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# Three Phase Multi-Level Inverter Topologies and Modulation Techniques

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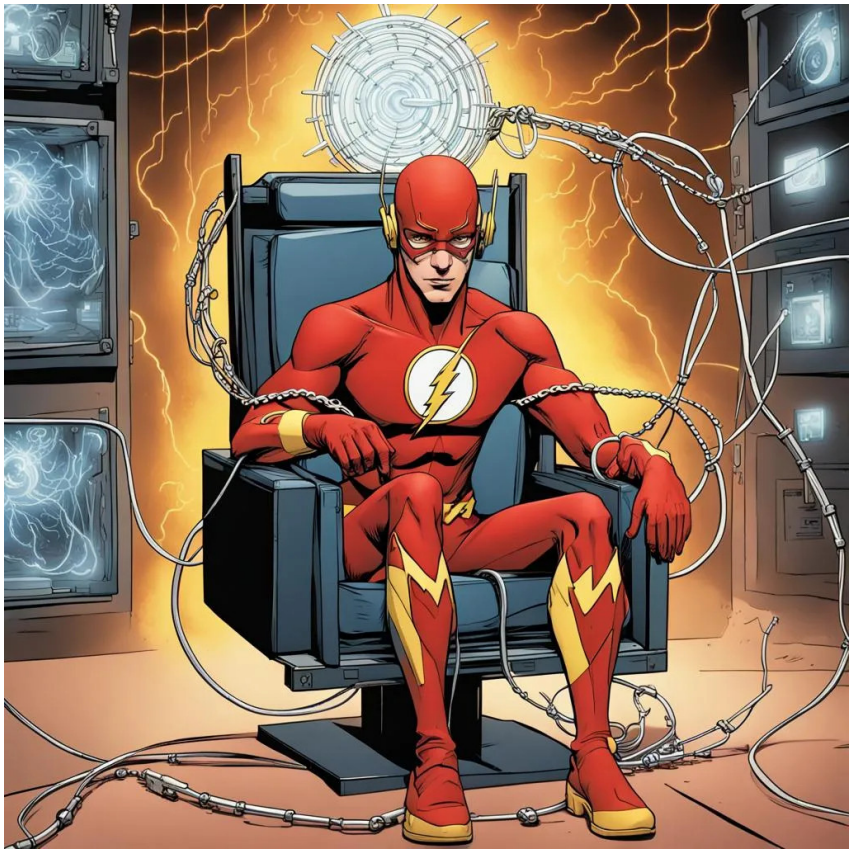


# Abstract


- To mention the vital role of power electronic converter in the power production domain
- The paper reveiews methodologies to control **three-phase multi-level Inverter** by PWD control techniques
- Proposal **three-phase multi-level Inverter topologies** and **Modulation Techniques**
- comparison among PWM control techniques **phase disposition (PD)**, **phase opposite disposition (POD)**, and **alternate phase opposite disposition (APOD)**
- Analysing **THD** and **common mode** between methodologies

# Reference Papers


- Anup Kumar Panda and Yellasiri Suresh, “Research on cascaded multilevel inverter with single DC source by using three-phase transformers,” Electrical Power and Energy Systems. no 40, pp. 9–20, 2012.
- Bendre A, Krstic S, Meer JV and Venkataramanan G., “Comparative evaluation of modulation algorithms for neutral point clamped converters,” IEEE Trans Ind Appl 2005;41:634–43.
- Colak I, Kabalci E and Bayindir R., “Review of multilevel voltage source inverter topologies and control schemes,” Energy Convers Manag 2011; 52:1114–28.
- Anup Kumar Panda.: Yellasiri Suresh.: Research on cascaded multilevel inverter with single DC source by using three-phase transformers. Electrical Power and Energy Systems. no 40, pp. 9–20, 2012.
- Suresh.Y., Panda A.K.: Research on a cascaded multilevel inverter by employing three-phase transformers. IET Power Electron., Vol. 5, no. 5, pp. 561–570, 2012
- R. Gonzalez, E. Gubia, J. Lopez, and L. Marroyo, “Transformer less single phase multilevel-based photovoltaic inverter,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2694–2702, Jul. 2008

