Y9.ET5.1 High Voltage Distributed Energy Storage Device Based on a Fractional Converter

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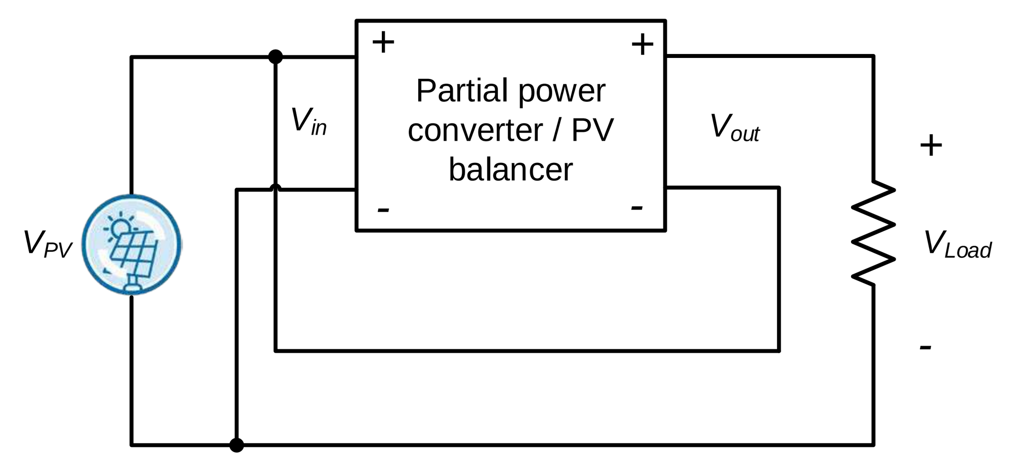
Background

- Originated in the 1990s, fractional converter or partial power converter [1], a converter that processes partial input /output power has become attractive with high-efficiency, low device power rating and low-cost features in PV and motor drive applications [2-5]. Fractional converters are not new topologies but new connections between sources and loads as a new application.



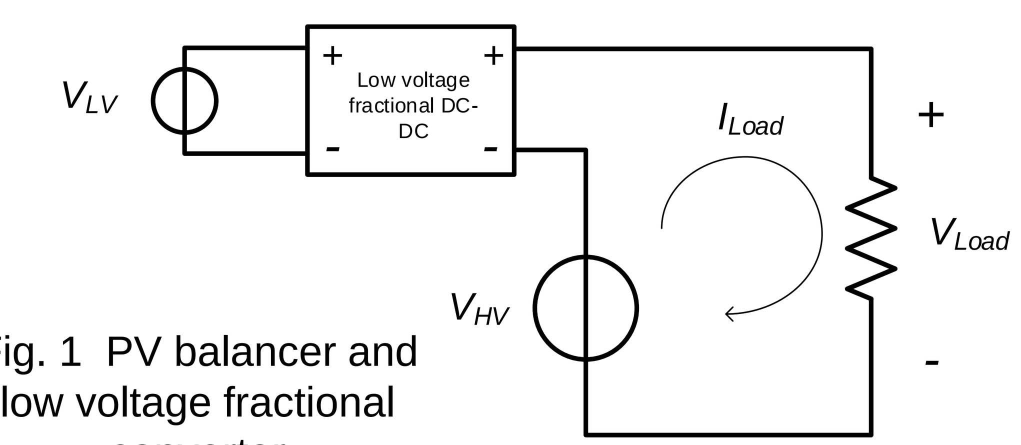


Fig. 1 PV balancer and low voltage fractional converter

Problem Statement

Conventional ways use a two port full power converter has the following drawbacks.

- With the development of large scale energy storage system, expensive high voltage high current switches should be used in the power conversion systems.
- The high battery voltage variation is larger, the converter operates at non-optimal point thus results in low efficiency.

Experimental Design

Fig. 2 shows the structure of BESS based on basic non-isolated fractional converters. V_{LV} can be part of the battery V_{HV} or a separate battery, which potentially makes the cost even lower. Isolated topologies can be used too.

