

Active filters

Active filters are typically used with diode/thyristor rectifiers, electric arc furnaces, etc. Their use in electric power utilities, industry, office buildings, water supply utilities, and transportation is increasing as cost reductions in power semiconductor devices and signal processing devices make use of these filters more economically attractive. In addition to harmonic filtering, active harmonic filters are used for damping, isolation, termination, power-factor correction, voltage regulation, load balancing, and voltage-flicker reduction. Compared to passive filters, active harmonic filters provide superior filtering performance and more flexible operation, and they are more compact. However, both the cost of active filters and their operating loss are currently slightly higher than for passive filters. Unlike passive filters, active filters provide the capability of controlling reactive power for inductive loads. While active filters for power conditioning are now commercially available, the manufacturers should strive to improve the filtering performance and efficiency of these units and to reduce costs so they can better compete with traditional passive filters.

As an example of a pure active filter, a filter that draws compensating current from an ac supply to cancel out harmonic currents produced by the load. A passive high-pass filter on the ac side of the active filter eliminates switching ripples, but plays no role in canceling out dominant fifth- and seventh-harmonic currents produced by the load. The active filter control circuit uses digital signal processors, field-programmable gate arrays, and A/D converters for digital signal processing, operational and isolation amplifiers for analog signal processing, and Hall-effect current/voltage sensors.

The active filter also used for flicker compensation of ac arc furnaces. The filter uses compact injection enhancement gate transistors. Together with two single tuned filters, the active filter compensates for fluctuating reactive, negative sequence, and harmonic currents.

Pure active filters can be classified into *shunt (parallel)* active filters and *series* active filters from their circuit configurations. At present, shunt active filters are more preferable than series

active filters in terms of form and function, and therefore series active filters are suitable exclusively for harmonic filtering.

Parallel Active Power Filters (APFs)

Their principle of operation consists in eliminating those components in a non-linear load current which are not active currents, i.e. not sinusoidal and cophasal with corresponding phase voltages (Figure 7.50). A power electronics system generates a current waveform opposite in phase to the unwanted component in the load current. This device, connected in parallel to the disturbing load, unbalanced and non-linear, as seen in Figure 7.51, causes the supply currents to be near sinusoidal, balanced and cophasal with the corresponding supply voltages.

