

## Maximizing Integrated Battery Charger Performance with Intelligent Thermal Control

*New multi-function power management ICs promise to reduce PCB size by integrating multiple blocks onto a single chip. Such integration can threaten system integrity by exceeding the thermal limits of the device package. An intelligent thermal control circuit eliminates this problem by dynamically managing power usage and, in the process, maximizing battery charger performance.*

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As designers of the latest generation of consumer electronics products have increased functional integration and reduced product footprint, they have also increased the number of power management circuits required while applying pressure to integrate them together into fewer packages and less PCB area. Today a growing number of products, including smart phones, digital cameras, handheld instruments, MP3 players and portable media players, are built around a relatively high powered processor or DSP that requires different voltages to power its core and an I/O. Sometimes the power supply for the I/O also powers other ancillary application circuitry. Many of these systems are powered by a single-cell Lithium-ion battery sized in the 1000 to 1500 mAh range. Accordingly, they require multiple voltage converters and a fairly sophisticated battery charger circuit to support basic operation.

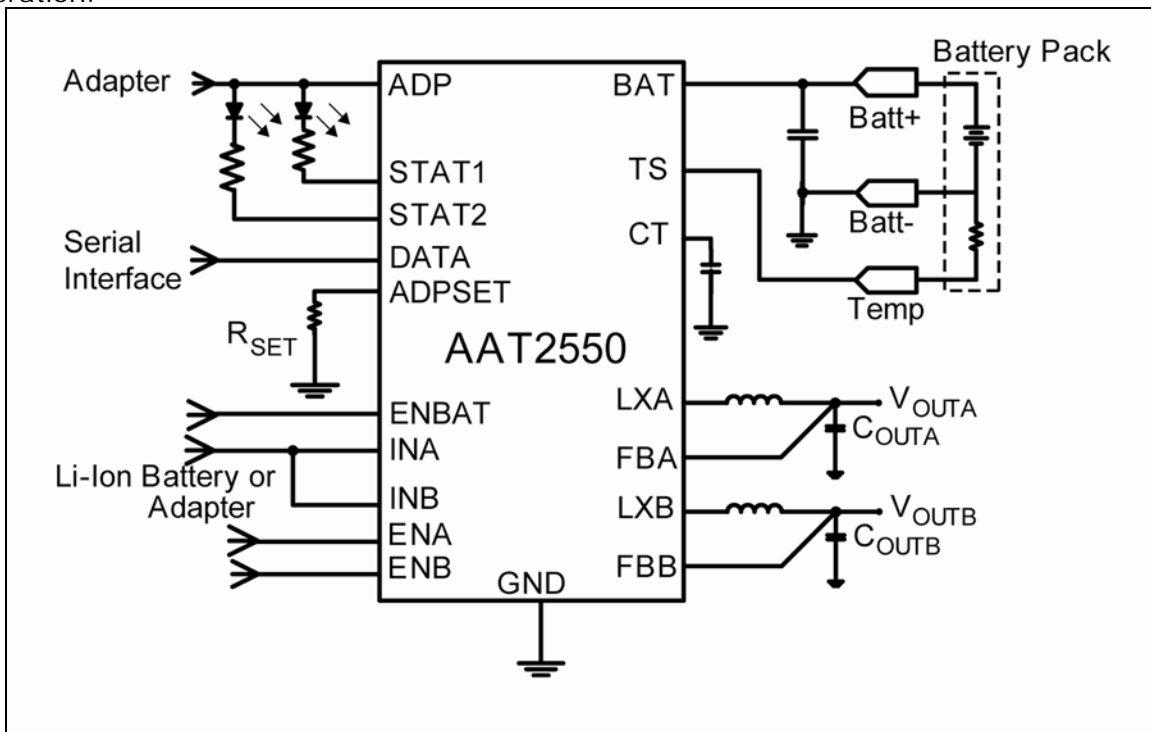


Figure 1 : AAT2550 Typical Application Diagram

In this new breed of portable products described above, traditionally portable system designers have used single function buck converters and battery charger ICs to power the processor core, processor I/O and charge the battery. Today IC developers can dramatically reduce the required PCB space by integrating these blocks together, e.g. one IC containing a 1A battery charger and two step-down converters capable of delivering up to 600 mA of current each in a compact 4 mm x 4 mm QFN package.

The problem power IC designers face, however, is the cumulative heat these three power functions generate when inside the same IC. While power dissipation capability varies with several factors, together these three common power functions can easily generate more heat than the single IC package can handle. When that occurs, the heat generated could adversely impact the operation of the buck converters and potentially cause an I/O error, a processor interrupt or a system shutdown. At the same time, if the battery charger circuit does not run at maximum efficiency or is interrupted, the user would experience an extended battery charge time and possibly reduced charge cycle life. As a result, designers face a formidable challenge. How do they integrate these functions, guarantee the operation of the system and still maximize charge current to the battery and, in the process, minimize charge time?

