



PLECS

DEMO MODEL

Multi-Phase Current Source Inverter

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1 Overview

This model features a multi-phase current source inverter (CSI). The CSI is an inverter circuit which creates AC current and voltage from a DC current source. The multi-phase CSI is implemented with a configurable subsystem which showcases the 3-phase, 4-phase and 5-phase topology.

The circuit parameter is chosen with no specific reasons. The inverter is controlled in open-loop fashion. The highlight of this demo is to demonstrate the modeling of a generic modulation strategy for multi-phase CSI, proposed by the authors in [1].

Note

This model contains model initialization commands that are accessible from:

PLECS Standalone: the menu **Simulation > Simulation Parameters... > Initializations**

PLECS Blockset: right click in the **Simulink model window > Model Properties > Callbacks > InitFcn***

2 Model

The top-level schematics of the demo model is shown in Fig. 1. It consists of a “Modulator” subsystem and a “CSI” subsystem. PWM signals are connected between the two subsystems to form an open-loop control.

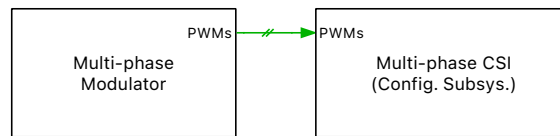


Fig. 1: The figure caption of the main schematic

Since the invention of the MOSFET, voltage source inverters (VSIs) have been far more widely used in various applications compared to CSIs. As a result, advancements in modulation and control techniques in power electronics have primarily focused on VSIs. One of the most well-known modulation techniques is Space Vector Modulation (SVM), introduced for three-phase VSIs.

VSIs used Pulse Width Modulation (PWM) on a per-phase basis, whereas CSIs do not operate on a per-phase basis; instead, the switches connected to the upper (positive) rail are treated as a unified entity, as the DC link current flow must always be maintained. Similarly, switches near the lower (negative) rail are also considered as a single entity.

2.1 Plant

The plant subsystem is a configurable subsystem which has 3 configurations: 3-phase, 4-phase and 5-phase CSI topology. It can be viewed by right-clicking on the **“Multi-phase CSI” subsystem + Subsystem + Open subsystem**. The parameter n is used in the model initialization commands to choose the number of phases, hence the corresponding topology configuration. These 3 configurations are depicted in Fig. 2, Fig. 3 on p. 4 and Fig. 4 on p. 5 respectively.

The inverter is powered by a fixed DC link current source I_{dc} . The inverter consists of $2n$ unidirectional switches, implemented with upper switch S_{u1} to S_{un} with upper diodes D_{u1} to D_{un} , and lower switches S_{l1} to S_{ln} with lower diodes D_{l1} to D_{ln} .

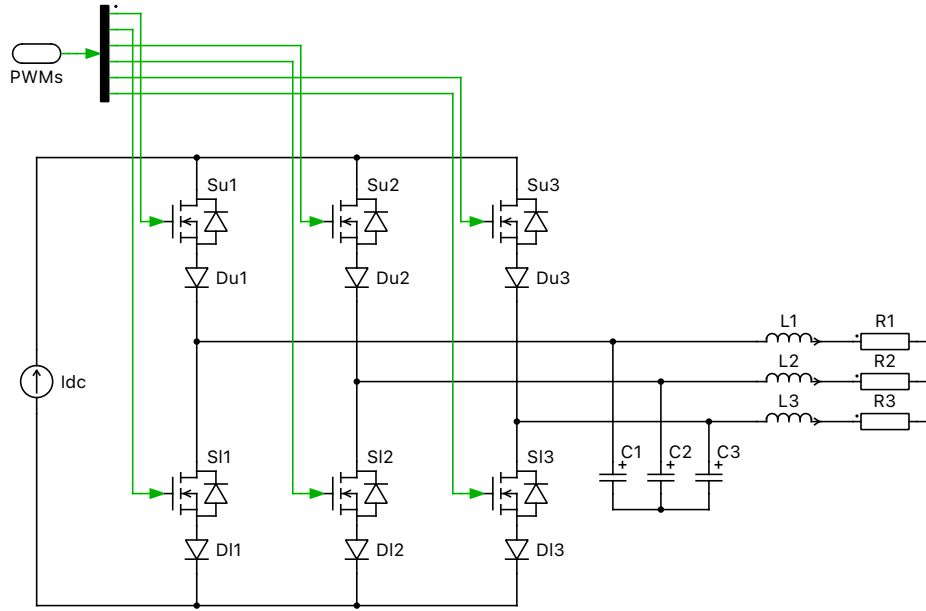


Fig. 2: 3-phase current source inverter schematic

2.2 Controller

More details about the modulator can be found in [1]. Fig. 5 on p. 5 shows the controller schematic. The PLECS schematic is built following that of Fig. 6 of [1]. A PWM method tailored specifically for CSIs without any requirements typical for SVM, such as sector identification, is used here.

