

# Power Converter Systems

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## Graduate Course EE8407

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**Ryerson Campus**

# Topic 8

## Other Multilevel Voltage Source Converters



**Five-Level NPC/H-Bridge Inverter System with dual 18-pulse rectifier**  
LEDAR, Ryerson University

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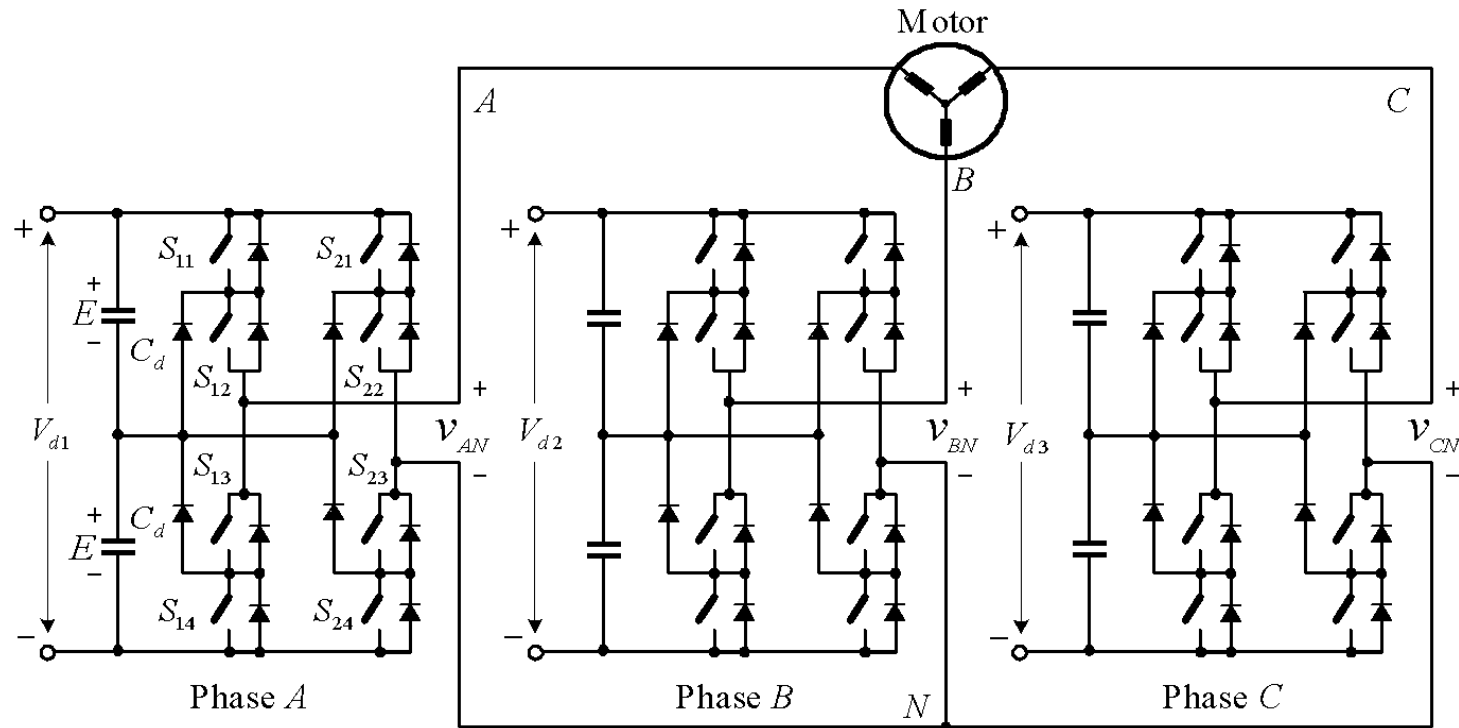
# **Other Multilevel Voltage Source Converters**

