A Predictive Inductor Multiplier for Integrated Circuit DC-DC Converters

Luke Milner

Gabriel A. Rincón-Mora

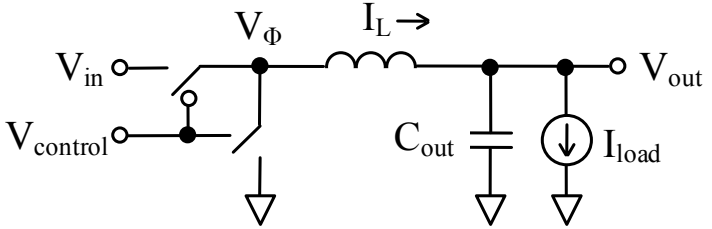
Georgia Tech Analog and Power
IC Design Lab, April 4, 2005

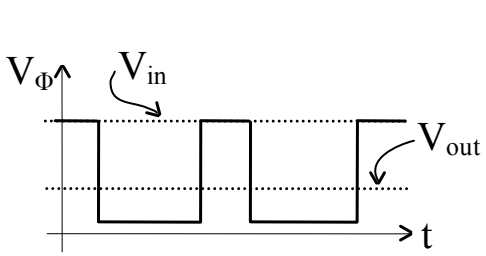
Motivation

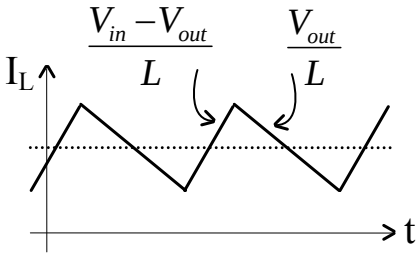
- Portable electronics could be integrated into everything from clothing to coffee mugs.
- However, power management circuits rely on large passive elements, and they perform better if the elements are larger.

Motivation

- Inductor based switching regulators like the Buck converter are more efficient than linear regulators, and more flexible than charge pumps.
- However, inductors are relatively large.