The primary objective of the proposed modulation strategy in [1] is to use linear algebra to determine the average duty ratio values d_{uk} for upper cells and d_{lk} for lower cells (for $k = 1, \dots, n$). They are represented by the Signal Goto tag named “du” and “dl” respectively in the schematic presented in Fig. 5 on p. 5.

These values are then applied to the proposed multi-threshold modulator (MTM), which generates the PWM switching signals that control S_{uk} and S_{lk} , ultimately ensuring the desired average values for the inverter output currents. As an example, Fig. 6 on p. 5 shows the schematic of the upper-cell MTM for the 3-phase CSI. Note that the MTM uses the identical algorithm for the upper and lower cells. Furthermore, its pattern is easily extendable from a 3-phase up to multi-phase CSI application.

The control signals in Fig. 5 on p. 5 before the MTM subsystem are vectorized to fit the dimension of n (number of phases). The MTM is a configurable subsystem, whose configuration is selected automatically to match the definition of n in the model initialization commands.

3 Simulation

The main simulation results are depicted in Fig. 7 on p. 6, Fig. 8 on p. 6 and Fig. 9 on p. 7, respectively for the 3-phase, 4-phase and 5-phase CSI. They exhibit a good agreement with the results presented in Fig. 7 of [1].

4 Conclusion

This demo aims at showcasing a novel modulation technique for current source inverters with an arbitrary number of phases.

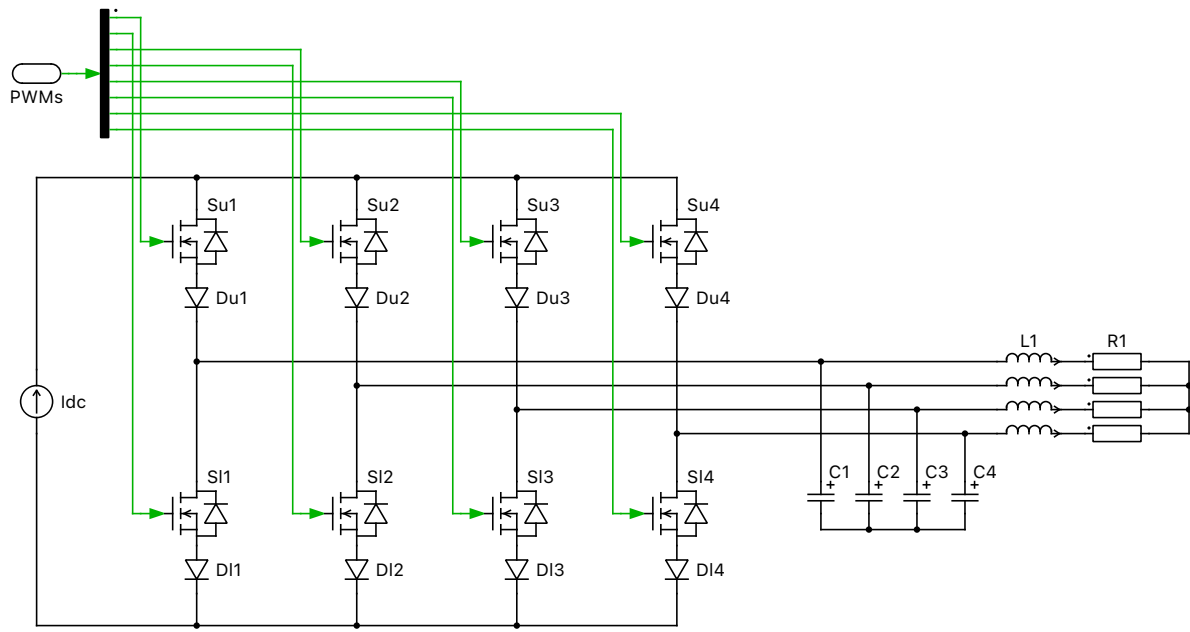


Fig. 3: 4-phase current source inverter schematic

5 Bibliography

- [1] Pejović, P., Ohno, T., Borović, U. and Mirić S., "Pulse width modulation for current source inverters with arbitrary number of phases," in *Scientific Reports* 15, 8744 (2025). Available: <https://doi.org/10.1038/s41598-025-92388-9>. [Accessed: Aug. 28, 2025].

