High Power, Fully Integrated, Synchronous Boost Converter with Optimized Features for Portable and Battery-Operated Applications

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Introduction

The superior properties of Li-ion batteries, such as high energy density, light weight, no memory effect, and less self-discharge, make them a very popular option in portable applications. ICs with boost topology are needed in portable applications since the voltage fluctuation of most Li-ion batteries ranges from 4.2V (fully charged) to 3.0V (fully discharged), while the post-circuit input voltage is up to 12V or more. Portable applications, such as Bluetooth audio, quick-charge power banks, and portable POS systems employ various boost products available in the market, including discrete controller with external MOSFETs, non-synchronous boost converters with external diode, limited input/output voltage range or features (see Figure 1). These solutions take up more space, require more components while providing less efficiency, and compromise performance in terms of noise and reliability.

The MP3432 from Monolithic Power Systems (MPS) operates from an input voltage as low as 2.7V, supports an operating input voltage from 0.8V to 13V, and an output voltage up to 16V. Furthermore, the MP3432 integrates two synchronous MOSFETs with optimized features, such as a programmable switching current limit up to 21.5A, up to 30W of load power from a 1-cell battery, pass-through mode in pulse-skip mode (PSM) operation, various operation modes, and high power density in a QFN (3mmx4mm) package.

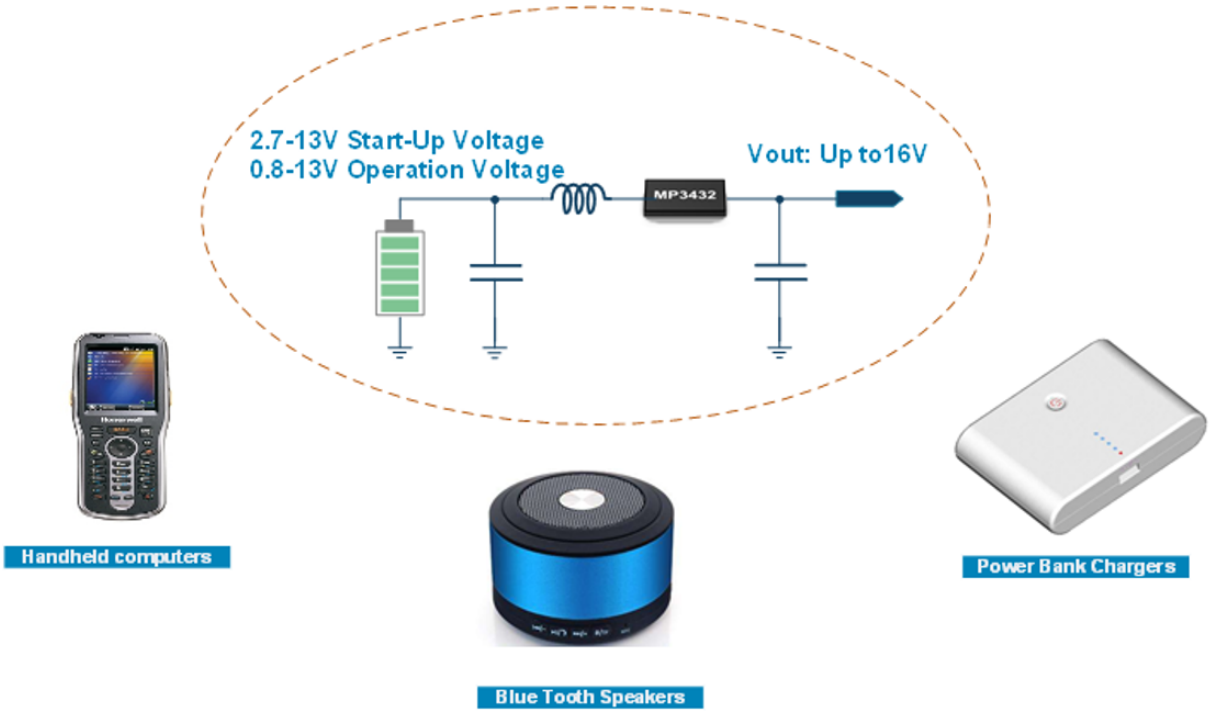


Figure 1: Li-Ion Battery Portable Applications

Small Size, High Power Density

The MP3432 eliminates the need for inefficient and bulky external Schottky diodes by integrating small 6.5mΩ and 10mΩ $R_{DS(ON)}$ power MOSFETs using MPS’ latest process technology, advanced circuit design techniques, and packaging technology. The MP3432 achieves peak efficiency up to 97% at a 4.2V input voltage and more than 85% in the main operating range with excellent thermal performance (see Figure 2 and Figure 3).

