A Series-*LC*-Filtered Active Damper for AC Power Electronics Based Power Systems

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Outline

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- Background and Challenge
- Series-LC-Filtered Active Damper
- Performance Validation
- Conclusions

Background

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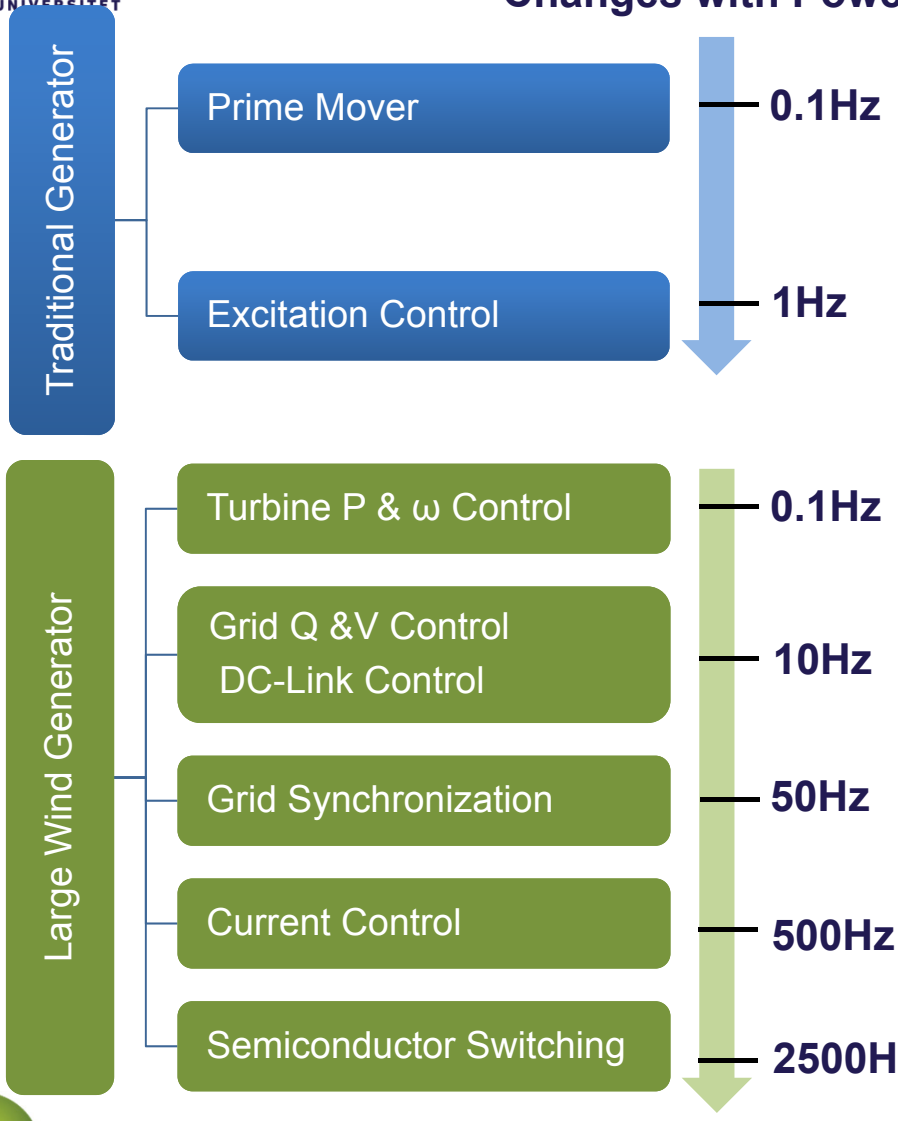
Power Electronics Based Power Systems

