*User's Guide*

# *Achieving Ship Mode With the BQ24075, BQ24076, BQ24078, and BQ24079*


**ABSTRACT**

With more and more devices becoming small and portable, the capacity and run time of a product depends on the capacity of the battery and the amount of current needed to power the device. However, as devices get smaller, so does the space a battery can take up. This means getting the most out of a battery is a very important aspect when designing the power stage of a product. Ship mode is a feature which allows a device to be in the lowest possible power state reducing the quiescent current that is pulled from the battery when the device is not active. This feature has become very popular because it allows batteries to last longer and also reduces how much a battery needs to be charged before being shipped to customers. Features like SYSOFF allow the use of external components to achieve this function. This document covers how to get the important ship-mode function in devices that did not originally come with them.


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## Trademarks



## 1 Introduction

The BQ2407x family of devices consists of the BQ24072, BQ24073, BQ24074, BQ24075, BQ24078, and BQ24079. These are typically used in applications that require around 1.5-A charging current without having to worry about switching noise and EMI that would be caused by the inductor and switching behavior of a switch mode charger. With user experience being an important factor and more devices having higher power requirements being more prevalent while being standalone and easy to configure, the battery state of charge when the user turns on the product is a big consideration. Ship mode allows the device to be in the lowest $I_Q$ state when the device is in deep sleep and power is not needed.

## 2 Implementation

At a basic level, ship mode is a way to cut off battery supply to all parts of the circuit while still having a way to exit this low power state on demand. In the BQ24075, BQ24076, BQ24078, and BQ24079 devices, the SYSOFF pin controls the FET that connects the battery to the system or OUT pin. SYSOFF can be used to turn on the BATFET by pulling the pin low or turn off the BATFET by pulling the pin high. By default, the BATFET is turned off due to the 5-MΩ resistor pulled up internally to VBAT. However, this pin cannot be left floating and needs to either be pulled low or high externally. Normally, the SYSOFF pin needs to be held low to enable charging as well as supply power to the system when in battery-only mode. This ability to control when the battery is connected to the system allows the choice to enter and exit ship mode.

As Figure 2-1 shows, the implementation of ship mode consists of a few resistors, a push-button, and a FET that is controlled through an MCU General Purpose Input/Output (GPIO). With the push-button, the SYSOFF pin can be pulled low when pressed or the SYSOFF will be pulled high when the push-button is not pressed which puts the device into the ship-mode state. This feature can also be used as a battery undervoltage protection. If the microcontroller in the application has an ADC to monitor the battery voltage, this feature can allow the device to go into ship mode before the battery is deeply discharged or the battery protection IC trips through a General Purpose Input/Output (GPIO) to pulldown the SYSOFF pin through a FET. This can help increase battery life. When VIN is plugged in, the system is powered and SYSOFF can be pulled low using the GPIO to keep the battery connected to the output for charging.

| SYSOFF State | SYSOFF Functionality | Result |
|---|---|---|
| High | Turn off the FET connecting the battery to system output | Battery is disconnected and charger is in ship mode |
| Low | Turn on the FET connecting the battery to system output | Battery is connected and charger is powered by battery |

