Application Note

How to Implement a Standalone High-Power Supercapacitor Backup Design with BQ25822

Christian Moyer

ABSTRACT

This application note outlines the design of a high-power supercapacitor backup system using the BQ25822 charger IC. Key considerations such as system load management, charge current control, and converter efficiency are addressed to verify reliable and efficient operation. Test results confirm the BQ25822 as a preferred design for high power supercapacitor-based backup applications.

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1 Introduction

In high-power systems, fast transient load conditions can impose instantaneous and high current demands that can exceed the dynamic response capability of the main power supply. In many cases, the supply is not designed to deliver the full peak power or respond quickly enough to satisfy transient requirements. Therefore, maintaining a relatively constant input profile under varying load conditions is essential.

The BQ25822, when used in combination with a localized storage element such as a supercapacitor, provides an effective design to these challenges. This approach enables rapid transient response and reliable peak-power delivery while reducing stress on the main supply. This is achieved by discharging the local energy storage during peak-power events, charging during light-load conditions, and dynamically adjusting the charging current when the load is moderate to maximize overall efficiency

2 BQ25822 Overview

The BQ25822 is a multi-chemistry buck charge controller with a wide input operating range of 4.2V to 70V, designed to support Li-ion/Li-polymer, $LiFePO_4$, and supercapacitor charging application. The charger comes equipped with hardware-programmable limits for charge current (ICHG), charge regulation voltage (VCHG), input current limit (ILIM_HIZ) and under/over voltage protection (ACUV/ACOV), with forward and reverse current magnitude directly controlled through the ILIM_HIZ and/or ICHG pins, allowing for either host-controlled or fully standalone system.

One of the primary advantages of the BQ25822 is the bidirectional power flow capability with fast transition times, enabling seamless switching between the charging and discharging modes. The device transitions from forward mode charging and reverse mode discharging, and vice versa, in approximately 150μs. These short transition times minimize latency, allowing the system to respond quickly to load changes and maintain stable operation during dynamic conditions.

The BQ25822 also integrates Dynamic Power Management (DPM), which continuously monitors input current and voltage, and dynamically reduces or increase charging power to maintain stable charger operation without overloading the input supply. In addition, the BQ25822 supports ±3% charge-current regulation accuracy with a max charge current of 40A, which enables precise control of charging profiles. This level of accuracy helps verify that the battery/supercapacitor is charged safely and efficiently, minimizing stress on cells and extending overall system lifetime. For higher power application, the BQ25822 can be stacked, allowing multiple devices to operate in parallel and scale system capability beyond what a single phase can provide.