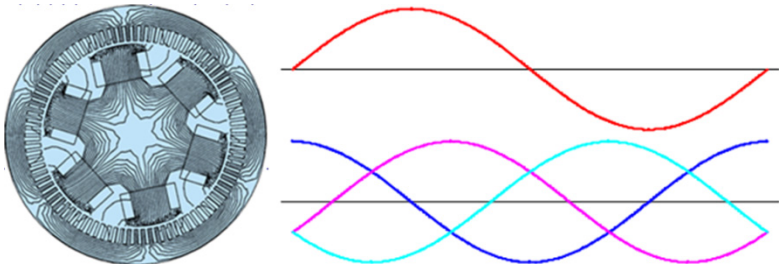




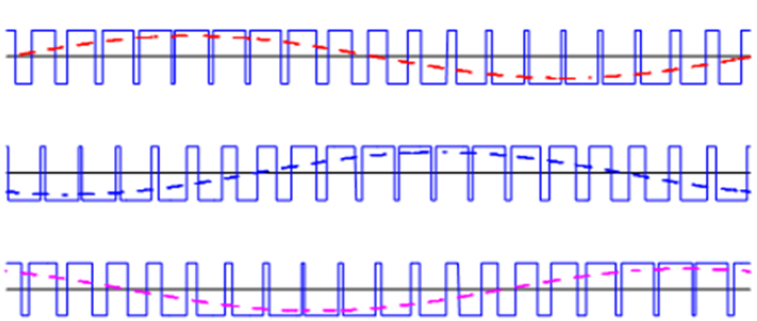

Background

Changes with Power Electronics

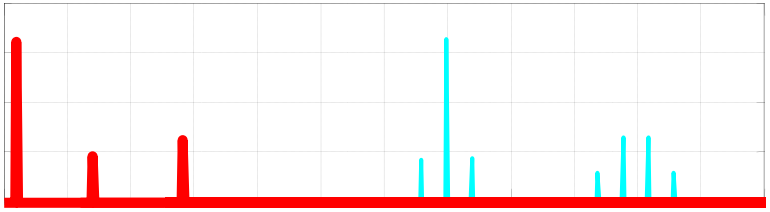




Traditional Generator Output Voltage



Wind Generator Output Voltage



Harmonic Spectrum

Challenge

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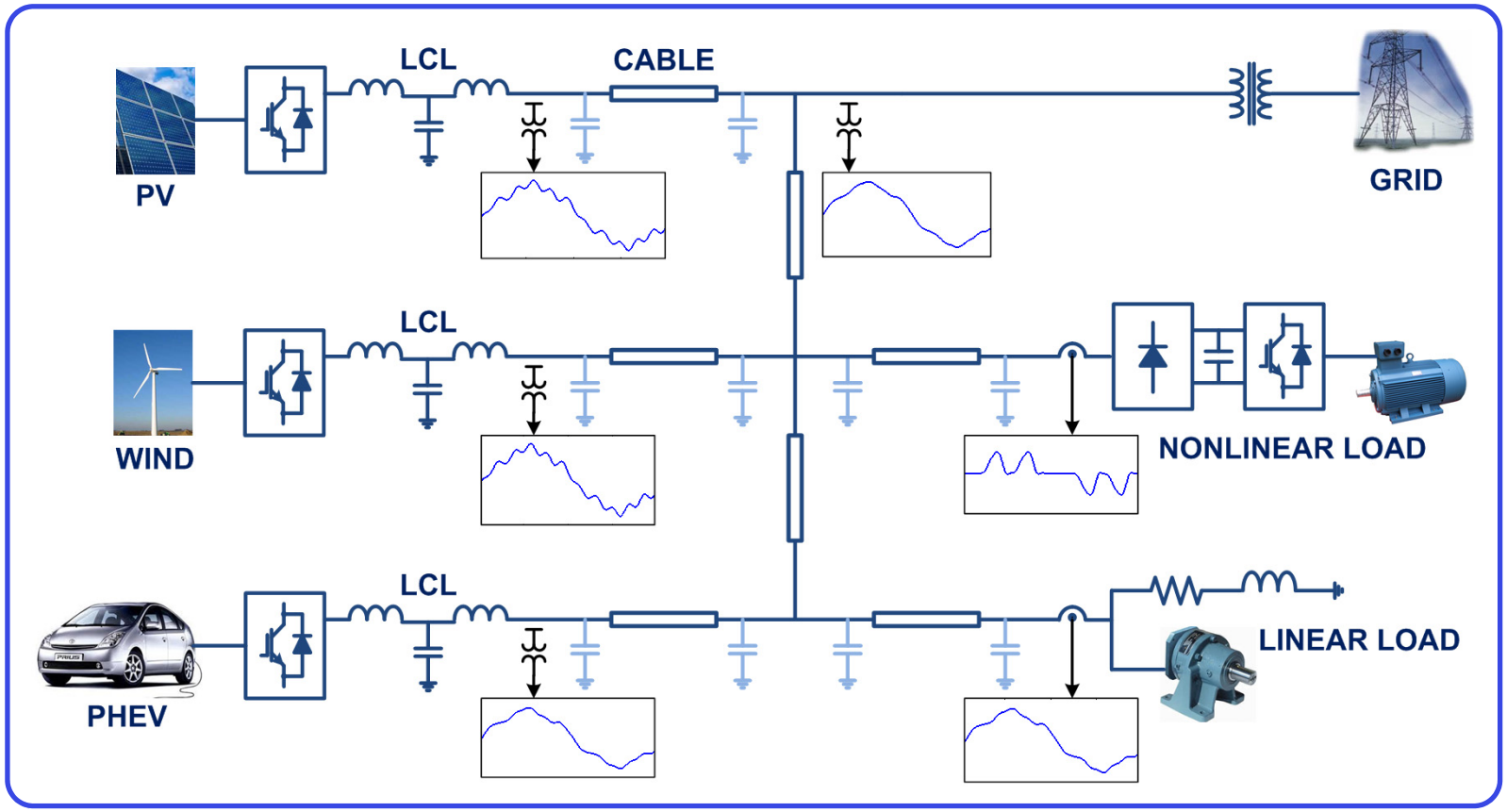

- Cost-effective diode rectifiers – low-order (50 Hz - 2 kHz) harmonics
- Increasing high-order (2 kHz - 150 kHz) switching harmonics
- Wideband controller interactions of converters – harmonic instability

