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3 level NPC T-Type AFE converter with different strategies for DC-Link voltage balancing

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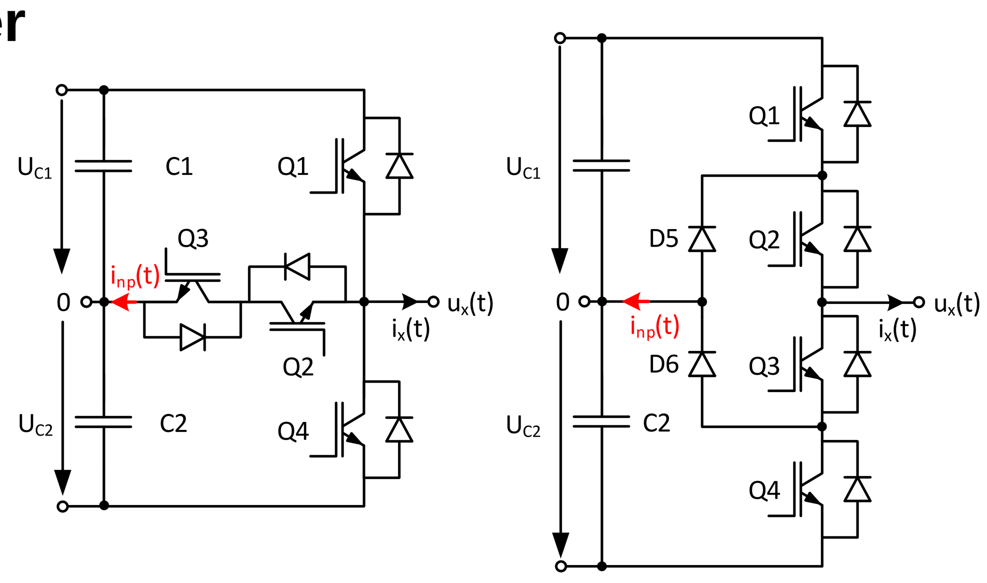
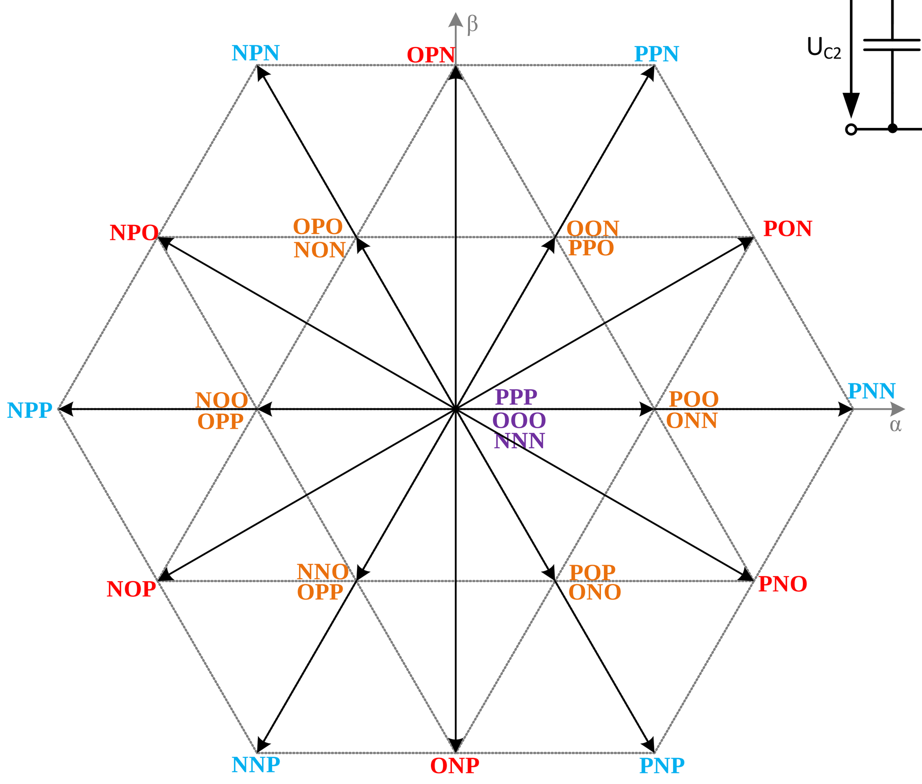
Hardware and control concept