## **Lecture Topics**

- **NPC/H-Bridge Inverters**
- **Flying-Capacitor Inverters**

# NPC/H-Bridge Inverters

## • Five-Level Topology

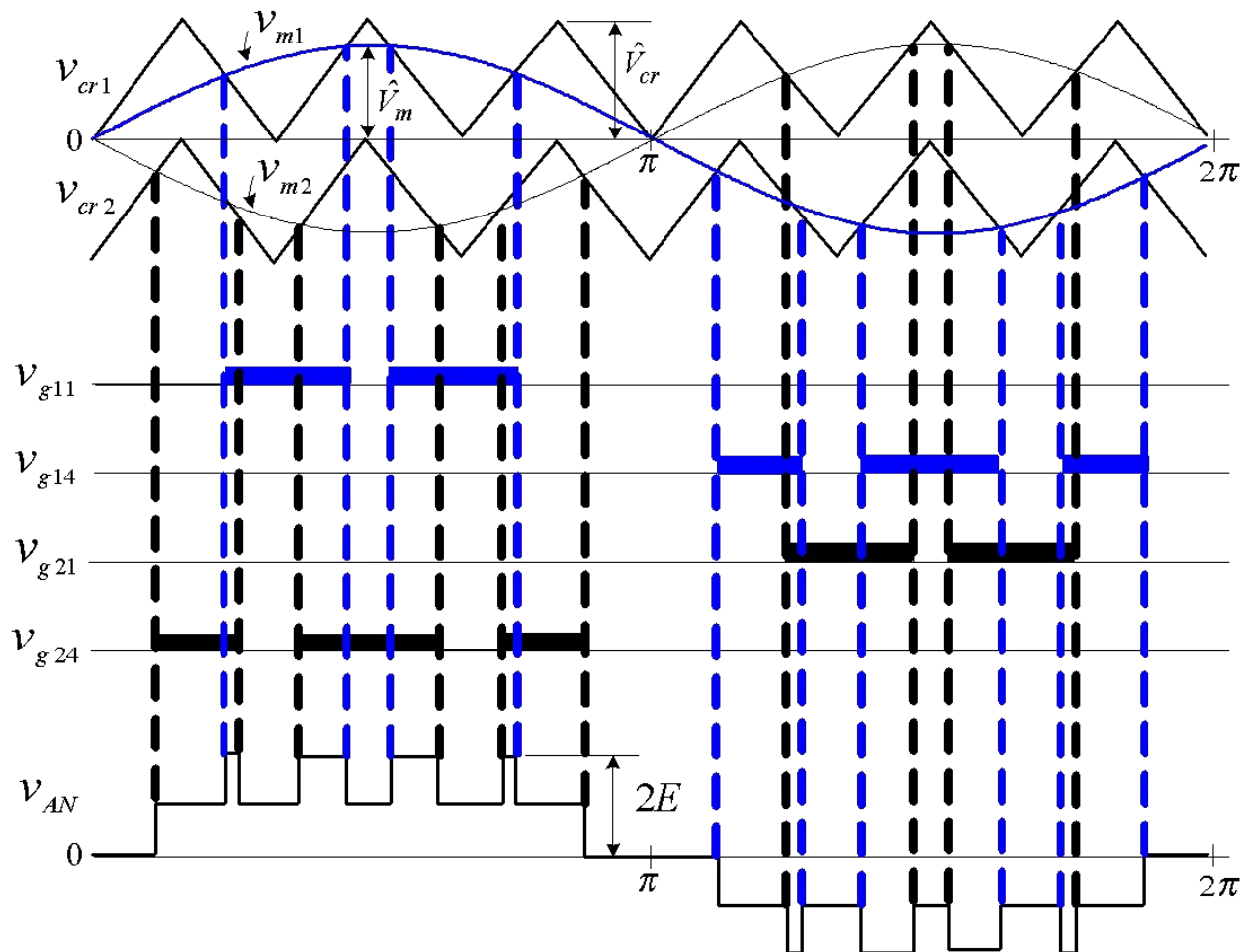


**Compared with three-level NPC Topology:**

- Voltage levels increases from three to five
- Inverter output voltage and power are doubled
- Device count is doubled