Challenge

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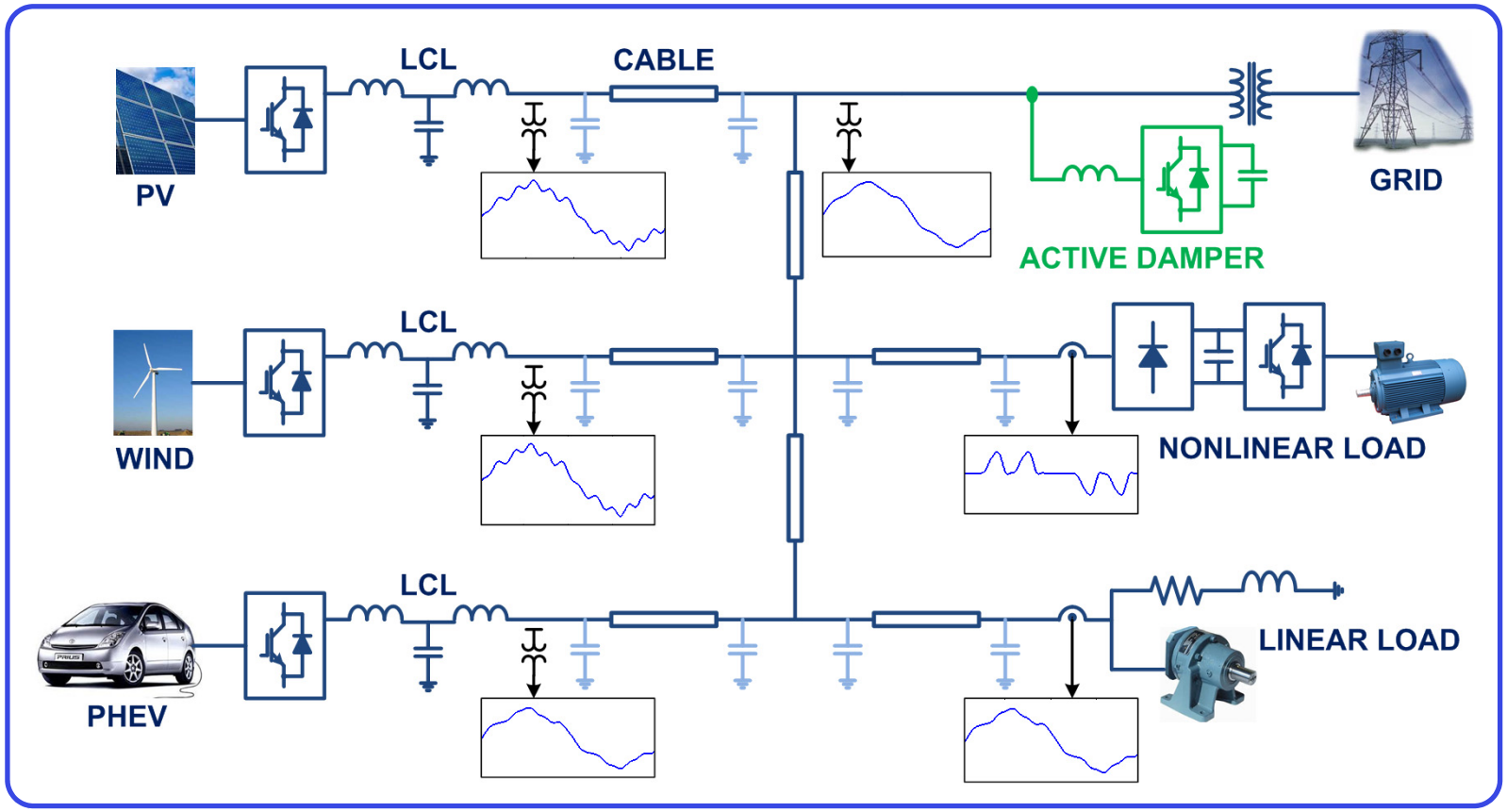

- Stabilizing converter-converter and converter-grid interactions
- Variable damping of harmonic resonance
- High dc-link voltage for high-frequency output current

Series-LC-Filtered Active Damper

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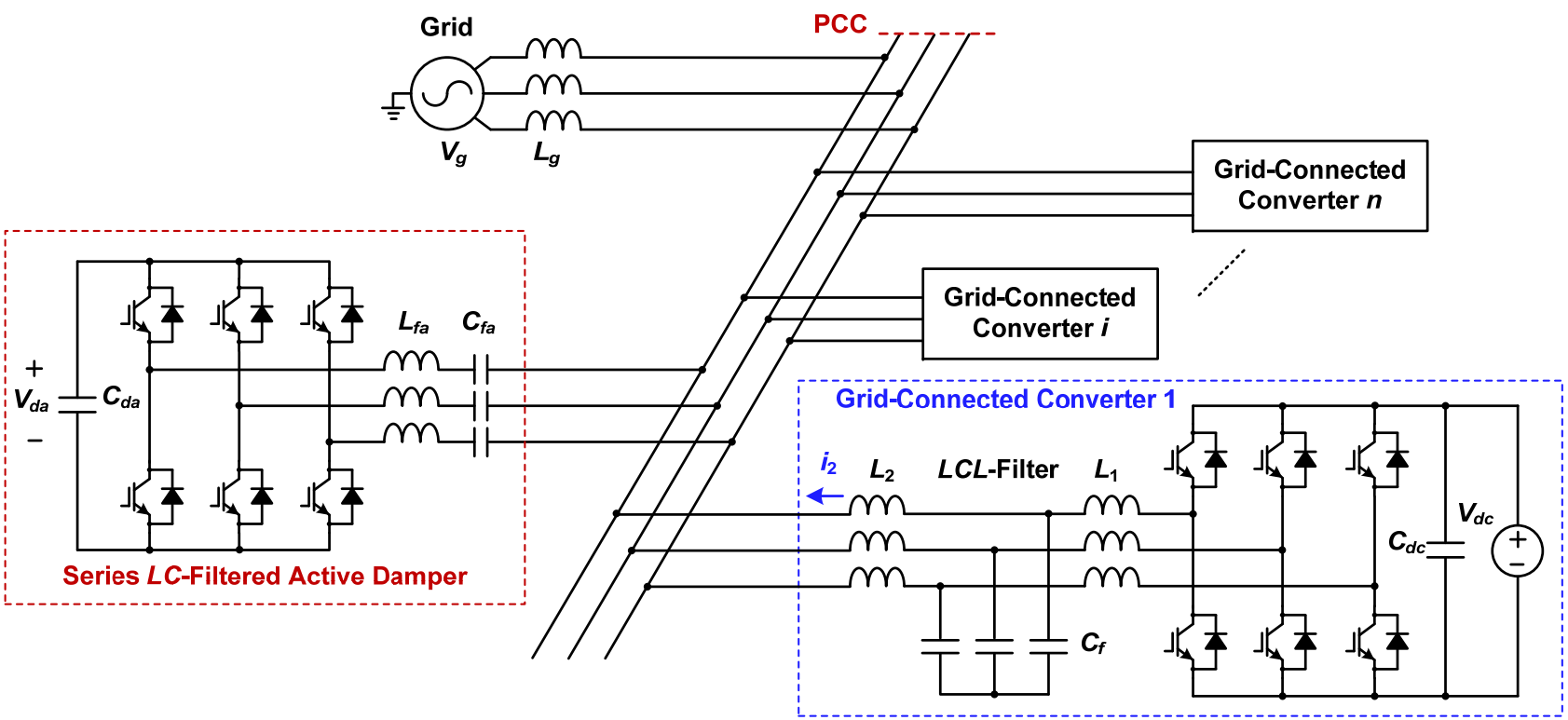

