

Active Damping of LLCL-Filter Resonance Based on LC-Trap Voltage or Current Feedback



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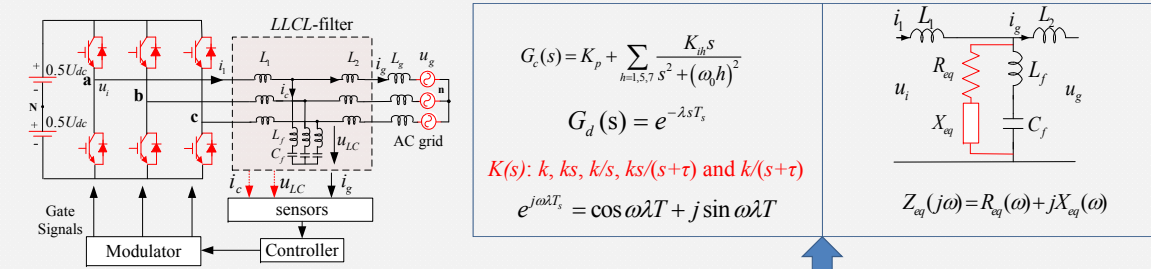
Min Huang, Xiongfei Wang, Poh Chiang Loh, Frede Blaabjerg
Department of Energy Technology, Aalborg University, Denmark

DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

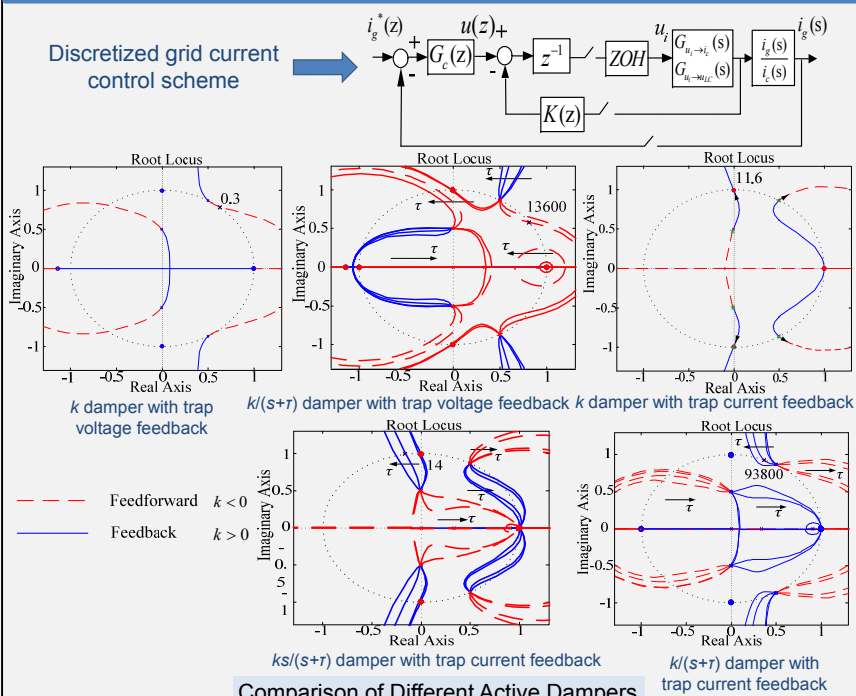
Abstract

In this paper, a capacitor current damper is investigated for LLCL-filter with its limitations clarified with and without delays considered. The investigation is also performed with LC-trap voltage feedback, which based on the formulated transfer functions and experimental results, allows a simple proportional damper to be used with much faster dynamic and lesser anticipated complications. Characteristic circuit equivalences for all dampers presented have also been derived, from which quick damping insights can easily be drawn. These equivalences can therefore be helpful tools to the practicing engineers.