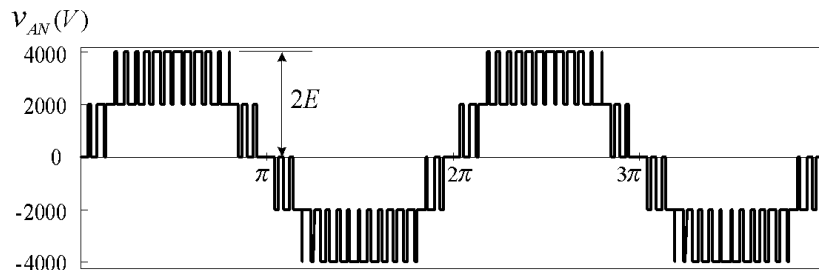
# NPC/H-Bridge Inverters

- IPD Modulation

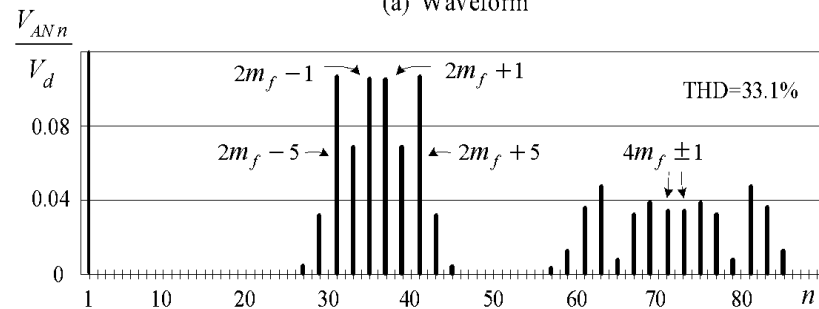


# NPC/H-Bridge Inverters

- Waveforms and FFT (Five Level)