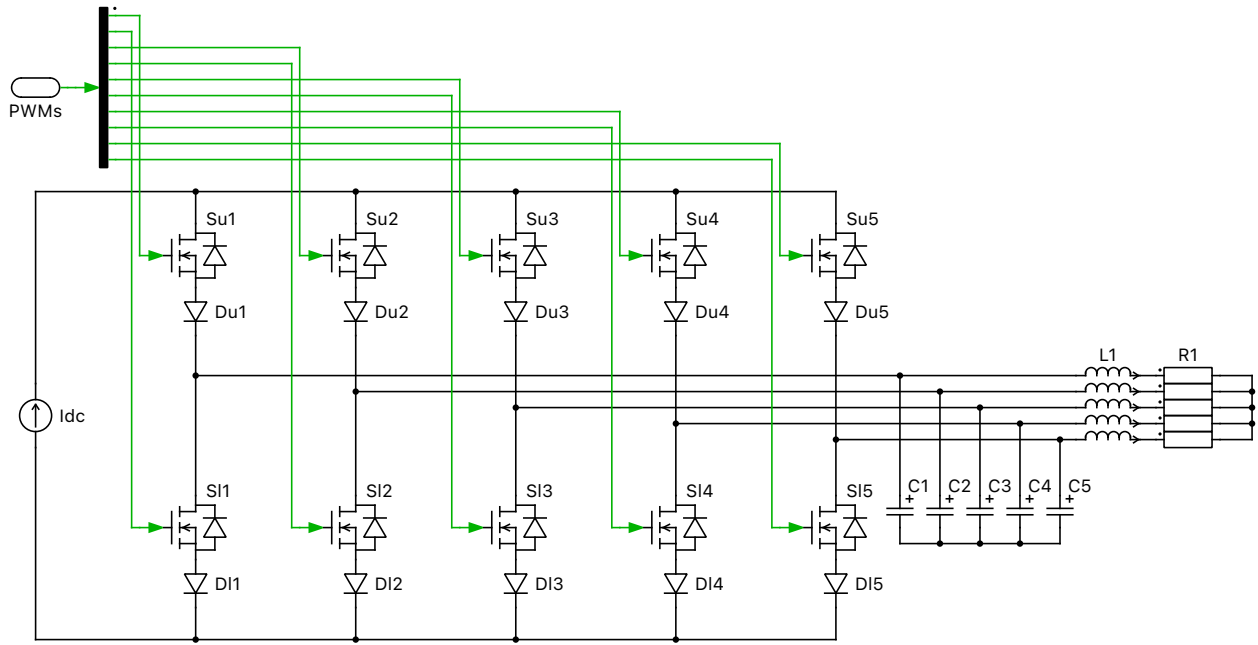


Fig. 4: 5-phase current source inverter schematic

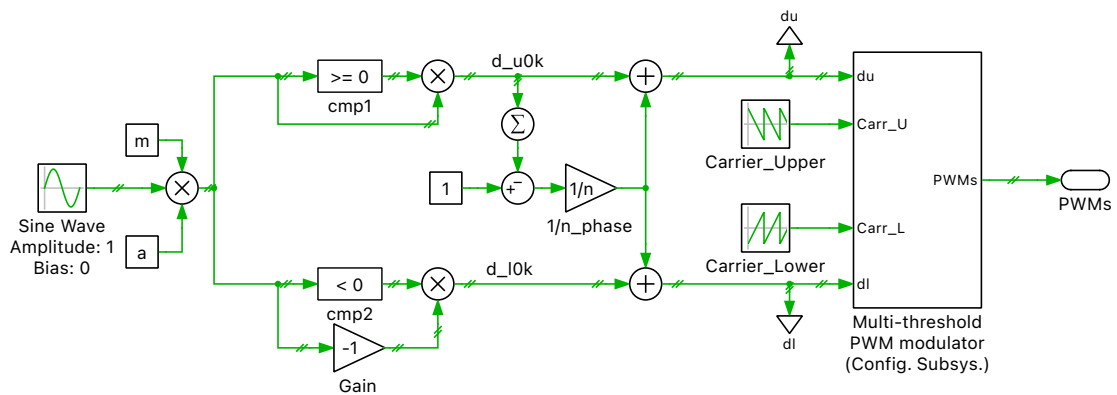


Fig. 5: Control schematic of the multi-phase CSI

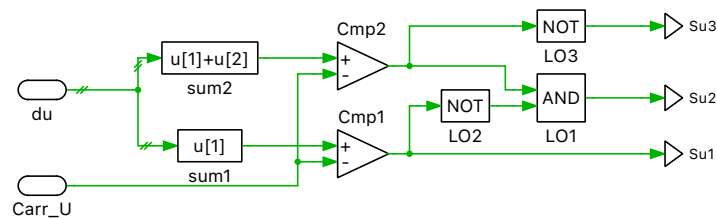