# Review Objective

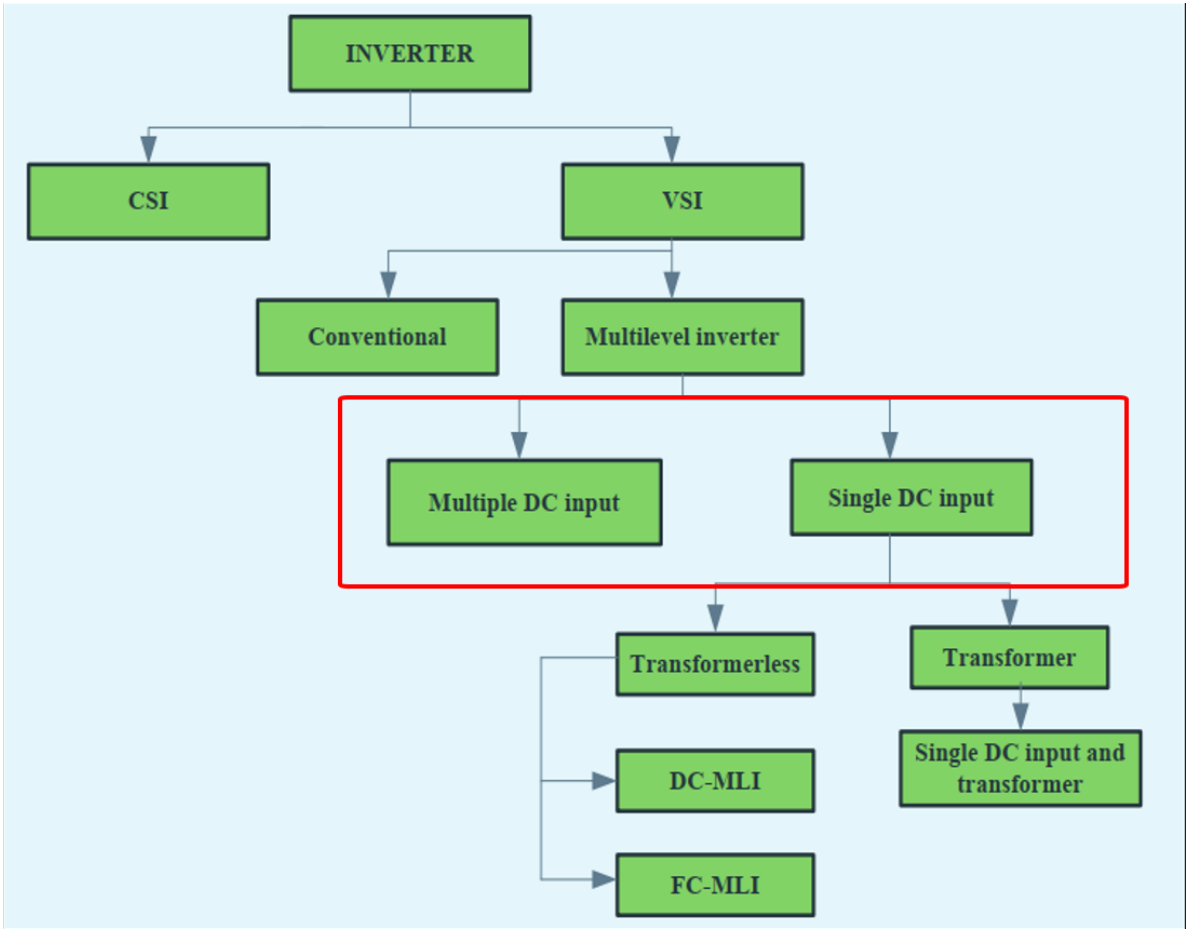
- Three-Phase multi-level Inverter
  - Diode clamped Inverter
  - Flyting capacitor Inverter
  - Cascaded H-Bridge Inverter
- Single DC source with single phase transformer H-Bridge (topology 1)
- Single DC source with single phase transformer H-Bridge (topology 2)
- Modulation techniques
  - phase disposition (PD)
  - phase opposite disposition (POD)
  - alternate phase opposite disposition (APOD)

# Introduction

- The paper sets the target that can propose the topologies Inverter aim reduce cost, size, and weight
  - Reducing the number of active switches
  - Decreasing source components such as DC source
  - Esailer to control

- finding a solution to design three phase Inverter using signle DC source
  - Topology designs used to enhance the output voltage without increasing the number of levels
  - Having ablility to adapt for utility applications

# Introduction about three-Phase Inverter



# Introduction about three-Phase Inverter

- The three-phase converter include voltage source Inverter (VSI) and current source Inverter (CSI)
- voltage source Inverter (VSI)
  - fundamental three-phase Inverter with 2 level
  - multi-level three-phase Inverter (3, 5, or 7 level)