3 Level 3 phase converter

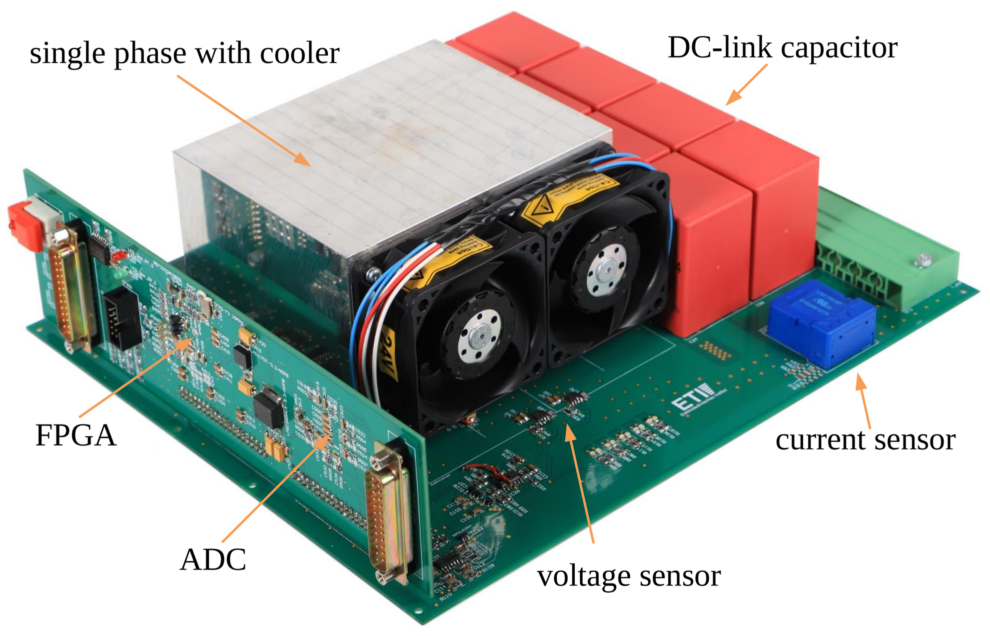
- T-Type Topology
- Balancing Capacitor voltages





- 27 Possible switching states
- **Large** vectors
- **Medium** vectors
- **Small** vectors (each two complementary)
- **Free wheeling** states

Parameter	Value	Unit
dc-link voltage	680	V
Phase current	80	A
Switching frequency	16	kHz
Line voltage	400	V



