Application Report
SLUA349A–August 2005–Revised December 2005

Design Changes to the bq24032

PMP Portable Power

ABSTRACT

This application report discusses the four design changes made to the bq24032 IC and implemented in the bq24032A device.

1 Introduction

Design modifications have been made to the bq24032, bqTINY™-III single-chip charge and dynamic power-path management IC to add new features and improve manufacturability. The new, improved device is the bq24032A. This report details the changes and includes data to show the results of those changes.

The original released revision was bq24032. Design modifications listed in the following table and discussed in this report apply to the bq24032A device.

Change Number	Change Name	Reason for Change	Short Description of Change
1	Ichg/25 Termination	Prevent early termination	Termination threshold switched between 250 mV and 100 mV
2	Timer Fault	Prevent false timer fault	Hold down floating node with spare transistor
3	Change Termination	Ensure charge termination	Charge termination controlled by logic state and not logic edge
4	TMR Pin Operation	Ensure that termination and safety timer are both turned off	Connecting the TMR pin to the LDO pin disables termination

2 Detailed Description of Design Changes

2.1 Design Change 1

When operating in USB mode and with the ISET2 pin set low, the maximum input current is 100 mA. Early termination occurs in this operating mode if the programmed charge termination current is greater than 100 mA.

2.1.1 Example

Charging Current, Ichg = Vset × Kset/Rset = 2.5 V × 425/1 kΩ = 1.06 A

Charge Termination Current, Iterm = Vterm × Kset/1 kΩ = 0.25 × 425/1 kΩ = 106 mA

If ISET2 is low and USB mode is selected, the actual charging current is limited by the input current regulation; the specification is 80 mA to 100 mA. In this case, battery charging stops when the voltage on the battery exceeds the Recharge Threshold, Vrch = 4.1 V. The Recharge Threshold signal is used internally to prevent charge termination for battery voltages less then Vrch.

The design change added a switch to select a lower Vterm voltage when operating in USB mode. The new Vterm voltage is typically 100 mV. There are now two termination thresholds: 250 mV or 100 mV. The lower value is selected when in USB mode. The charge termination currents for the new bq24032A, are:

AC input power and PSEL = Hi, Vterm = 250 mV. Iterm = 0.25 A × 425/1 kΩ = 106 mA.
For all other cases, Vterm = 110 mV, Iterm = 0.1 A × 425/1 kΩ = 46.8 mA.

Figure 1 shows the two charge termination thresholds.

