Wishlist: Multi-Resonant
ZVS-MR Buck

Operating Modes

Figure 10.7: Load-to-output DC characteristics of a 2V-MR converter operating in modes \((I, I')\).

Figure 10.2: Typical waveforms for a 2V-MR converter operating in modes \(I_1\) (a), \(I_1\) (b) or \(II_2\) (c).
Identification of Resonant Switch
Switching Cell Conversion Ratio
Conversion Ratios of Various Switch Cells

\[ P_{1/2}(x) = \frac{1}{2\pi} \left[ \frac{1}{2} x + \pi + \sin^{-1} x + \frac{1}{x} \left(1 - \sqrt{1 - x^2}\right) \right] \]

\[ P_1(x) = \frac{1}{2\pi} \left[ \frac{1}{2} x + 2\pi + \sin^{-1} x + \frac{1}{x} \left(1 - \sqrt{1 - x^2}\right) \right] \approx 1 \]

<table>
<thead>
<tr>
<th>Switch Cell</th>
<th>Conv. Ratio ( \mu )</th>
<th>Current Range</th>
<th>Conv. Ratio Range</th>
<th>Requirements on ( Q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM</td>
<td>( D )</td>
<td>N/A</td>
<td>( 0 \leq \mu \leq 1 )</td>
<td></td>
</tr>
<tr>
<td>ZVS-QR (half)</td>
<td>( 1 - FP_{1/2}(J_L) )</td>
<td>( 1 \leq J_L \leq \infty )</td>
<td>( 0 \leq \mu \leq 1 )</td>
<td></td>
</tr>
<tr>
<td>ZVS-QR (full)</td>
<td>( 1 - FP_1(J_L) )</td>
<td>( 1 \leq J_L \leq \infty )</td>
<td>( 0 \leq \mu \leq 1 )</td>
<td>Bidirectional voltage</td>
</tr>
<tr>
<td>ZCS-QR (half)</td>
<td>( FP_{1/2}(J_L) )</td>
<td>( 0 \leq J_L \leq 1 )</td>
<td>( 0 \leq \mu \leq 1 )</td>
<td>Unidirectional Current*</td>
</tr>
<tr>
<td>ZCS-QR (full)</td>
<td>( FP_1(J_L) )</td>
<td>( 0 \leq J_L \leq 1 )</td>
<td>( 0 \leq \mu \leq 1 )</td>
<td></td>
</tr>
</tbody>
</table>
Resonant Switch Identification Examples
ZCS-QR Boost
SSM - PWM Parent

\[ V_s(t) + v_1(t) - v_2(t) + \int_0^t v_1(t) dt - i_1(t) - i_2(t) + v_2(t) - \int_0^t v_2(t) dt = 0 \]
SSM, PWM Case

Textbook, Fig. 7.17(a)
ZVS-QR Switch Cell SSM
SSM, Soft-Switching Buck
PWM Transfer Functions
QR Transfer Functions
Example
Control-to-Output Transfer Function
Control-to-Output Transfer Function