- Series ac capacitor for reduced dc-link voltage
- LC-filter resonance frequency < system resonance frequency
- Capacitive filter plant below the filter resonance frequency

T35.4 - Current control of grid converters connected with series ac capacitor

Series-LC-Filtered Active Damper

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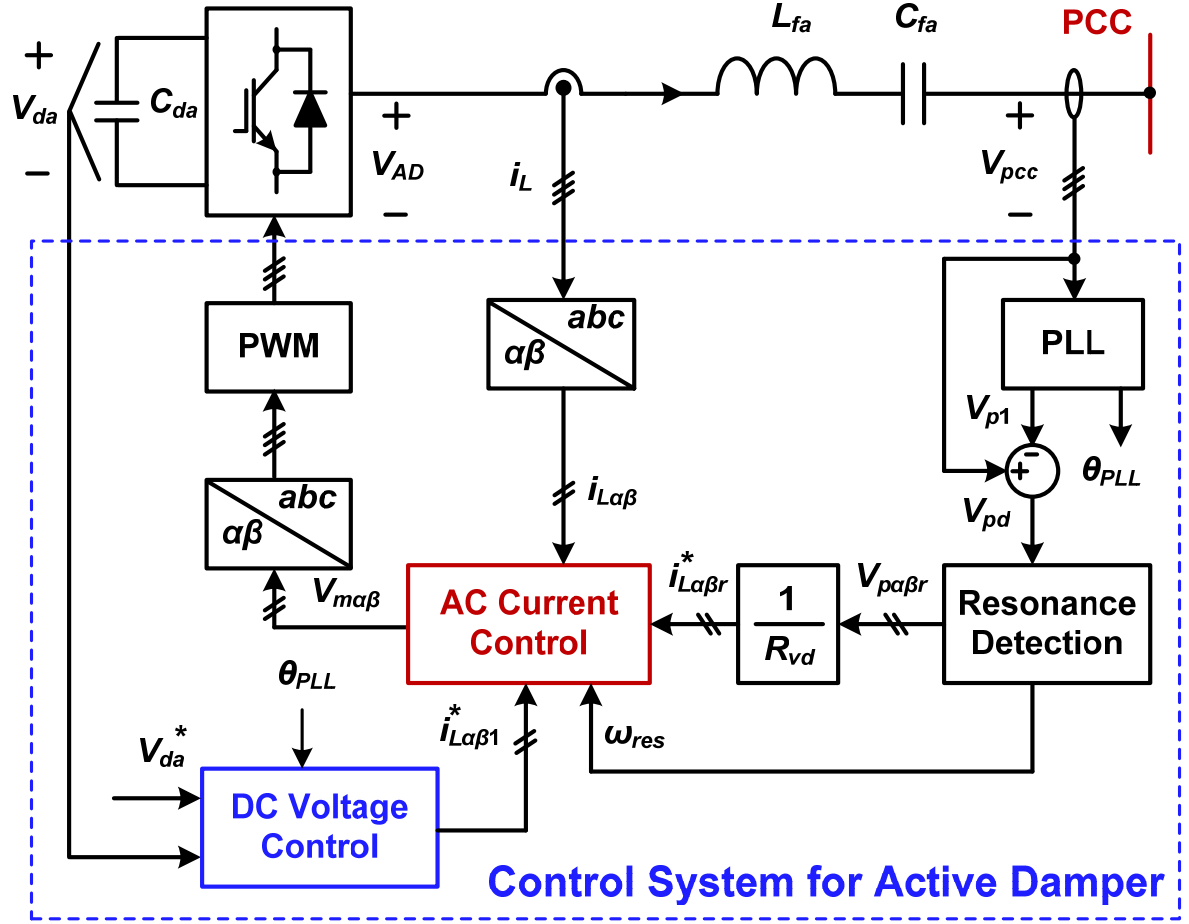

