

A Zero-Vector-Based DC Chopper Control Strategy for Current Source Converter Wind Turbines to Enhance LVRT Capability

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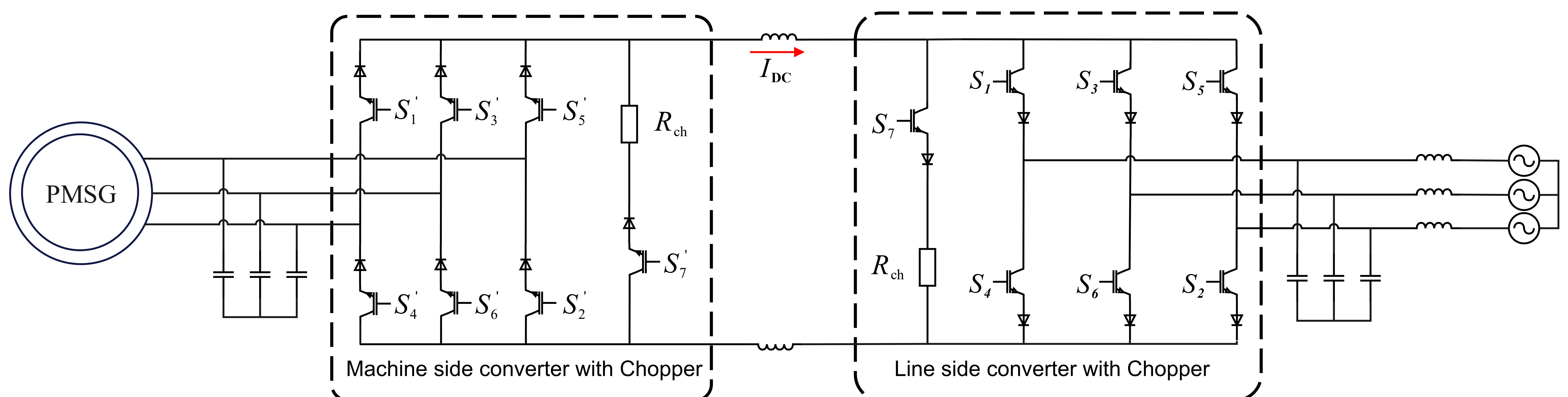
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This paper was made within the framework of the research project “GridConWilG” (03EE2040)

