Comparative Study of Parallel Hybrid Filters in Resonance Damping

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***Abstract* -The resonance damping of parallel hybrid filters is analyzed. Active filters can be made to behave as variable resistances and/or inductances when they are connected in power systems; and the operating condition of the complete system can be adjusted dynamically to damp resonance. The effect of the hybrid filter configuration and the control strategy has been evaluated on the resonance damping, as well as harmonic filtering. The frequency characteristics of three parallel hybrid filters topologies are discussed. The principles are validated by simulation and key time-domain results are presented.**

Keywords: Parallel hybrid filters, harmonic resonance, active damping, variable impedance, harmonic filtering

I. INTRODUCTION

Apart from harmonic compensation, harmonic resonance damping in distribution systems is a problem that now needs special attention. The most effective and economic solution is to adopt hybrid filters in which the active filters works like variable fictitious components to change the system operating conditions dynamically, so as to damp resonance. Moreover, the performance of the passive filter is also improved. Depending on the filter system configuration and control strategy, the generated component may be either resistive or inductive or both. It should be emphasized that harmonic filtering and resonance damping are not always compatible with each other. A control aimed at harmonic filtering in the steady state might have a negative effect on resonance damping during system transients. This paper has made a through study of the effects of the configuration and the associated control strategies on resonance damping. Three topologies of parallel hybrid filters shown in Table I are considered. The analyses are performed mainly in the frequency domain and system frequency characteristics are studied. Simulation results are also given to show the behavior of the hybrid filter in both the steady state and transient state.

II. CONCLUSIONS

Parallel hybrid active filters can provide good resonance damping as well as harmonic filtering, but the performance depends on the configuration as well as the control strategy. The active filter acts as a fictitious impedance in the circuit and therefore changes the frequency characteristics of the system. As the nature of the active impedance can be varied by control, it provides an adaptive solution for harmonic resonance damping. However, a compromise needs to be made between harmonic filtering and resonance damping.

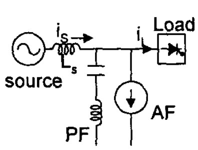
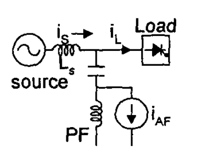
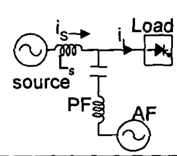
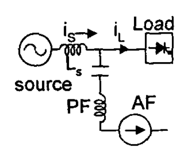
System configuration				
Types	Type-1	Type-2	Type-3	Type-3
Circuit connection of active filter	Parallel active filter and parallel passive filter	Active filter in parallel with the inductor of passive filter	Active filter in series with parallel passive filter	Active filter in series with parallel active filter
Adaptive harmonics	Current harmonic source	Current and voltage harmonic source	Current and voltage harmonic source	Current harmonic source
Damping control	$i_{AF}=-K_d di_{sh}/dt$	$i_{AF}=-K_i\int i_{Sh}dt$	$v_{AF}=K_p i_{Sh}$	$i_{AF}=V_{F1}/Z_F-i_{Lh}$, $V_{AF}=I_{Lh}Z_F$
Active impedance	$Z_D=r_D$ $r_D=L_s/K_d$	$Z_D=r_D+1/sC_D$ $r_D=K_iL_F$, $C_D=1/K_iR_F$	$Z_D=r_D$, $r_D=K_p$	$Z_D=-Z_F$
Damping method	Inject resistive current to increase the damping factor	Inject partially resistive current to increase the damping factor	Insert a voltage to the line to isolate harmonic propagation between source and load	Insert a negative voltage to the PF to shortcircuit the load harmonic current
Filtering performance	Excellent for $f \geq f_n$*	Excellent for $f \geq f_n$	Excellent for $\|f-f_n\| \leq \Delta f$	Excellent for $f \geq f_0$
Damping effects	Effective on parallel resonance	Effective on both parallel and series resonances	Effective on both series and parallel resonances	Effective on parallel resonance
Disadvantages	Amplify the voltage harmonics	Required K_i is comparably large	Filter's bandwidth is low	No effect on series resonance

TABLE I - SUMMARY OF PARALLEL HYBRID FILTERS ON RESONANCE DAMPING
*f_n: the resonant frequency of the system