State Current Controller with Oscillatory Terms for Three-level Grid-connected PWM rectifiers under Distorted Grid Voltage Conditions

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Objectives

Development of a control method based on a linear-quadratic (LQ) current controller which enables a three-phase grid-connected converter to:

- draw balanced input currents from a balanced/unbalanced voltage source,
- shape near sinusoidal inputs currents in the presence of a distorted voltage source.

PWM rectifier control strategy

LQ current controller with integral and oscillatory terms

Selective harmonic compensation: \( W^{(k)} = -\text{diag}([\text{diag}(h_{\omega})^2, (h_{\omega})^2]) \), where \( h = \{2, 6, 12\} \) – harmonic order

Tustin approximation with frequency prewarping: \( H(s)^{(k)} = \frac{s+1}{2s+1}, H(s)^{(0)} = \frac{s+1}{2s+1} \)

Experimental results

An LQ current controller in the synchronous reference frame has been designed for PWM rectifier operated under distorted grid voltage conditions. Two current control strategies are verified in the experiment:

- In the case A, the presented state regulator without the oscillatory terms is applied, wherein the obtained currents are polluted by higher order harmonics.
- In the case B, six oscillatory terms are incorporated to ensure balanced currents and reduce the components of the pulsations 5\( \omega \), 7\( \omega \), 11\( \omega \) and 13\( \omega \) (the most influential low-order voltage harmonics) in the current represented in the natural coordinates. The converter current THDs have decreased twofold. The currents are balanced as it is apparent from RMS of the 1st harmonic.

Summary

The exemplary numerical model is available at MATLAB Central as “LQ current controller with oscillatory terms”.

Table

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{dc} )</td>
<td>350 V</td>
<td>Nominal DC-link voltage</td>
</tr>
<tr>
<td>( V )</td>
<td>185 V</td>
<td>Nominal grid voltage RMS value</td>
</tr>
<tr>
<td>( \omega )</td>
<td>100( \pi )</td>
<td>Nominal pulsation of the grid voltage</td>
</tr>
<tr>
<td>( L )</td>
<td>2.0 mH</td>
<td>Inductances of the input filter</td>
</tr>
<tr>
<td>( R_{load} )</td>
<td>66 ( \Omega )</td>
<td>Resistances of the load</td>
</tr>
<tr>
<td>( F_s )</td>
<td>10 kHz</td>
<td>Switching/sampling frequency</td>
</tr>
</tbody>
</table>

Numerical model

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Contact Information

Invitation