Application Note

AS1337

Where is the limit for the minimum battery voltage?

Content Guide

1 Where is the limit for the minimum battery voltage?

Most battery powered products have inside integral circuits that need different power supply buses. However, there is only one main power supply, given by battery, and all other have to be converted from this one with power management circuits. This article presents applications with low battery as only supply and needed power management solution for them.

2 Why the low battery voltage is needed

Because of the low cost reasons, the alkaline batteries are very often used for different portable devices. Most devices use dual cell solution, but in the future also single cell solution will be more and more implemented. The reason for this is easy: double lower cost and double smaller space needed for battery. Also the integrated circuits in the device need always lower voltage supply as future solutions, to be in trend low-power, low-voltage.

The effective zero-load voltage of a fresh alkaline battery varies from 1.5V to 1.7V. The average voltage under the load varies from 1V to 1.4 V. The fully discharged cell has a remaining voltage in the range of 0.9V or even lower.

The most integrated circuits in devices that are supplied with these batteries need supply bus of 3V or 5V. So, the step up or boost converter is needed. It should be able to work even if battery voltage (and in the same time converter input voltage) goes under 0.9V.

3 Where is the limit for minimal battery voltage?

There are actually two parameters that need to be considered for the boost converter input voltage: minimal startup voltage and minimal operating voltage. While the operating voltage can go very low, because in normal operating condition the inside blocks of the converter are supplied via output, the startup voltage is critical, because during startup the input voltage is only supply for all internal blocks. Very critical is also functioning of the startup oscillator and startup logic (that will control switching), if its supply is very low.

Also during operating condition the desired output voltage is already reached, while during startup output starts usually from 0V and big effort is needed for reaching desired output voltage.

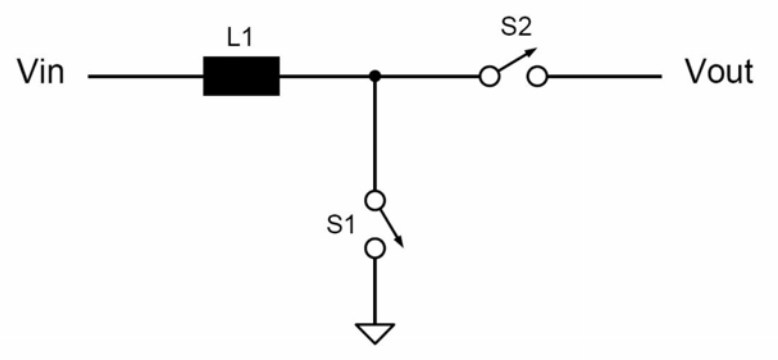

Figure 1: Typical boost converter

However, the biggest limiting factor for minimal startup input voltage is threshold of switch S1 (see Fig. 1), realized usually as NMOS transistor. For the conducting energy in coil, in the first phase the NMOS has to be ON. To be able to realize this, the converter input voltage (battery voltage) has to be bigger than NMOS threshold voltage. In 0.35 um CMOS technology this threshold is between 0.5V and 1V.

4 Real-world implementation and performance

As example AS1337 boost converter with buck conversion possibility will be used. Typical minimal startup voltage is 0.85V, and typical minimum operating voltage is 0.55V. This is exactly advantage that makes possible operation with only one cell alkaline battery. In Fig. 2 we see that minimum operating voltage is very low in the whole temperature range.

Fig. 3 shows that the efficiency is high (85% for load of 10mA, and output of 3.3V) even if the input voltage is lower than 0.9V (empty alkaline battery).

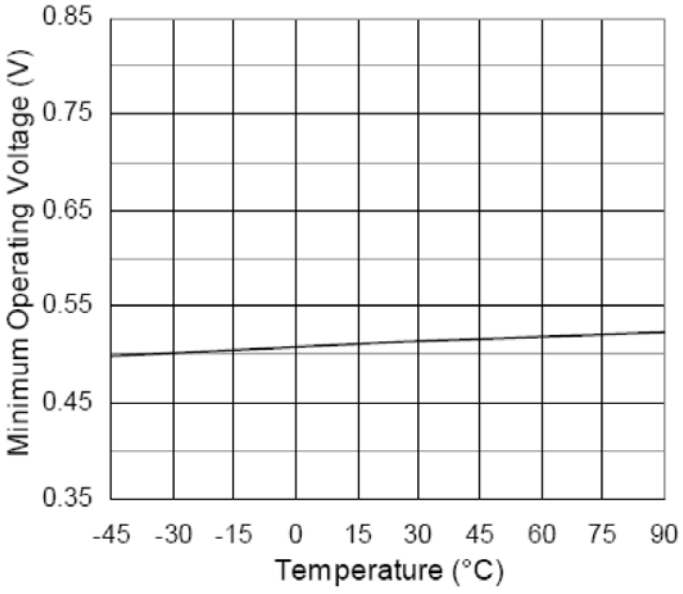

Figure 2: Minimum operating voltage of AS1343

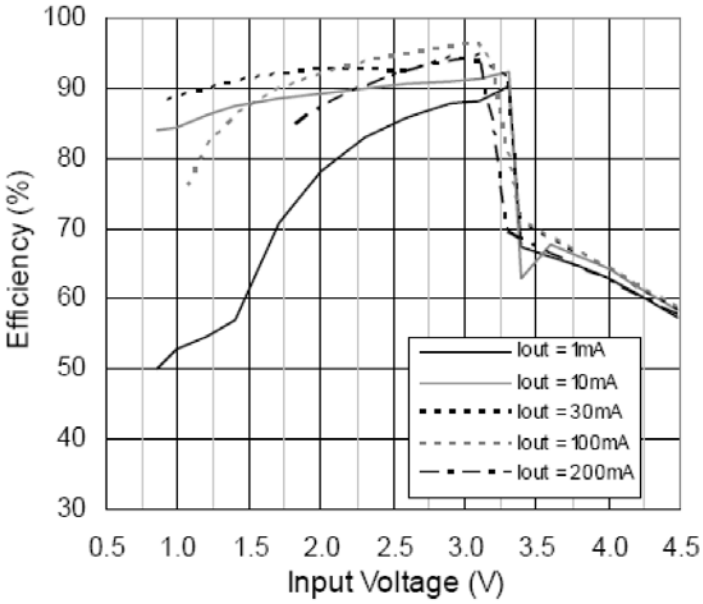

Figure 3: Typical efficiency of AS1343

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7 Revision Information

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