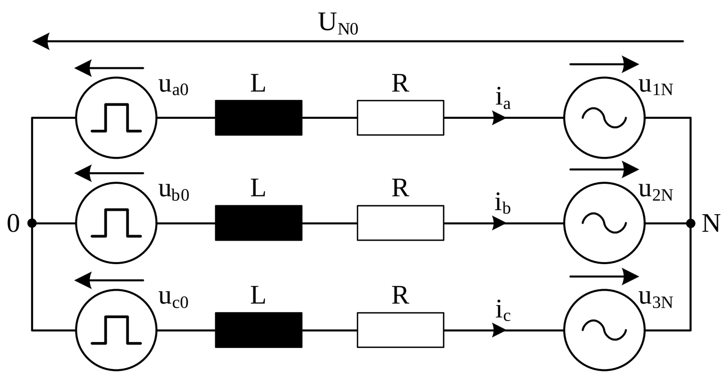
Control of the AFE converter

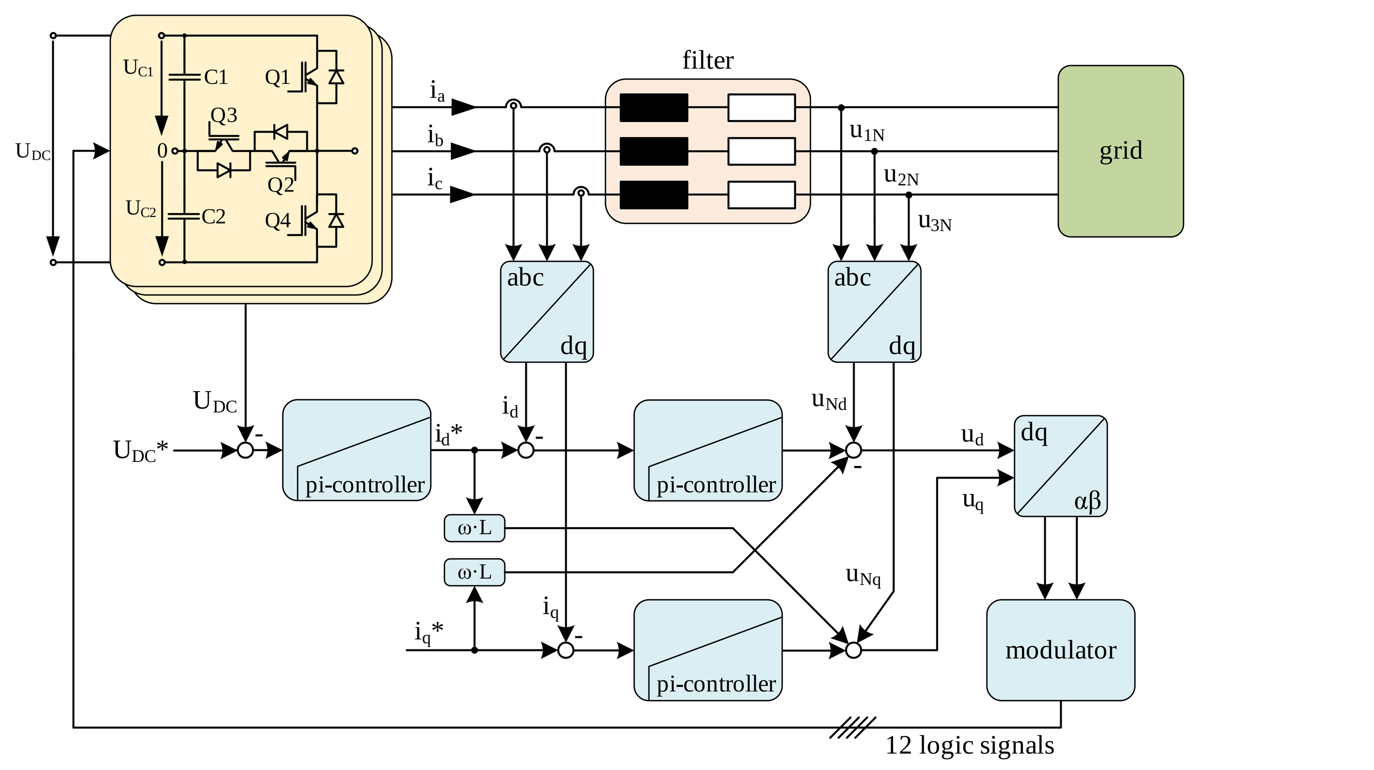
- Dynamic control of active and reactive power
- Maintaining a constant dc-link voltage

