

# Application of Multilevel Current Source Inverters in renewable energies interface with the electric grid

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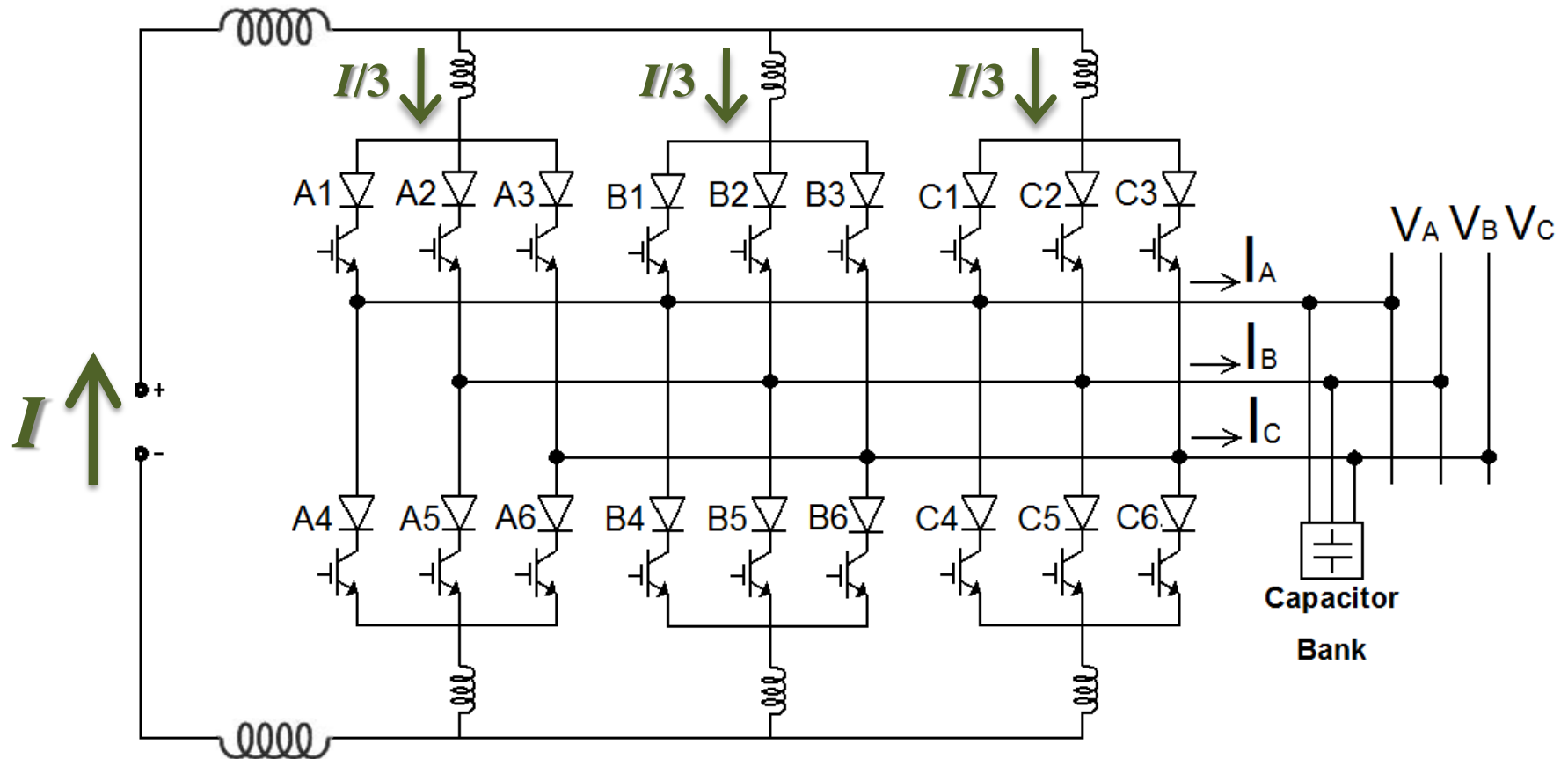
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<sup>2</sup>CIDEI – Instituto Tecnológico de Buenos Aires (ITBA)



