Improvement of the Shunt Active Power Filter

Dynamic Performance

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Harmonic compensation circuit with current-fed active power filter without feedback (with unity gain)

The shunt active power filter injects AC power current \( i_s \) to cancel the main AC harmonic current. The line current \( i_L \) is the result of summing the load current \( i_L \) and the compensating current \( i_s \).

\[ i_L = i_L + i_s \]

Discussion about possible solutions

For predictable loads:
1. Typical APF with non-causal control algorithms
2. Typical APF with recursive control algorithms
For unpredictable loads:
1. High speed APF
2. High power low-speed APF
3. APF with modified output inverter

The APF output inverter current ripple calculation

The circuit resonant inductance \( L_s \) at the resonance of reactor \( L_s \) is \( L_s \).

For switching state 5:0, 5:1 compensating current \( i_s \) can be calculated by formula

\[ i_s(t) = \frac{\alpha_0 L_s}{L_s} \left( \frac{1}{2} \right) \left( 1 - \cos \left( \frac{\pi t}{T_s} \right) \right) \]

and for state 0:0, 0:1, 1:0, 1:1, \( i_s \) can be calculated by formula

\[ i_s(t) = \frac{\alpha_0 L_s}{L_s} \left( \frac{1}{2} \right) \left( 1 - \cos \left( \frac{\pi t}{T_s} \right) \right) \]

where:
\[ \alpha_0 = \frac{L_s}{L_s} \]

Block diagram of APF control algorithm

Tests circuit of classical three-phase shunt active power filter

Simplified scheme

(Simplified inverter model connected to the mains power, used for current ripple calculation)

Block diagram of the output inverter simulation circuit

Time diagram of idealized compensating current \( i_s \)

Simulation waveforms of single-phase active power filter with modified output inverter in steady-state with the resistive load

Simulation waveforms of single-phase active power filter with classical output inverter in steady-state with the resistive load

Frequency spectra of line currents

Classical APF

Modified APF

For noise type nonlinear loads (such as in a arc furnace) where the load currents are not periodic and stochastic, the proposed APF with improved dynamic performance is good solution.

Conclusion

Experimental waveforms of classical active power filter in steady-state with the resistive load

Single-phase active power filter with modified inverter

Simplified diagram of modified inverter model connected to the mains power

Step responses of two inverters

Classical Inverter

Modified Inverter

Inductors for high frequency switches

Inductors for low frequency switches