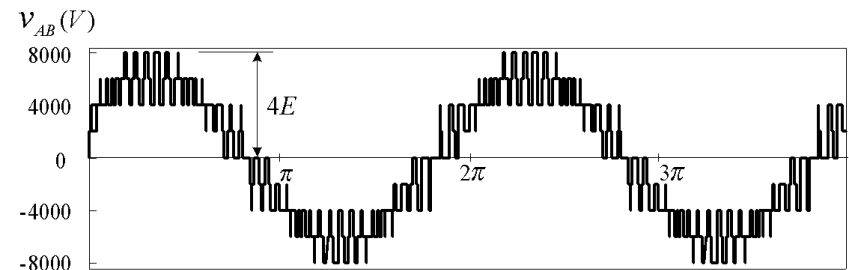


(a) Waveform

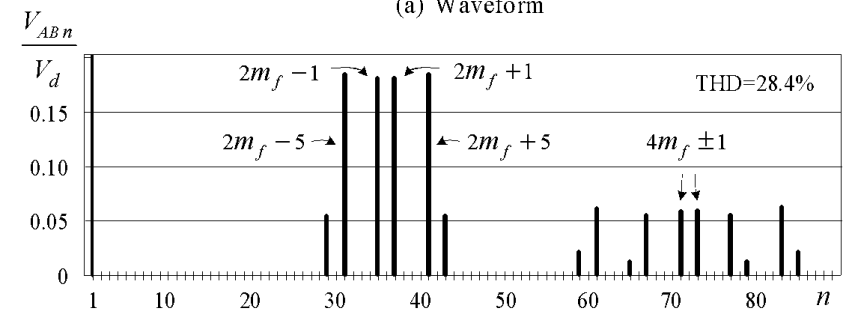


(b) Spectrum

Inverter Phase Voltage



(a) Waveform

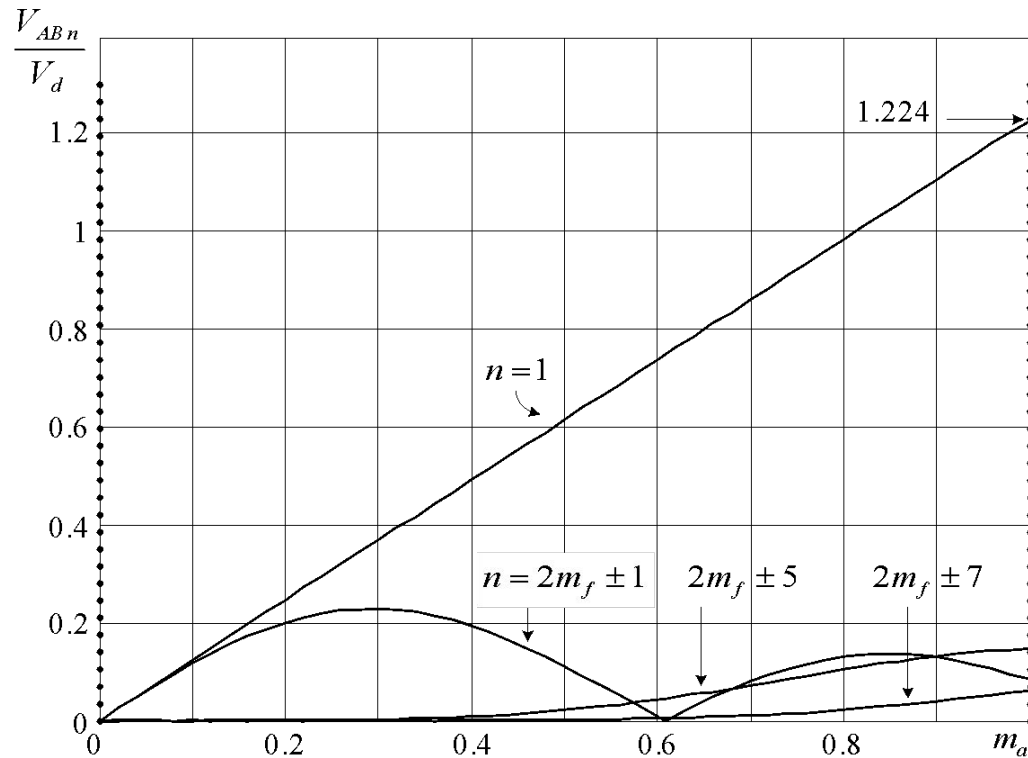


(b) Spectrum

Line-to-line Voltage

# NPC/H-Bridge Inverters

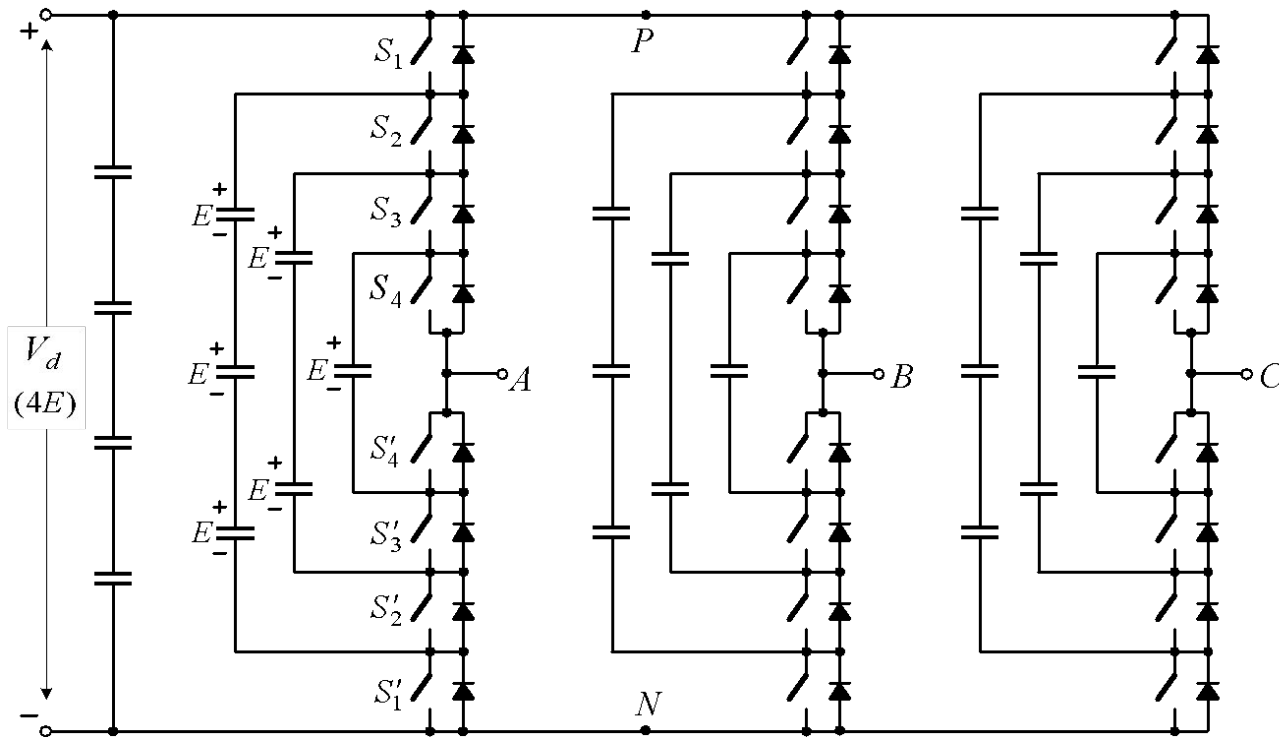
- Waveforms and FFT (Five Level)



Frequency modulation index:  $m_f = 18$

# Multilevel Flying Capacitor Inverters

## • Five Level Topology



Complementary

Switch pairs:

$S_1$  and  $S'_1$ ;

$S_2$  and  $S'_2$ ;