Argentina

# Multilevel Current Source Inverter

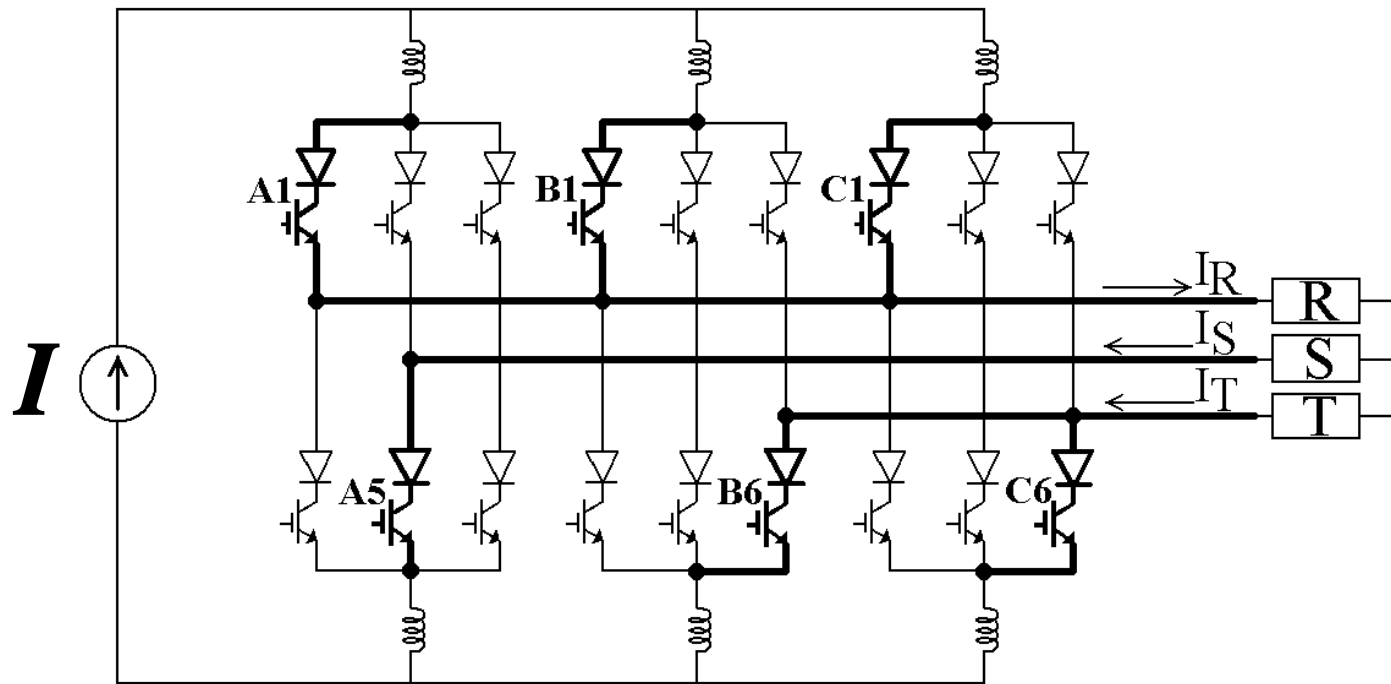


### Basic operation

$$I_R = I$$

$$I_S = -1/3 I$$

$$I_T = -2/3 I$$

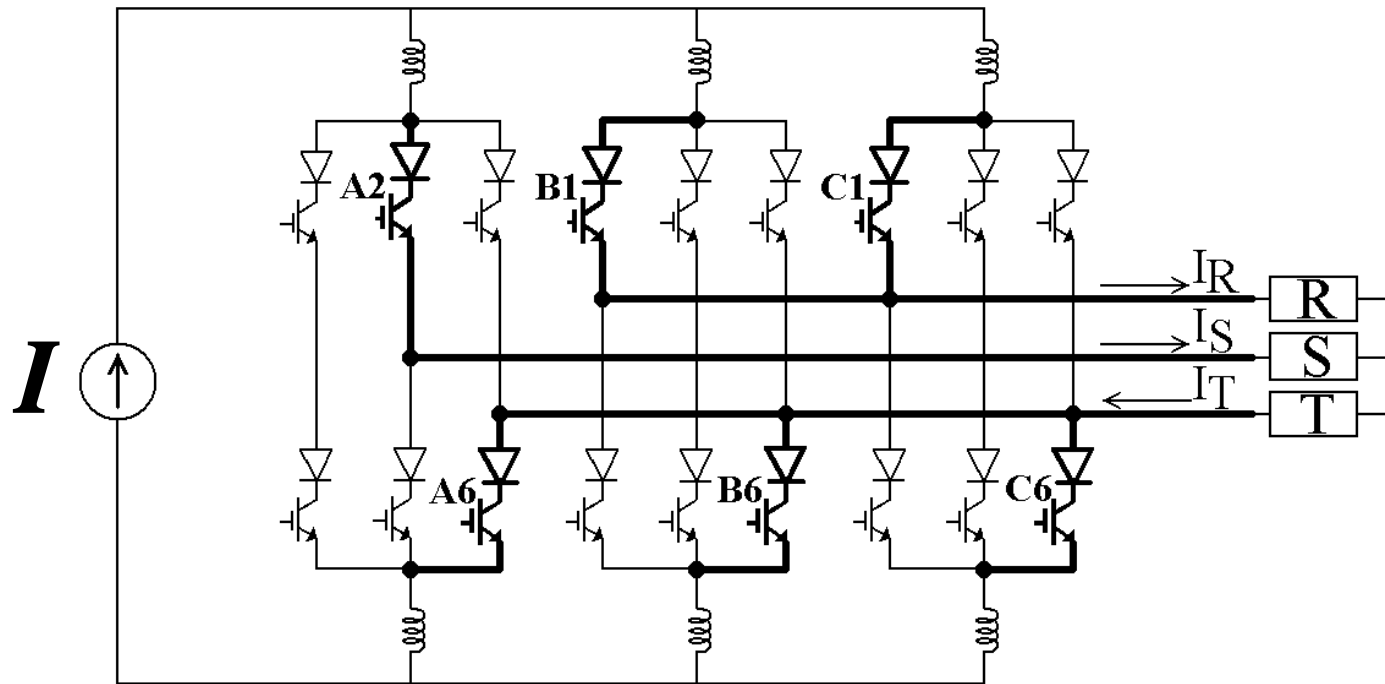


### Basic operation

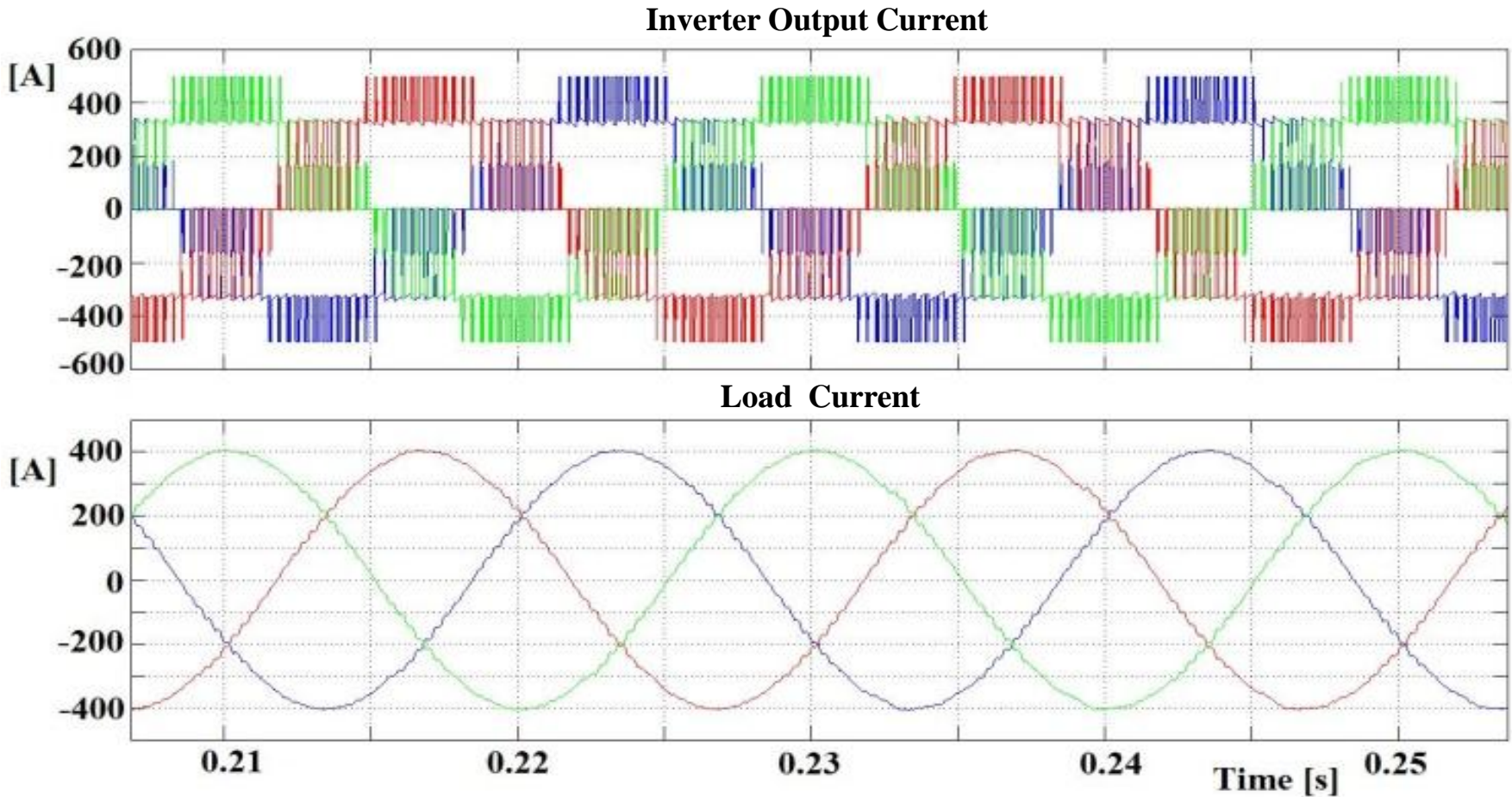
$$I_R = \frac{2}{3} I$$

$$I_S = \frac{1}{3} I$$

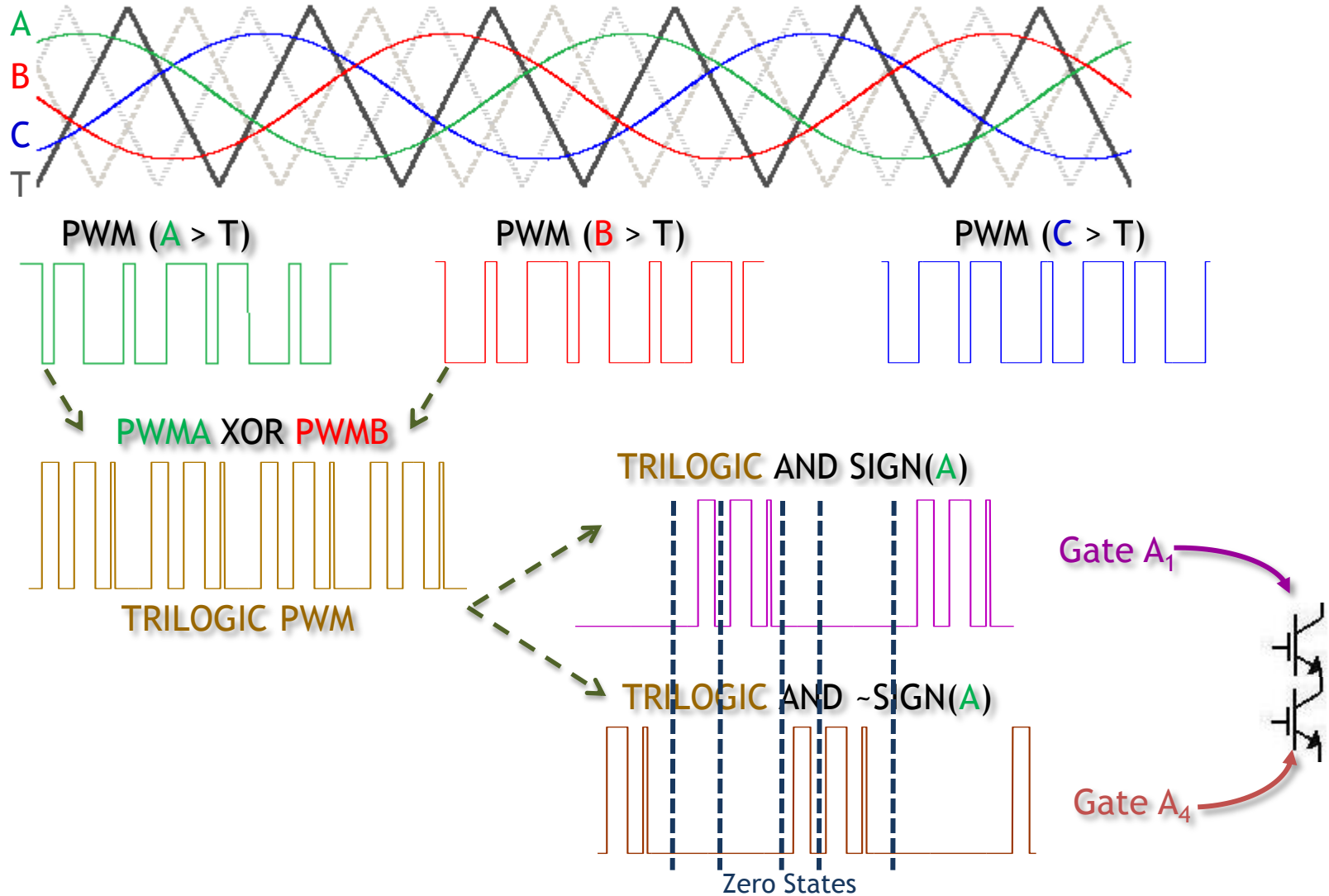
$$I_T = -I$$



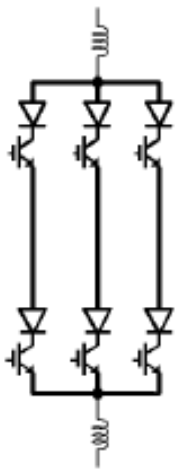
# MCSI Output Current



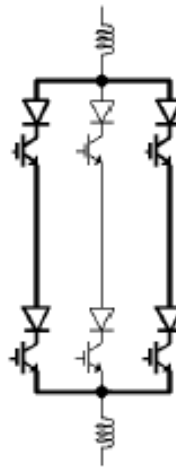
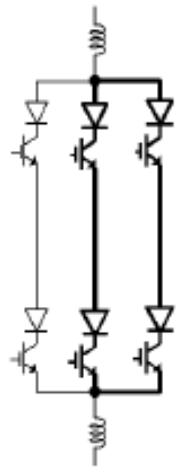
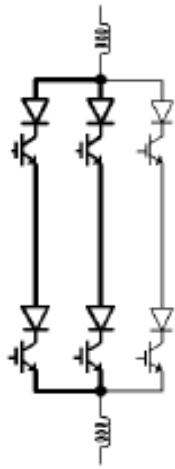
## Phase Shift Carrier SPWM



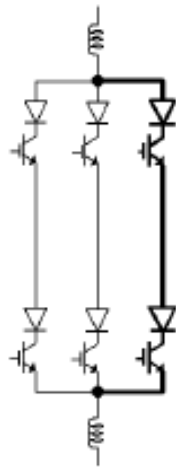
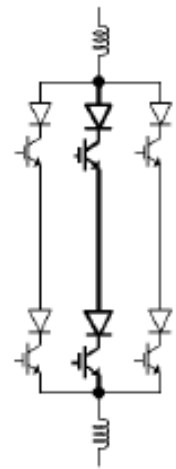
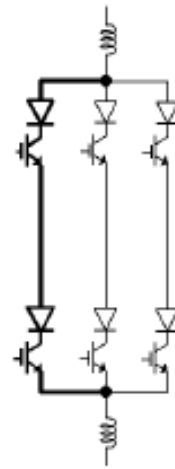
## MCSI Zero States Redundancy



(a)

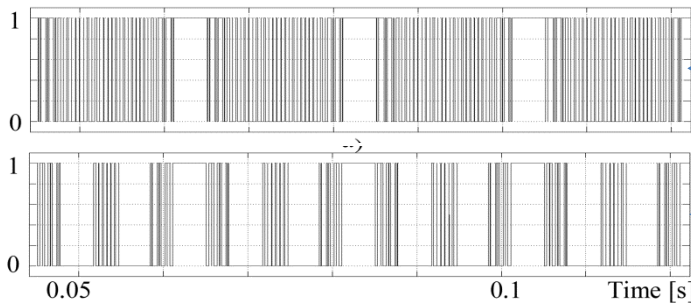
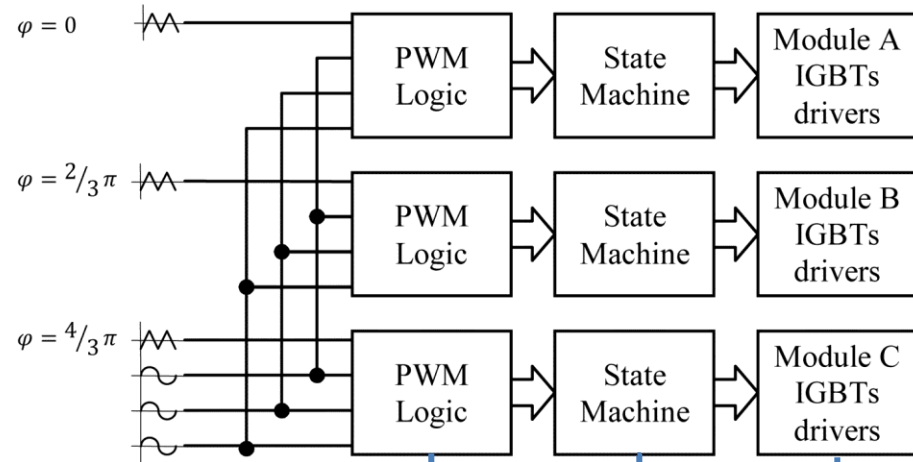
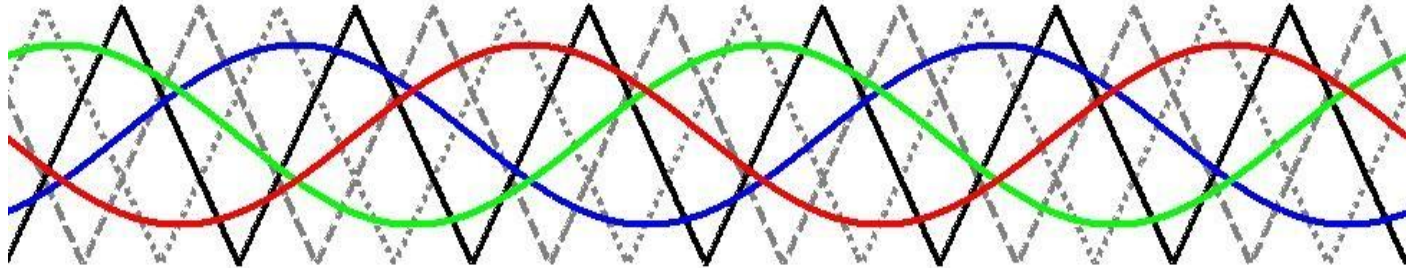


(b)



(c)