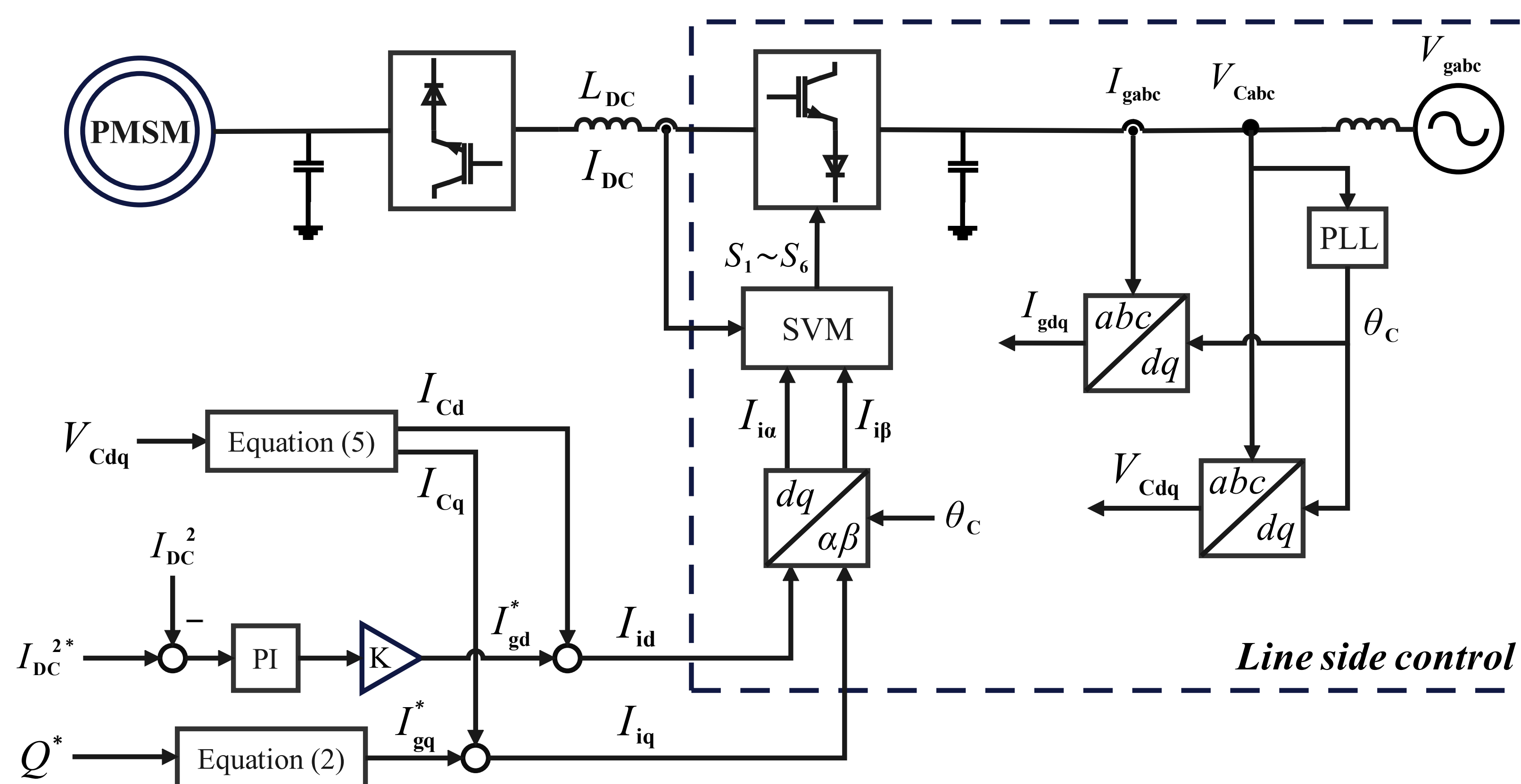
Introduction

- Introduces a DC chopper integrated into a back-to-back current source converter (CSC) for PMSG-based wind turbines.
- Proposes a zero-vector-based chopper control strategy for low-voltage ride-through (LVRT).
- Compares the system dynamic performance under LVRT between the proposed control strategy and conventional hysteresis control.



System Control

Line side converter control



LSC control structure

- CSC control is based on VOC using a PLL.
- DC-link current is regulated by balancing the power between the MSC and LSC.
- Reactive power is controlled by reactive current I_q .
- Filter current compensation is considered for current modulation.

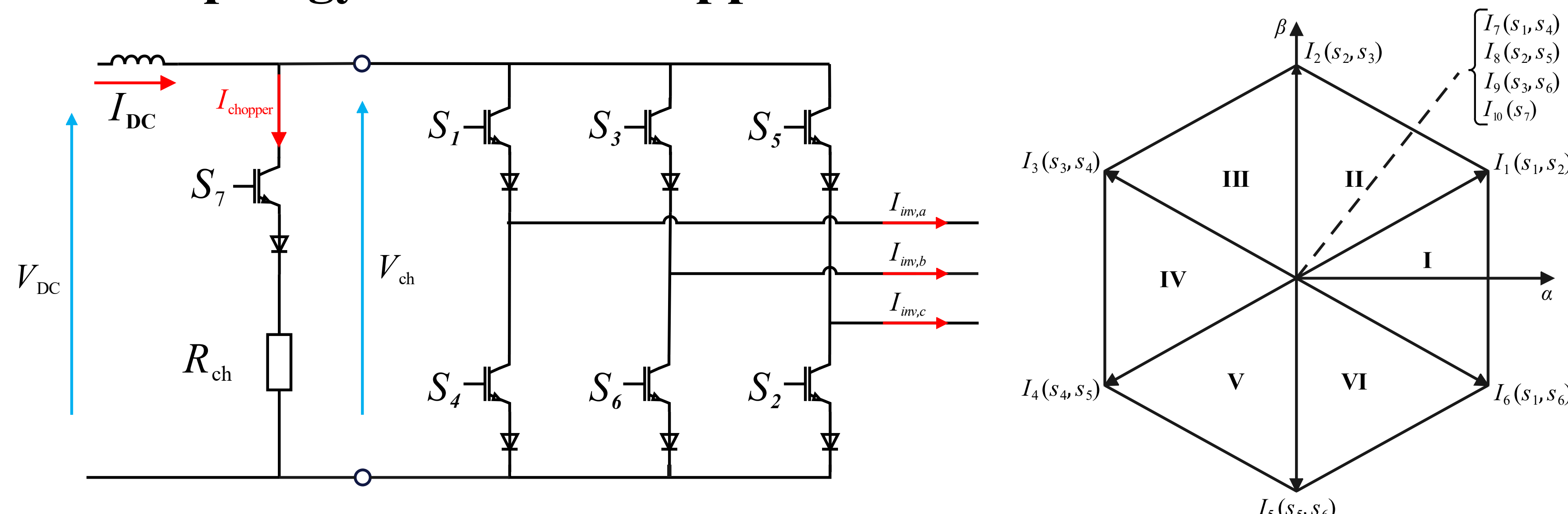
Equation (2):