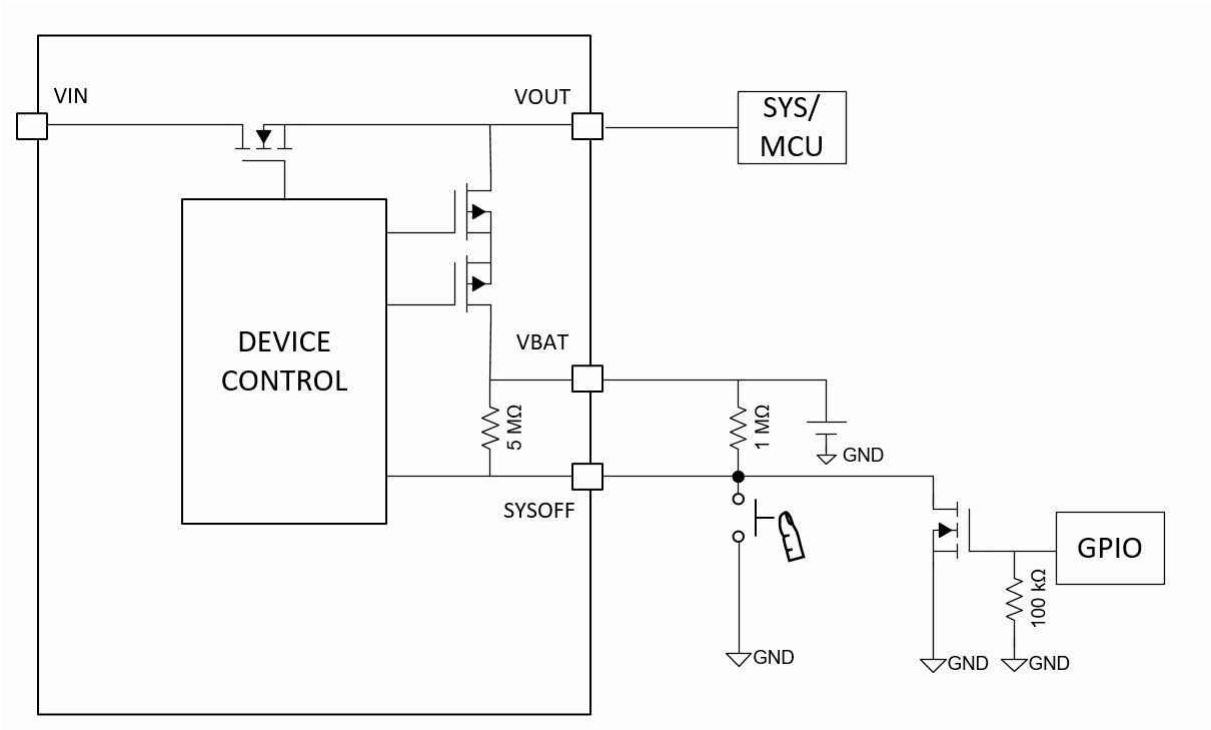


**Figure 2-1. Implementation**

## 3 Battery Insertion

As Figure 3-1 shows, when the battery is inserted, the device automatically enters ship mode because the SYSOFF pin is pulled high and the device waits for a push-button control to pull SYSOFF low. This ensures the user has control over when to exit ship mode.