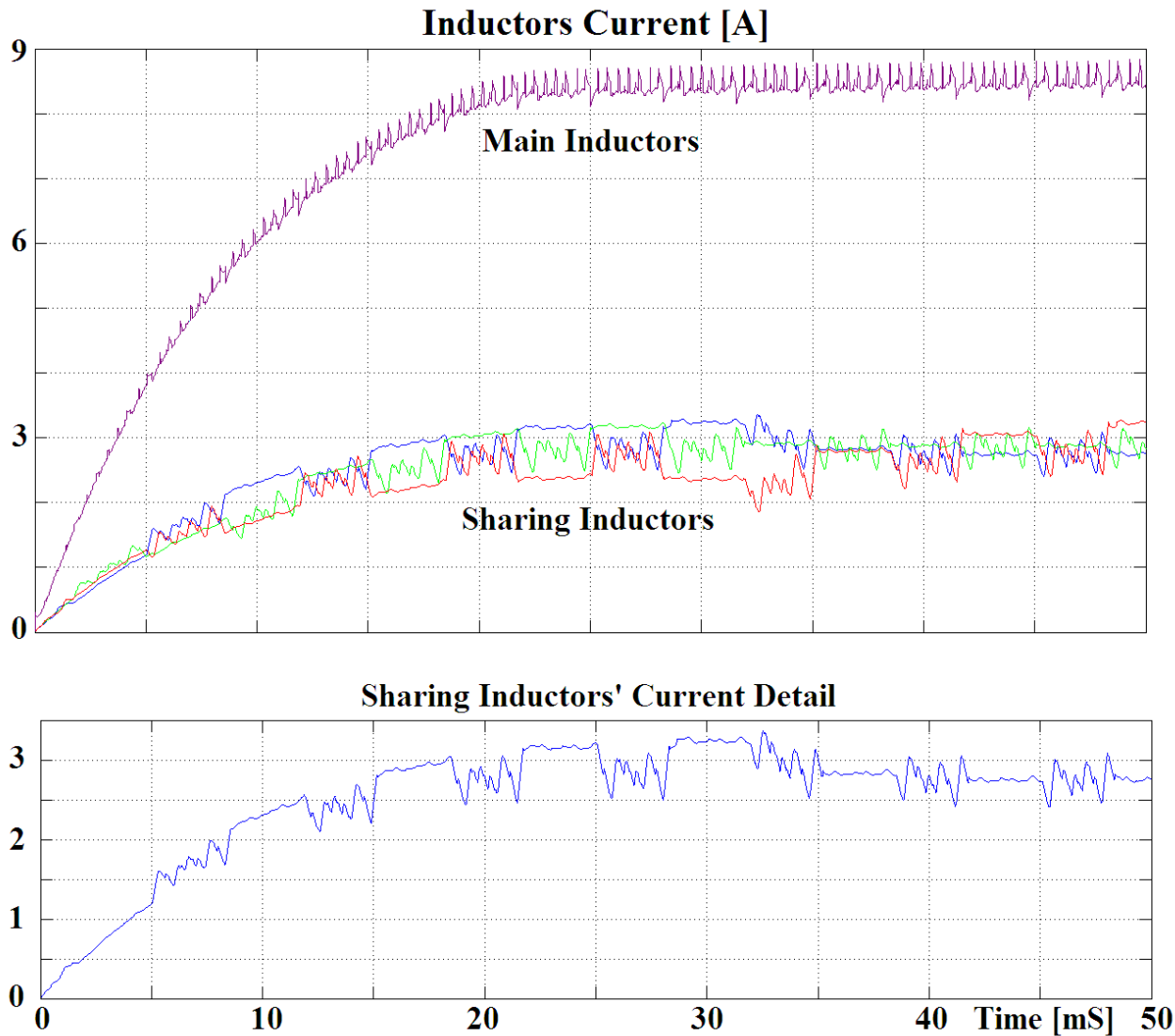
# Phase Shift Carrier SPWM



Less switching power losses !



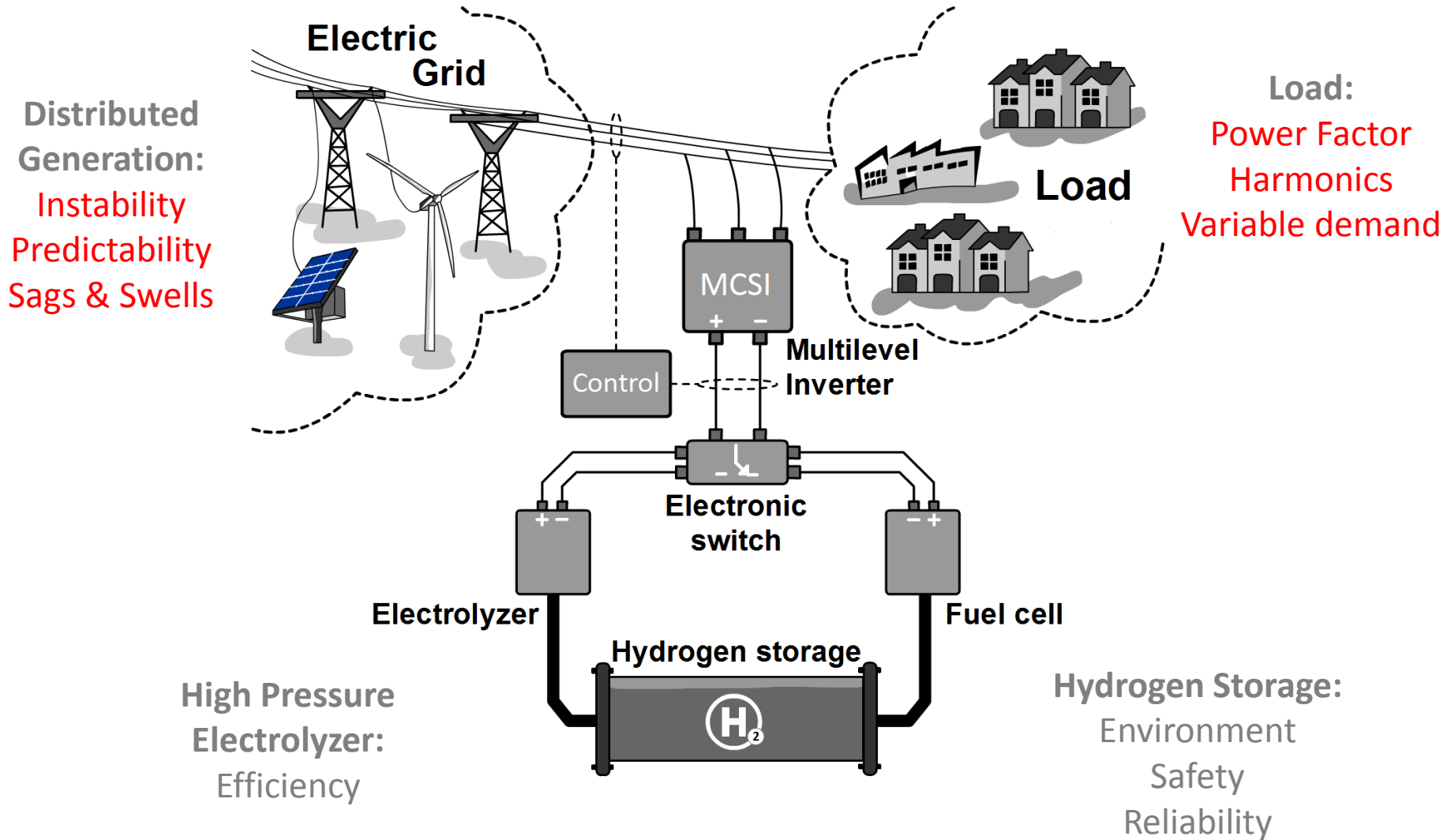
## Natural Current Balance (PSC-SPWM)



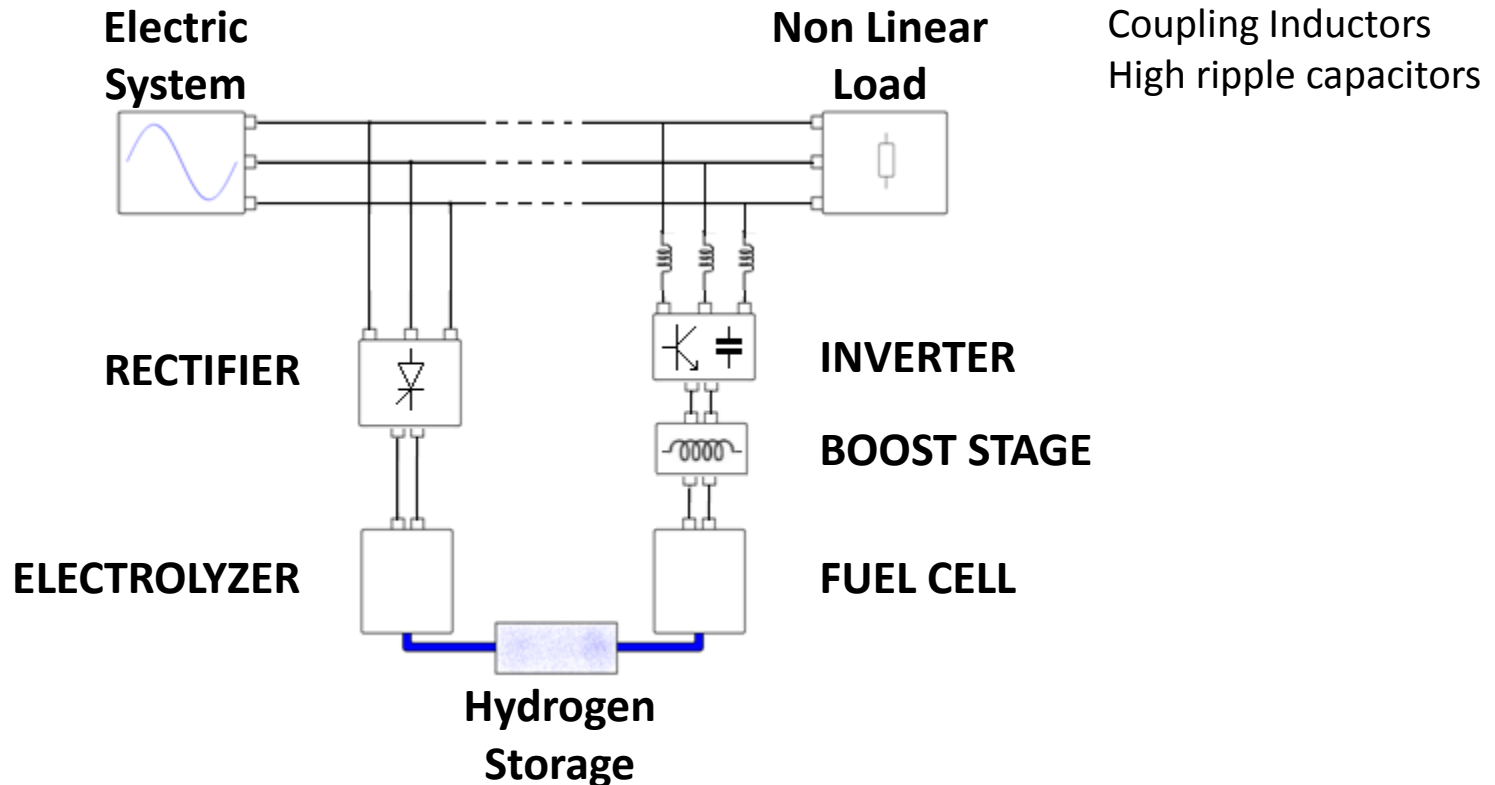
# Applications

- Grid interface for renewable energies
  - Wind Generation
  - Hydrogen Storage
    - Electrolyzers
    - Fuel Cells
  - Photovoltaic
  
