Inductor Multipliers

Active solutions for enhancing the effects of inductors to enable SOP integration of power management systems.

Inductor Enhancing Effects of Active Ripple Filters

\[ L \cdot \Phi_{IL} = \frac{dt}{di} \]

If switching frequencies are limited, then decreasing the inductance requires that the voltage across the inductor also decrease (a) or else the excess ripple must be subtracted from the output (b) to maintain accuracy.

(a)  
(b)

Methods Proposed in the Literature

A. Makharia and G.A. Rincón-Mora

Ideally the ripple is redirected into the circuit and away from the output, but voltages in the circuit prevent this, and the ripple must be directed to ground.

The series elements in a voltage mode inductor multiplier present inherent loss.

Methods Proposed in the Literature

L.E. LaWhite and M.F. Schlect

Use two transistors and a small inductor to efficiently sense the voltage or current before the inductor and drive a ripple cancelling voltage or current.

Analysis of Methods

The voltage sense / current drive technique achieves the highest inductance of all the active solutions.

Methods Proposed in the Literature

D.C. Hamill and O.T. Toh

P. Midya and P.T. Krein

Sense the ripple current before the current sink and after it to achieve higher attenuation.

Predict the ideal ripple-cancelling current from knowledge of the duty cycle and the inductance.

SOP Integration of Portable Electronics

- Consumer
- Biomedical
- Military
Inductors as Passive Filters in Buck Converters

Inductorless Alternatives

Linear Regulators and Virtual Inductors are inefficient, while Charge Pumps can only provide small currents.
Inductor Enhancing Effects of Active Ripple Filters

\[ V_L = L \cdot \frac{di_L}{dt} \]

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L.E. LaWhite and M.F. Schlect
### Analysis of Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Magnitude</th>
<th>Accuracy</th>
<th>Efficiency</th>
<th>Space</th>
<th>Power</th>
<th>Stability</th>
<th>Cost</th>
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<tbody>
<tr>
<td>External Inductor</td>
<td>NA</td>
<td>NA</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Moderate</td>
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<tr>
<td>Integrated Inductor</td>
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<td>Poor</td>
<td>Good</td>
<td>Moderate</td>
<td>Good</td>
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<tr>
<td>Virtual Inductor</td>
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<td>Moderate</td>
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<td>Good</td>
<td>Moderate</td>
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<td>Sensor Multiplier</td>
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<td>Good</td>
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</tr>
</tbody>
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