$$I_{gq} = \frac{-2Q}{3V_{cd}}$$

Equation (5):

$$\begin{aligned} I_{cd} &= -\omega_g C V_{cq} \\ I_{cq} &= \omega_g C V_{cd} \end{aligned}$$

CSC Topology with DC Chopper



Chopper OFF:

$$L_{DC} \frac{dI_{DC}(t)}{dt} = V_{DC}(t) - V_{ch}(t)$$

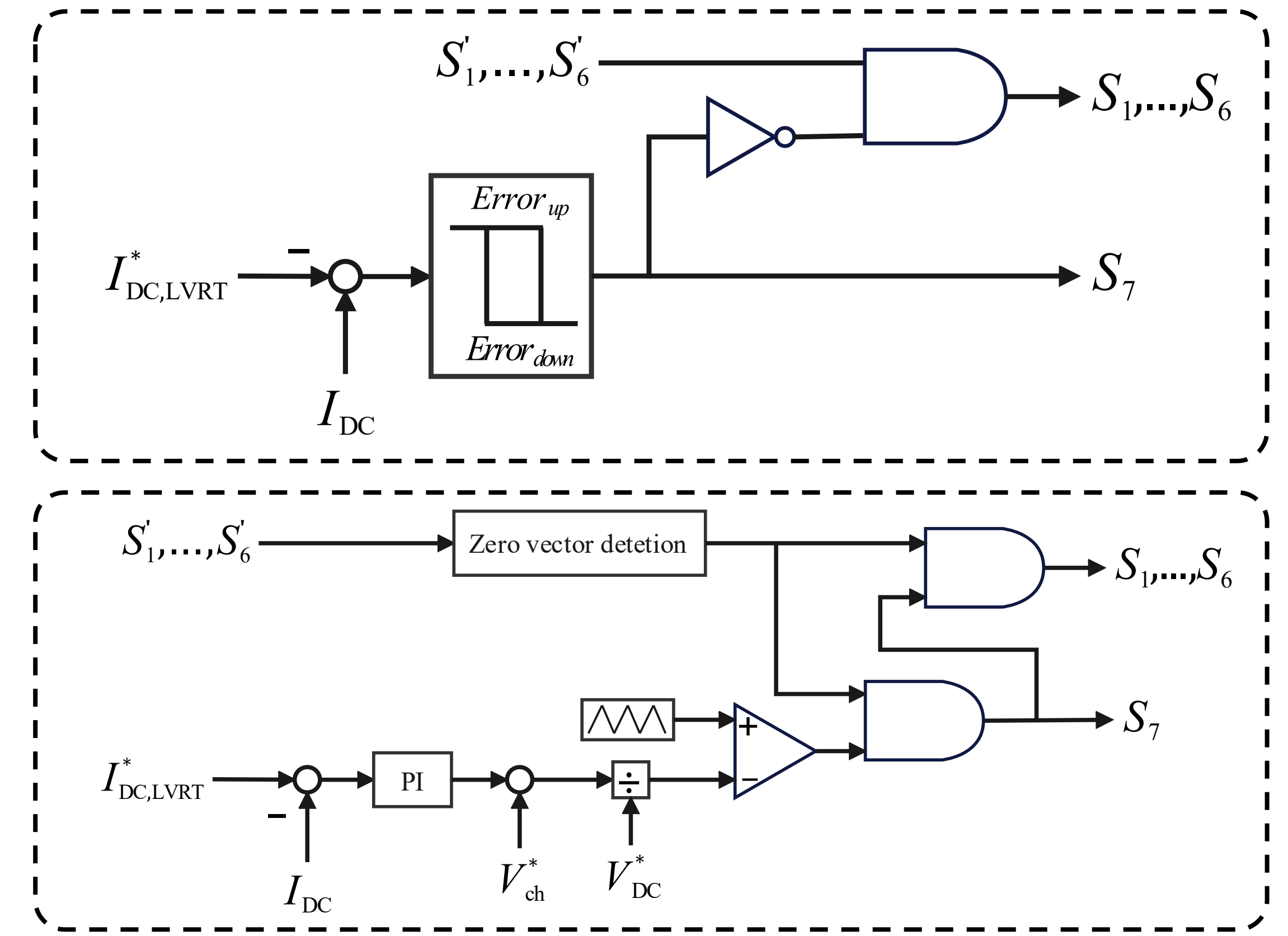
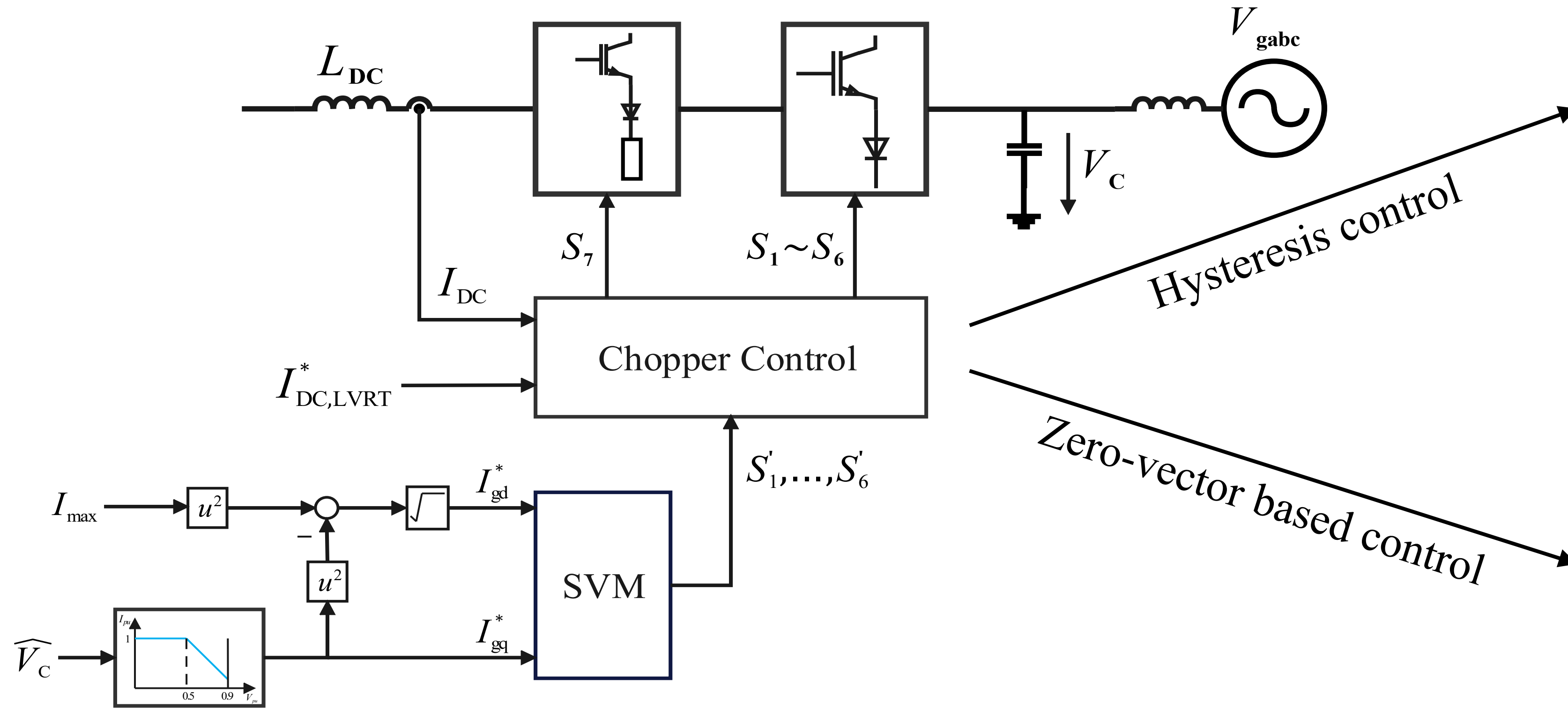
Chopper ON:

$$R_{ch} I_{DC}(t) + L_{DC} \frac{dI_{DC}(t)}{dt} = V_{DC}(t)$$

RL Plant Transfer Function:

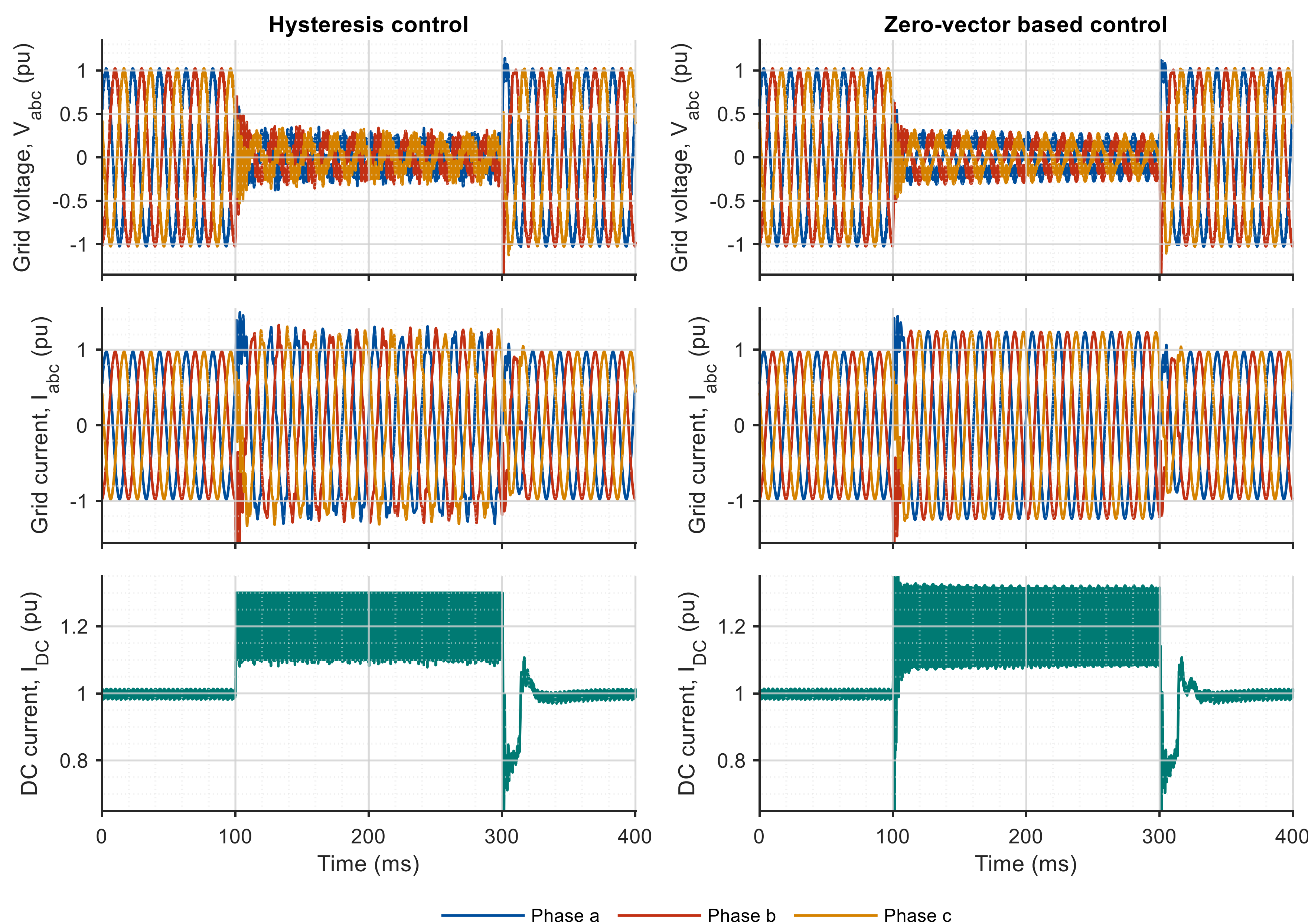
$$I_{DC}(s) = \frac{V_{DC} D_{ch}(s) - V_{ch}}{sL_{DC} + R_{ch}}$$