# Three-Phase multi-level Inverter with Diode clamped Inverter

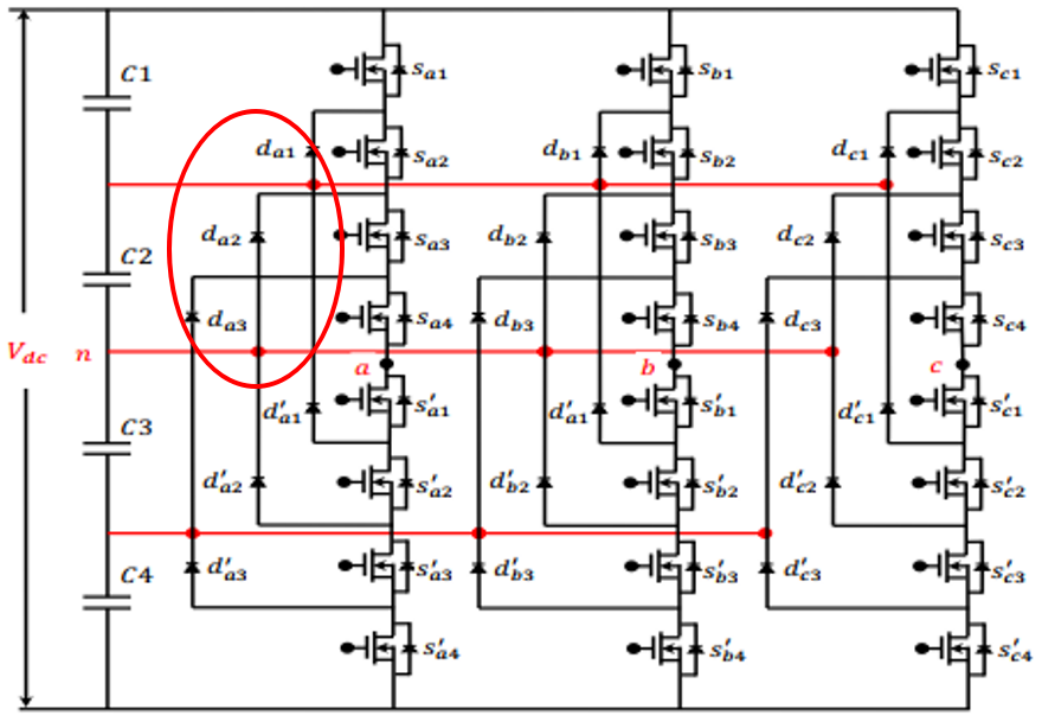



Fig. 2. Diode clamped inverter

# Three-Phase multi-level Inverter with Diode clamped Inverter

- three phase multi-level 5 steps using diode clamped Inverter
- Using single source DC and containing DC bus voltage with 4 capacitor C1, C2, C3, and C4
- Each capacitor have one supply voltage and single capacitor voltage is limited by the voltage stress from switches
- using cascaded diodes to connect from switches S' to S

# Three-Phase multi-level Inverter with Flyting capacitor Inverter

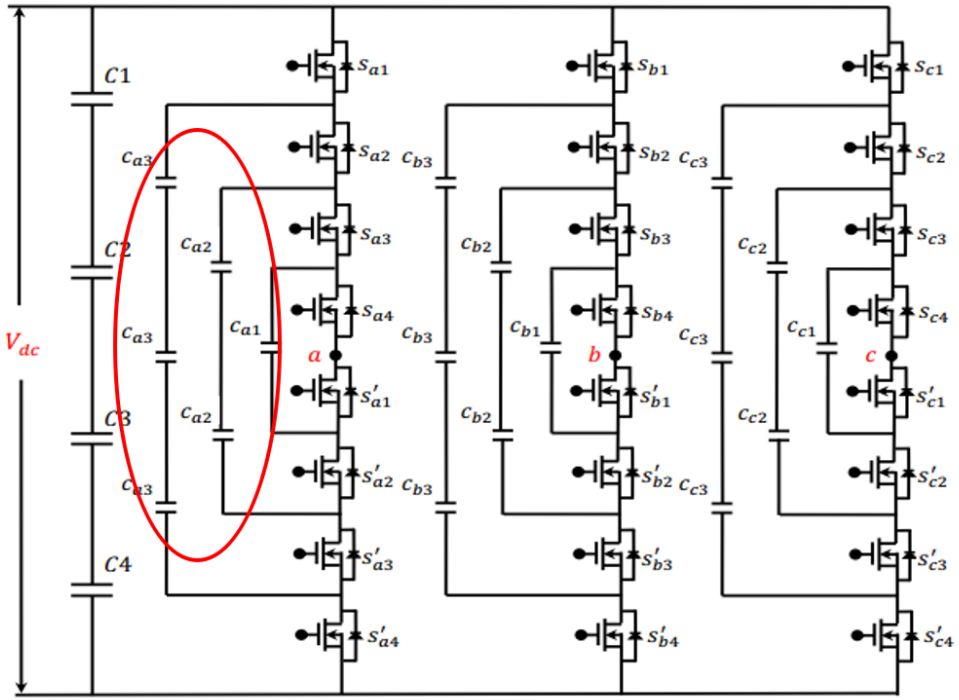



Fig. 3. Flying capacitor inverter

# Three-Phase multi-level Inverter with Flyting capacitor Inverter

- three phase multi-level 5 steps using Flyting capacitor Inverter
- Using single source DC and containing DC bus voltage with 4 capacitor C1, C2, C3, and C4
- Each capacitor have one supply voltage and single capacitor voltage is limited by the voltage stress from switches
- using cascaded capacitor to connect from switches S' to S

