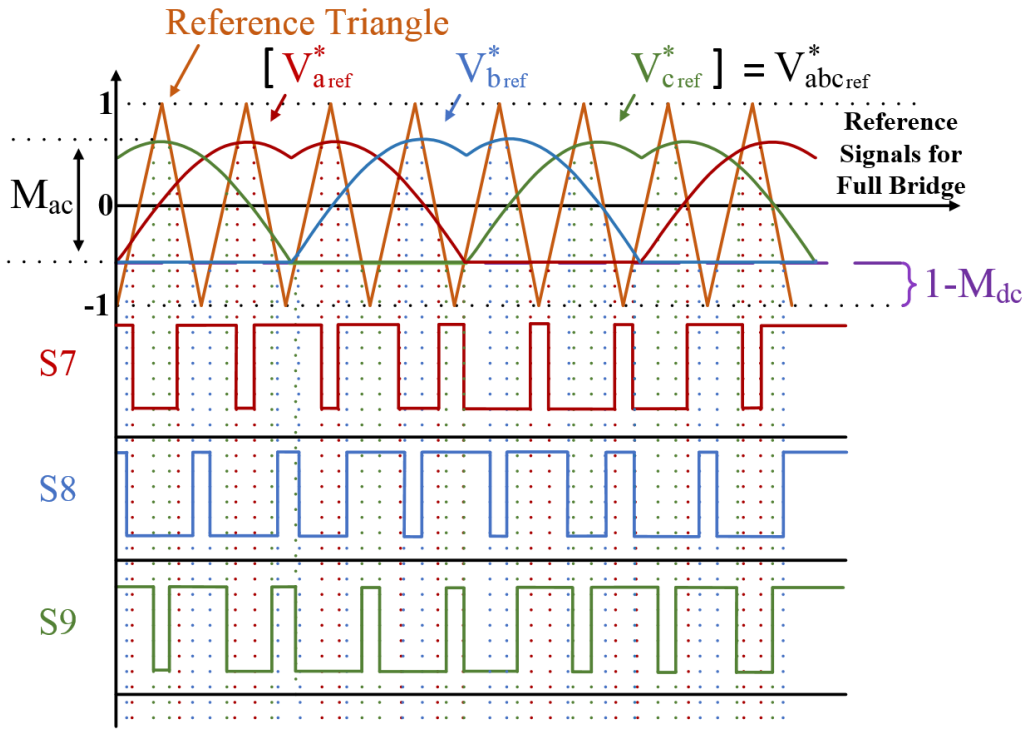


Inverter Bridge and EV port Circuit Topology

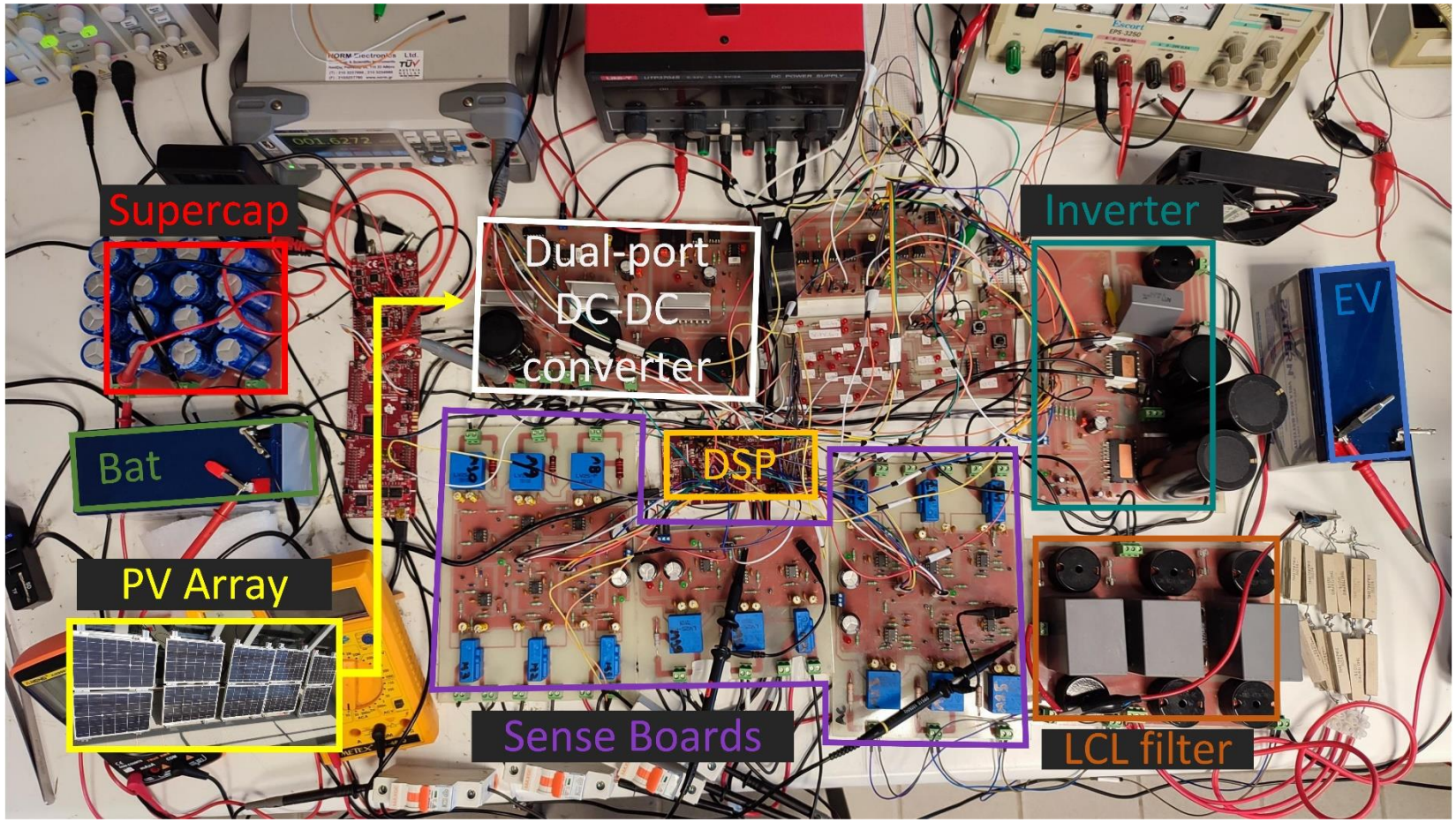


Driving Pulses for EV port and Inverter Bridge



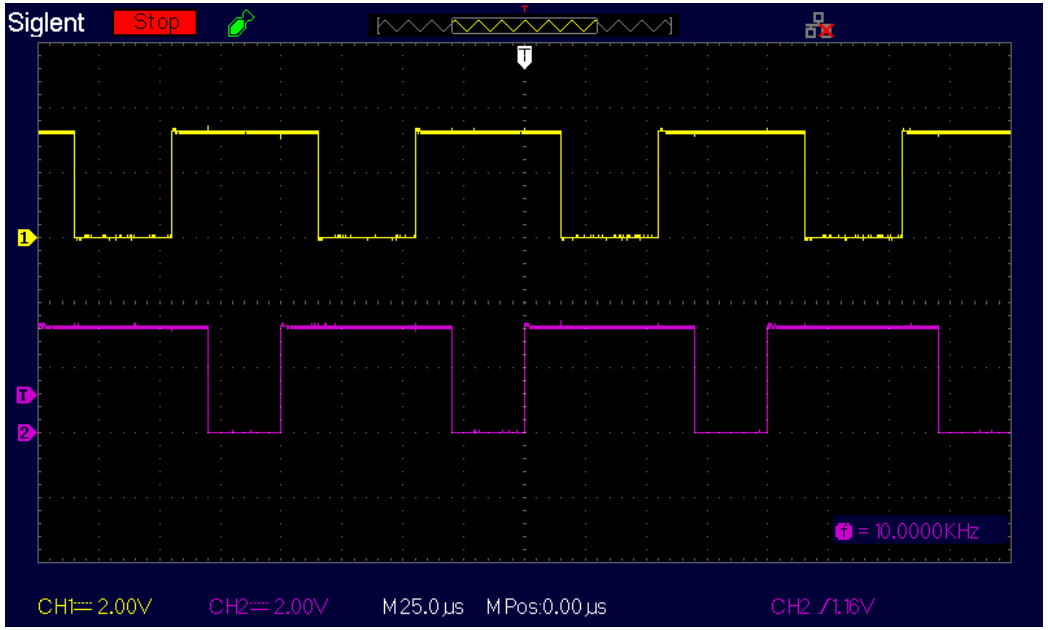


Experimental Prototype of the proposed MPC

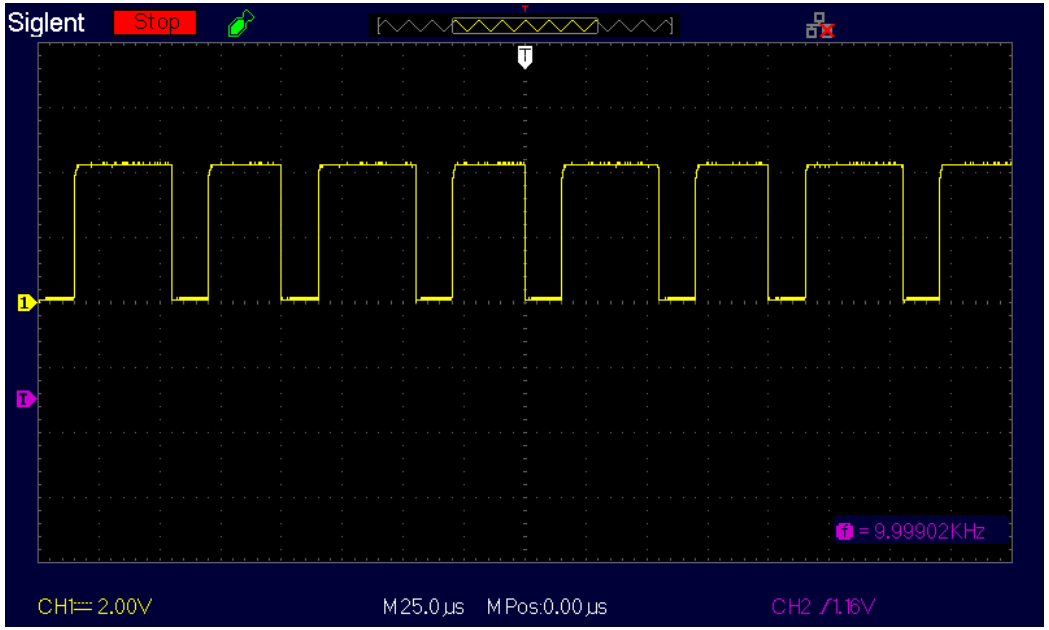