Residing in a (3mmx4mmx0.9mm) QFN package, the power density of the MP3432 is 40.9kW/inch^3, making it one of the only commercially available boost converters with the highest power density in the 30W class. Additionally, the MP3432 adopts a constant-off-time (COT) control topology, which provides fast transient response and reduces the output capacitance, which further contributes to reducing the overall solution size.

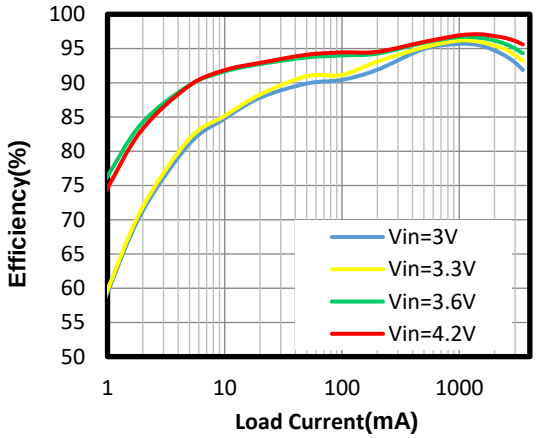


Figure 2: MP3432 Efficiency in PSM vs. Load Current

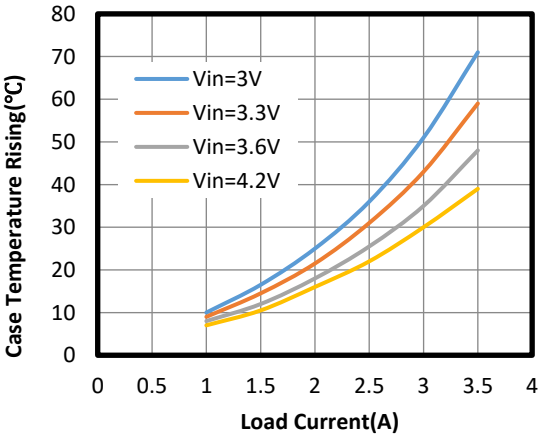


Figure 3: MP3432 Thermal Performance

Enhanced Performance and Reliability

In battery-powered Bluetooth audio applications, not only is the audio quality critical, but so is the battery life. The MP3432's MODE pin supports the selection of PSM, forced continuous conduction mode (FCCM), and ultrasonic mode (USM) in light-load condition. The MP3432 can achieve high efficiency in PSM, produce a very small V_{OUT} ripple in FCCM, and prevent audible noise in USM.

The MP3432 uses a programmable switching peak-current limit to provide accurate overload protection for many different applications.

The peak current limit can be programmed accurately through a resistor on the ILIM pin and can be calculated with Equation (1):

$$I_{LIM} = \frac{320}{R_{ILIM} - 4} \quad (1)$$

Where RILIM is the resistor on ILIM. With this resistor, the MP3432 peak current can be programmable from 4A to 21.5A. In each cycle, the internal current sensing circuit monitors the low-side MOSFET (LS-FET) current signal. Once the sensed current reaches the setting current limit, the LS-FET Q1 turns off (see Figure 4).