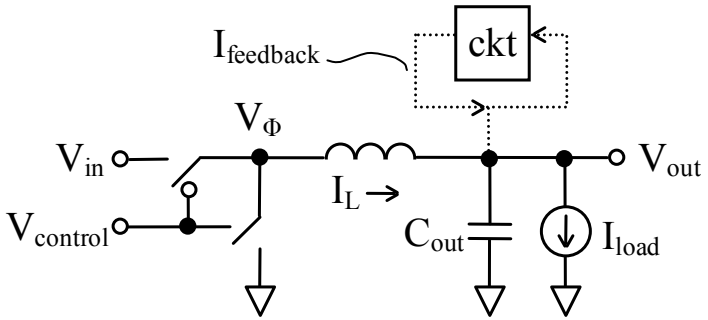




Approaches

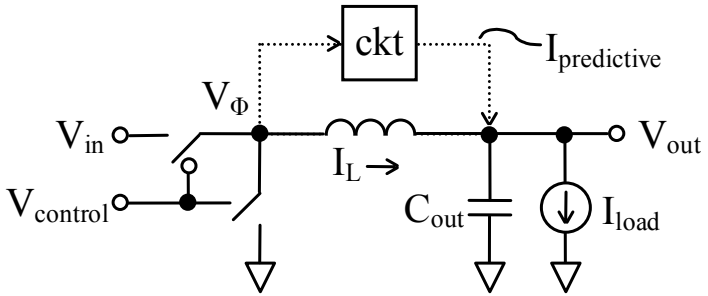
- Feedback

  relies on capacitor ESR



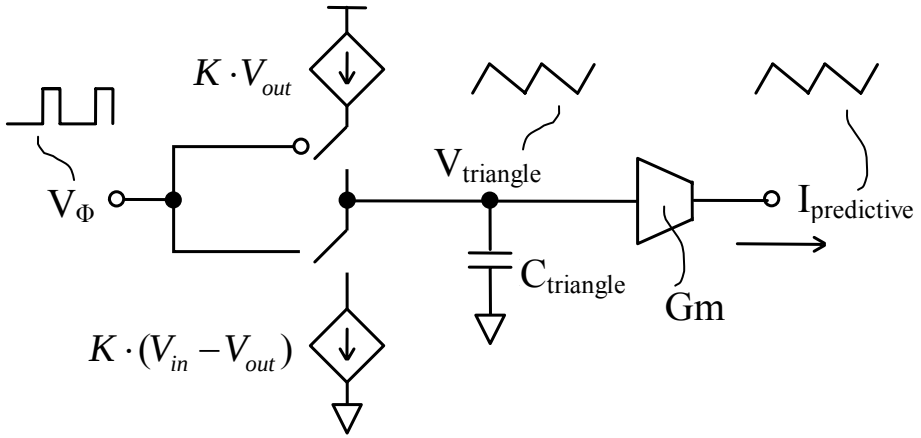
- Feedforward/Predictive

  not as accurate

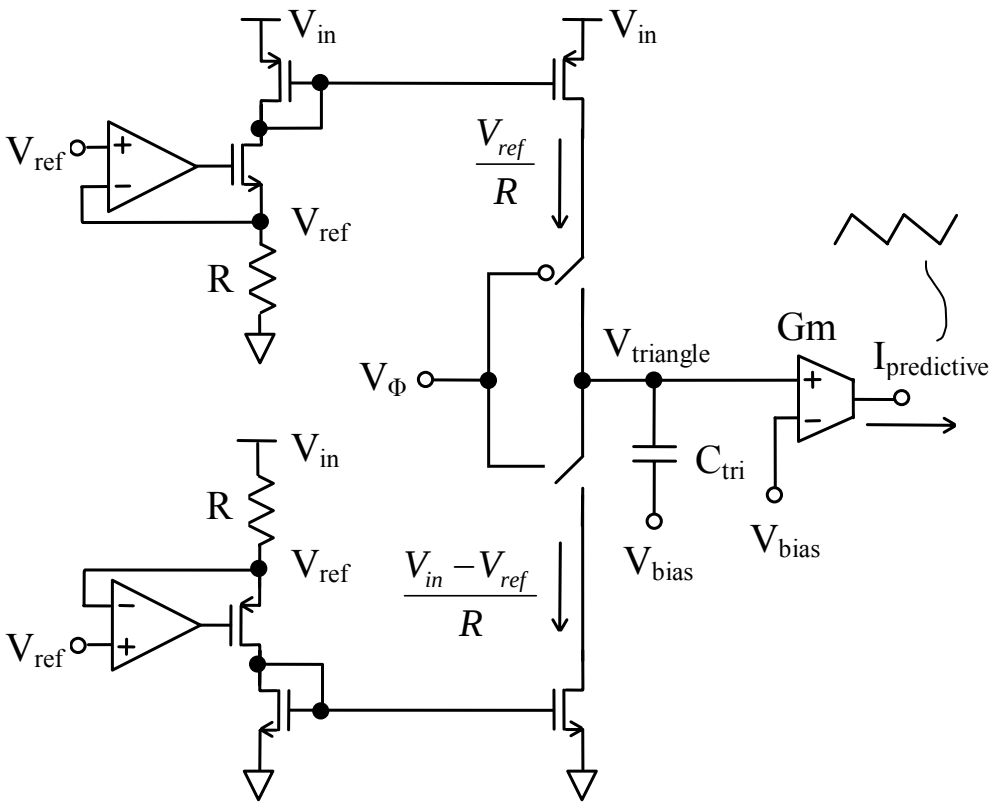


Predicting Ripple

- We generate a triangular voltage waveform of the right proportions, by controlling the flow of current into and out of a capacitor.