3 Implementing High-Power Supercapacitor Backup Design with BQ25822

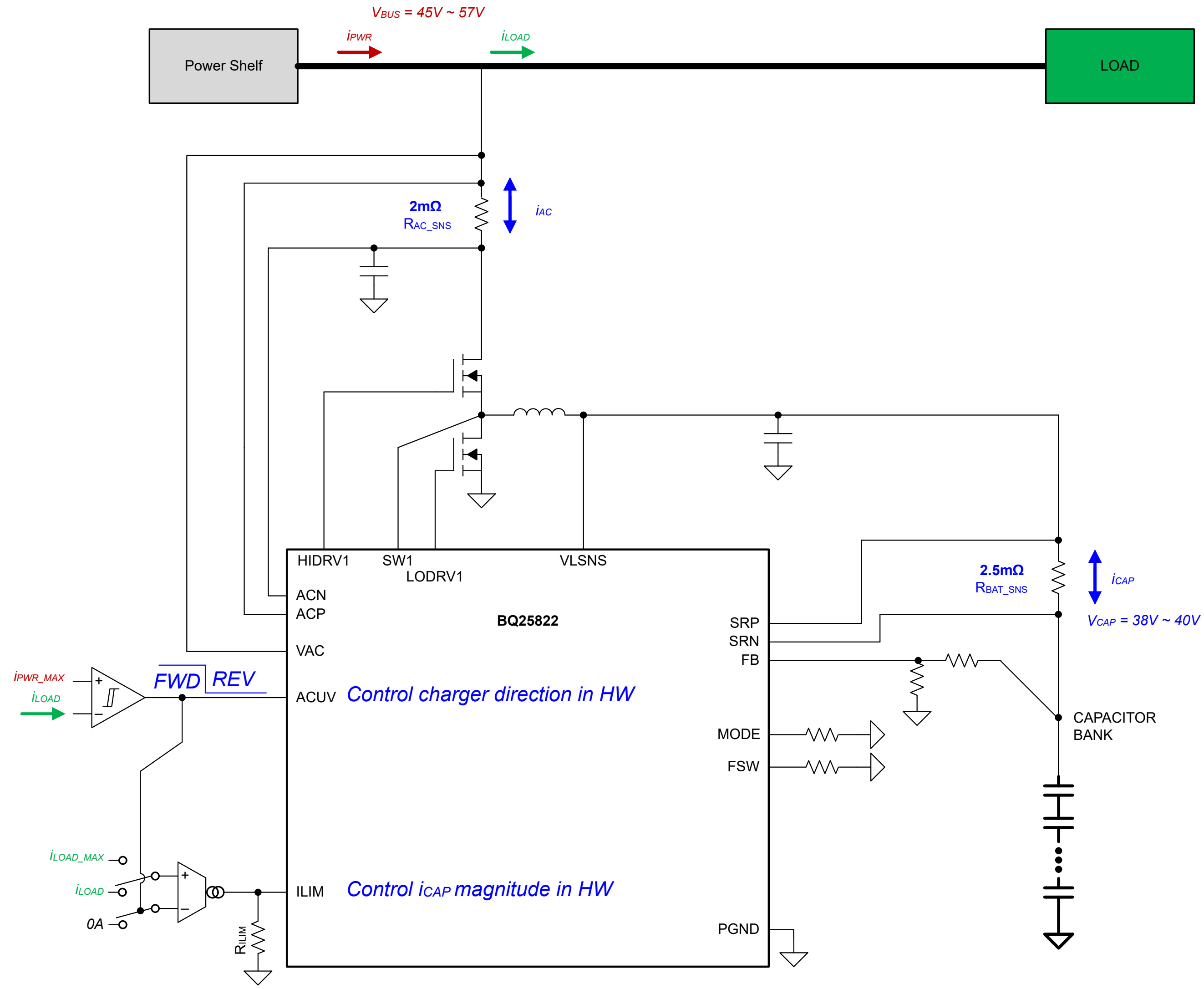


Figure 3-1. BQ25822 Supercapacitor Backup Design

To implement the BQ25822 in a supercapacitor backup application, a simplified control architecture can be used to manage both the direction and magnitude of current flow. Direction control is handled by a comparator that compares the load current against the maximum current available from the main power supply, verifying that supplemental current is only delivered when required. When the system load current (i_{LOAD}) is less than the maximum available power (i_{PWR_MAX}), the ACUV pin is pulled high and the BQ25822 operates in forward charging mode. If i_{LOAD} exceeds i_{PWR_MAX}, the ACUV pin is pulled low and the BQ25822 immediately transitions into reverse mode to provide supplement current. Magnitude control is implemented by injecting a reference current into the ILIM_HIZ pin, enabling an operational transconductance amplifier (OTA) to adjust the forward or reverse supplemental current in real time based on system load conditions, i_{LOAD}.

When designing the BQ25822 supercapacitor backup supply, several key parameters must be considered to verify reliable operation. The following example demonstrates this process for a 20kW application. The process begins with identifying the nominal bus voltage, the maximum system load, and the maximum available power from the main supply

$$V_{BUS\_nom} = 54V \tag{1}$$

$$I_{PWR\_max} = 370A \tag{2}$$

$$I_{Load\_max} = 740A \tag{3}$$

Next, the charge and discharge limits of the supercapacitor bank are defined, along with supplement power required during transient loads.

$$V_{Cap\_chg} = 46V \tag{4}$$

$$V_{Cap\_dschg} = 39V \tag{5}$$

$$P_{Cap\_Supplement} = \left(V_{BUS\_nom} \times I_{Load\_max}\right) - \left(V_{BUS\_nom} \times I_{PWR\_max}\right) = 20kW \tag{6}$$

$$I_{Cap\_Supplement} = \frac{P_{Cap\_Supplement}}{V_{Cap\_dschg}} = 515A \tag{7}$$