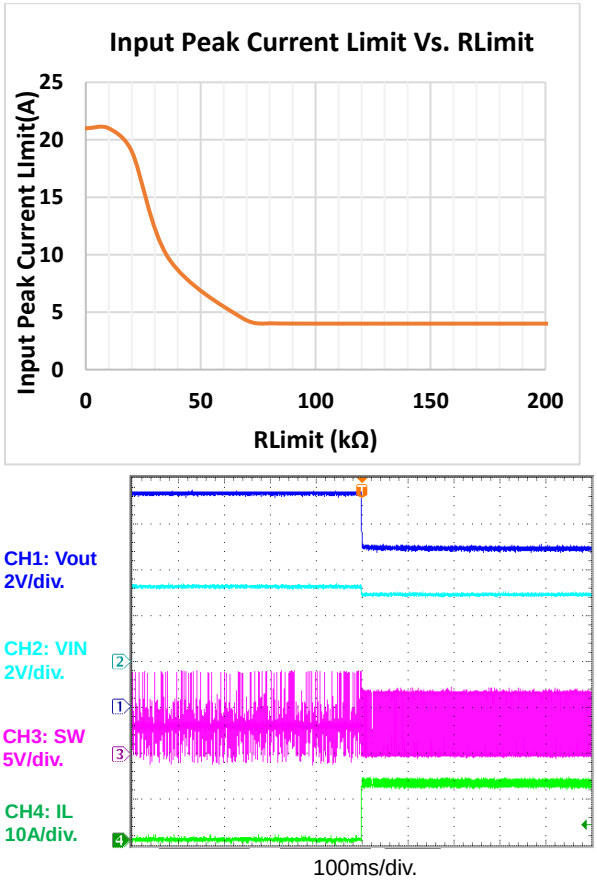
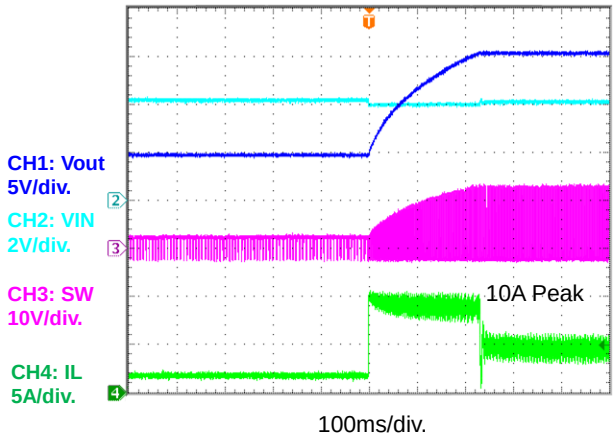


Figure 4: MP3432 Offers Accurate Input Peak Current Limit

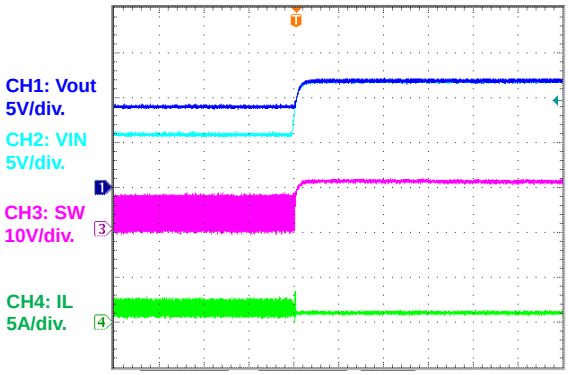
The programmable peak current limit can meet different requirements in many applications. Figure 5 shows that MP3432 can charge the output voltage quickly at the maximum power, and there is no overshoot in the transient if the output voltage transitions to a higher value.



Test condition: V_{IN} = 4.2V, V_{OUT} = 4.5V/1A → 15V/1A, I_{LIMIT} = 10A

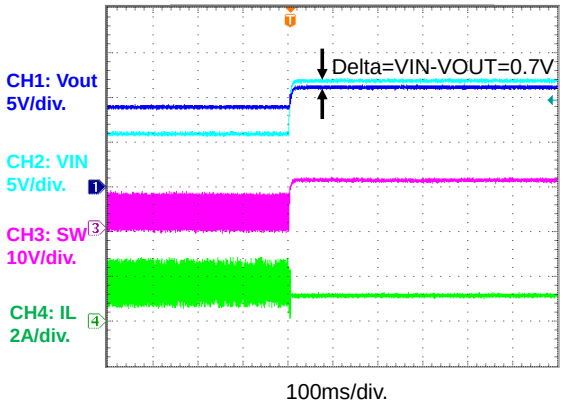
Figure 5: MP3432 Output Voltage Transient