Fig. 6: Schematic of the upper-cell multi-threshold modulator in the 3-phase CSI

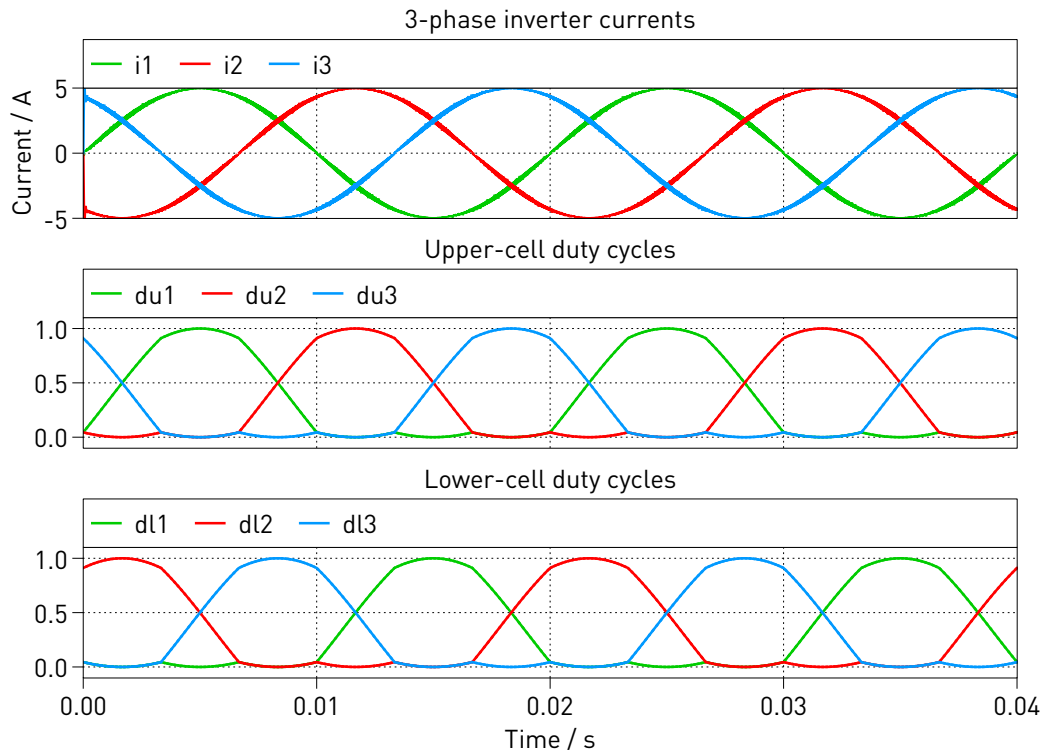


Fig. 7: Simulation results for the 3-phase CSI

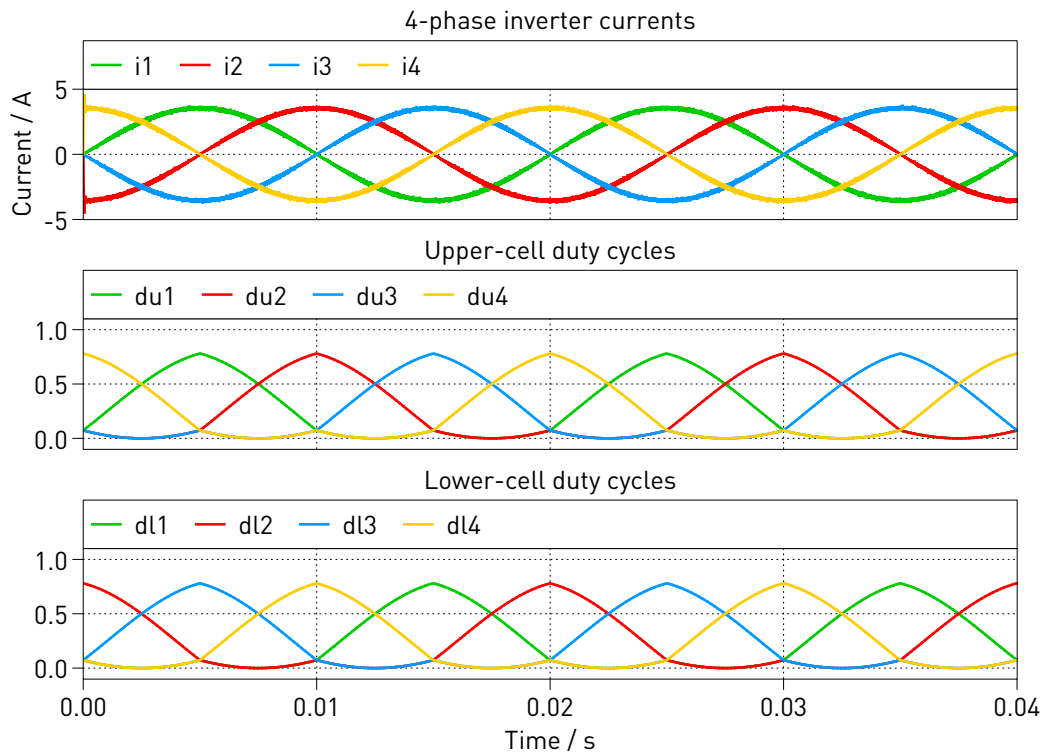