- Resonance Detection
- DC Voltage Control
- AC Current Control

Series-LC-Filtered Active Damper

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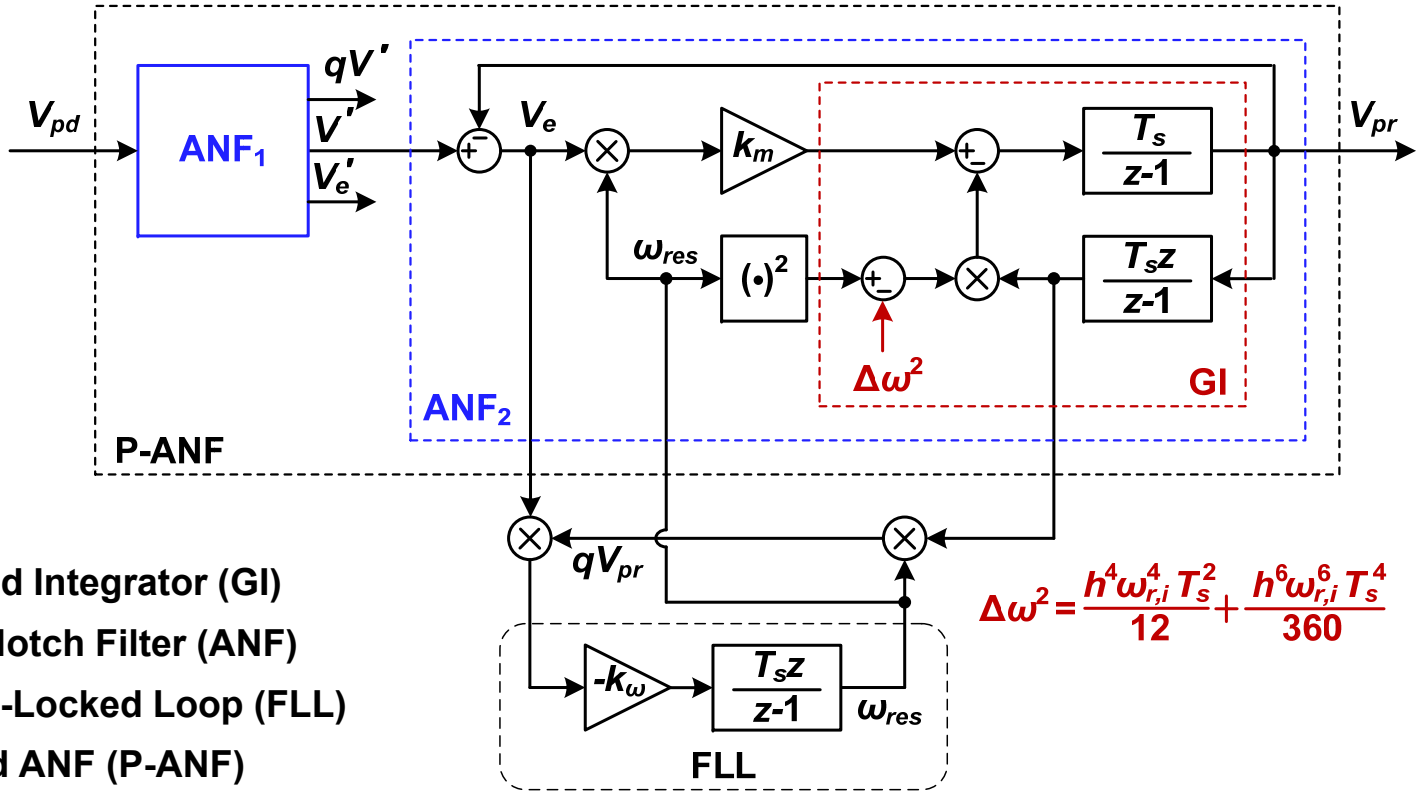
- **Resonance Detection for Unknown Frequency**



$$\Delta\omega^2 = \frac{h^4\omega_{r,i}^4 T_s^2}{12} + \frac{h^6\omega_{r,i}^6 T_s^4}{360}$$

- **Generalized Integrator (GI)**
- **Adaptive Notch Filter (ANF)**
- **Frequency-Locked Loop (FLL)**
- **Pre-filtered ANF (P-ANF)**

X. Wang, F. Blaabjerg, and M. Liserre, "An active damper to suppress multiple resonances with unknown frequencies," IEEE APEC 2014, pp. 2184-2191.