# Multiple DC sources with H-Bridge Inverter

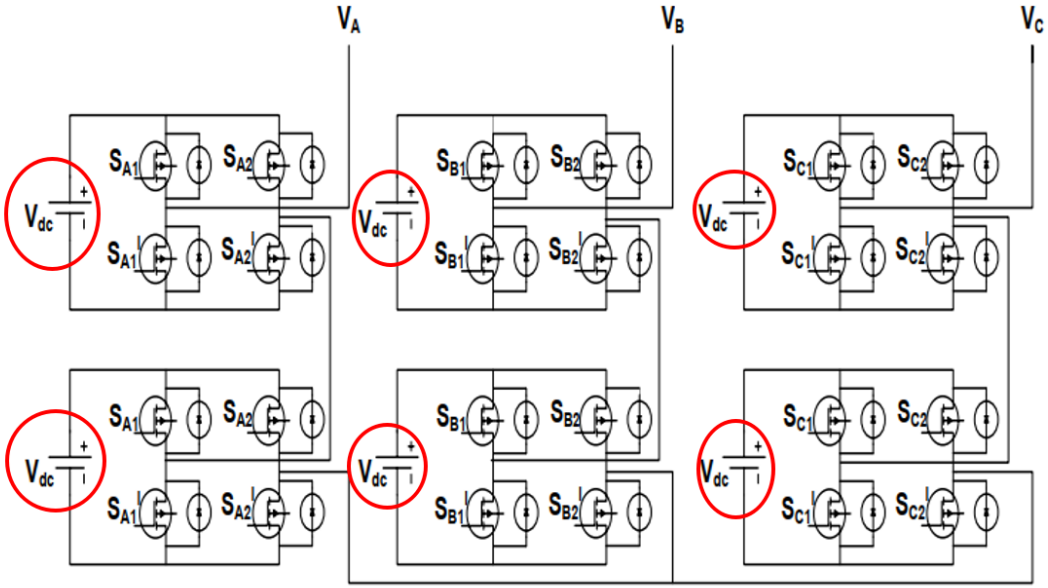



Fig. 4. Cascaded H-Bridge Inverter

# Multiple DC sources with H-Bridge Inverter

- Using Multiple DC source for each full-Bridge Inverters
- containing 6 full-Bridge Inverters that divide to three level
- The cascaded level 1, 2, and 3 corresponding with phase A, B, and C respectively
- The drawback of Multi-DC source H-Bridge Inverter is using a lot of DC source