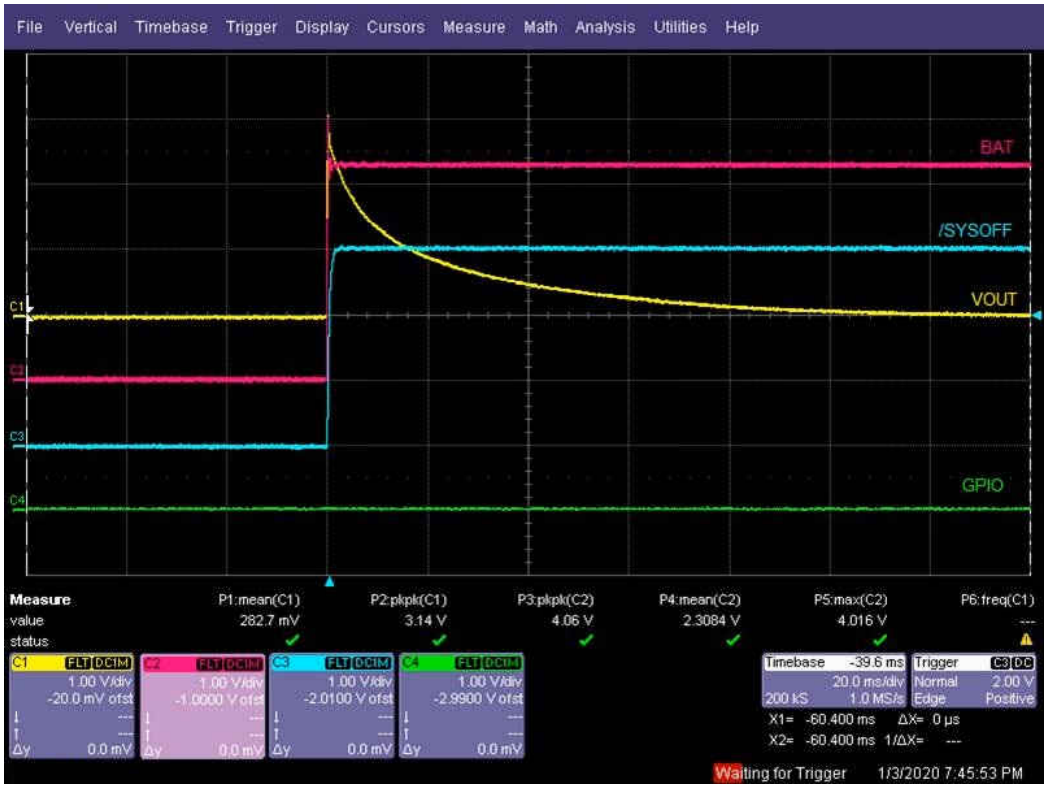


**Figure 3-1. Ship Mode Upon Battery Insertion**

## 4 Ship Mode Exit

When the push-button is pressed, the SYSOFF is pulled low and the MOSFET between BAT and OUT is turned on. When this happens, the OUT pin is powered by the battery and the MCU is powered. The duration of how long the push-button needs to be pressed to exit ship mode can be controlled by having a delay in software before the GPIO is set high. When the GPIO is set high, the NMOS is turned on which pulls SYSOFF low even when the push-button is not pressed.


**Figure 4-1. Ship Mode Exit With Push-Button**

## 5 Ship Mode Reentry

To reenter ship mode, all that is required is to drive the GPIO signal. If the push-button is pulled low when the GPIO is turned off, the device will not enter ship mode until the push-button is released. This turns off the BATFET which turns off power to the system. Note that if $V_{IN}$ is present when this occurs, the system is still powered by the input voltage and the battery is not charged. The $\overline{PGOOD}$ pin can be used to determine when the input is present or absent.


**Figure 5-1. Ship Mode Reentry**

## 6 Summary

This solution gives the ability for chargers to have the ship-mode function which can reduce system $I_Q$ and ensure a good end-customer experience with more battery state of charge. This solution also allows the system to be shutdown and restarted on demand with programmable wait time. While this solution requires external discrete components, newer solutions for the power path charger such as BQ25180 have increased push-button functionality and support ship mode without discrete components.

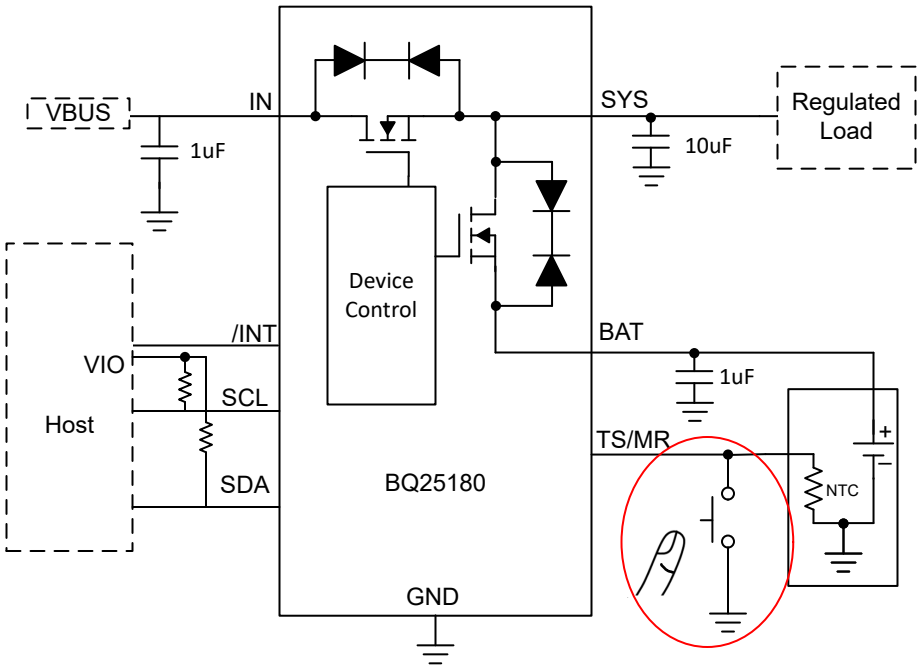


**Figure 6-1. BQ25180: 1A Li-ion I2C Programmable Charger With Power Path and Ship Mode**

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