Line side converter control under LVRT



Results

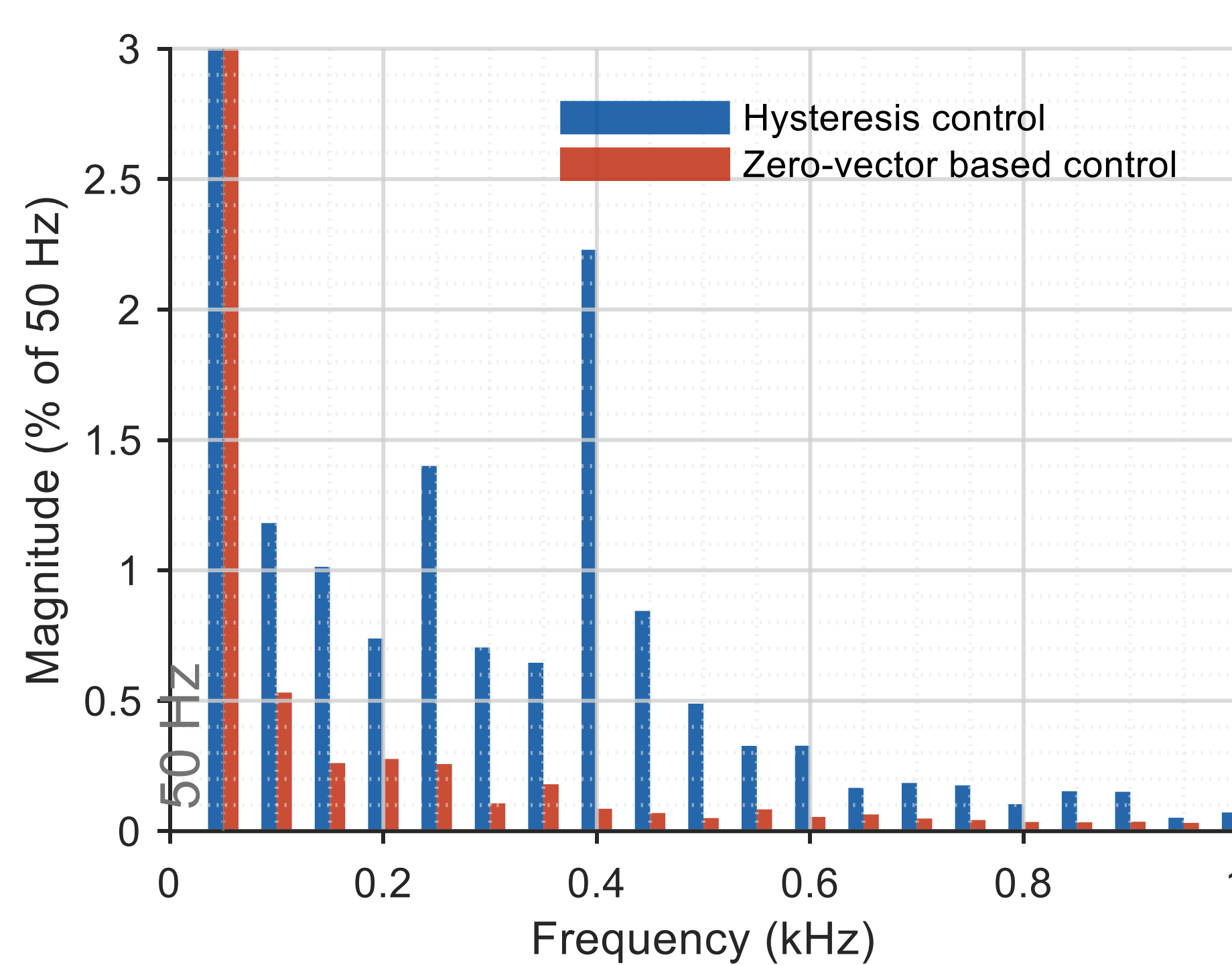
90% three phase voltage fault test for 0.2s