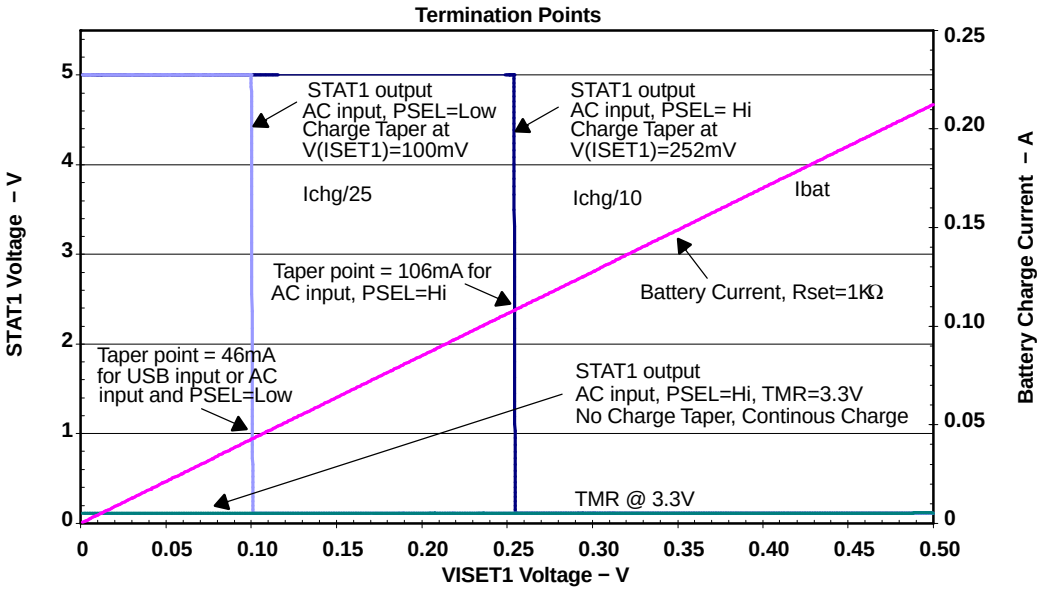

Figure 1. Charge Termination Currents

2.2 Design Change 2

A logic control error in the Charge Control state machine causes a false Charge Safety Timer Fault condition after a normal charge cycle. When a normal charge cycle is completed, the Charge Safety Timer is reset. However, because of the logic error, the Charge Safety Timer starts running again. Therefore, on the bq24032, a Charge Safety Timer Fault condition is indicated at the STAT1 and STAT2 pins one Max Charge Time Period after the completion of a normal charge cycle.

This problem is shown in Figure 2. For this test case, a partially discharged battery was used. The Max Charge Time was set to 5 hours, Rtmr = 50 kΩ. A normal charge cycle is completed at Time = 65 minutes. At Time = 375 minutes, the STAT pins change from indicating Charge Complete (STAT1 = Hi, STAT2 = Low) to Fault (STAT1 = Hi, STAT2 = Hi). The difference in time from Charge Complete to Fault is 375 – 65 = 310 minutes, or approximately 5.2 hours. The Fault state at Time = 375 minutes is the problem and should not occur.

Figure 3 shows the same test with the new bq24032A. No Fault state occurs after a normal charge cycle completes.

