PWR SOC 21

Philadelphia, Pennsylvania USA
Oct. 24-27, 2021

Low Frequency and Low Power DC-DC Switched Battery Converter

C. A. Berlitz[1,2], E. Perez[1], S. Oukassi[1], B. Allard[2], G. Pillonnet[1]

[1] CEA-Leti, Université Grenoble Alpes, F-38000 Grenoble, France
[2] Univ Lyon, INSA Lyon, Université Claude Bernard Lyon 1, Ecole Centrale de Lyon, CNRS, Ampère, UMR5005, 69621 Villeurbanne, France

CONTEXT AND MOTIVATION

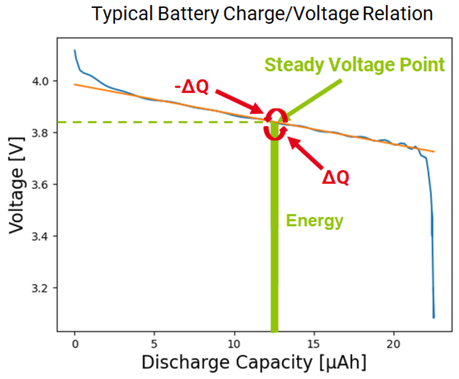
- DC-DC switching converters performance is highly dependent on passive technologies used;
- Lower frequency operation reduces switching losses, but limits power output and miniaturization in traditional passives.

Type	Max energy [J]	Max power [W]	Power @ 100 Hz [mW]
Inductor	5.3×10^{-6}	1.4	0.53
Capacitor	90×10^{-6}	2.7	4.50
Battery	259×10^{-3}	7.2×10^{-3}	7.20

All passives have similar physical sizes for an appropriate comparison

SWITCHED BATTERY CONVERTER

A new topology for low frequency switched DC-DC converters using a battery as flying passive instead of traditional passives.

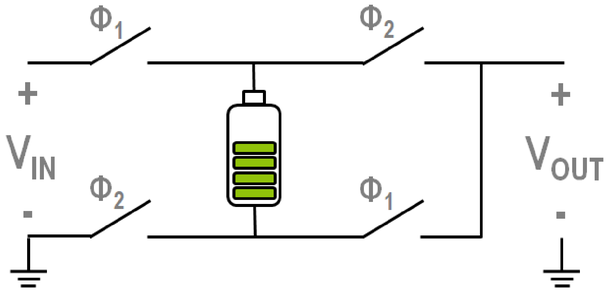


To retain the batteries' steady voltage point, a micro-cycle is performed, in which a small amount of energy (in comparison with the steady state) is cycled in the batteries.

TOPOLOGY EXAMPLE

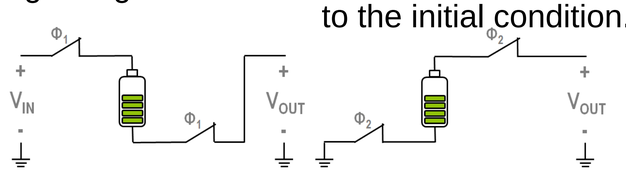
For a 2:1 converter using one battery we operate in two phases.

We assume to transport a normalized charge Q in each phase.



Φ_1: V_{IN} is connected in series with the battery in reverse polarity, effectively charging it while providing charge to the output.

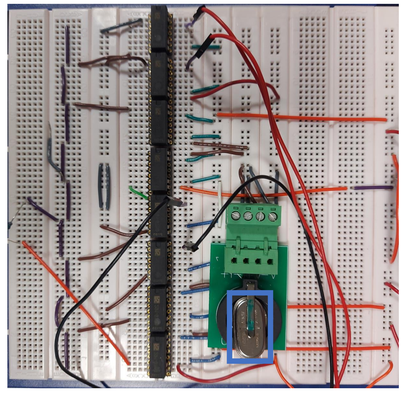
Φ_2: The battery is connected directly to the output V_{OUT} and discharges the previously obtained charge, returning to the initial condition.



Element	Phases	
	1	*2*
Input source V_{IN}	-Q	-Q
Battery	Q_0+Q	Q_0
Output V_{OUT}	+Q	+2Q

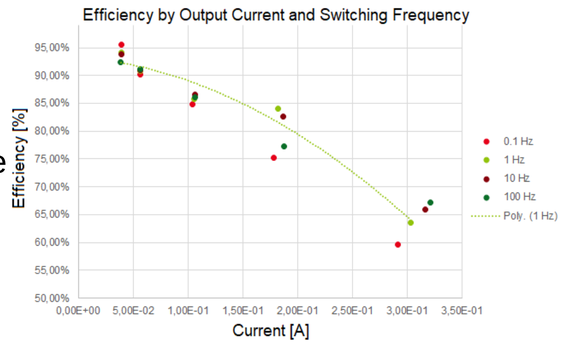
At the end, the source provides Q at $V=V_{IN}$ and the output receives 2Q at $V=0.5\ V_{IN}$
It gives a theoretical efficiency of 1

EXPERIMENTAL RESULTS

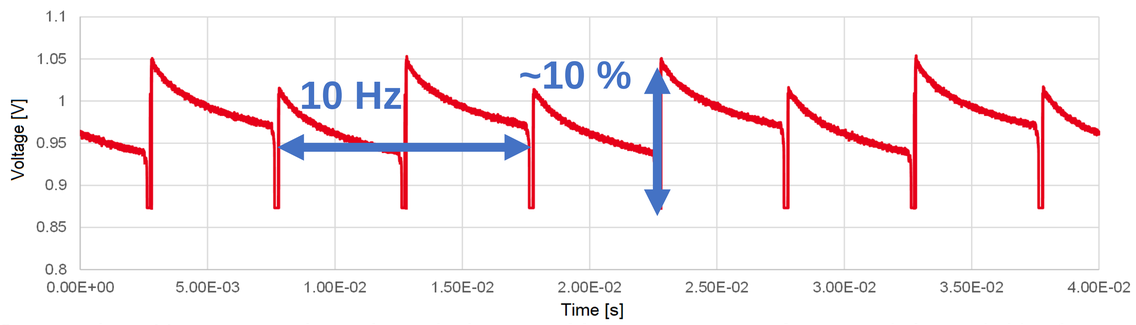


Implementation of proof of concept with discrete components readily available in the market.

Battery: V150H
- 150 mAh
- ~3.6 cm²



Output Voltage V_{OUT}



Output voltage V_{OUT} presents low voltage ripple even **without output capacitance** and slow switching frequencies.

PERSPECTIVE

As the battery operation is outside the conventional use cases (high frequency, small amount of Q transfer, many cycles), we are exploring the battery behavior under these energy demand profiles. We are also quantifying the charge-sharing and conduction losses.

CORRESPONDING AUTHOR

carlos-augusto.berlitz@cea.fr