- Active Filter

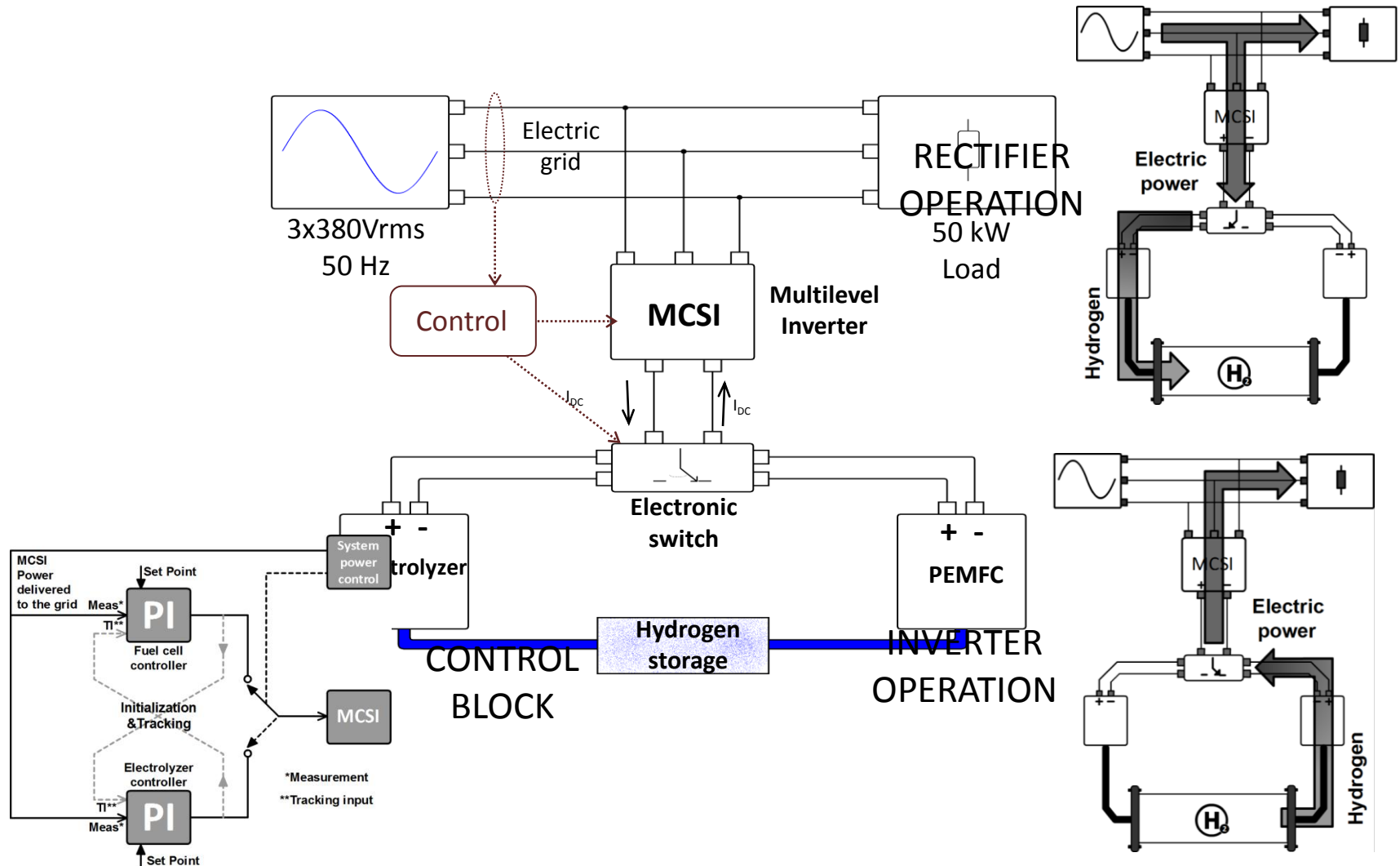
# Hydrogen storage



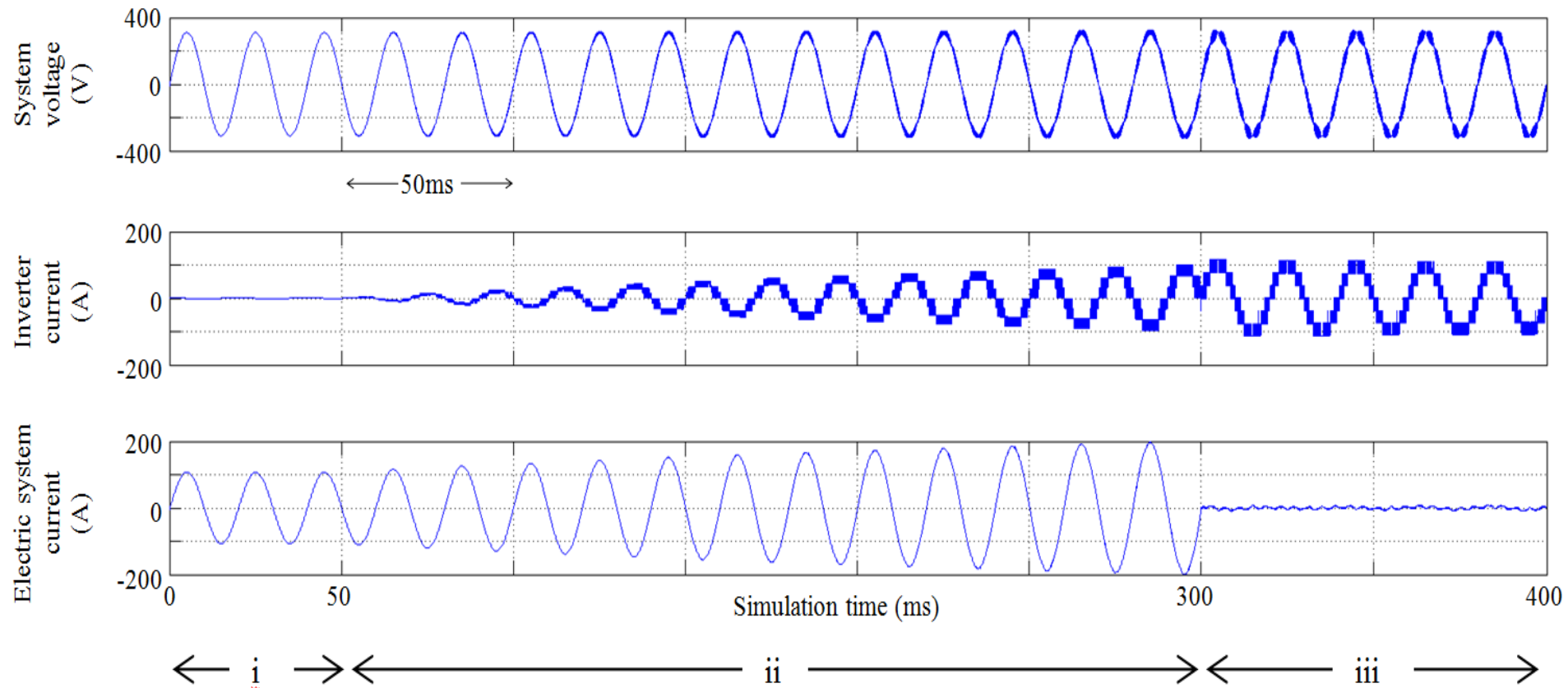
# Conventional Approach: Rectifier + Inverter



