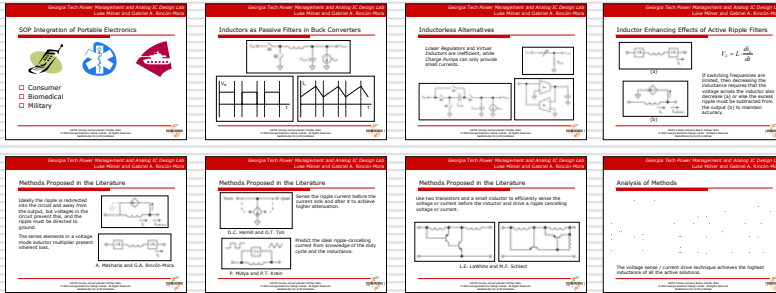
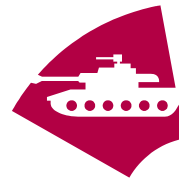


Inductor Multipliers

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

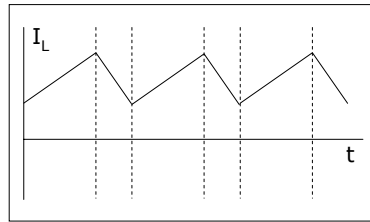
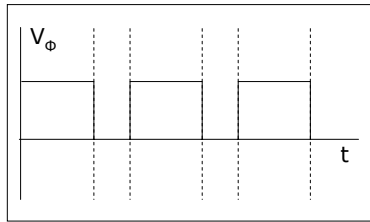
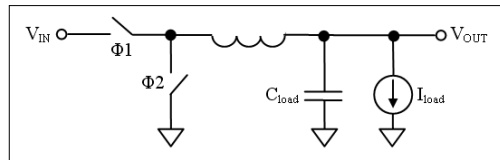


SOP Integration of Portable Electronics



- Consumer
- Biomedical
- Military

Inductors as Passive Filters in Buck Converters

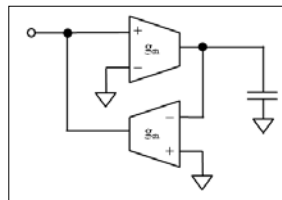
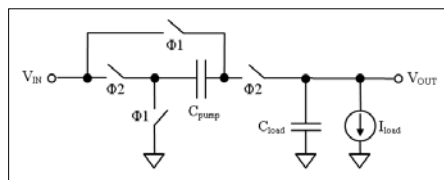
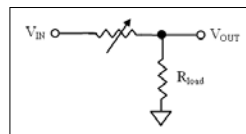


GEDC Industry Advisory Board, October 2004.
 © 2004 Georgia Electronic Design Center. All Rights Reserved.
 Redistribution for profit prohibited.



Inductorless Alternatives

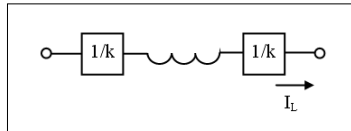
Linear Regulators and Virtual Inductors are inefficient, while *Charge Pumps* can only provide small currents.



GEDC Industry Advisory Board, October 2004.
 © 2004 Georgia Electronic Design Center. All Rights Reserved.
 Redistribution for profit prohibited.



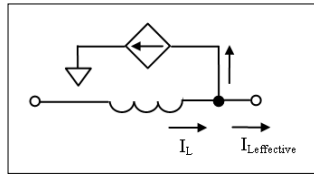
Inductor Enhancing Effects of Active Filters



(a)

$$V_L = L \cdot \frac{di_L}{dt}$$

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.

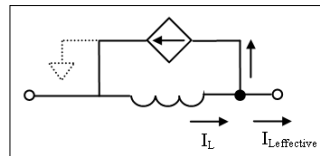


(b)

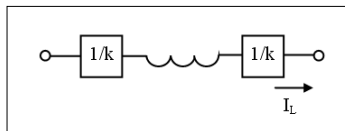


Methods Proposed in the Literature

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.



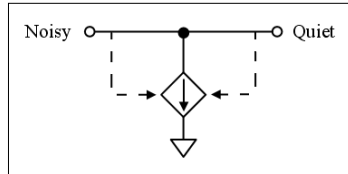
The series elements in a voltage mode inductor multiplier present inherent loss.



A. Makharia and G.A. Rincón-Mora

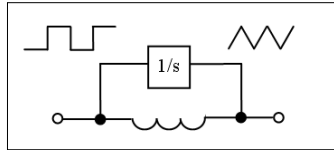


Methods Proposed in the Literature



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

D.C. Hamill and O.T. Toh



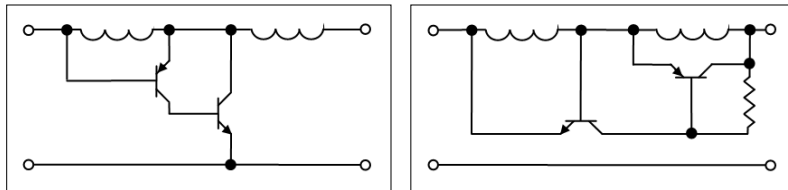
Predict the ideal ripple-cancelling current from knowledge of the duty cycle and the inductance.

P. Midya and P.T. Krein



Methods Proposed in the Literature

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.



L.E. LaWhite and M.F. Schlect



Analysis of Methods

	External Inductors	Integrated Inductors		Inductor Multipliers					
		Virtual Inductor [5] [6]	MEMS [7] [8] [9]	Current Drive				Voltage Drive	
				Current Sense		Voltage Sense		Current Sense [1]	Voltage Sense [1]
				Combination [2]	Feedback [1]	Predictive [3]	Feedback [1] [4]		
Magnitude	NA	NA	NA	Good	Good	Good	Excellent	Poor	Good
Accuracy	Excellent	Moderate	Poor	Excellent	Good	Moderate	Excellent	Poor	Good
Efficiency	Excellent	Poor	Moderate	Moderate	Moderate	Good	Good	Moderate	Good
Space	Poor	Excellent	Poor	Poor	Poor	Moderate	Good	Poor	Good
Power	Excellent	Poor	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Stability	NA	Good	NA	Moderate	Moderate	Good	Moderate	Moderate	Moderate
Cost	Moderate	Good	Poor	Good	Good	Good	Good	Good	Good

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

