



AN2093 APPLICATION NOTE

ST1S03 BUCK CONVERTERS FOR HDD POWER SUPPLIES

1. ABSTRACT

The ST1S03 is a step down DC-DC converter optimized for powering the low-voltage digital core in HDD applications and, generally, replacing the high current linear solution when the power dissipation may cause excessive heating of the application environment. It provides up to 1.5A over an input voltage range of 3V to 16V. A high switching frequency (1.5MHz) allows the use of tiny surface-mount components, as well as the use of a resistor divider to set the output voltage value. Only an inductor, a Schottky diode and two capacitors are required. Besides, a low output ripple is guaranteed by the current mode PWM topology and by the use of low E.S.R. SMD ceramic capacitors. The device is thermal protected and current limited to prevent damages due to accidental short circuit. The ST1S03 is available in DFN6 (3x3) package.

Figure 1: Assembled Board



2. INTRODUCTION

Purpose of this application note is to provide a brief summary of the specifications and the functionality of the application board.

The ST1S03 is an adjustable current mode PWM step-down DC/DC converter with internal 1.5A power switch.

It is a complete 1.5A switching regulator with an internal compensation that eliminates additional components.

The constant frequency, current mode, PWM architecture and stable operation with ceramic capacitors results in a low, predictable output ripple. In order to maintain the regulation with light load, the device starts to work in pulse skipping. In a typical application where the input voltage is 5V and Vout is 1.2V, the device goes in pulse skipping for Iout lower than 15mA.

Rev. 2

The minimum efficiency guaranteed in the typical application is higher than 70%. In some conditions the efficiency can reach values equal to 90%.

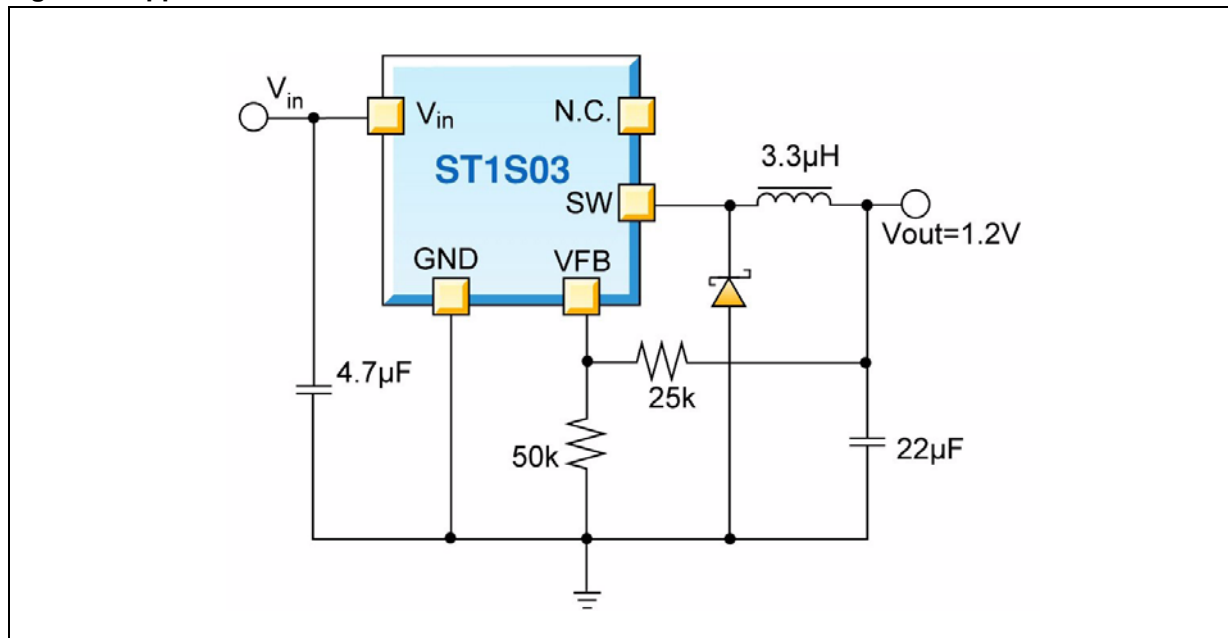
To clamp the error amplifier reference voltage a soft start control block generating a voltage ramp has been implemented. Besides, an on-chip power on reset of 50=100µs ensures a proper operation when switching on the power supply. Other circuits fitted to the device protection are the thermal shut down blocks, which turn off the regulator when the junction temperature exceeds 150°C typically and the cycle-by-cycle current limit that provides protection against shorted outputs.