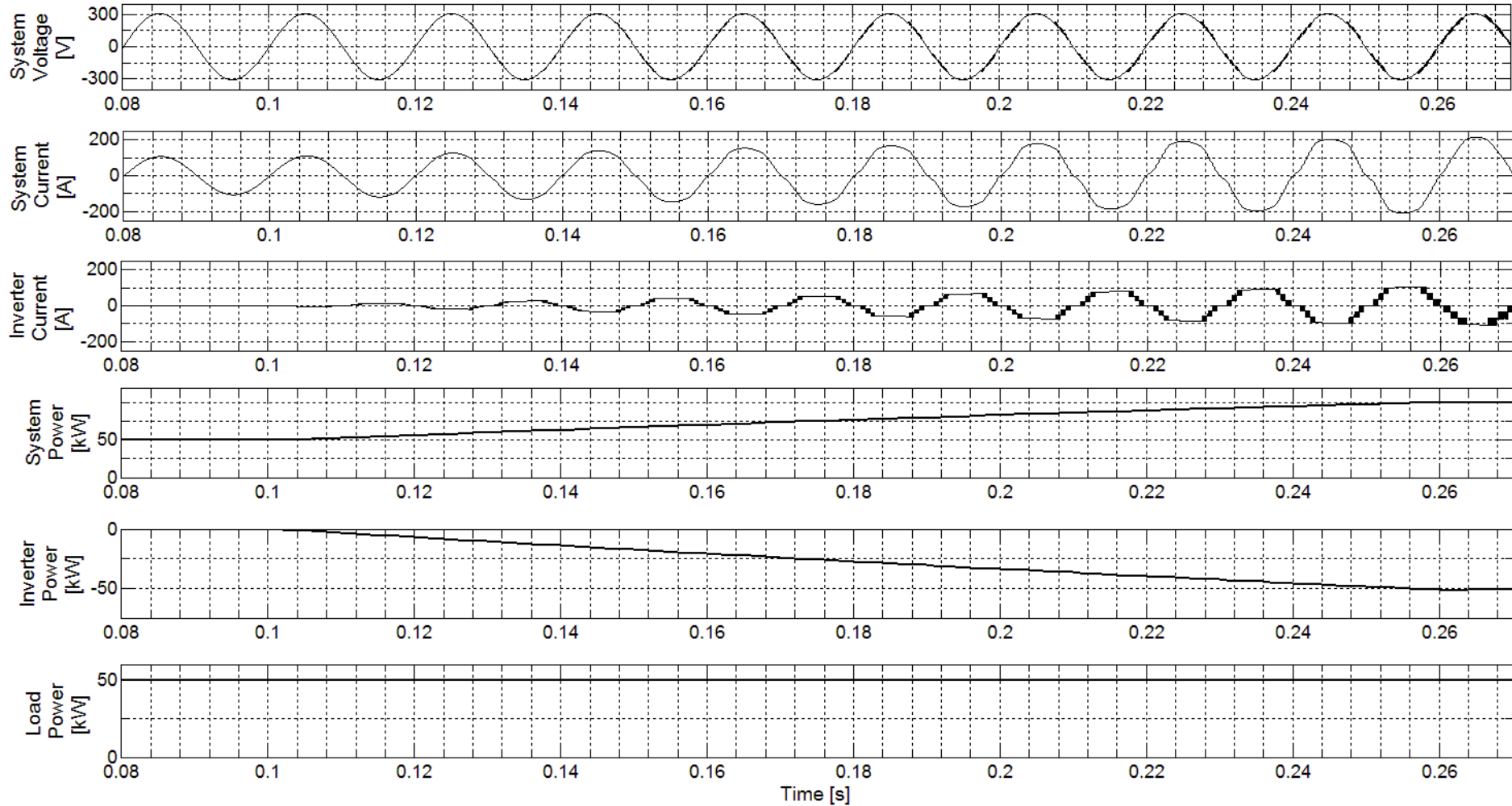
# Proposed Approach



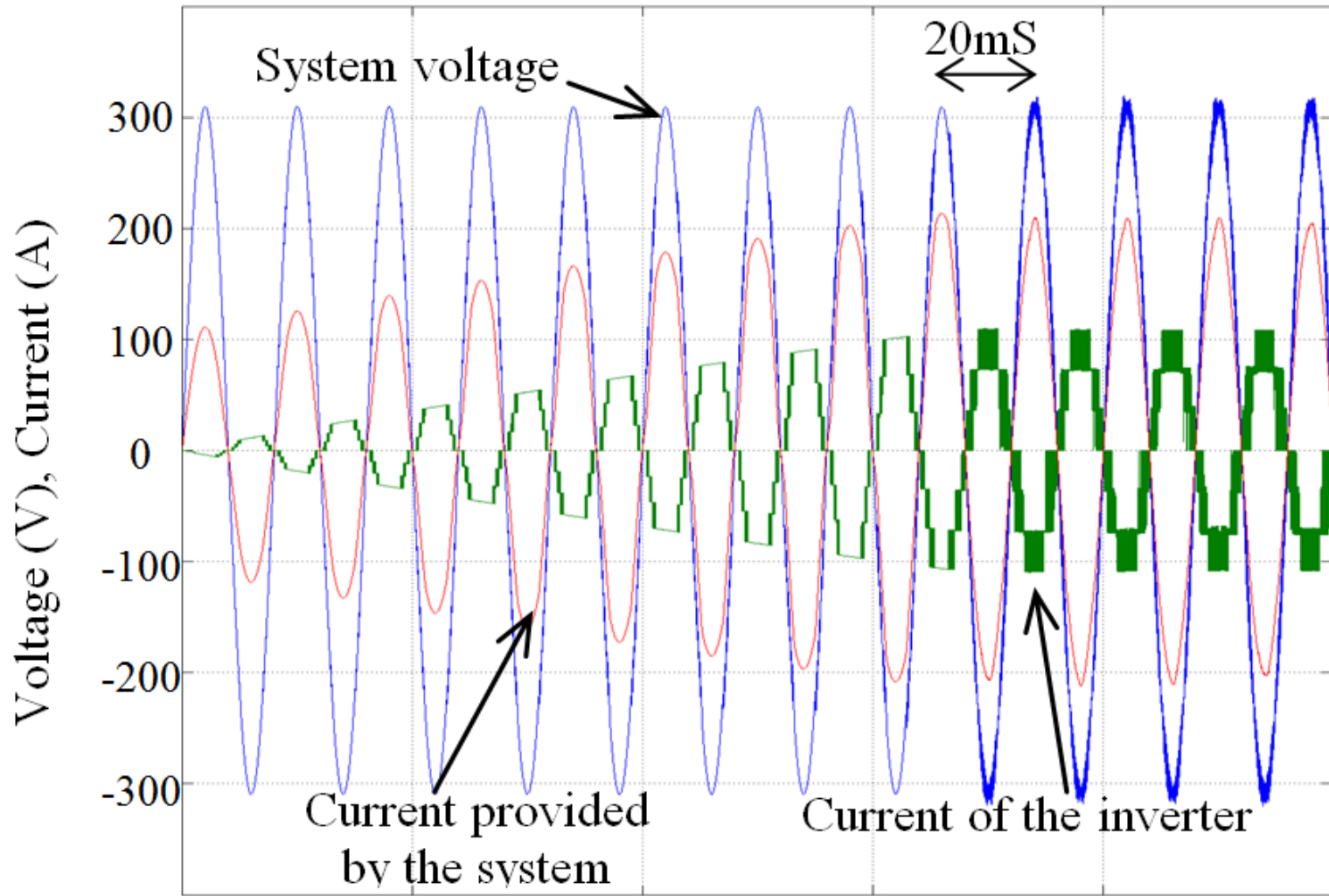
# System behavior



# Rectifier operation



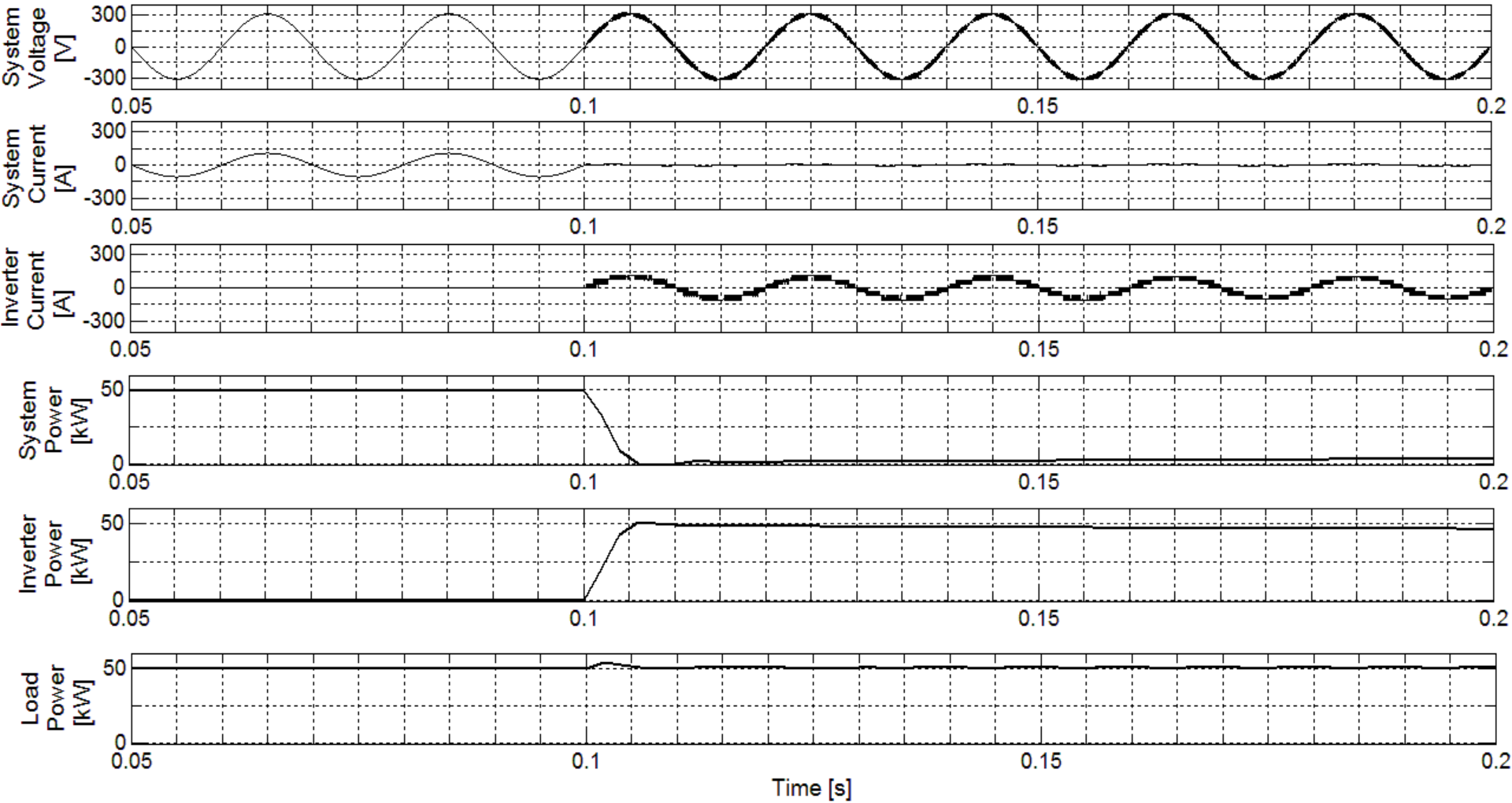
# Rectifier operation



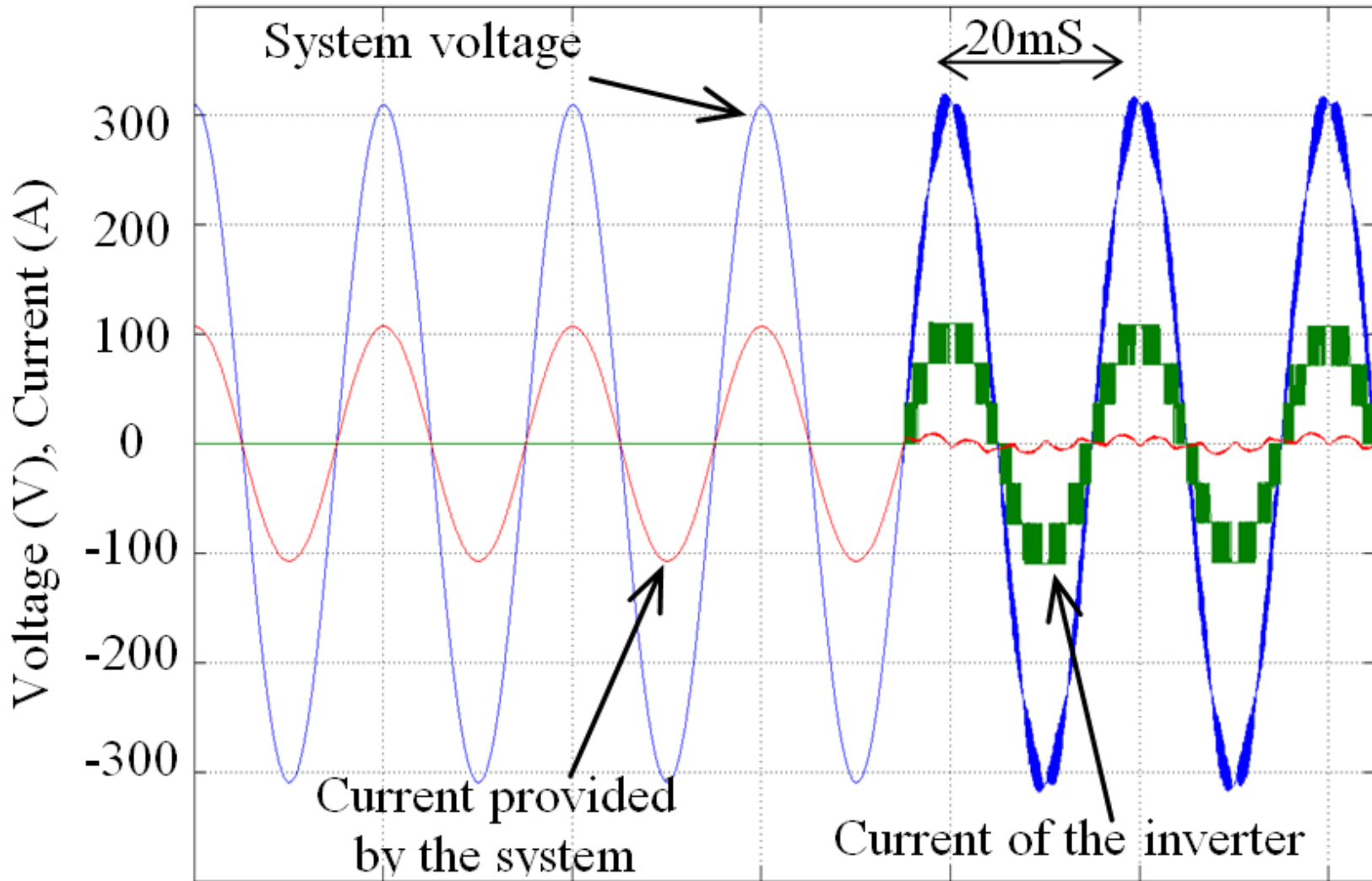