Control of LLCL-Filtered Grid Converter



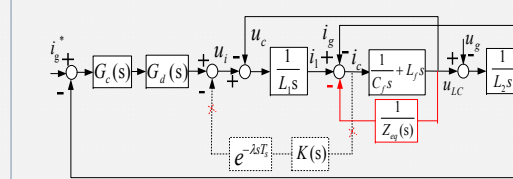
Root-Locus Analyses with Different Active dampers



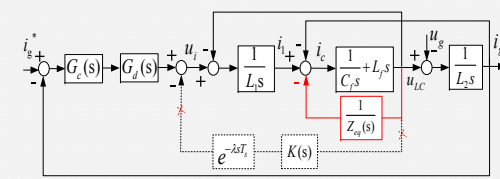
Comparison of Different Active Dampers

Sensed Variable	Trap voltage, u_{LC}		Trap current, i_c		
	k	Low-pass, $k/(s+\tau)$	k	High-pass, $ks/(s+\tau)$	Low-pass, $k/(s+\tau)$
Damper Type	k	Negative k	k	Positive k	Positive k
Stable Range	$-0.3 < k < 0$	Negative k Lower limit dependent on τ	$0 < k < 11.6$	Positive k Upper limit dependent on τ	Positive k Upper limit dependent on τ
Critical Frequency, f_n	$f_s / 3$	Between $f_s / 6$ and $f_s / 3$	$f_s / 6$	Between $f_s / 6$ and $f_s / 3$	Between 0 and $f_s / 6$
Features	Simple	Tunable with τ	Simple	Tunable with τ , but may have noise complication	Tunable with τ

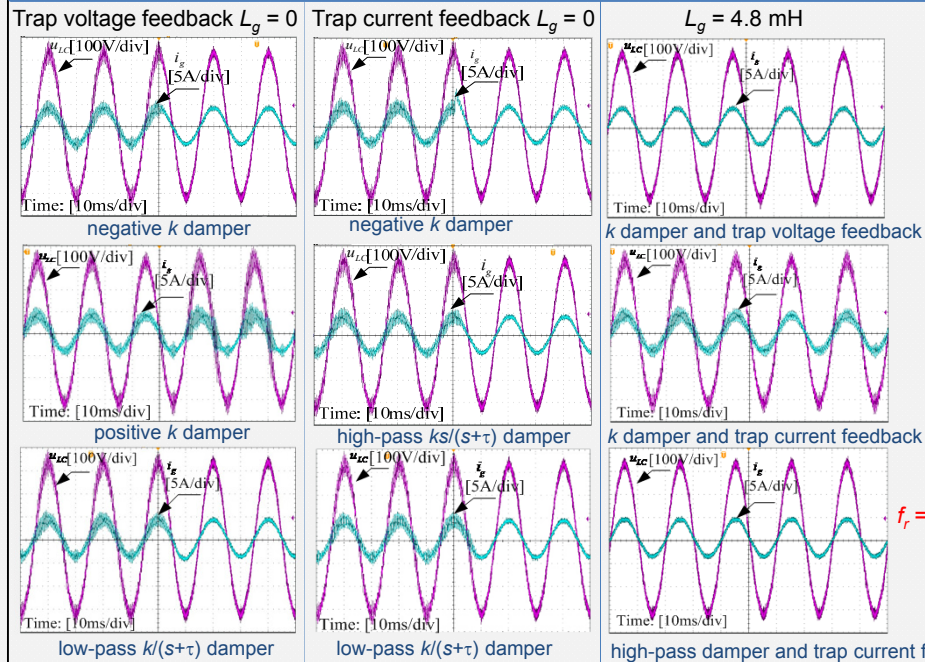
Active damper based on trap current feedback



Active damper based on trap voltage feedback



Experimental Results



System Parameters

DC-link voltage U_{dc}	650 V
Grid phase voltage U_g	220 V
Converter-side L_1	1.8 mH
Trap L_f, C_f	64 μ H, 4 μ F
Switching frequency f_{sw}	10 kHz
Sampling frequency f_s	10 kHz
Resonance frequency f_r	2.45 kHz
Grid-side L_2	2 mH
Grid inductance L_g (unless stated otherwise)	0 mH

$f_r = 1.62$ kHz is closer to $f_s / 6$