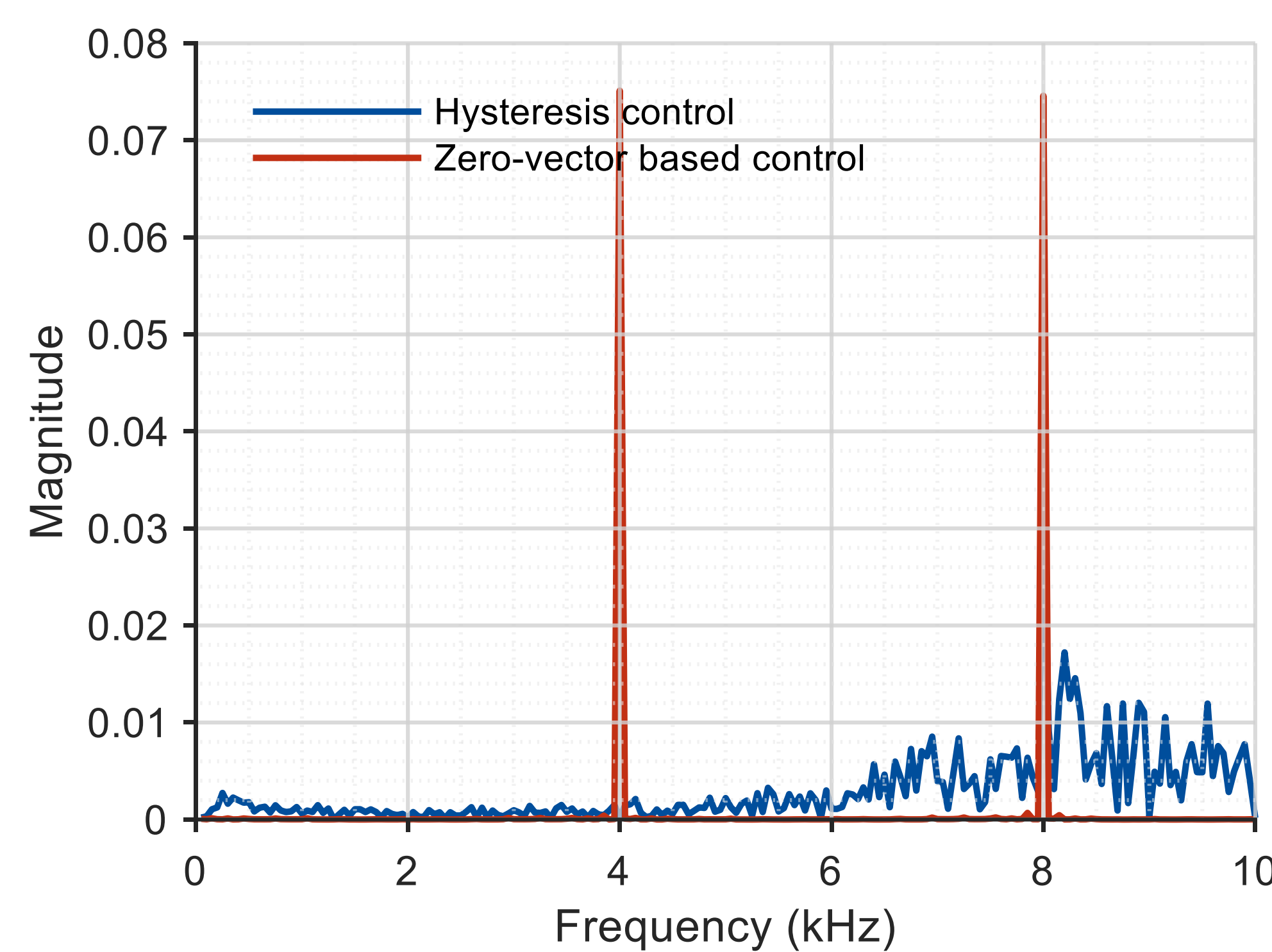
Parameters

Rated power P_n	6 MW
Grid voltage $V_{g,LL}$	690 V
Grid current I_g	5 kA
Grid frequency f_g	50 Hz
Switching frequency f_{sw}	4 kHz
Filter capacitance C_f	7.1 mF
Grid inductance L_g	25 μ H
DC link current I_{DC}	8 kA
DC Inductance L_{DC}	39 μ H
Chopper resistance R_{ch}	0.75 Ω