Series-LC-Filtered Active Damper

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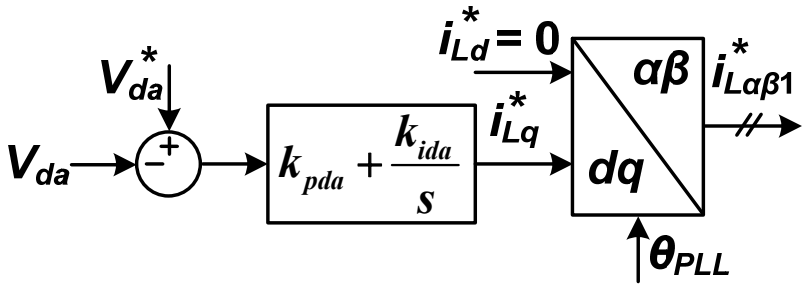
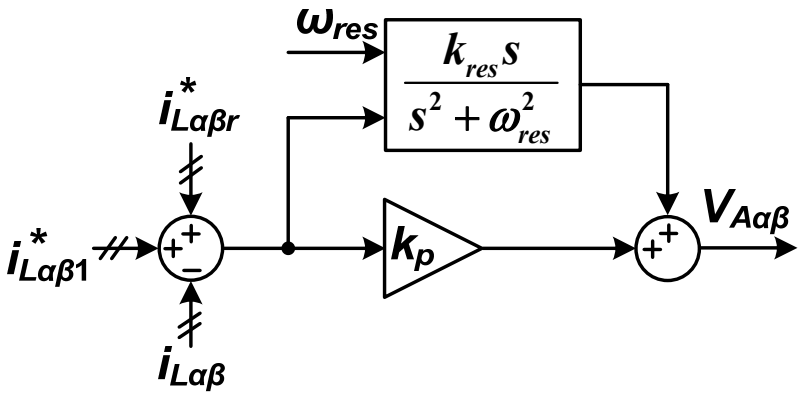
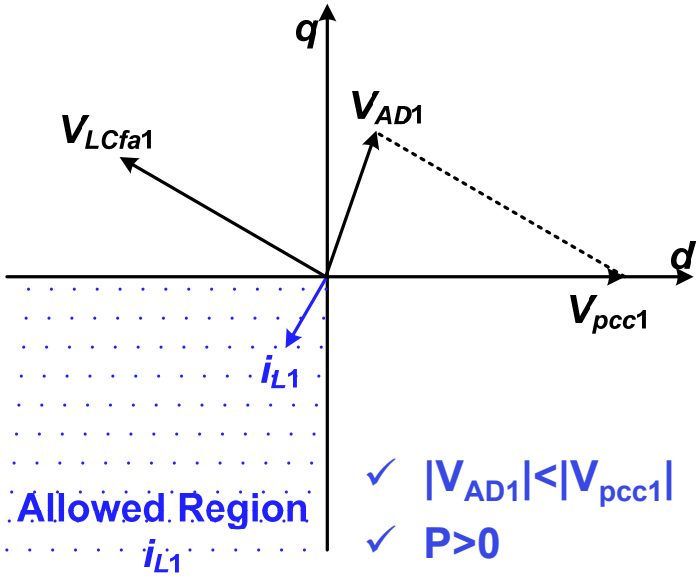
- DC-link voltage control – *q*-axis



- AC current control – proportional control





Series-LC-Filtered Active Damper

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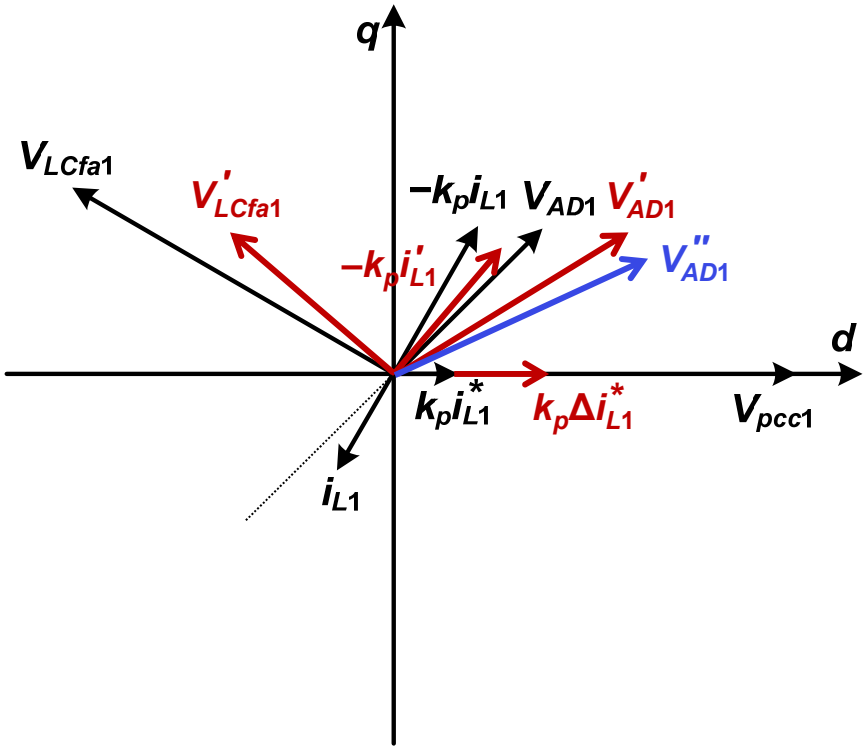
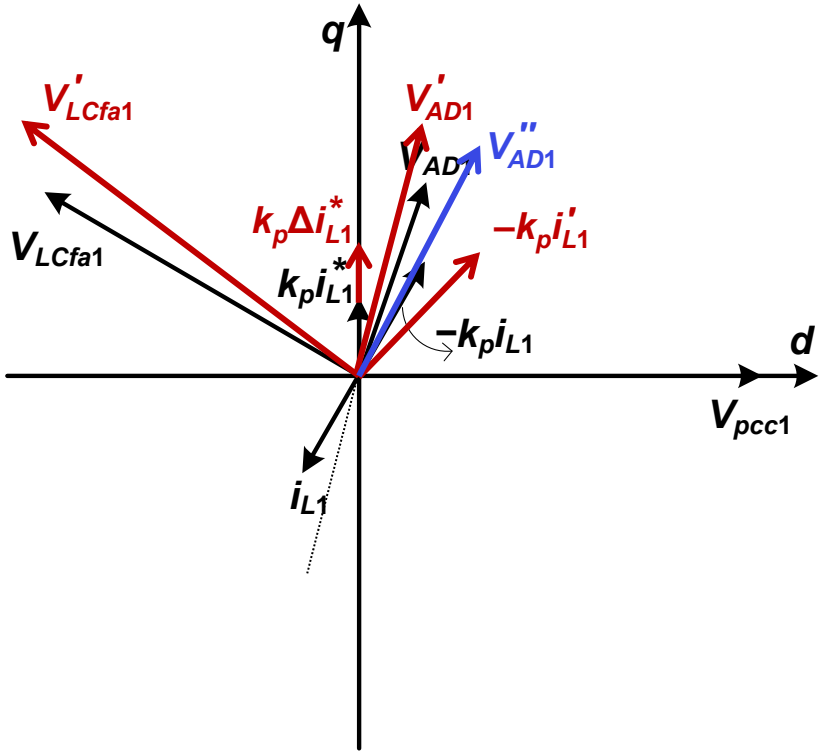
- Why aligning at *q*-axis ?