Fig. 8: Simulation results for the 4-phase CSI

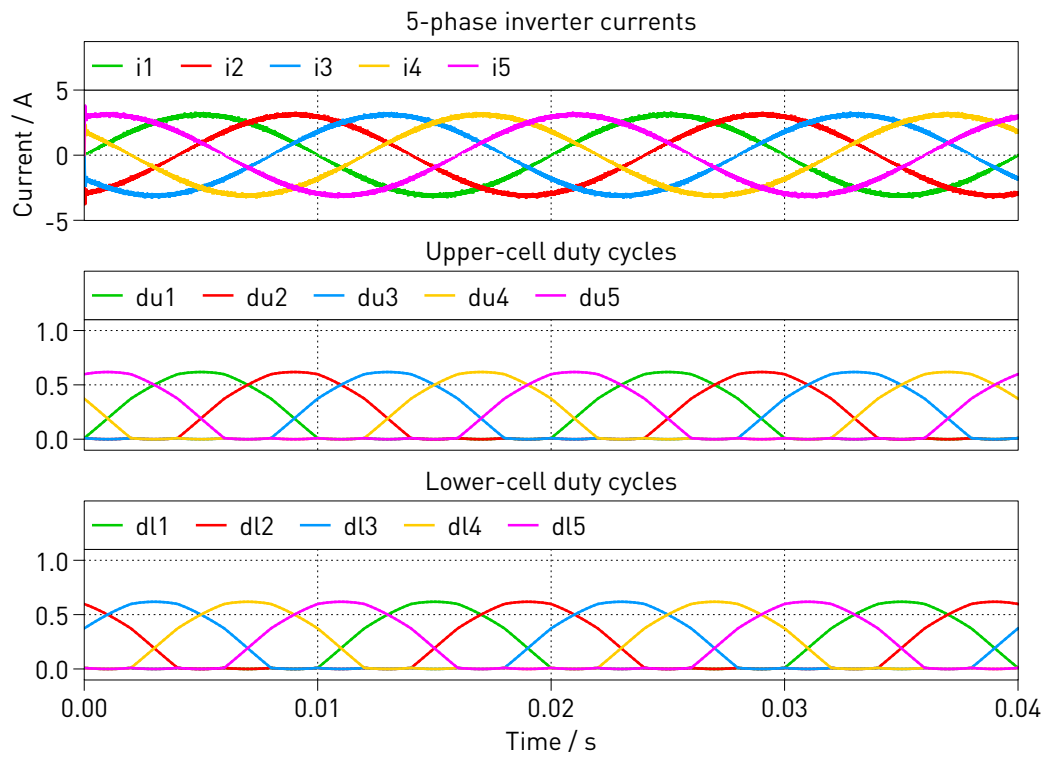


Fig. 9: Simulation results for the 5-phase CSI

Revision History:

PLECS 5.0.1 First release

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