From these values, the required energy storage and minimum capacitance are calculated based on the specified hold-up time $T_{Supplement}$ verifying sufficient backup capability during transient load events:

$$T_{Supplement} = 0.25s \tag{8}$$

$$E_{req'd} = P_{Cap\_Supplement} \times T_{Supplement} = 5{,}000J \tag{9}$$

$$C_{req'd} = \frac{2 \times E_{req'd}}{\left(V_{Cap\_chg}\right)^2 - \left(V_{Cap\_dschg}\right)^2} = 20F \tag{10}$$

Finally, the number of BQ25822 devices connected in parallel is established according to the 40A per-phase current limit,verifying proper current sharing and scalability for higher-power designs.

$$n_{Phase} = \frac{I_{Cap\_Supplement}}{40} = 15 \tag{11}$$

Note

When designing with the BQ25822 for high-power applications, component selection and PCB layout play a critical role in verifying high efficiency, thermal reliability, and safe operation. The switching MOSFETs and inductors must be chosen with adequate electrical ratings and thermal margins to handle high currents and switching losses.This is not always be possible to completely cool the charger through PCB copper area alone, so external cooling (such as airflow or heatsinks) can be required.

Table 3-1. Recommended Components:

COMPONENT	VALUE	RECOMMENDED PART NUMBER
Switching MOSFETS	80V, 2.9mΩ	IAUT165N08S5N029
Inductor	4.7µH, 4.5mΩ	VCMI177T-4R7MN5

4 BQ25822 Evaluation

To demonstrate the BQ25822 supercapacitor backup operation, two BQ25822 evaluation modules (EVMs) were connected in parallel to increase the available power for charging and discharging the backup supply. In this setup, a mechanical switch on the ACUV pin is used to control the direction of current flow, and a PWM signal on the ILIM_HIZ to control the current magnitude

Note

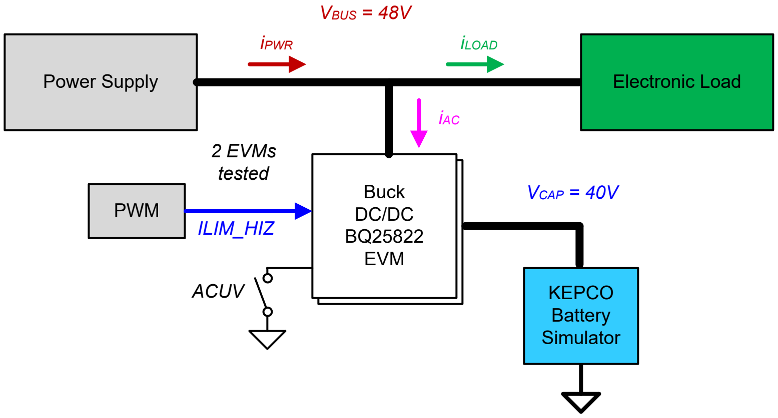
Due to equipment limitations, forward mode was evaluated at 20A charge current, and reverse mode was evaluated at 10A discharge current.

4.1 Equipment

To test the functionality of the BQ25822 supercapacitor backup supply, the following equipment is required:

1. **TI EVMs:**
   a. Two BQ25822 EVMs
2. **Power Supply**
   a. A power supply capable of supplying 48V at 40A. Chroma 62012P-100-50, or equivalent is recommended
3. **Localized Storage Element :**
   a. A four-quadrant or two-quadrant power supply capable of supplying 40V at 20A. Kepco: BOP 50-20MG, or equivalent is recommended
   b. When testing without a real battery, connect 2000µF of capacitance across the input of the two/four-quadrant power supply.
4. **Load:**
   a. An electronic load in constant current mode. Kikusui PLZ164WA, or equivalent is recommended
5. **ACUV Pin Controller**
   a. A mechanical switch, or function generator, or equivalent device is recommended to toggle the ACUV signal, enabling transistion between forward and reverse mode.
6. **Function Generator**
   a. A function generator to provide PWM signal to ILIM_HIZ pin, to emulate the performance of the OTA and control the current magnitude in forward and reverse directions.

