# Overview of Post-Fault Operation Strategies for Open-End Winding Machines Considering ZSC

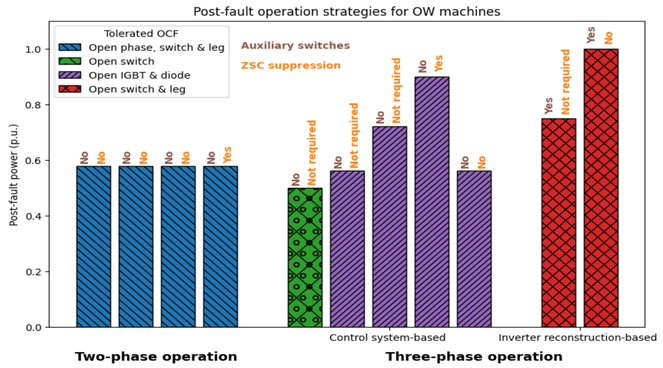

**Abd Alrahman Dawara, Annette Muetze**

**Electric Drives and Machines Institute, Graz University of Technology**

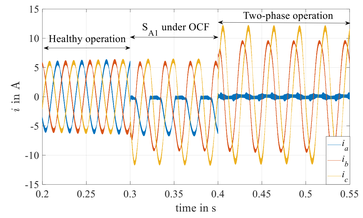

## Introduction

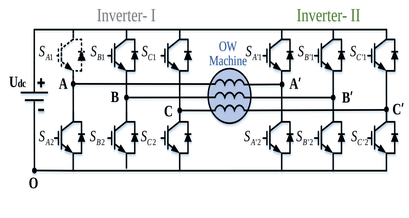
- With the increase of motor drive system dependability requirements, the post-fault operation capabilities offered by open-end winding (OW) machines have seen growing interest.
- This paper discusses the existing post-fault operation strategies for different configurations of the OW machine topology, specifically their advantages and disadvantages, as well as post-fault output power, and tolerated faults.
- Notably, the zero-sequence current (ZSC) associated with the topologies is discussed, as it may introduce harmful side-effects into the operation.

## Methods




- **Two-phase operation mode**: in the dual inverter scheme with a common dc-link, when an open phase fault (OCF) occurs:
  - Two-phase post-fault operation mode can be automatically realized.
  - Without adding additional hardware components as compared to the standard star/delta-connected machine.
  - The remaining two-phase currents should be increased by a factor of 1.73.

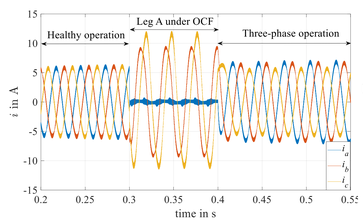


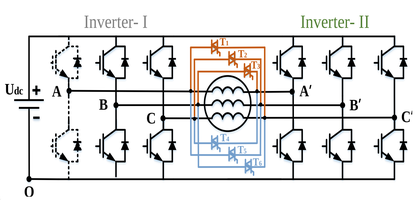




- **Three-phase operation mode**: strategies can be divided into two categories: control system-based and inverter reconstruction-based methods.

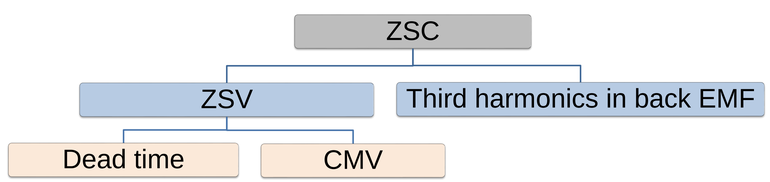
a. Control system-based methods:
  - Three-phase operation mode can be achieved by modifying the control system.
  - Without changing the construction of the inverter.
  - Without adding additional hardware components.
  - The same output power as a healthy three-phase operation remains unachievable.

b. Inverter reconstruction-based methods:
  - Three-phase operation mode can be achieved while maintaining the output power capability.
  - Post-fault operation is achieved by reconstructing the dual inverter configuration.
  - Auxiliary switches are required.



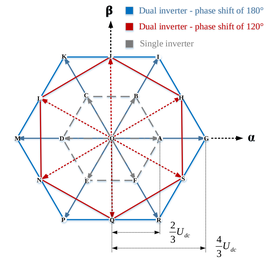




## ZSC associated with OW machines

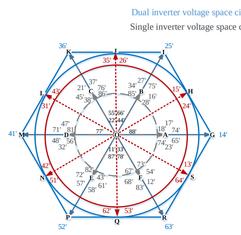



## CMV

Voltage vectors of the dual inverter topology



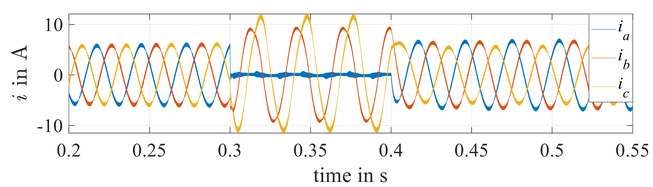

Switching combinations

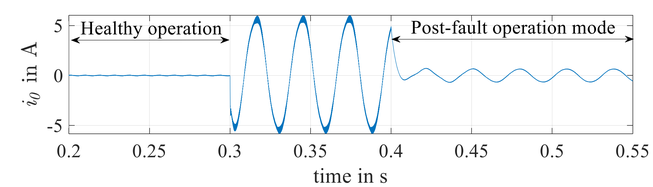



- Only seven voltage vectors among the 19 available voltage vectors do not generate CMV in the stator windings.
- These seven voltage vectors form the red hexagon.
- ZSC caused by modulation techniques can be suppressed by using only hexagon HJLNQS.

## Dead time effect

- During post-fault operation mode, dead time may lead to a large ZSC.
- Which causes serious torque ripple.
- The dominant harmonic of ZSC is the fundamental one, leading to unbalanced three-phase currents.




Contact info

SCIENCE ▪ PASSION ▪ TECHNOLOGY