Experimental Results

Driving pulses of S_1 and S_3

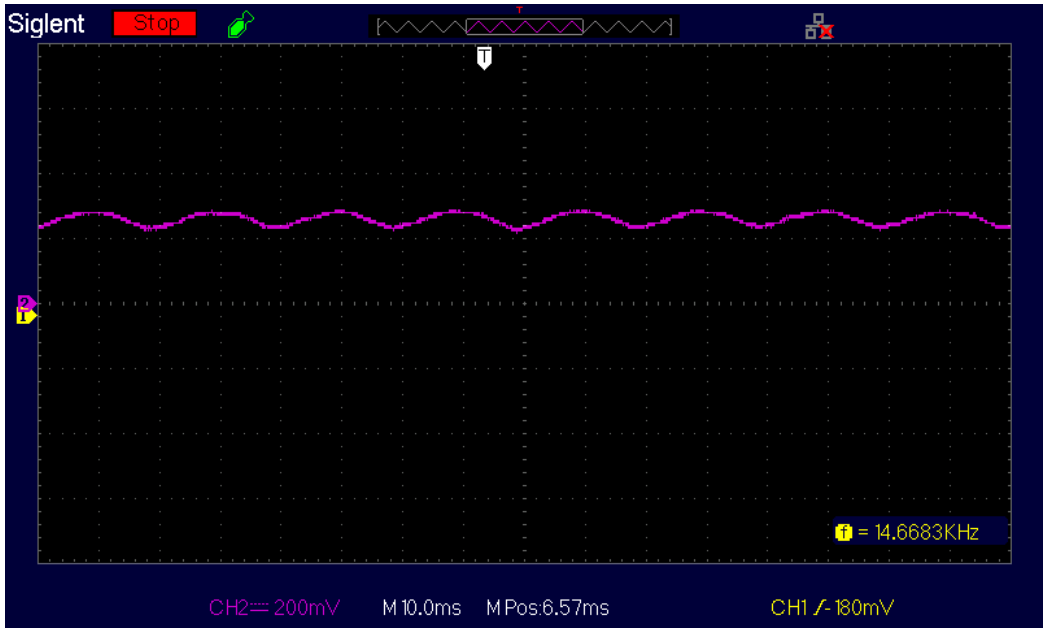


Driving pulse of S_2 produced by the NAND logic function between S_1 and S_3

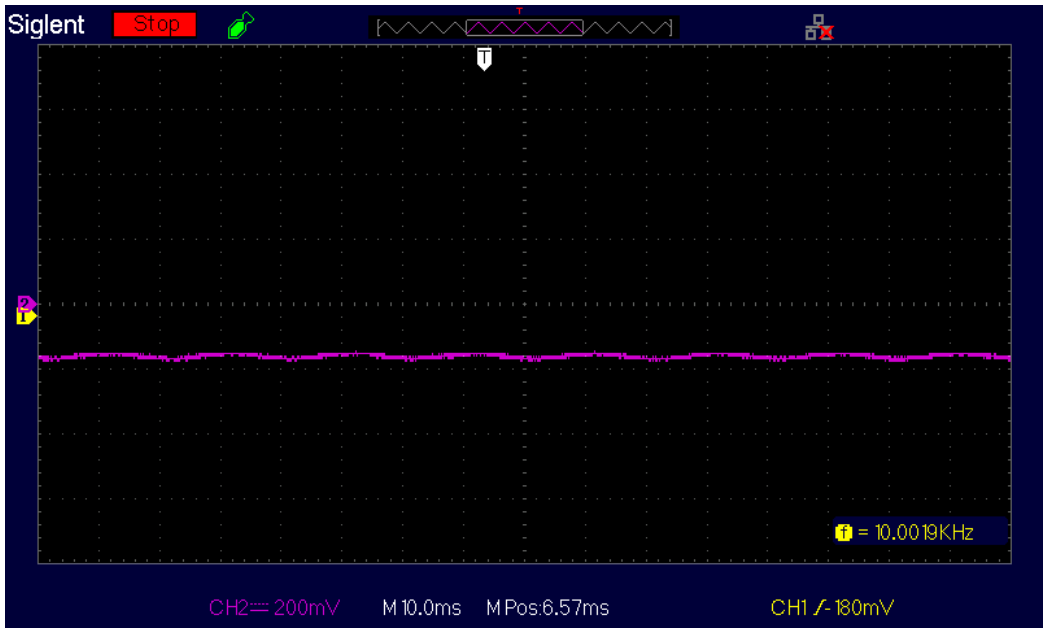


Experimental Results

Discharging of the battery at 1.5 A

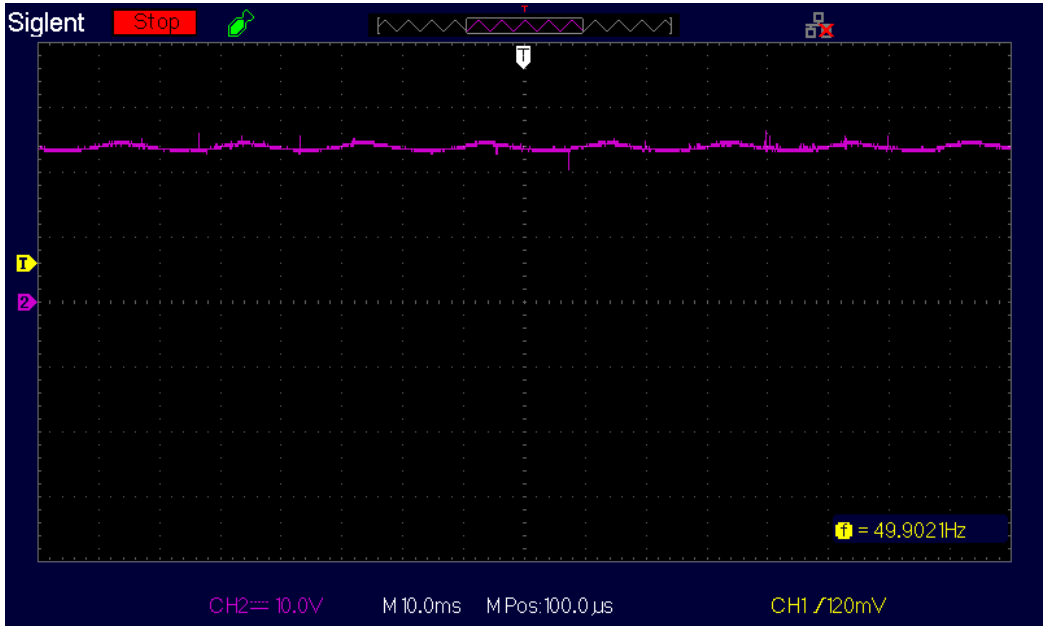