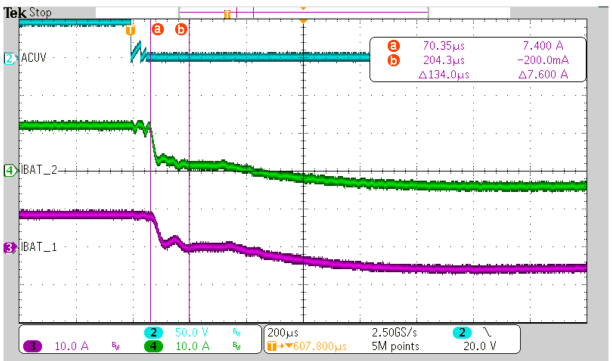
4.2 BQ25822 EVM Setup



Use the following steps to evaluate the functionality of the BQ25822 supercapacitor backup supply

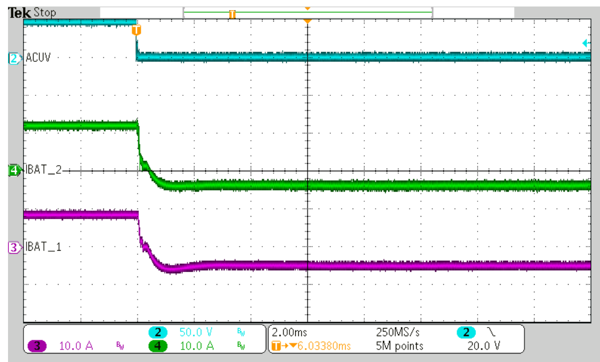
1. Connect the 48V power supply to the input of both EVMs (J1).
2. Connect the electronic load in parallel with the power supply.
3. Connect the 40V local storage element to the output of both EVMs (J3).
4. Tie the ACUV pins of both EVMs together, along with a mechanical switch or similar device to toggle between forward or reverse mode. Pull ACUV low to enter reverse mode and pull high to enter forward mode
5. Tie the ILIM_HIZ pins of both EVMs together, and connect the PWM signal to the ILIM_HIZ pin to adjust the current limit dynamically

4.3 Evaluation and Results



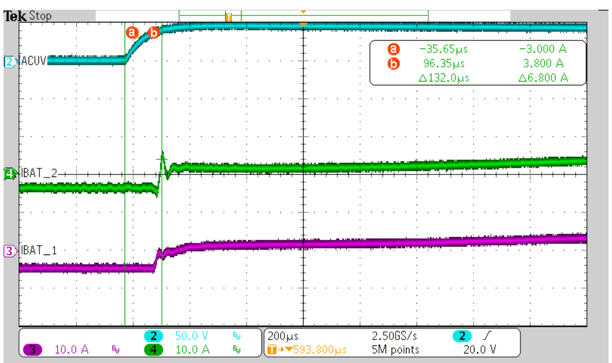
When ACUV is pulled low, the BQ25822 transitions into reverse supplement mode within 150µs

Figure 4-1. Forward to Reverse Mode Transition Recovery



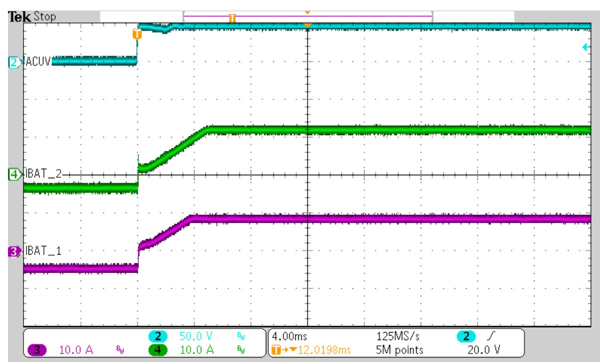
The BQ25822 delivers 20A of charging current (10A per EVM), then transitions to 10A of supplement current (5A per EVM).

Figure 4-2. Forward to Reverse Mode Transition Recovery



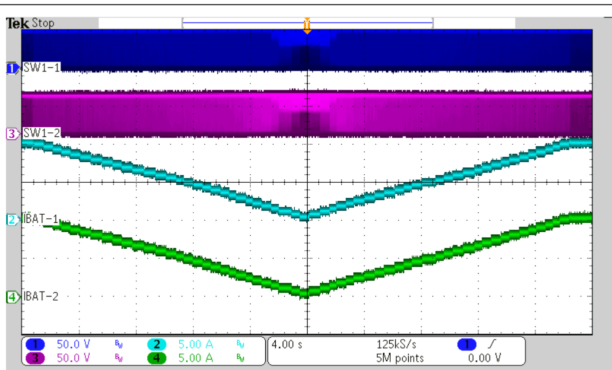
When ACUV is pulled high, the BQ25822 transitions into forward charging mode within 150µs