The MP3432 can work in pass-through mode (PSM) by setting the MODE pin low. In PSM, if V_{IN} is higher than VOUT_SET, the MP3432 runs into auto-pass-through mode, in which the high-side MOSFET (HS-FET) is always on and the LS-FET always off (see Figure 6). Pass-through mode prevents HS-FET body-diode conduct power loss when V_{IN} is higher than VOUT_SET. Figure 7 shows the performance when V_{IN} is larger than V_{OUT} in a similar device without pass-through mode in PSM and the body diode is working.



Test condition: V_{IN} = 6V → 12V, V_{OUT} = 9V/1A

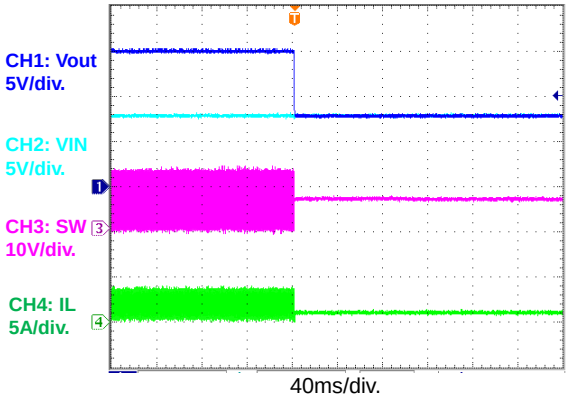
Figure 6: MP3432 Pass-Through Mode in PSM



Test condition: V_{IN} = 6V → 12V, V_{OUT} = 9V/1A

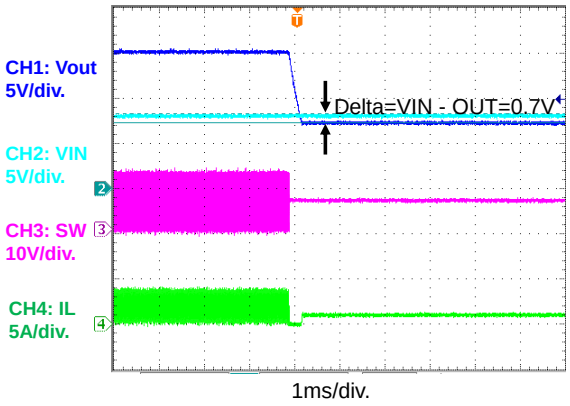
Figure 7: Another Device without Pass-Through Mode in PSM

Pass-through mode is very useful in Bluetooth speakers. The output voltage of the boost converter must be directly proportionate to the audio signal of a Bluetooth speaker. If the audio signal or the airflow is very small, the output voltage must decrease to as low as V_{IN} to save boost switching power loss. However, traditional solutions can only support high output boost switching mode. This may cause bad sound quality at the small audio signal. Even if the body diode of the old solutions work, the efficiency and thermal performances are not optimal, and the worst-case scenario would result in power MOSFET damages at a high load current due to the body diode temperature rising (see Figure 8). However, the MP3432 can work in pass-through mode, providing excellent sound quality and no smoking without high temperature or damage issues. Figure 9 shows the performance when V_{OUT} is decreasing to be equal to V_{IN} for another device without pass-through mode in PSM and the body diode is working.



Test condition: V_{IN} = 8V, V_{OUT} = 15V → 8V/1A

Figure 8: MP3432 Pass-Through Mode in PSM, V_{OUT} Decreasing



Test condition: V_{IN} = 8V, V_{OUT} = 15V → 8V/1A

Figure 9: Another Device without Pass-Through Mode in PSM, V_{OUT} Decreasing

Conclusion

The MP3432 from MPS is a perfect choice for the first stage of battery-powered systems. The MP3432 can supply 30~40W of power to systems from the battery input target for portable applications and consumes the lowest power possible in standby and idle modes while still providing high efficiency at very low current levels, resulting in a longer battery life and application run time. The MP3432 enables excellent performances at all load ranges and offers the most efficient and extensive product portfolio for portable solutions on the market today.