$$u_{a0} - R \cdot i_a - L \cdot \frac{di_a}{dt} - u_{1N} - U_{N0} = 0$$

$$u_{b0} - R \cdot i_b - L \cdot \frac{di_b}{dt} - u_{2N} - U_{N0} = 0$$

$$u_{c0} - R \cdot i_c - L \cdot \frac{di_c}{dt} - u_{3N} - U_{N0} = 0$$





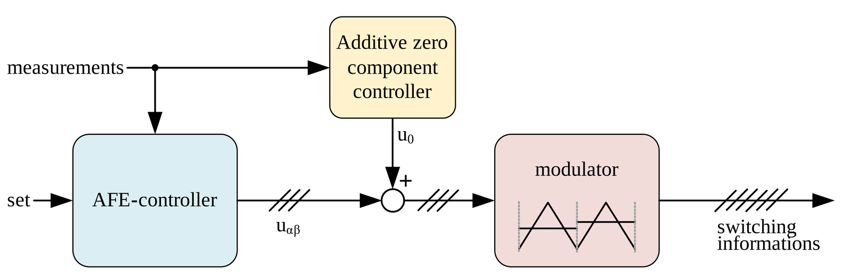
$$u_d - u_{Nd} = L \cdot \frac{di_d}{dt} + R \cdot i_d - \omega \cdot L \cdot i_d$$

$$U_{DC} = \frac{1}{C} \cdot \int (i_{DC} - i_L)dt$$

$$u_q - u_{Nq} = L \cdot \frac{di_q}{dt} + R \cdot i_q - \omega \cdot L \cdot i_q$$

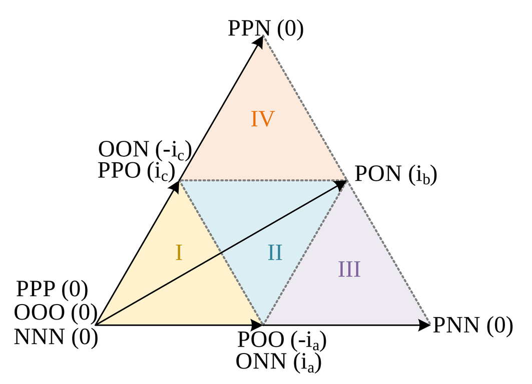
Modulation methods for balancing the DC link voltage

Additive zero component



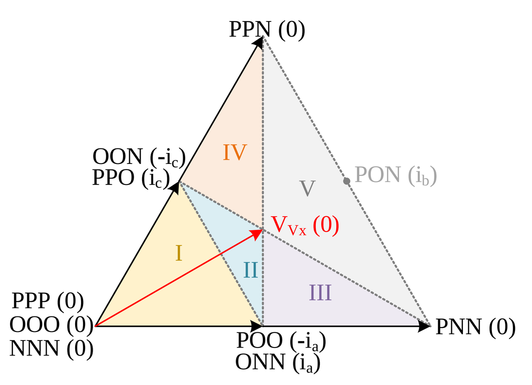
- No space vector modulation needed
- Control of DC-link voltage

Hysteresis controller



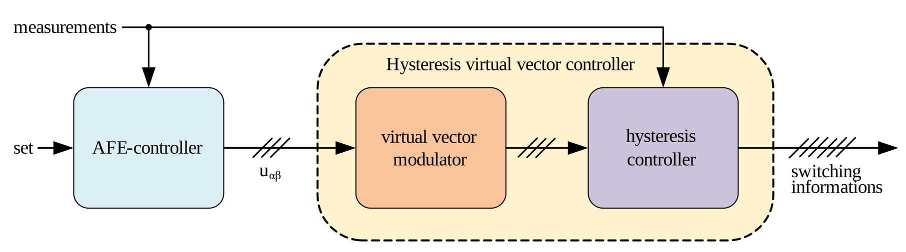
- Choose best small vector for capacitor balancing
- Control of DC-link voltage

Virtual vector



- Prevent zero point current with a new virtual vector
- No control of DC-link voltage

Hysteresis virtual vector



- No zero point current
- Control of DC-link voltage
- Reduction of capacitor possible

Measurement Results for testing the modulation methods

Measurement results

- Startup at 20A RMS grid-current
- Balancing starts at 30ms
- Current step to 6A RMS at 100ms
- Same results for simulation