# Inverter operation

Active power only

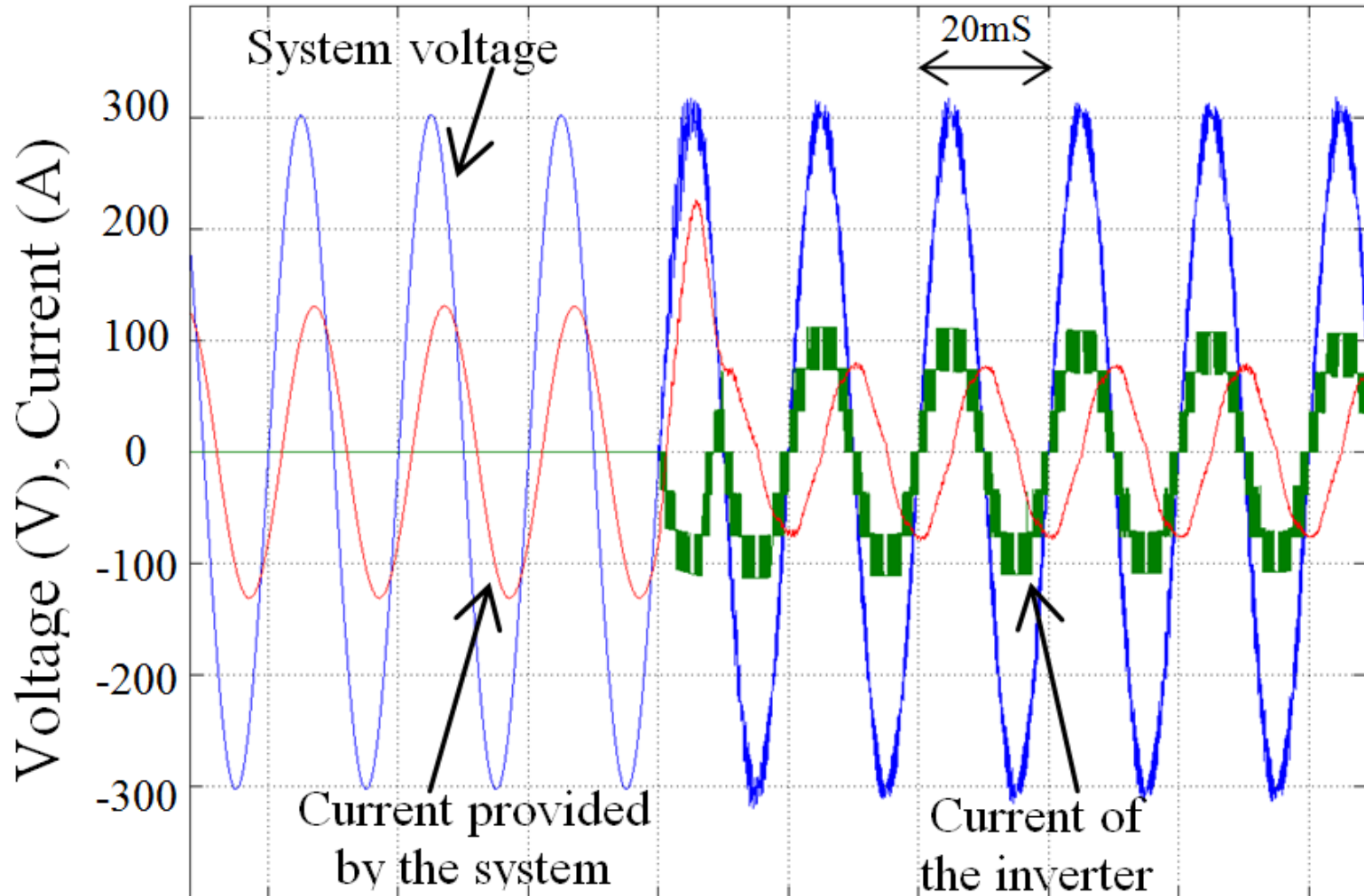


# Inverter operation



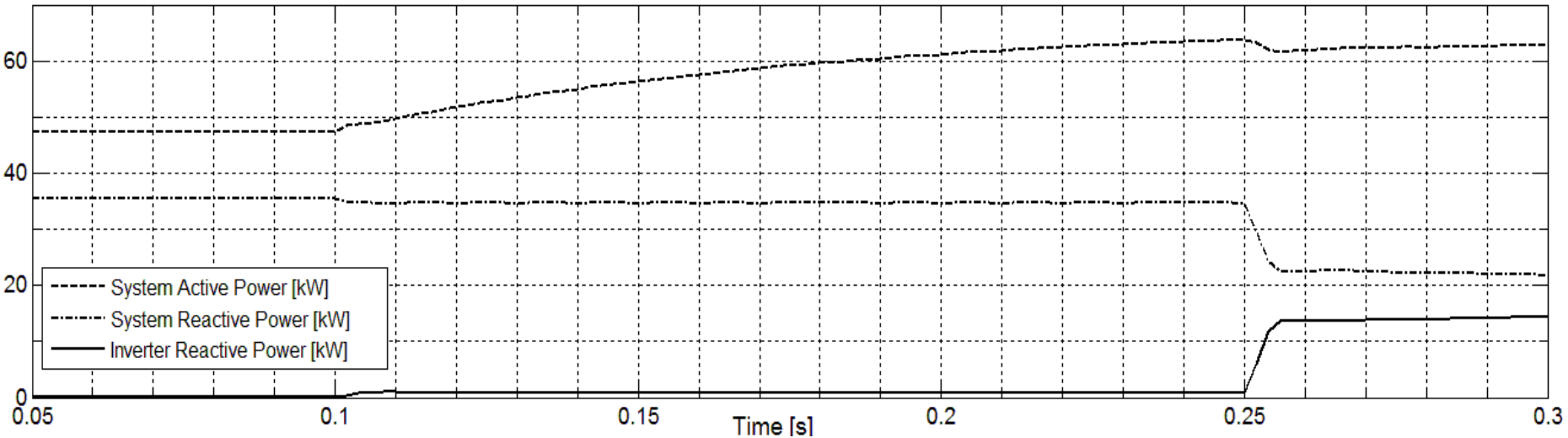
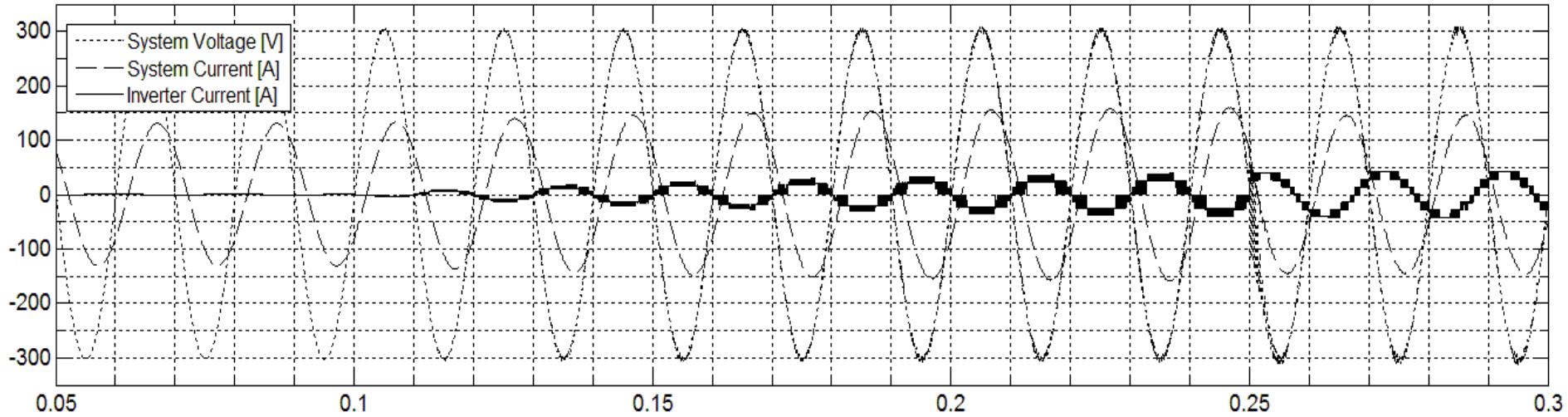
# Inverter operation

