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.

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.

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.

Fig. 1  PV balancer and low voltage fractional converter

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.

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