Figure 4-3. Forward to Reverse Mode Transition Time



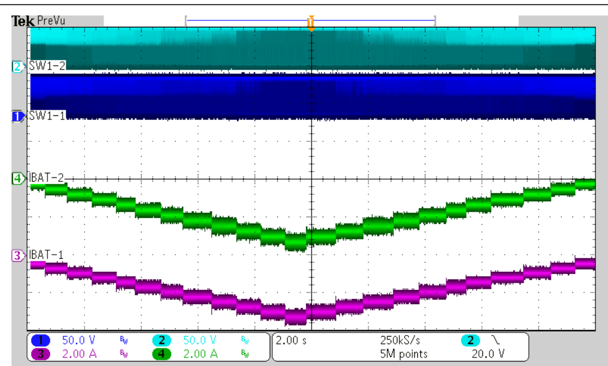
The BQ25822 delivers 10A of supplement current (5A per EVM), then transitions to 20A of charging current (10A per EVM).

Figure 4-4. Forward to Reverse Mode Transition Recovery



Adjusting PWM signal on ILIM_HIZ pin, allows the BQ25822 to step up or down the charging current in forward mode.

Figure 4-5. Forward Mode Current Control



Adjusting PWM signal on ILIM_HIZ pin, allows the BQ25822 to step up or down the supplement current in reverse mode.

Figure 4-6. Reverse Mode Current Control

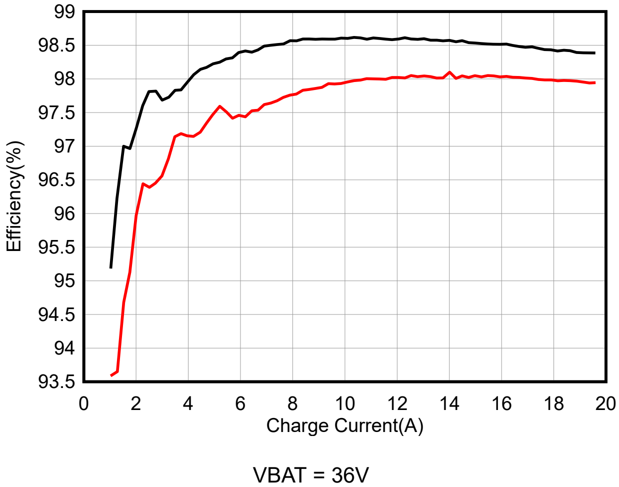


Figure 4-7. Forward Mode Efficiency (9s Battery Configuration)

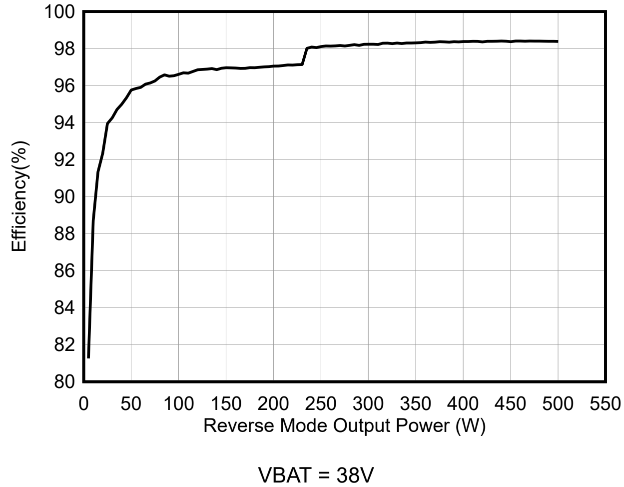


Figure 4-8. Reverse Mode Efficiency (9s Battery Configuration)

5 Summary

This application note describes a practical method for implementing the BQ25822 into a high-power supercapacitor backup supply systems. A 20kW design example is provided to show how the device can be applied in real systems and to outline the key design steps for high-power operation.

Testing confirms that the BQ25822 operates reliably when the load changes quickly, a condition that often creates challenges for backup circuits. This makes sure that power is maintained during short-term peak events when the main supply cannot respond fast enough or provide enough power. The results confirm that the BQ25822 can be used effectively in high-power designs where stable current regulation and fast transition response are needed.

6 References

- Texas Instruments, *BQ25822: Standalone Buck and Boost Backup Supply Controller*, data sheet.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265