Circuit Implementation



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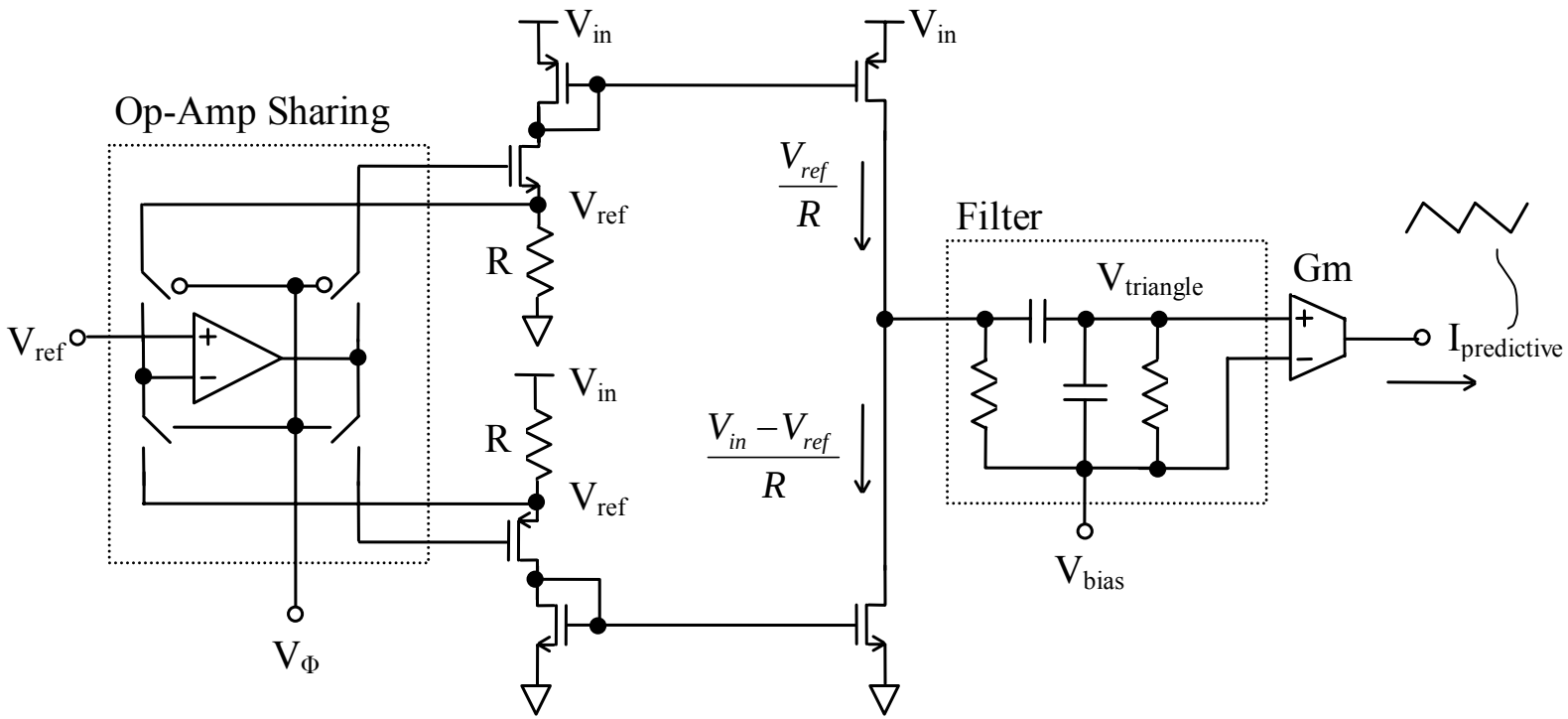
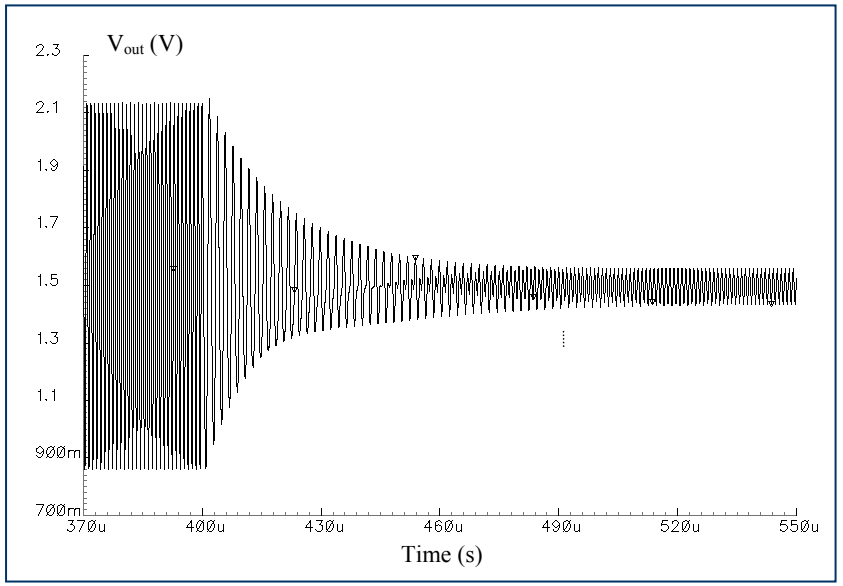


Simulation Results

- A multiplication factor of over ten has been achieved.
- A slower transient response is observed.

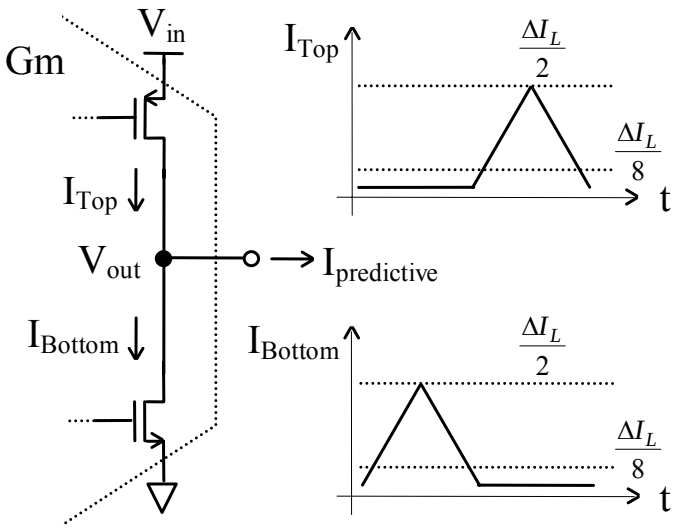


Trade-Off

- Generating the predicted ripple is inherently lossy.
- An alternative like operating the converter at a higher switching frequency can consume even more power.

  Under what circumstances?

$$P_{multiplier} = V_{in} \cdot \frac{\Delta I_L}{8} \cdot$$



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	Faster Switching	Inductor Multiplier	Big Discrete Inductor
f	5.5MHz	1MHz	1MHz
ΔI_L	136mA	750mA	25mA
DC	224mW	224mW	224mW
RMS	1.02µW	3.09mW	3.44µW
SW	660mW	120mW	120mW
LMX	0mW	280mW	0mW
Total	884W	628mW	344mW
Efficiency	77.2%	82.7%	89.7%

Future Work

- Define the set of circumstances in which it is more efficient to cancel the ripple than reduce it by switching faster.
- Build a PCB prototype.
- Improve the robustness of the circuit and the accuracy of the predicted ripple with tuning for the transconductor and filter.