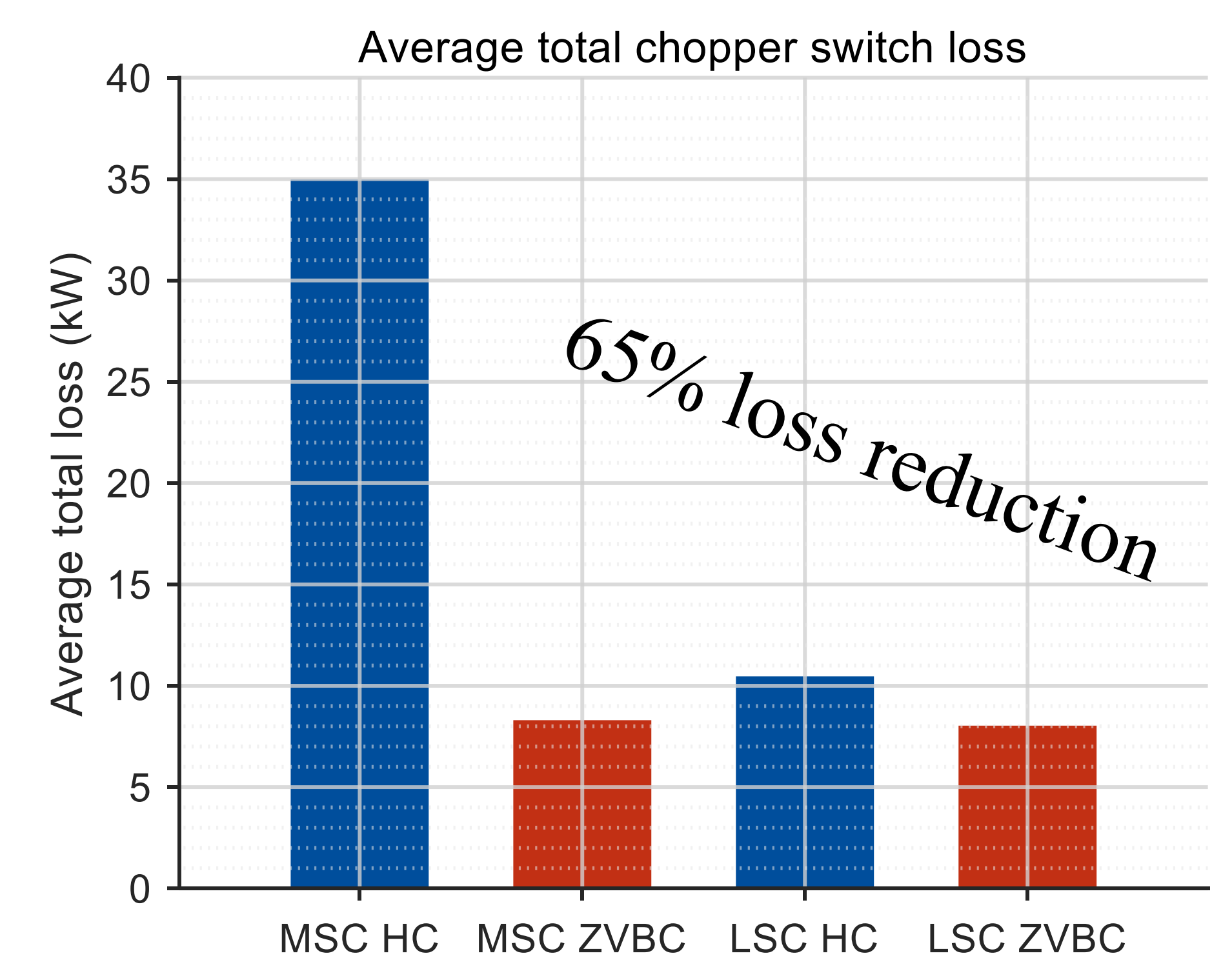
Grid Current spectrum



Chopper switching spectrum



LSC & MSC chopper switch losses



Conclusion

- The proposed control achieves better dynamic performance than conventional hysteresis control under LVRT.
- Compared with hysteresis control, switching losses are reduced by approximately 65%.
- Current harmonics during LVRT are significantly reduced.