Active Power Filter for Residential Distributed System

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Introduction
Nowadays, the rapid growth of nonlinear electronic home appliances has resulted in significant voltage and current waveform distortions in residential distribution systems. Although each of the consumer electronic devices is not individually a big source of harmonics, the collective effect will be considerable and can become a serious concern of utility companies.

The main purpose of this research is to invent a novel active power filter for residential power distributed system. Compared with the traditional centralized APF, distributed APF has its unique superiority for residential distribution system. The realization scheme of distributed APF is proposed in this research.

Features & Advantages of Distributed APF

• Unlike traditional centralized APF which are used in medium-voltage circumstance, distributed APF can be installed at either customers’ house or the secondary side of service transformer, which can address the distributed harmonics at residential system

• Compared with the centralized counterpart, distributed APF is used for low-voltage applications, and therefore it is more cost-effective

• The control scheme of distributed APF is very flexible. It can be controlled to exhibit a low resistive impedance at all of the harmonic frequencies while appearing as an open-circuit for the fundamental frequency component. “Virtual-impedance” scheme can be adopted to realize distributed APF

• Whether distributed APF is installed at service transformers or one of the houses, a portion of the harmonics from the other parts of system (associated with other service transformers) will be also mitigated.

Case Study

Parameters of the studied case:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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<tbody>
<tr>
<td>Primary equivalent impedance</td>
<td>Z_{eq} = 0.4806+2.5833j Ω</td>
</tr>
<tr>
<td>Service transformer voltage ratio</td>
<td>14.4kV/120V/120V</td>
</tr>
<tr>
<td>kVA rating</td>
<td>37.5kVA</td>
</tr>
<tr>
<td>Impedance</td>
<td>2%pu</td>
</tr>
<tr>
<td>Resistance</td>
<td>1.293 %pu</td>
</tr>
</tbody>
</table>

Performance of virtual-impedance APF when Rv=0.1ohm (kV=10b) by HPF scheme

System Level compensation results (from previous research at U of A): Performance of virtual-impedance APF by BPF scheme, and the same Rv case and selective Rv case (0.01ohms for 3rd harmonic, 0.005ohms for 5th harmonic, and 0.002ohms for the rest) are verified here.

Conclusions

• Distributed APF has its unique advantage for addressing the harmonics of residential distribution system.

• Virtual impedance scheme is adopted for the control of distributed APF.

• A case study is presented to verify the proposed scheme. For one service transformer, separate distributed APF can result in good performance at a properly designed value of virtual impedance.

• For HPF scheme, Rv should be greater than 0.016ohms; as for BPF scheme, the selective Rv values for separate harmonics can be smaller, and selective Rv values can lead better performance.