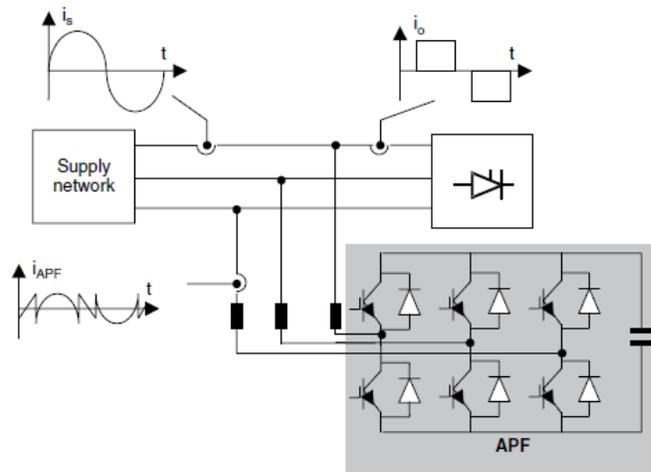


Figure 7.50 Shunt active power filter

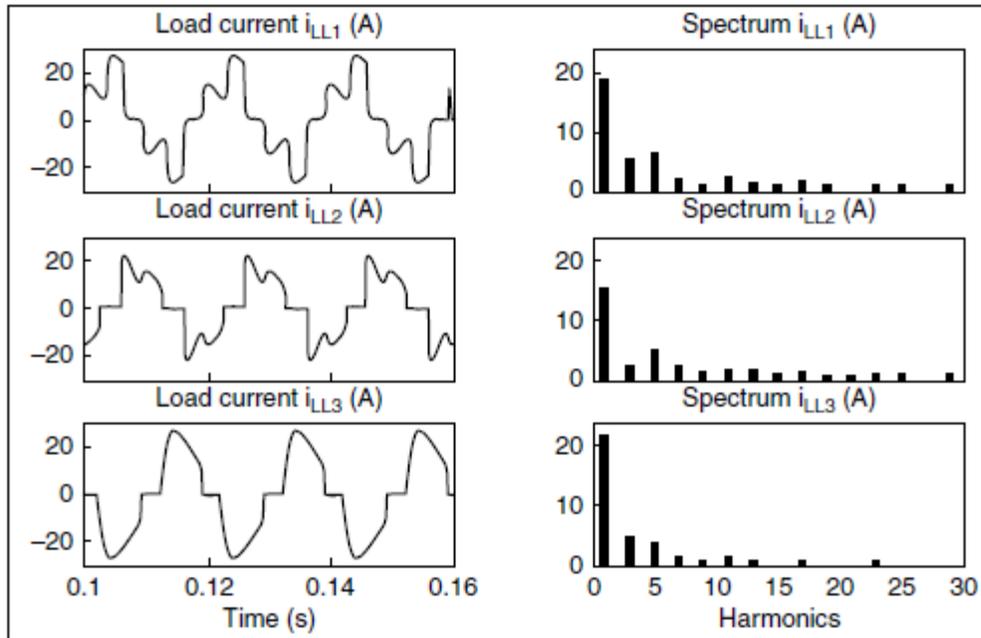


Figure 7.51 The time waveforms and frequency spectra of the supply current: prior to the active filter connection

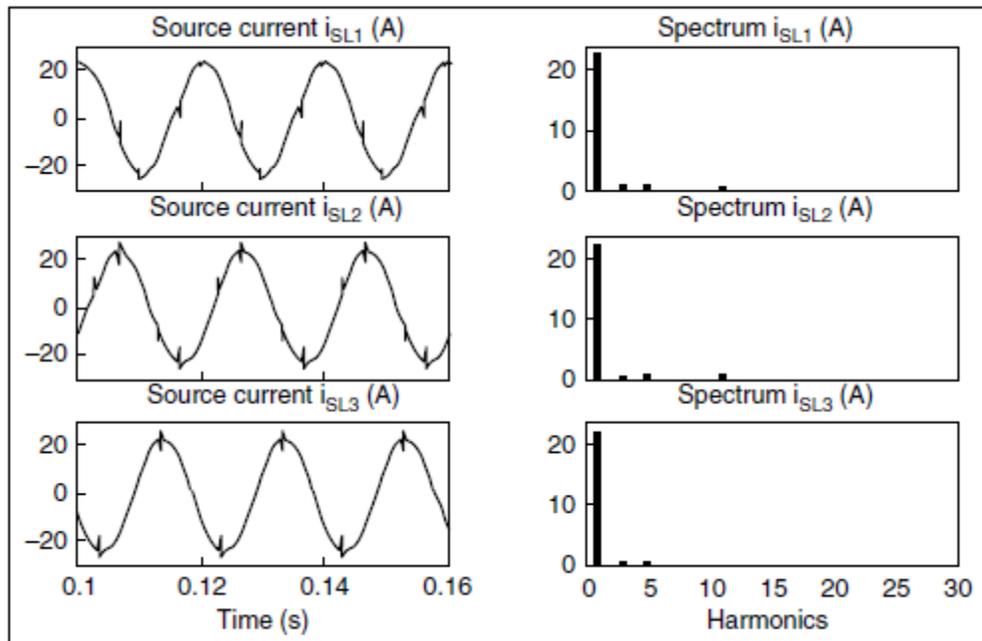


Figure 7.51 The time waveforms and frequency spectra of the supply current: after the active filter connection

Series Filters

Series filters belong to those technical solutions which modify the impedance of supply networks. Their purpose is not to reduce the equivalent impedance of the source, but on the

contrary to increase it for selected harmonic(s) (Figure 7.52). As a result, they prevent the injection of selected harmonic currents into the supply network. For instance, the effectiveness of a parallel passive filter connected to a non-linear load, represented by the current source $I_{(n)}$ in Figure 7.52, is substantially improved. The value of the equivalent impedance Z_F of a series filter should be:

- Close to zero for the fundamental harmonic, in order not to affect the energy exchange between the supply source and the load (in the domain of this harmonic)
- Very large for the filtered (blocked) harmonic in effect this harmonic current will not be present in the supply network.