# Single DC source with single phase transformer H-Bridge (topology 1)

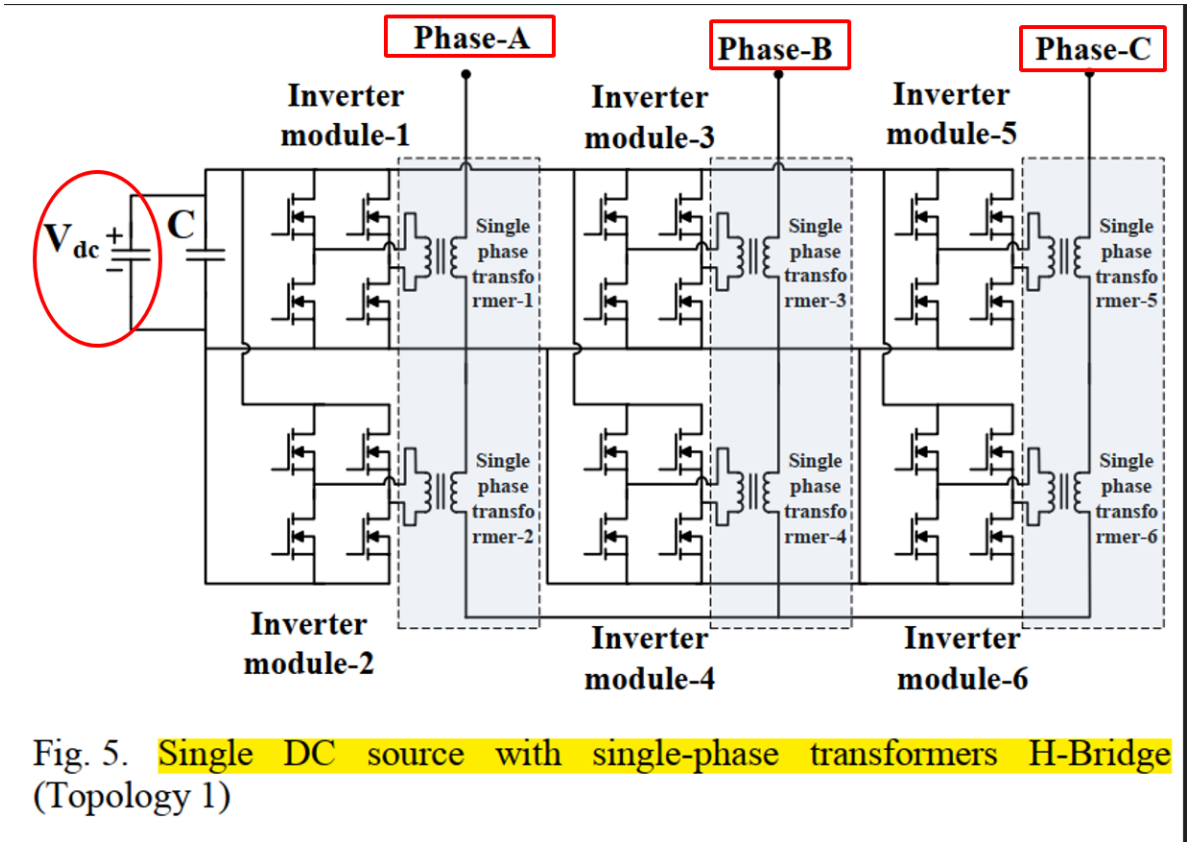



Fig. 5. Single DC source with single-phase transformers H-Bridge (Topology 1)

# Single DC source with single phase transformer H-Bridge (topology 1)

- Using only one DC source for a System
- transformers are imported between levels to gain amplification of output signal
- The cascaded level 1, 2, and 3 corresponding with phase A, B, and C respectively
- the benefit of this System is using only a single DC source

# Single DC source with single phase transformer H-Bridge (topology 2)

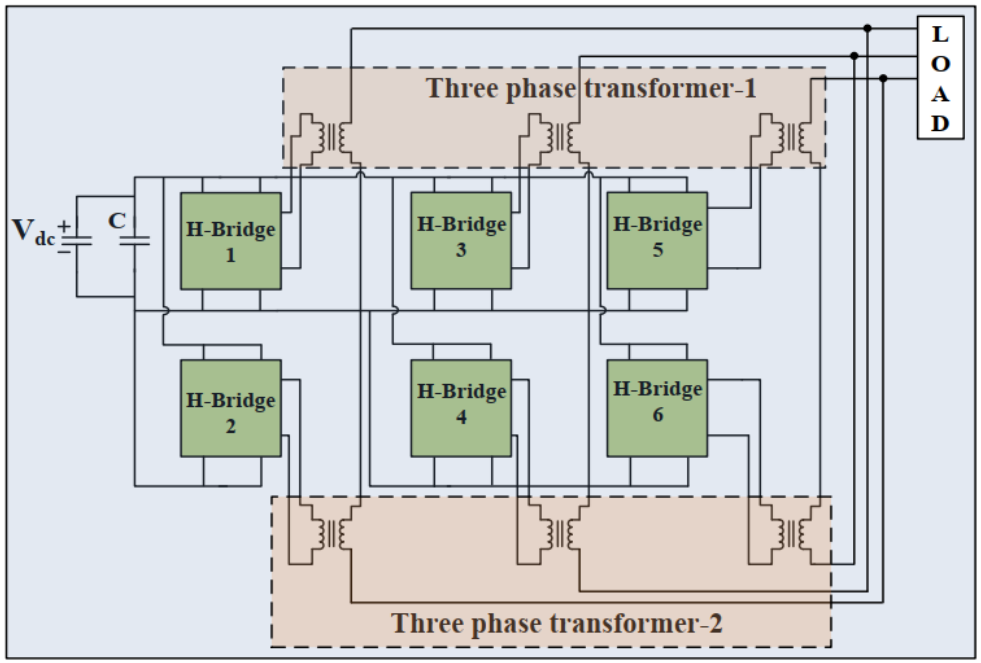



Fig. 6. Single DC source with three-phase transformer H-Bridge (Topology 2)

# Single DC source with single phase transformer H-Bridge (topology 2)

- Using only one DC source for a System
- transformers are imported between levels to gain amplification of output signal
- The cascaded level 1, 2, and 3 corresponding with phase A, B, and C respectively
- Three phase transformer 2 (below) is connected directly to LOAD
- in terms of increasing voltage level by connecting the second terminal of the transformer 2 to ouput LOAD that is the advantage of topology 2 comparing with topology 1