d-axis (inductive Q)



q-axis (capacitive Q)

Inherent positive feedback when aligning the reference at *d*-axis

Performance Validation

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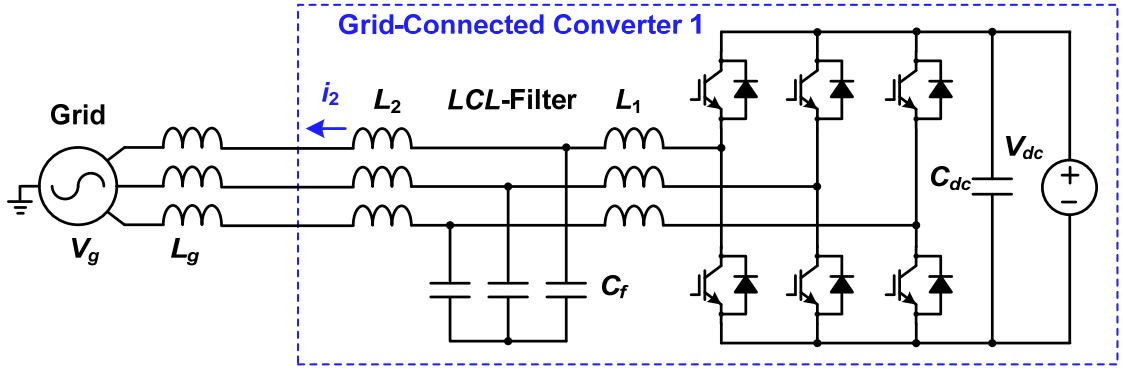
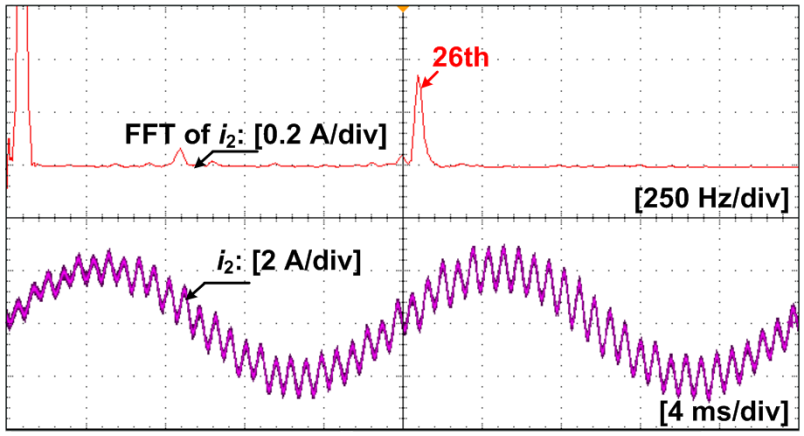
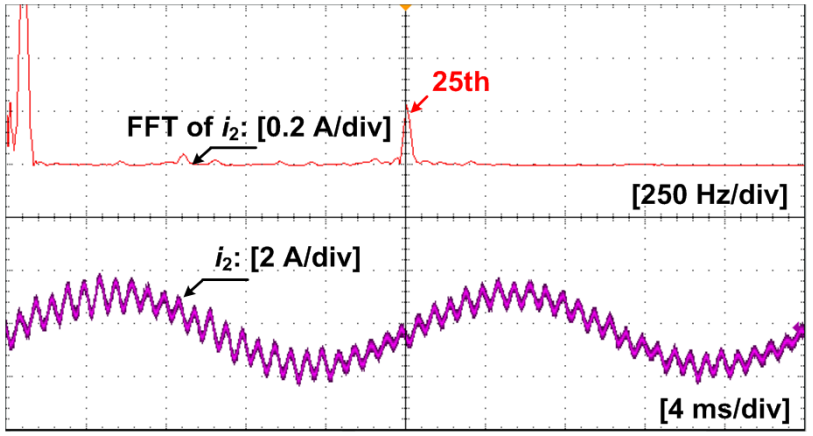
- **Unstable current control of grid converter**