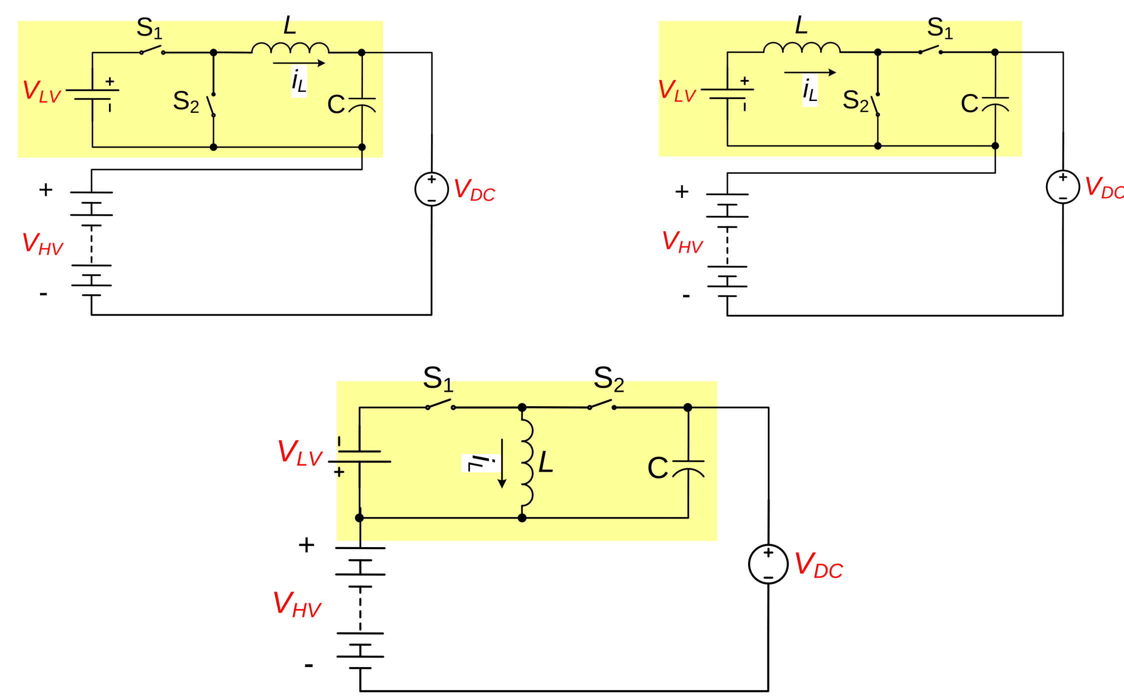


Fig. 2 DESD based on a fractional Buck, Boost and Buck-boost converter

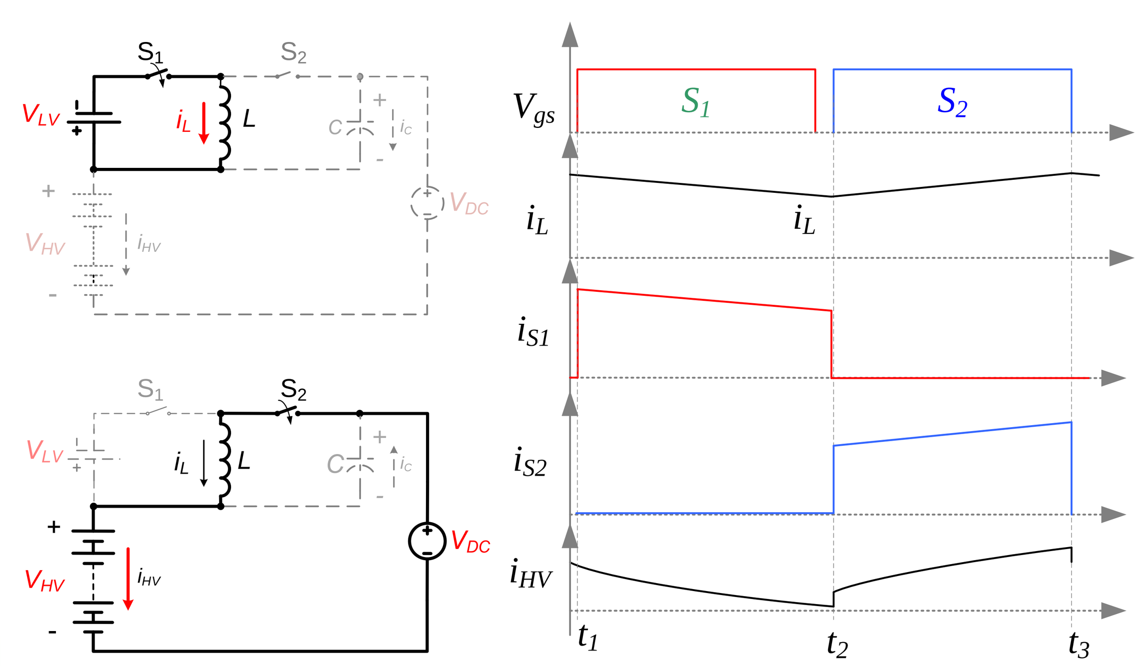


Fig. 3 Equivalent circuit in steady state (a) S_1 turns on; (b) S_2 turns on; (c) operating waveform.

1) Mode 1: LV battery charging

S_1 is on, S_2 is off. The inductor current is continuous and its direction is flowing into the LV battery (charging mode) .

2) Mode 2: HV battery charging

S_1 is off, S_2 is on. The inductor current keeps its direction, therefore the DC power supply charges the HV battery through the inductor.

Conclusion

Experimental results verified the feasibility of the proposed low cost, high efficiency HV battery energy storage device based on a fractional Buck-boost converter. The converter adopts 100V GaN HEMTs. A 70W (1kW system output power) principle verification prototype has been designed and tested. The system efficiency retains >99.0% over the whole power range. The configuration reaches ultra high efficiency and power density. It significantly reduce the cost.