# Modulation techniques

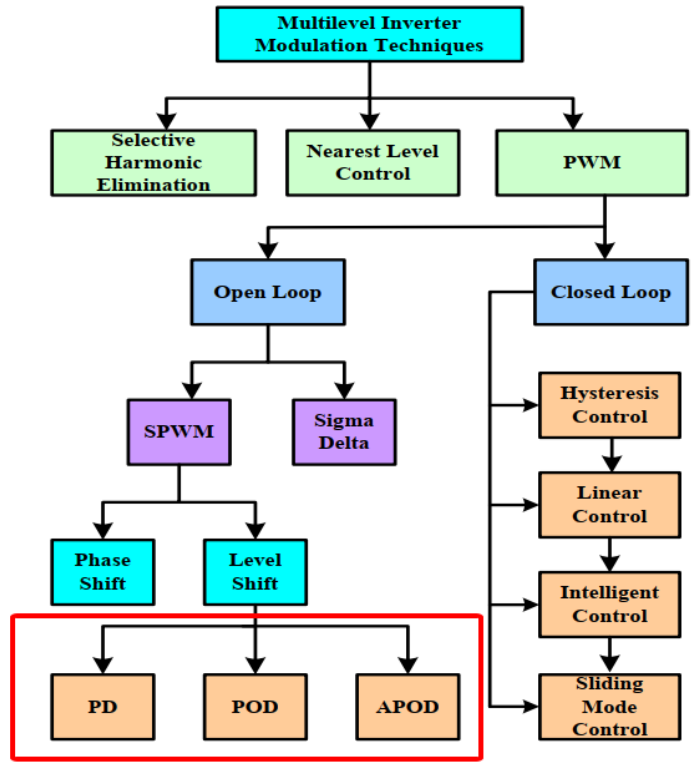
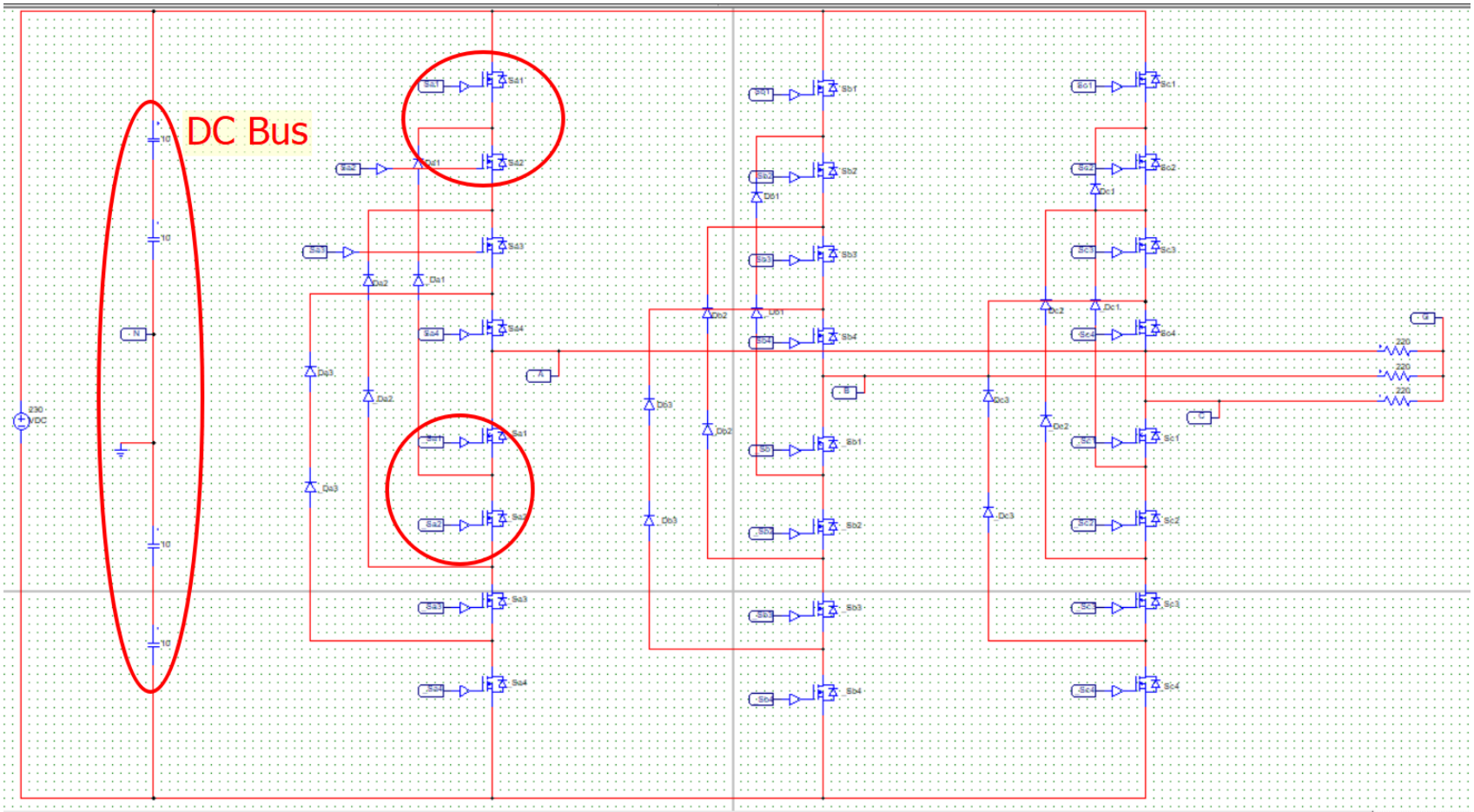