L_g = 0.9 mH



L_g = 1.8 mH

Performance Validation

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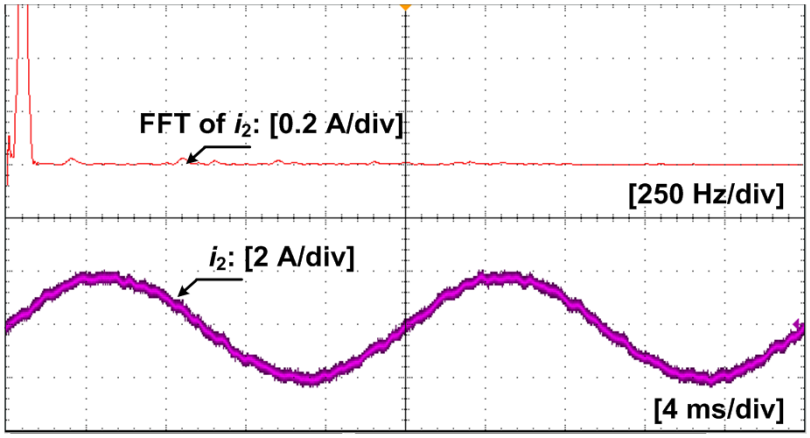
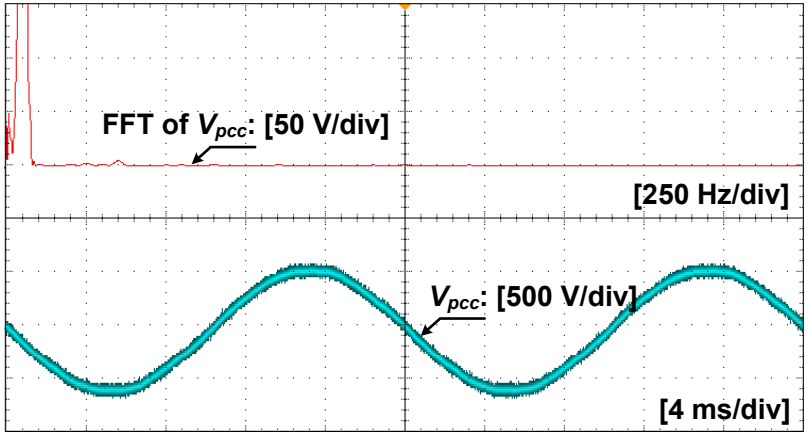
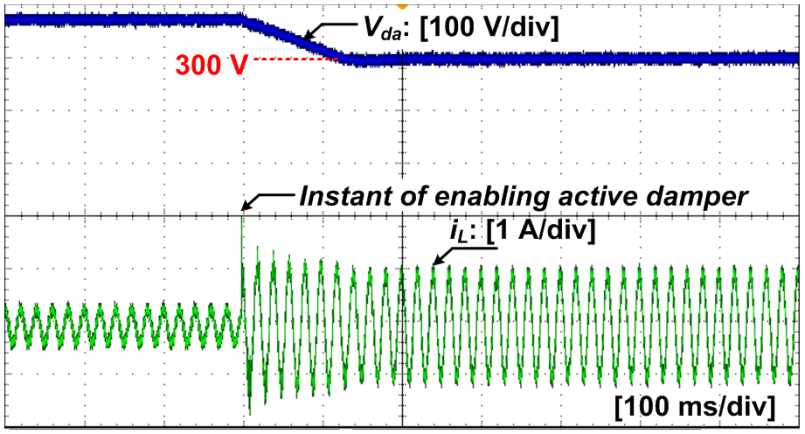
- **Stable current control of grid converter with active damper**



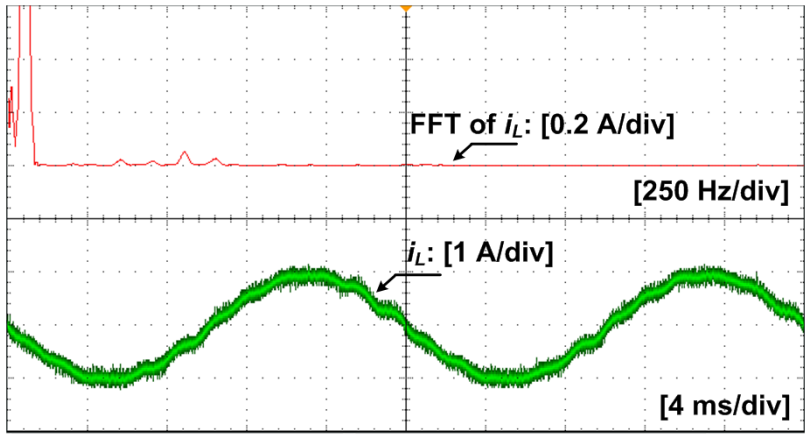
Current of grid converter



PCC voltage



DC-link voltage and ac current of damper



Damper current spectra

Conclusions

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- A series-LC-filtered active damper is proposed for stabilizing ac power electronics based power systems.
- An inherent positive feedback is elaborated when aligning the current reference at the *d*-axis.
- Experimental results validate the performance of the proposed active damper.

Acknowledgement

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IEEE JESTPE – Special Issue on Harmonic Stability and Mitigation in Power Electronics Based Power Systems

Extended Deadline: May 15, 2015

Thank You! Questions?

“ THE HIDDEN HARMONY IS BETTER THAN THE OBVIOUS ”

- P. PICASSO

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