System: Reactive + Active Power – Inverter: Active Power only

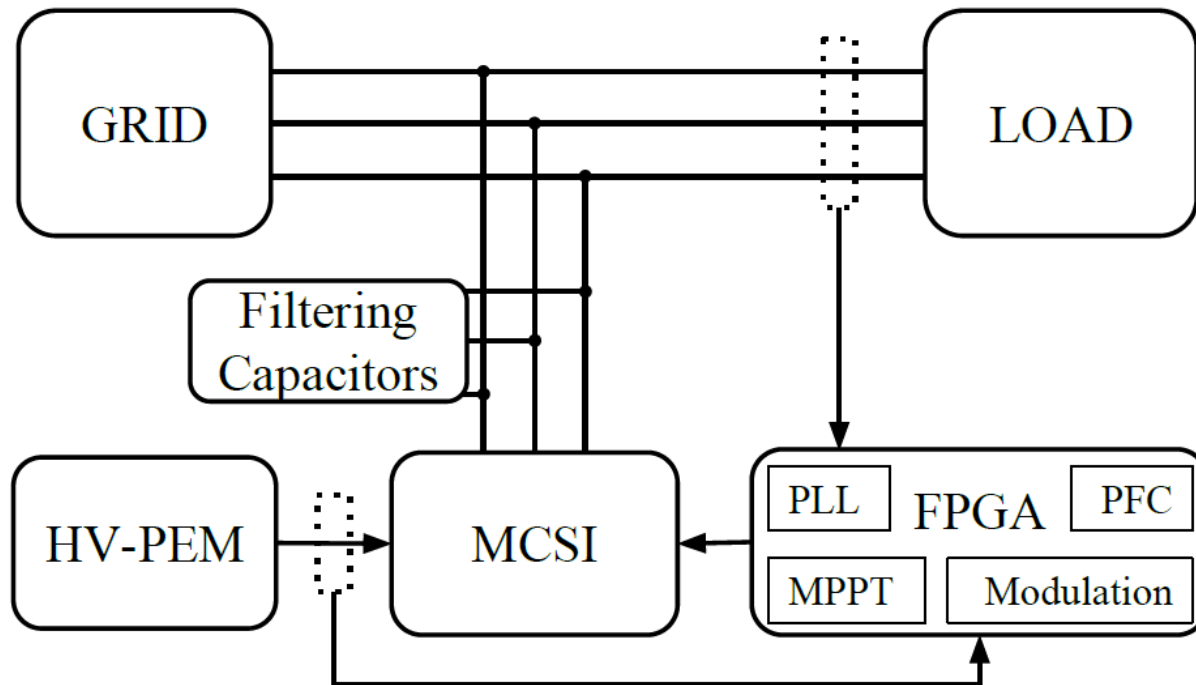


# Inverter operation

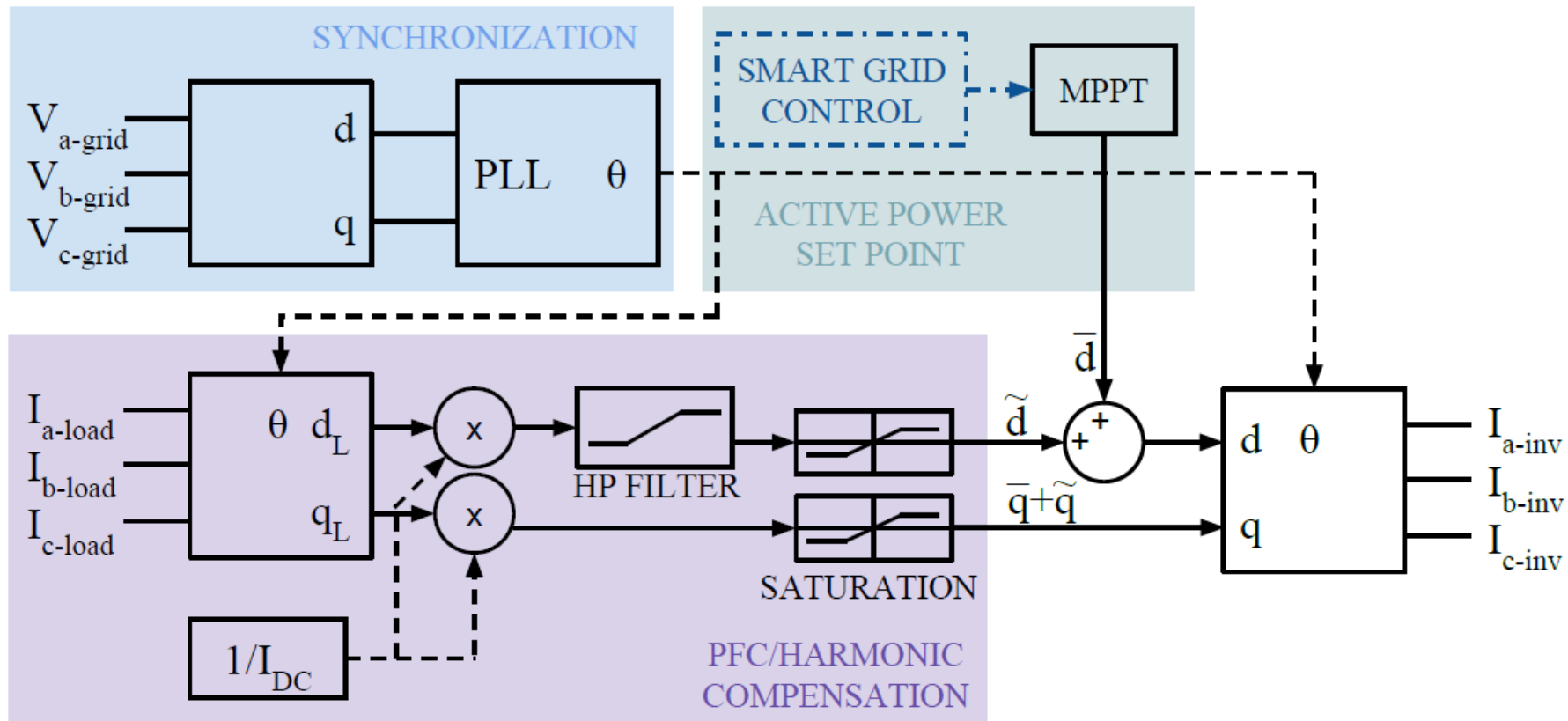
## Active & Reactive Power



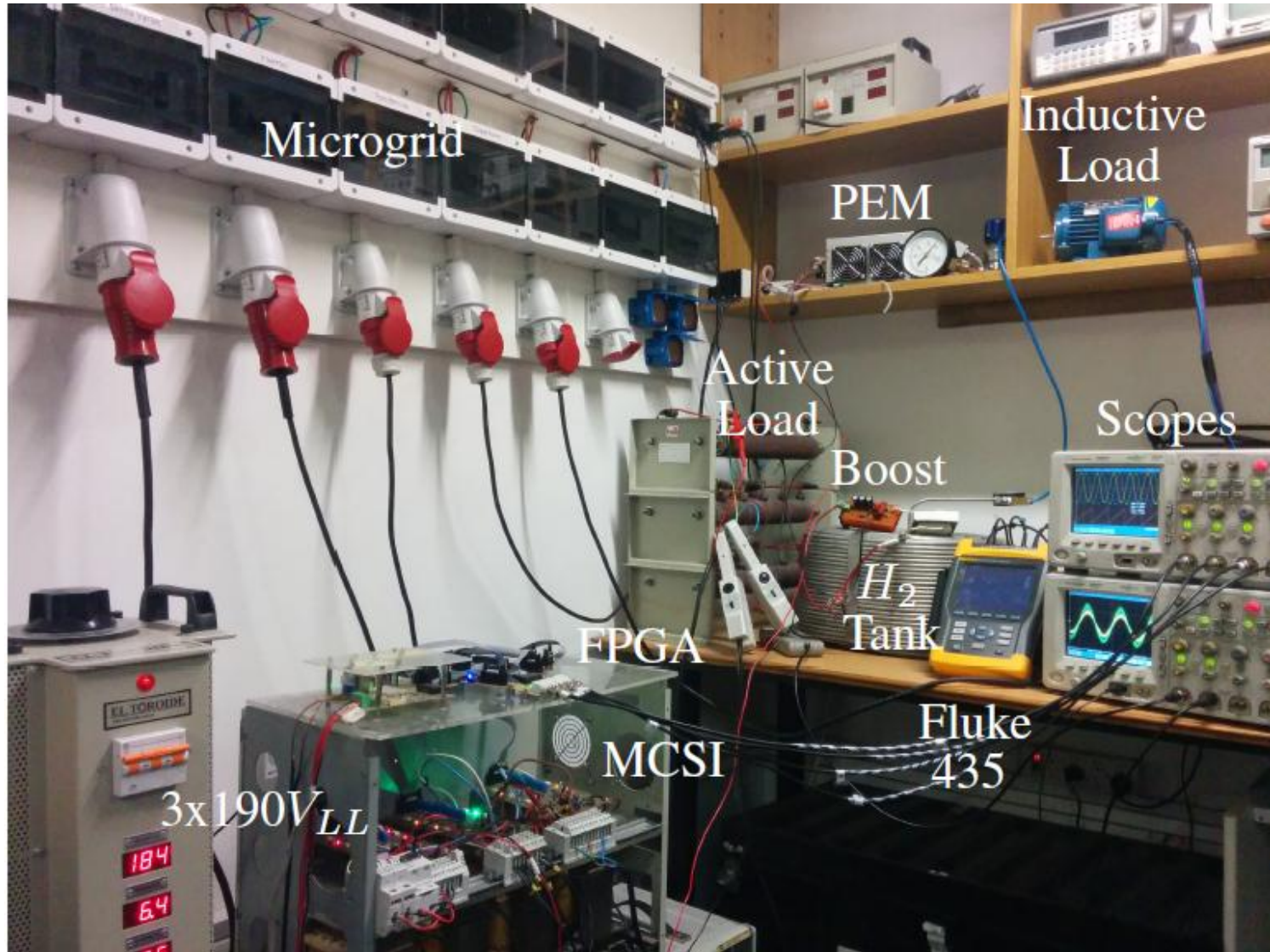
# Fuel Cell or PV Grid Interface



# Fuel Cell or PV Grid Interface Control Block

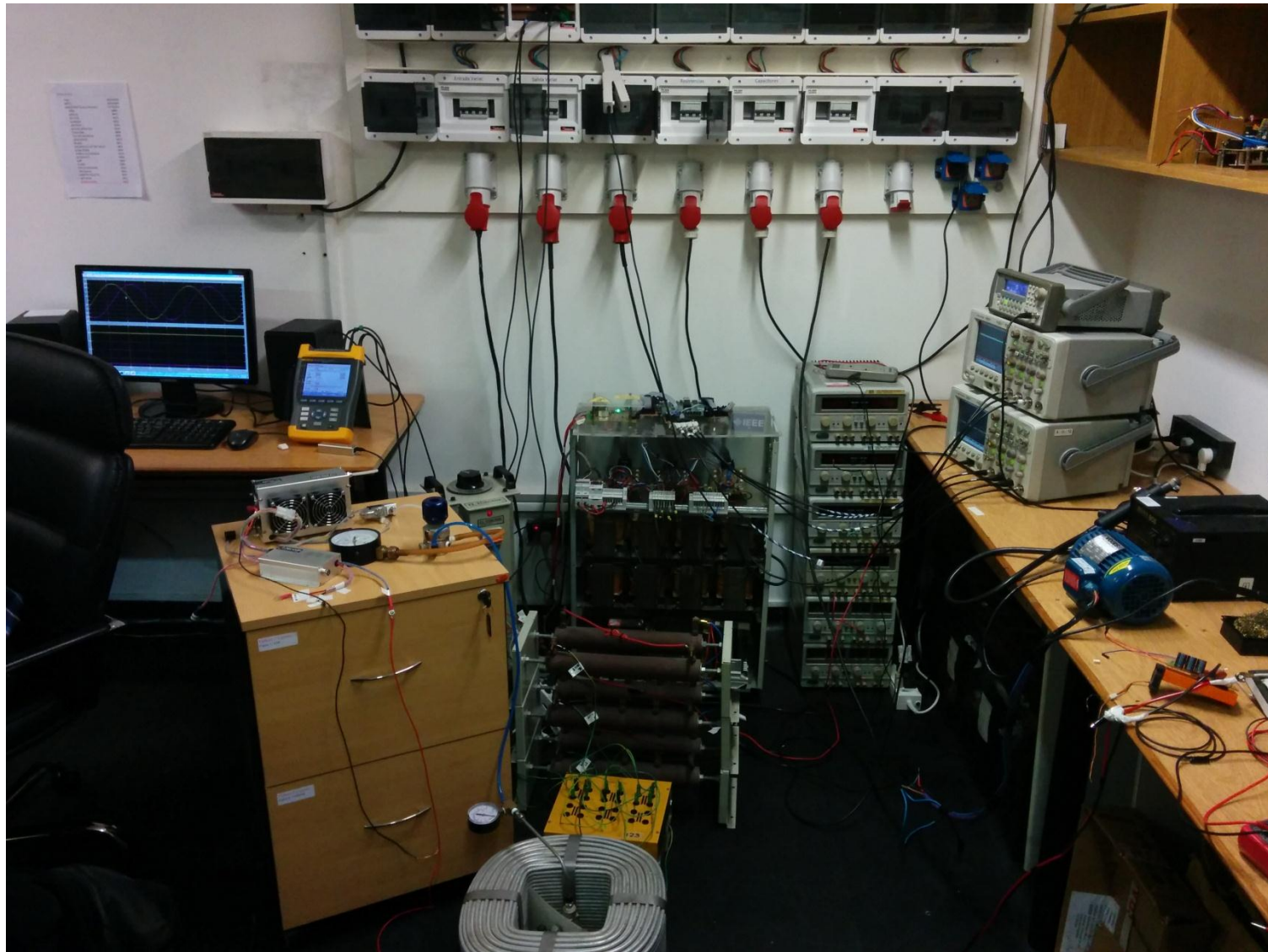


# Experimental set-up



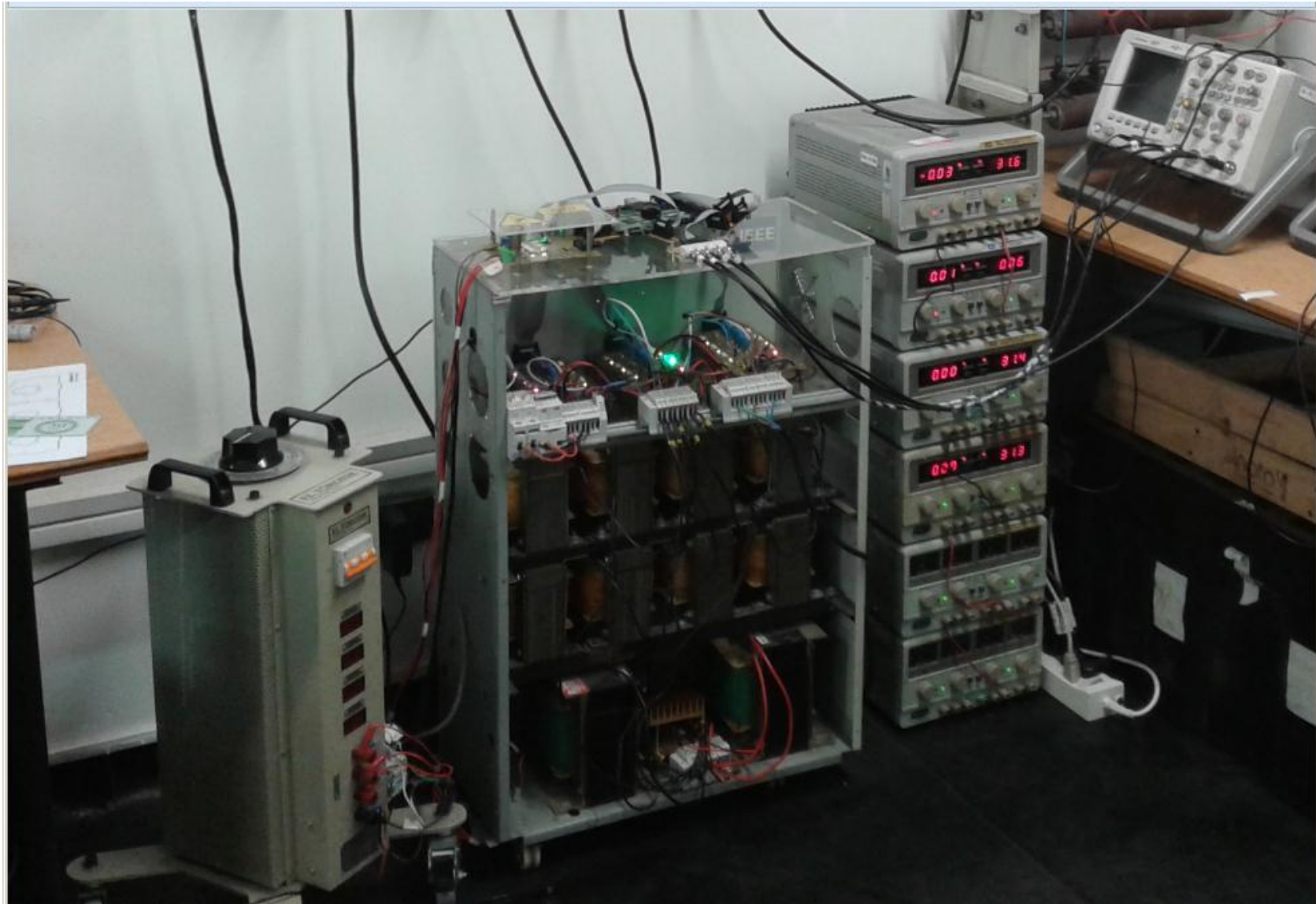


# Experimental set-up

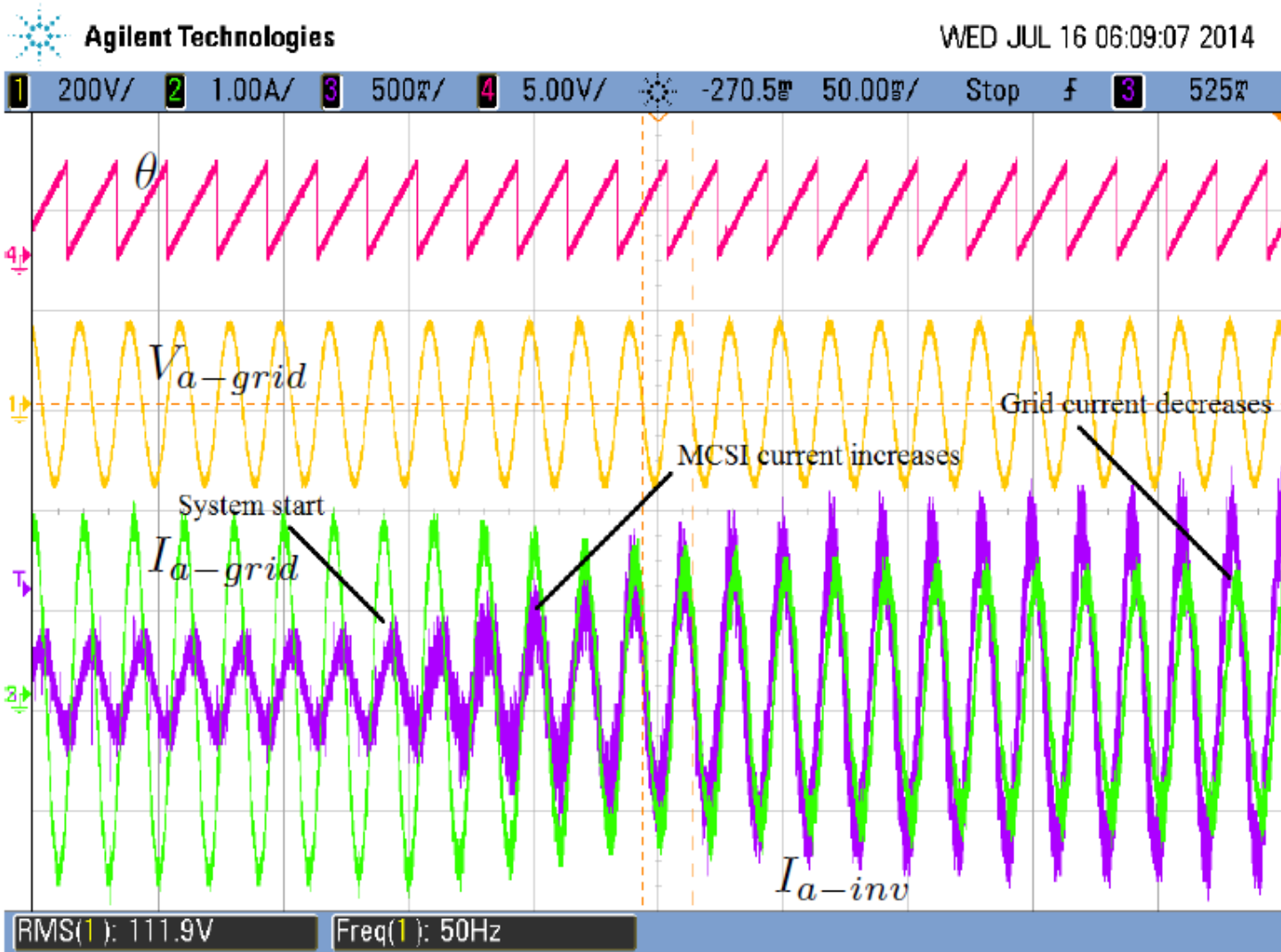




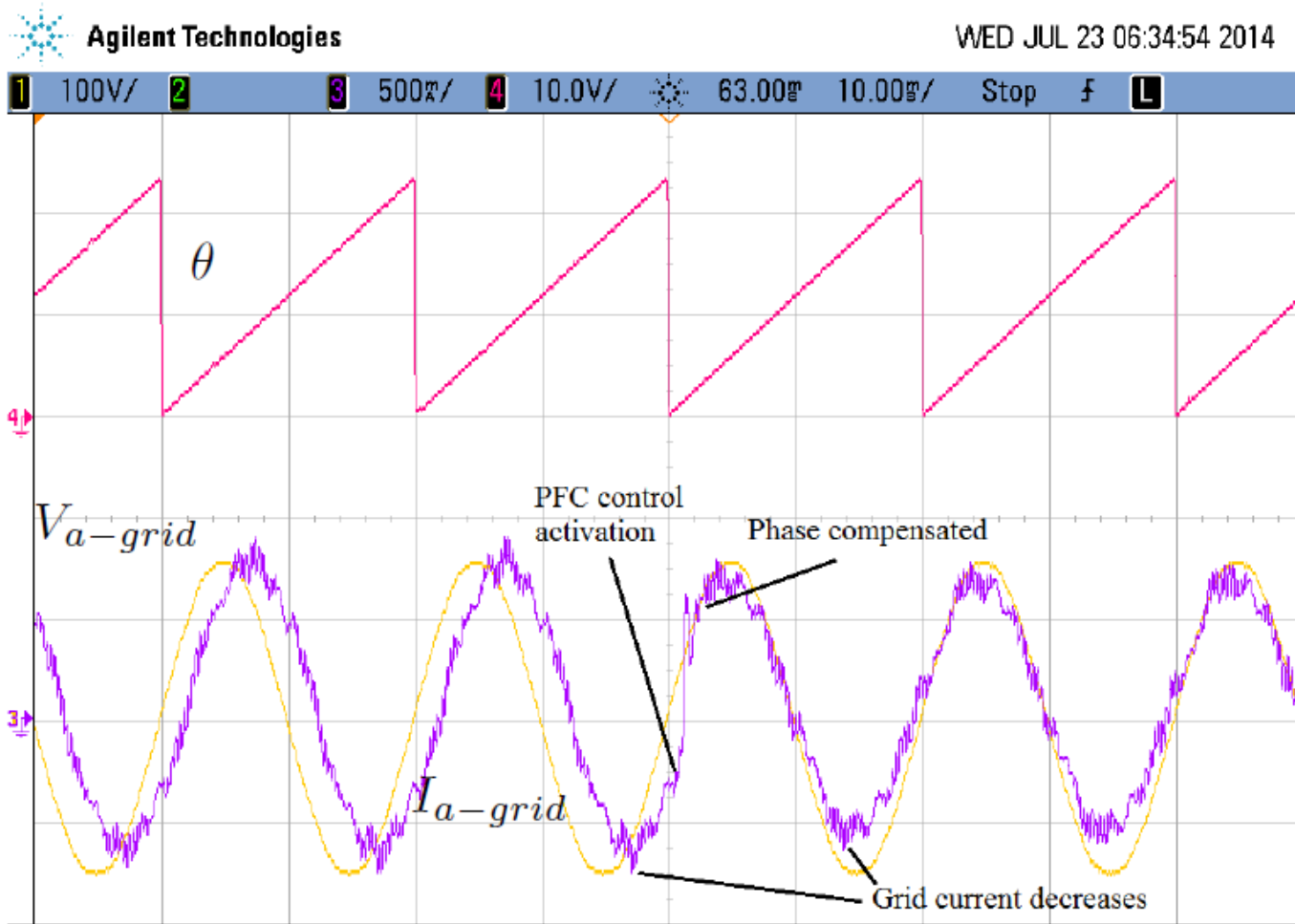
# Experimental set-up



# Experimental results



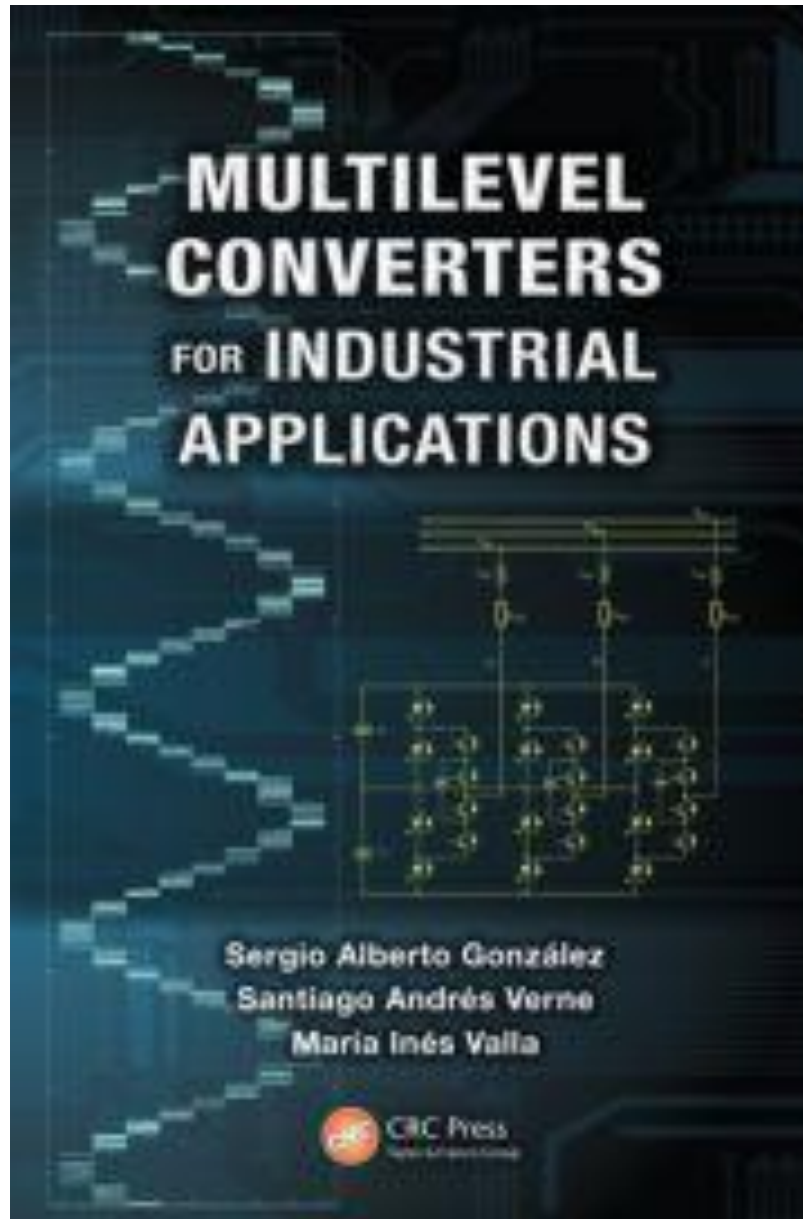
# Experimental results



# Pros & Cons

## Proposed MCSI:

- ☺Modularity and Fault Tolerant operation
- ☺Easy current balance
- ☺Multilevel output with single DC current source
- ☺Easy application of VSI control theories
- ☺Parallel processing of control signals →FPGA! →High speed control & safety
- ☺Matlab Simulink® Simulation & Programming →Software/Hardware simulation
- ☺Inductors vs. Capacitors life
- ☺ High efficiency → Zero state strategy & Overlapping conduction



# THANK YOU!

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