Fig. 9. PWM techniques and control methods

# Modulation techniques

- We forcus on three methods using PWD control level shift
  - **PD:** this method reduces dramatically THD of the three-phase multi-level Inverter. However, the drawback of this method increases common mode.
  - **POD and APOD:** By the Contrast, both methodologies will increase THD and reduce the common mode

# Simulation three phase 5 level with Diode clamped Inverter



# Five level three phase Inverter output voltage using APOD

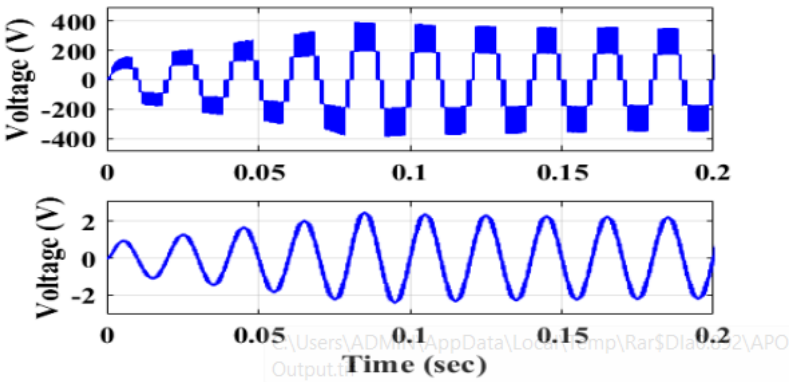



Fig. 10. Five level output voltage and current (Phase)

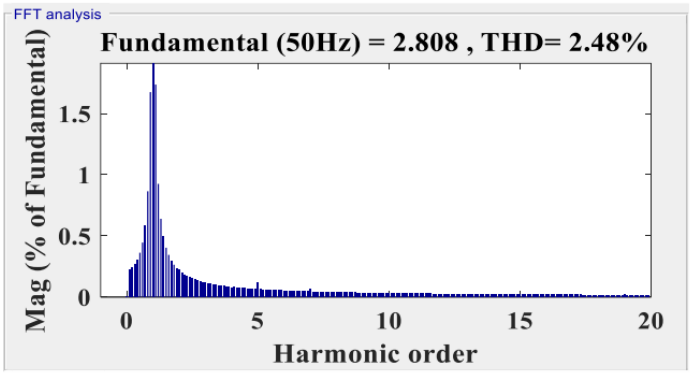



Fig. 12. THD at a modulation index of 1.0

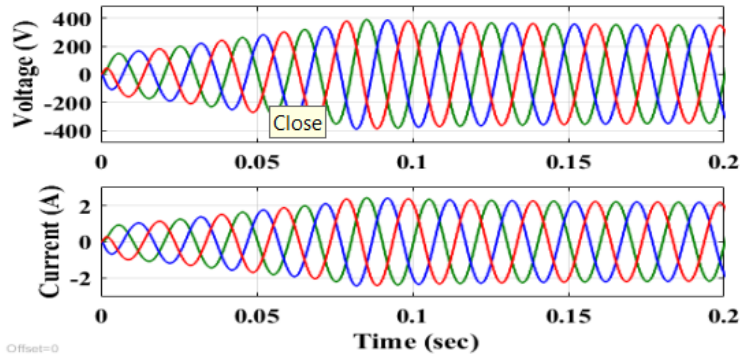



Fig. 11. Three phase output voltage and current (Phase)

- figures depicts the outut voltage and current in 1 phase and 3 phases
- THD = 2.48% by APOD control algorithm

# Five level three phase Inverter output voltage using PD

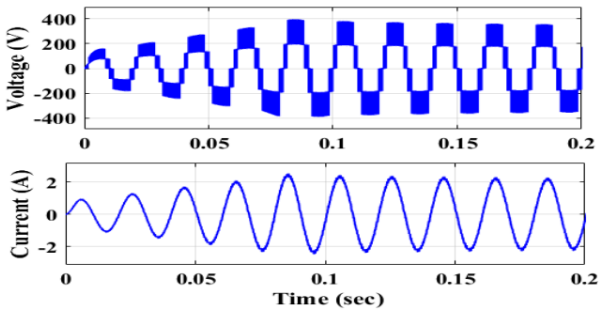



Fig. 13. Five level output voltage and current (Phase)