$S_3$  and  $S'_3$ ;

$S_4$  and  $S'_4$ ;



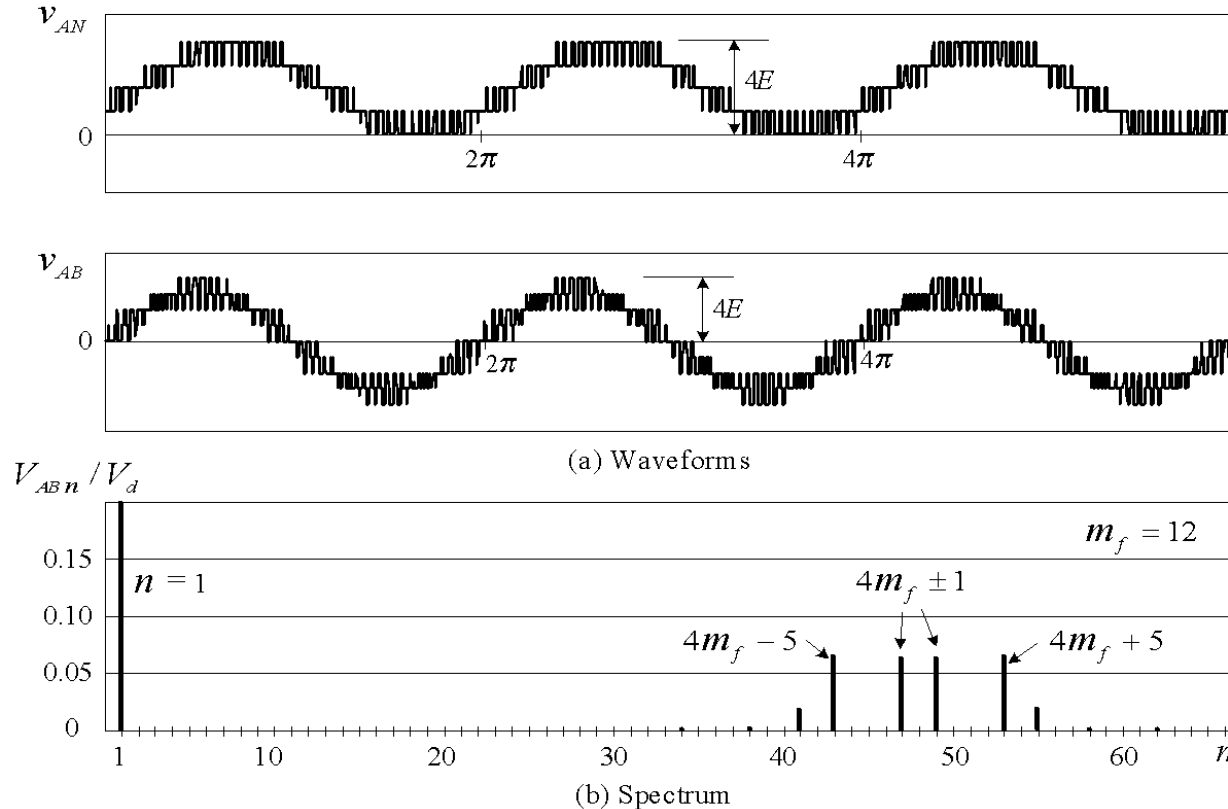
# Multilevel Flying Capacitor Inverters

- Switching State (five-level)

Output Voltage $V_{AN}$	Switching State			
	$S_1$	$S_2$	$S_3$	$S_4$
$4E$	1	1	1	1
$3E$	1	1	1	0
	0	1	1	1
	1	0	1	1
	1	1	0	1
$2E$	1	1	0	0
	0	0	1	1
	1	0	0	1
	0	1	1	0
	1	0	1	0
	0	1	0	1
$1E$	1	0	0	0
	0	1	0	0
	0	0	1	0
	0	0	0	1
$0$	0	0	0	0

# Multilevel Flying Capacitor Inverters

## • Phase-Shifted PWM



- $f_{sw (device)} = 60(m_f) = 720\text{Hz}$
- $f_{sw (inverter)} = 60(4m_f) = 2880\text{Hz}$

# Multilevel Flying Capacitor Inverters

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- Summary

## Features

- Low harmonic distortion with low  $dv/dt$
- Modular design

## Drawbacks

- Large number of dc capacitors
- Complex pre-charging circuits
- Difficulties in dc cap voltage balancing control



Thanks