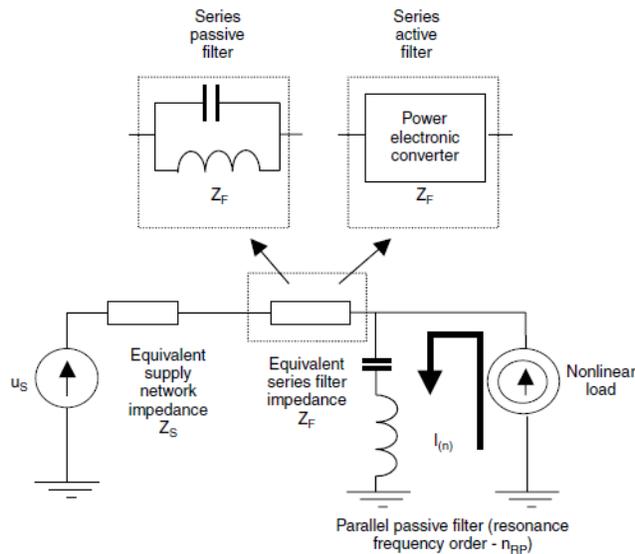


Figure 7.52 Series filter for supply voltage harmonic elimination

The series filter can be implemented as a passive or active device. In the first case, in its simplest form, it is a two-terminal LC network, in which parallel resonance for the harmonic of order n_R occurs, connected in series between the supply source and the load.

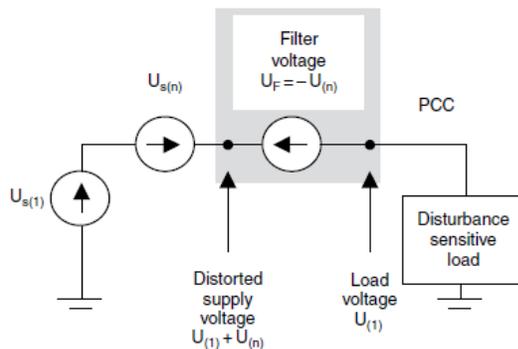


Figure 7.53 Active series filtering of supply voltage harmonics: (a) schematic diagram

For this harmonic the filter impedance is of very large value, thus its current flow in the supply network is blocked. The impedance Z_F of the series active filter is controlled by means of an appropriate power electronics circuit. If the supply voltage contains, apart from the fundamental harmonic, also a high harmonic, the latter can be eliminated at the sensitive load terminals by means of the series filter, as in Figure 7.53. This filter generates the voltage which is opposite in phase to the unwanted distorting component and in this way guarantees that the supply voltage at PCC is sinusoidal.

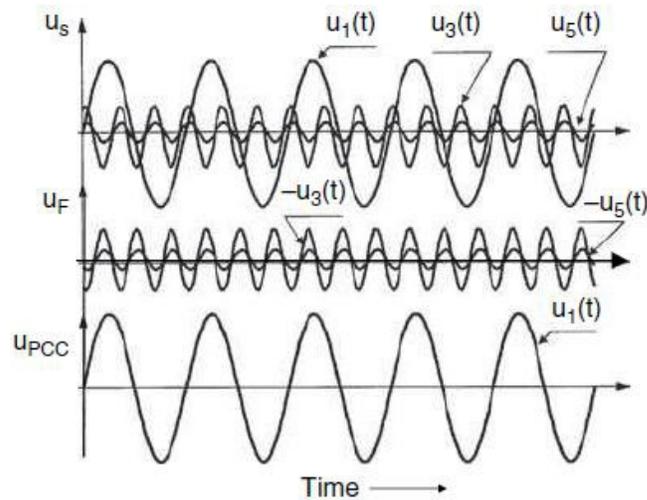


Figure 7.53 Active series filtering of supply voltage harmonics: waveforms illustrating the principle of operation

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