Charging of the Supercapacitor array at -1 A

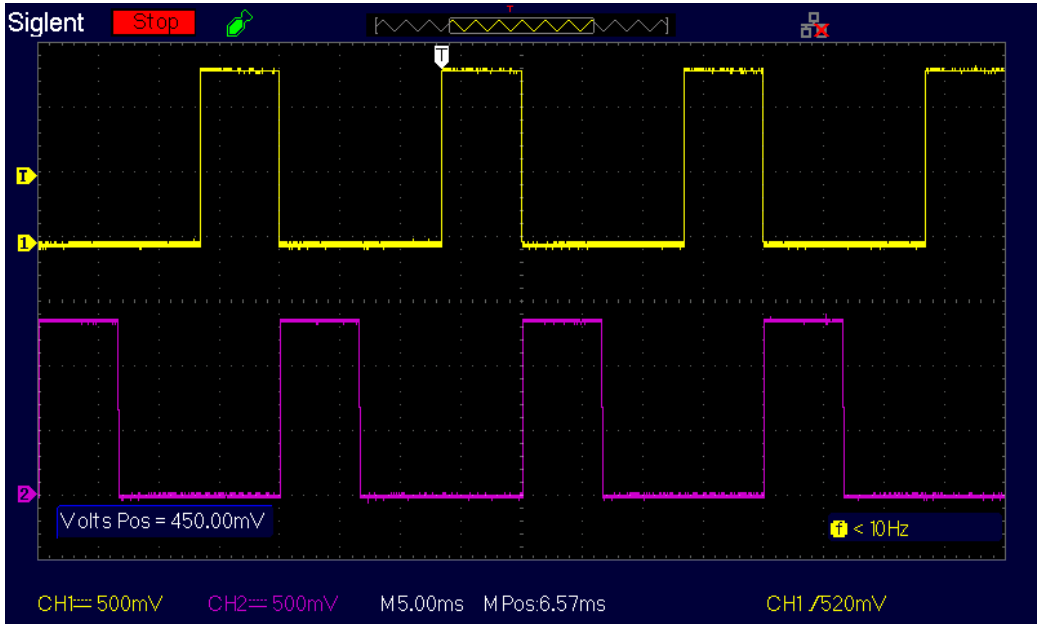


Experimental Results

DC-link voltage at 24V

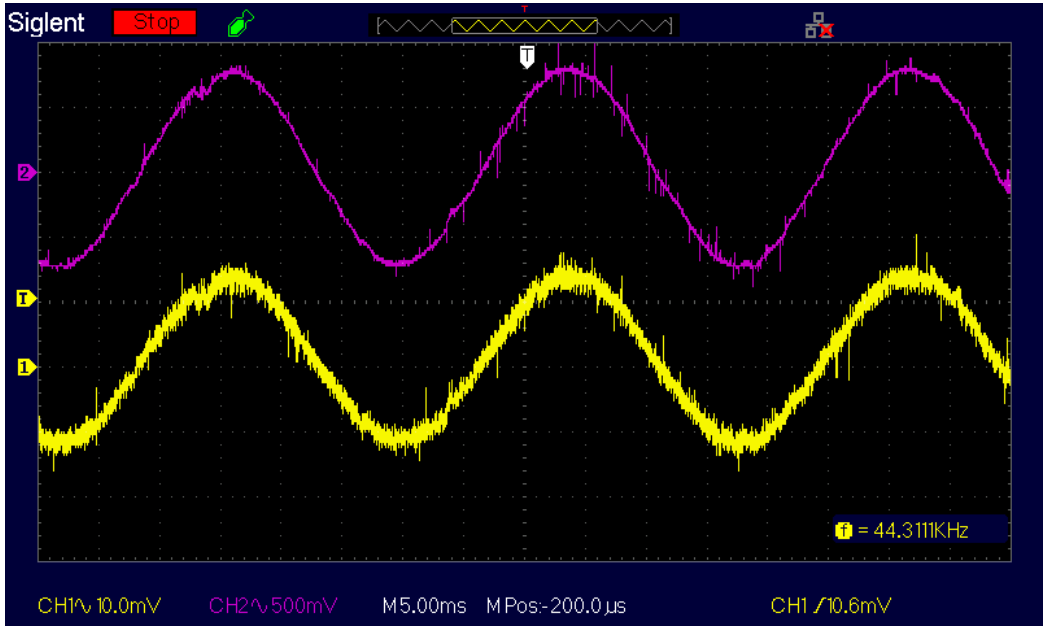


Driving pulses of S_5 and S_6

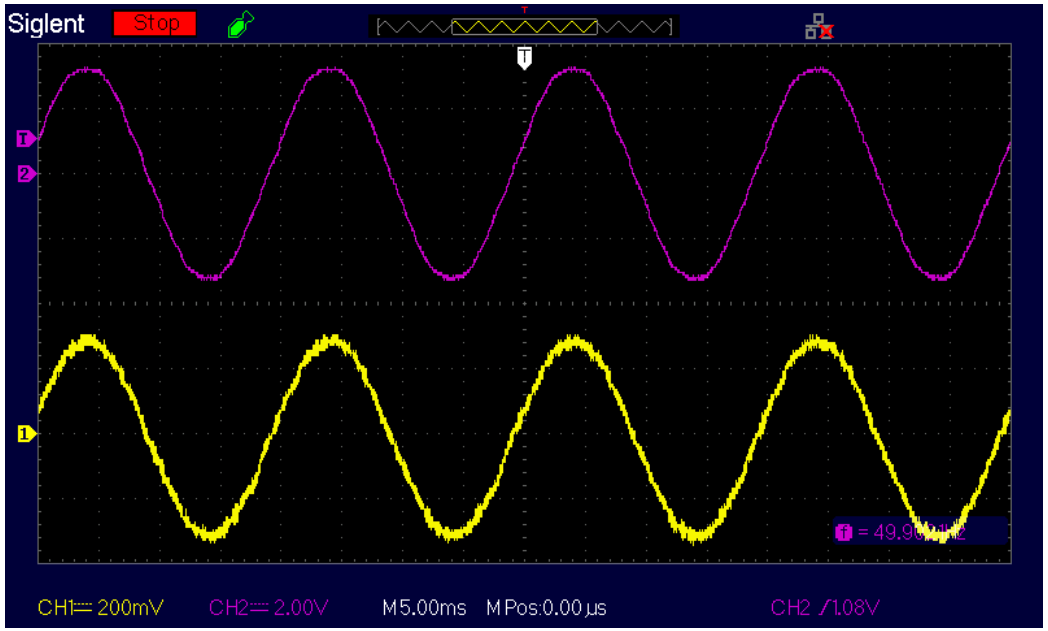


Experimental Results

Voltage V_a and Current I_a for Standalone operation



Voltage V_a and Current I_a for Grid-Connected operation



Conclusions

A novel three-phase non-isolated DC/AC MPC has been presented in this paper.

- It is able to interconnect a PV array and hybrid energy storage system comprising of a battery, supercapacitor and electric vehicle, with an AC load or the electric grid.
- It uses fewer passive components and active switches reducing the overall cost and the total power losses.
- It allows simultaneous power regulation among the four separate DC sources as well as exchange power with the electric grid.
- The three power switches connecting the EV battery bank to the inverter bridge can operate at the electric grid frequency, minimizing the switching power losses.
- The experimental results confirmed the successful operation of the proposed MPC inverter topology under various operating conditions.

Acknowledgement

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Thank you for your attention!