### **Digital Thermal Control**

To address this problem engineers at AnalogicTech have recently developed a digital thermal control loop circuit for their new AAT2550 SystemPower™ IC. Designed to reduce PCB real estate requirements in space-constrained portable applications, this IC combines a 1A battery charger with two 600 mA step-down converters in a 4mm x 4mm 24-pin QFN package. The battery charger in the device is a constant current/constant voltage linear charger with an integrated pass device and reverse blocking protection. The charge current on the device is programmable, via an external resistor, from 100 mA to 1 A. Both step-down converters operate at a relatively high 1.4 MHz switching frequency allowing the use of small external components. Each converter's efficiency is optimized for all load conditions from no load to 600 mA. Both converters operate off a 2.7 to 5.5V input and feature independent input, enable and feedback pins. No load quiescent current is 27  $\mu$ A per converter. An integrated soft start function eliminates voltage overshoot when the enable or voltage input is applied.

To control power dissipation and heat generation, and thus maximize performance, the IC includes an innovative digital thermal control loop circuit which monitors die temperature and automatically throttles back charge current when demand on the power system increases the die temperature in excess of the power dissipation capabilities of the device package. This thermal control circuit activates only when the die temperature exceeds 110° C.

Once that threshold is reached and the digital thermal control loop becomes active, the control circuit reduces the fast charge constant current ( $I_{CC}$ ) by an initial factor of 0.44. From that point forward the circuit measures the die temperature every 3.3 seconds and throttles back or increases the charge current in small incremental steps of approximately 35 mA until equilibrium current is reached which reduces the IC temperature to a safe level and ensures safe operation of the device, and thus the system in which it is used.