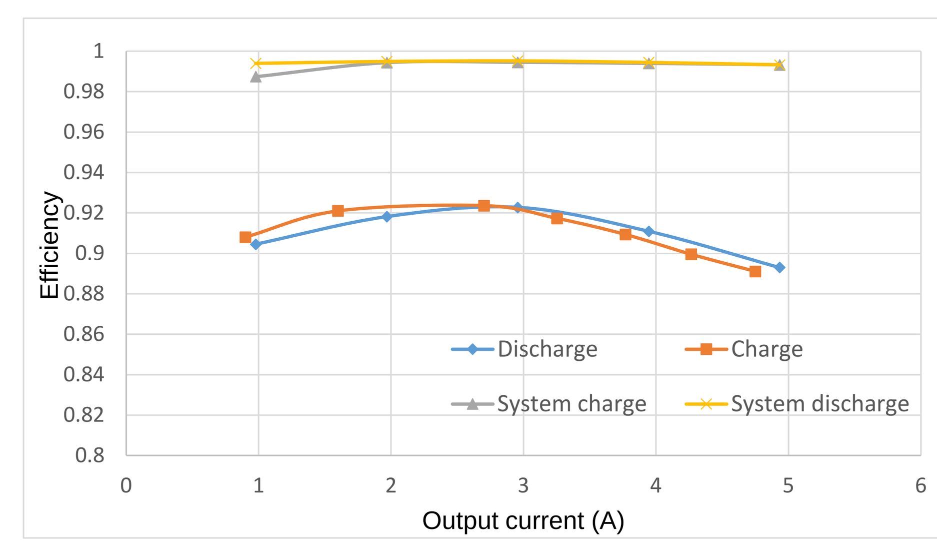


Fig. 4 System and converter efficiency curve.

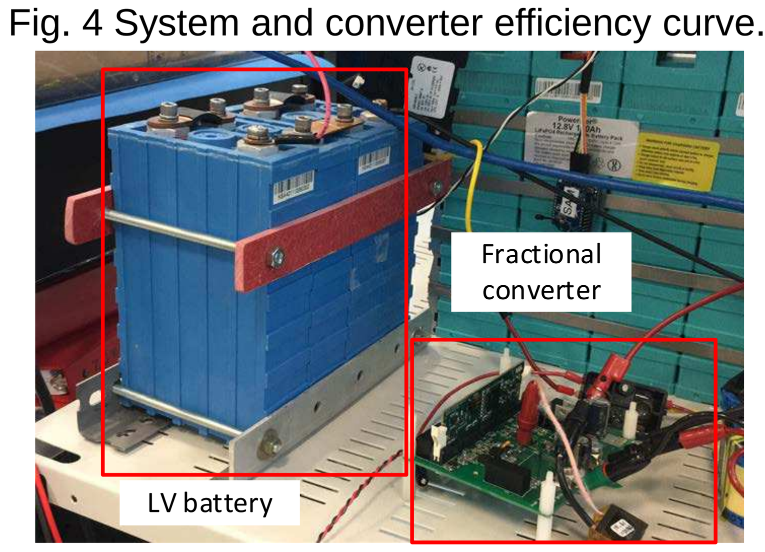


Fig. 5 System test experimental set-up

Table I System specs

Converter	Circuit topology	Buck-boost
	Input voltage	12 V
	Output voltage	0~60 V
	Switching frequency	100 kHz
	Load current	0A~6A
	Inductor	10uH
System	DC supply voltage	200V
	High voltage battery	140V~200V
	Power rating	1.2kW

Impact

- Change the paradigm of high voltage on-board battery charger market;
- Reduce the cost while increase the efficiency of energy storage system.

Future Work

- Validate the system reliability by multiple round-trip test.
- Research on corresponding battery management system.

References

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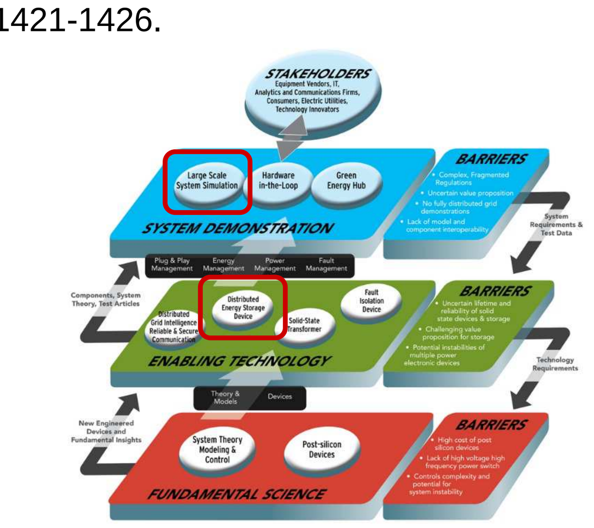

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