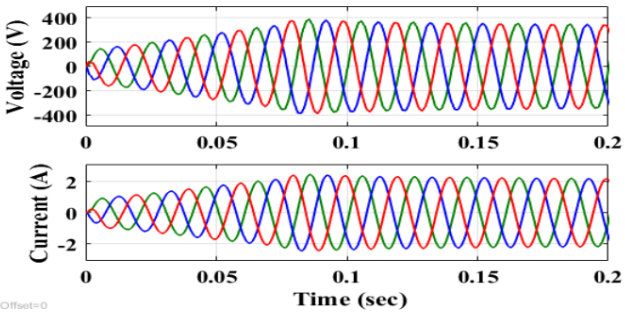



Fig. 14. Three phase output voltage and current (Phase)

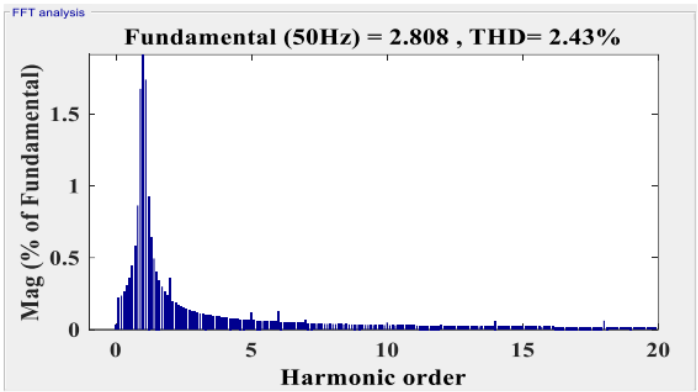



Fig. 15. THD at a modulation index of 1.0

- figures depicts the outut voltage and current in 1 phase and 3 phases
- THD = 2.43% by PD control algorithm

# Five level three phase Inverter output voltage using POD

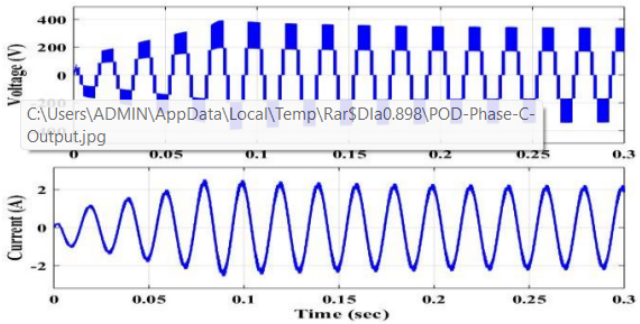



Fig. 16. Five level output voltage and current (Phase)

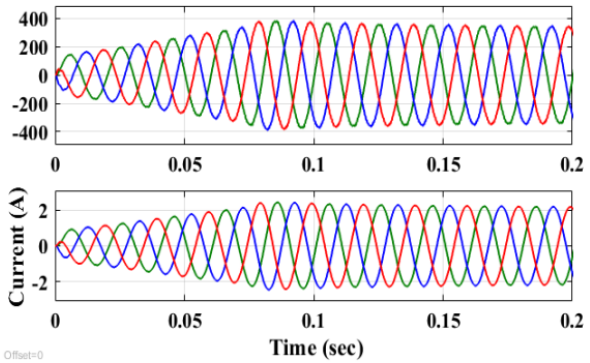



Fig. 17. Three phase output voltage and current (Phase)

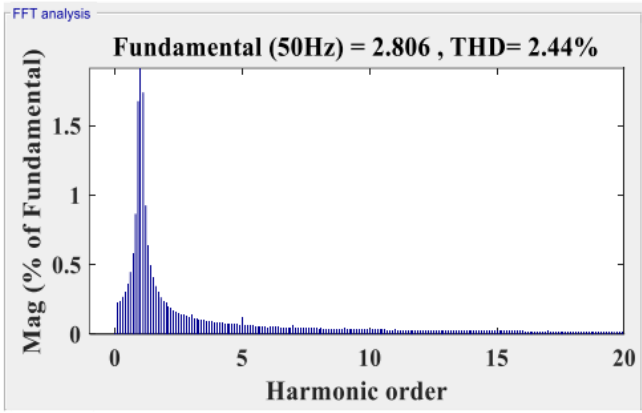



Fig. 18. THD at a modulation index of 1.0

- figures depicts the outut voltage and current in 1 phase and 3 phases
- THD = 2.44% by POD control algorithm

# comparing THD

Table: Comparing THD among methodologies

| PWM techniques | APOD | PD | POD |
|---|---|---|---|
| The percentage of THD | 2.48% | 2.43% | 2.44% |

The THD value controled by PD is lower than APOD and POD algorithms

# 5 level three phase Inverter simulation Result

# Content

# Thank You for your attention

**Presentation: Huan Nguyen-Duy**