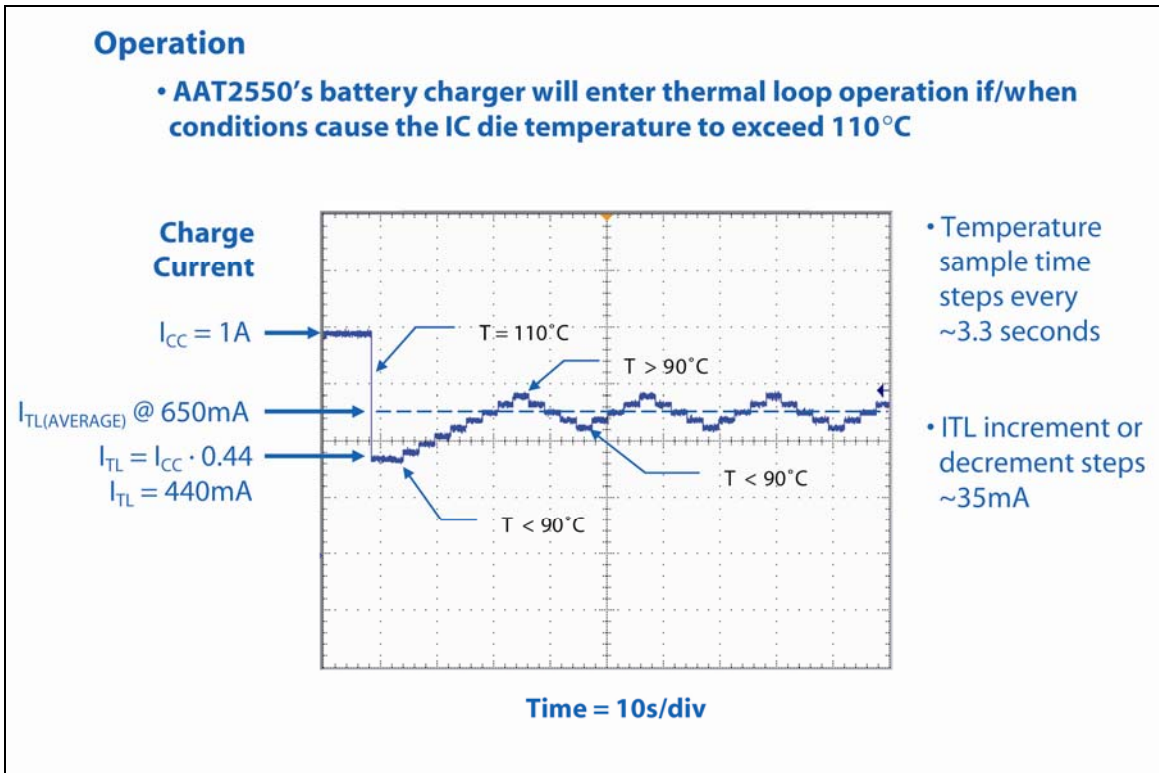


Figure 2: Digital Thermal Control Loop 1

This ability to automatically adjust the battery charge current up and down in small incremental steps distinguishes the digital thermal control loop circuit in the AAT2550 from alternative approaches. Traditionally, IC designers have not managed battery charger die temperature, or have managed battery charger die temperature only by setting two distinct charge current levels, one high for maximum charge current and a second low to ensure IC integrity. Once the die temperature exceeded its thermal limits, the charger was reset to the lower predetermined current level. In most cases this second charge level was set lower than necessary to protect the device. By moving to an extremely low charge current, however, this predetermined, dual-level approach also ensured that the charger did not utilize all current available within the IC's temperature limits and thereby unnecessarily extended the charge time.

AnalogicTech's digital thermal control loop offers a more dynamic approach to the problem. Once the digital thermal control loop is activated and the current is reset, the circuit continuously monitors the die temperature and adjusts the charge current up or down to meet thermal limits. This allows the device to adjust the charge current as the current used by the two integrated step-down converters increases or decreases. By constantly adjusting the charge level to varying die temperature conditions, this intelligent thermal management system permits the battery charger to charge the battery cell safely over a wide range of conditions. Furthermore, by utilizing the maximum available charge current, it ensures the battery will be charged in the shortest time possible for a given set of conditions, and even over a dynamically changing set of conditions.

If the die temperature drops below the threshold of 85°C, the AAT2550 terminates its thermal regulation mode and automatically resumes charging at the full programmed constant current level (see figure 3).

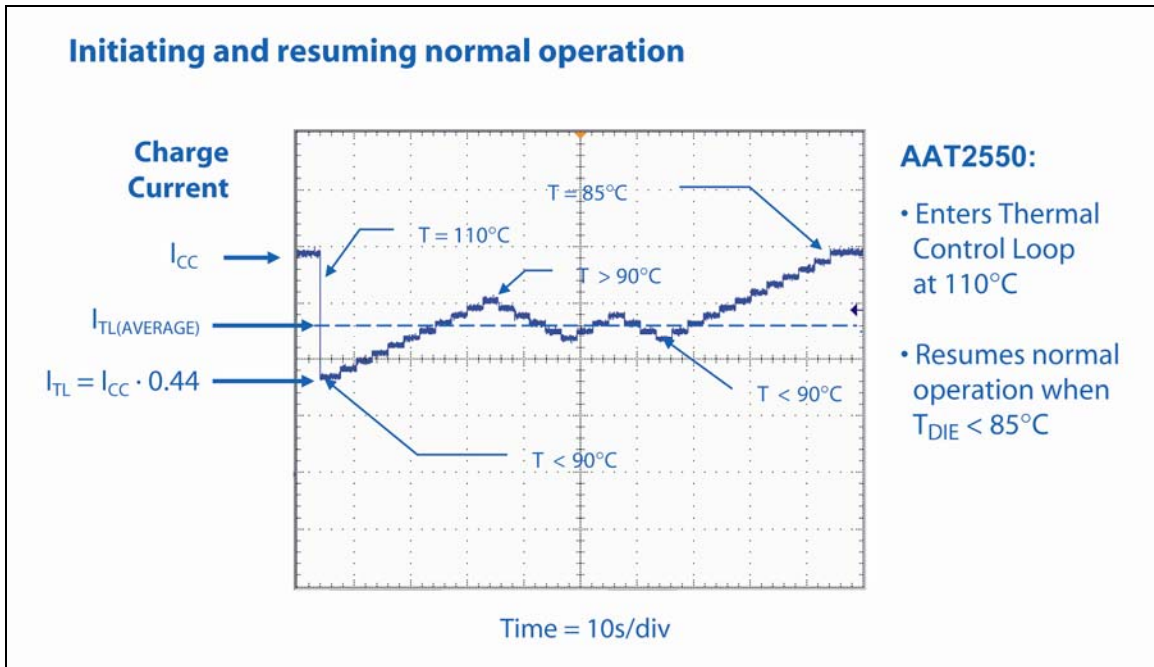


Figure 3 : Digital Thermal Control Loop 2

### Conclusion

Given the relentless pressure to build portable electronics devices in smaller footprints, the integration of multiple system power management functions into single-chip, highly integrated devices offers attractive possibilities. To take advantage of these new devices, however, designers will need more intelligent and automated schemes for managing the large amounts of heat generated when multiple high power functions are brought together on the same die. By allowing users to maximize charge current and minimize battery charge time while reducing PCB footprint, the digital thermal control loop described above offers an important step in this direction.