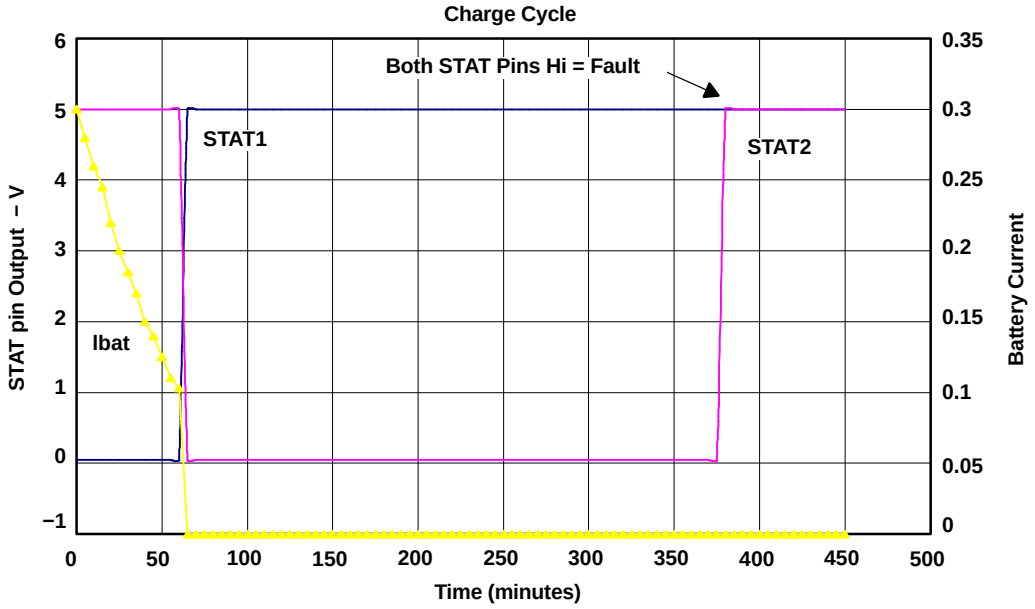

Figure 2. bq24032 Device Showing Fault After Normal Charge Cycle

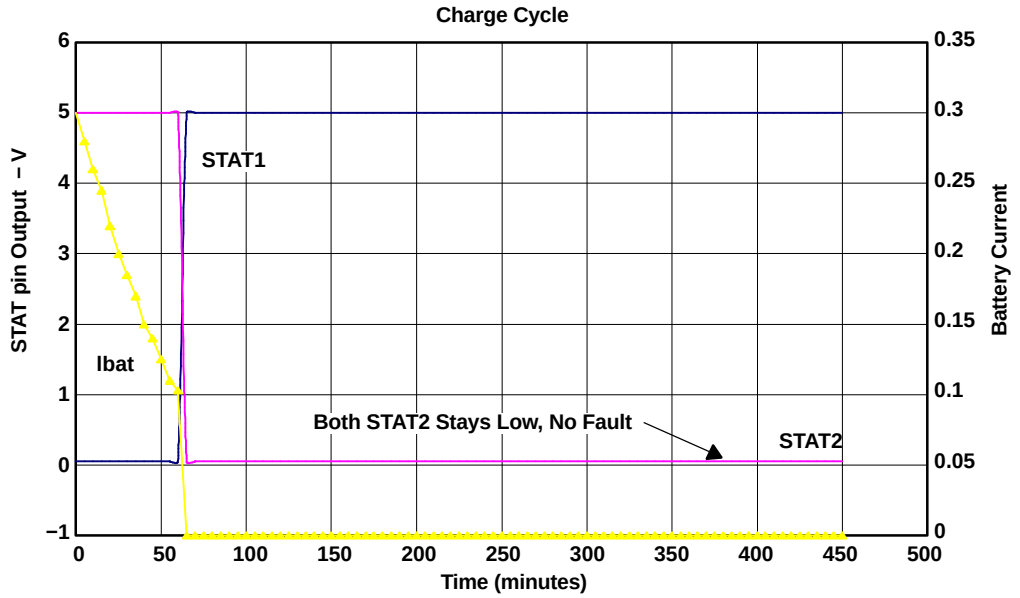

Figure 3. bq24032A Device Showing No Fault After Normal Charge Cycle

2.3 Design Change 3

A timing issue between the internal recharge signal and the internal termination signal edge causes the Ichg/10 termination to be missed if the recharge signal is still active when the termination signal edge occurs. The STAT pin still indicates charge. If left in this state, the fault time times out and terminates the LDO mode.

The transition from the Charging Done State to the Charging State occurs when the internal Recharge signal goes active. The Recharge signal goes active when the battery voltage falls below the recharge

level, Vrch. There is a 25-ms deglitch on the Recharge signal, going into both active and inactive states. An active Recharge signal resets the Charger State Machine. The transition from the Charging State to the Charging Done State occurs on the rising edge of the Termination signal. The Termination signal goes active when the battery charging current (and the voltage on the ISET1 pin) falls below the Termination Threshold. There is also a 25-ms deglitch on the Termination signal.

When power is applied and no battery is present, the Charger State Machine cycles between Charging State and Charging Done State. A race condition can occur between the Recharge signal and the Termination signal without a battery present. This is because when the Recharge signal goes active, charging begins; however, without a battery, the BAT pin voltage immediately rises above the Recharge voltage. This starts the 25-ms deglitch timer to make the Recharge signal go inactive. The 25-ms deglitch timer starts immediately because there is no charging current when the battery is absent. If the termination signal arrives at the Charger State Machine before the Recharge signal goes inactive, the Charger State Machine stays in the Charging State even though no battery is present. If a full battery (will not load the charger above the Ichg/10 level) with a terminal voltage greater than Vrch is inserted with the Charger State Machine stuck in the Charging State, no change in charger status occurs.

To correct this problem, the Charging State Machine was changed to be state controlled and not edge controlled by the Termination signal. This eliminates the race condition.

2.4 Design Change 4

The operation of the TMR pin is modified to disable termination along with the safety timer when the TMR pin is tied to the LDO pin. On the bq24032, connecting the TMR pin to the LDO pin disables the safety timer function but does not disable termination. On the bq24032A, a design change has been made to disable termination and the safety timer when the TMR pin is tied to the LDO pin.

3 Summary

The corrections and improvements implemented in the bq24032A and discussed in this application report should not typically be noticed as a difference in function or operation unless a unique application takes advantage of these differences. The lower USB termination threshold, Ichg/25, extends the charging time moderately, but charging in this mode is typically infrequent.

The timer fault issue is typically not seen unless the battery is left in the charger overnight, and resolving this problem should eliminate any confusion. The charge termination issue may be observed with an absent battery or if a full battery is inserted and implementing the solution allows the STAT pins to indicate the correct state.

The TMR pin function was changed to enable the charger to operate as an LDO when the safety timer is disabled.

All IC changes should improve the low-level USB termination and status indication issues of the part. The bq24032A should be selected for all new designs, and any designs using the bq24032 IC should be transitioned to the new part.

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