Being the ST1S03 an adjustable regulator, the output voltage is determined by an external resistor divider. The desired value is given by the following equation:

$$V_{out}=V_{FB}[1+R1/R2]$$

According to the previous formula, being $V_{FB}=0.8V$, if 1.2V is needed, the external divider must be $R1=25K\Omega$, $R2=50K\Omega$

Figure 2: Application Schematic



To make the device work, only other four external components are required: a Schottky diode, an inductor and two capacitors. The chosen inductor must be able not to saturate at the peak current level, that for this device typical value is 2.3A.

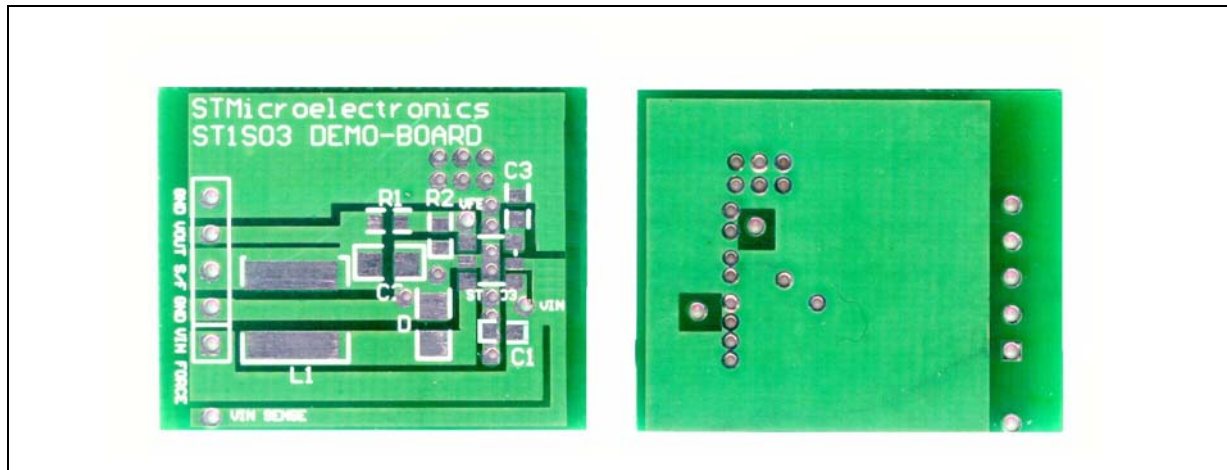
Besides, its value can be selected taking into account that a large inductor value increases the efficiency at low output current and reduces output voltage ripple, while a smaller inductor can be chosen when it is important to reduce the package size and the total cost of the application.

Finally, the ST1S03 has been designed to work properly with X5R or X7R SMD ceramic capacitors both at the input and at the output. This kind of capacitors, thanks to their very low series resistance(ESR), minimize the output voltage ripple. Other low ESR capacitors can be used according to the need of the application without invalidate the right functioning of the device.

Table 1: Suggested Components

| | | Material | Brand | P/N |
|----|-------------|----------|-------|-------------------|
| C1 | 4.7 μ F | Ceramic | TDK | C3216 X7R 1C475K |
| C2 | 22 μ F | Ceramic | TDK | C3225 X7R 1C 226M |
| L1 | 3.3 μ H | | TDK | RLF7030T-3R3M4R1 |
| D | - | - | ST | STPS2L30A |

Even if we suggest a particular brand, the device is stable with all the other brands in the market.

Figure 3: Board Layout

Due to the high switching frequency and peak current, it is important to optimize the application environment reducing the length of the PCB traces and placing all the external component near the device.

Figure 3 shows the recommended board layout.

It is very important to connect the two input pins 4mm far from the device, it avoids noise inside the control circuit, coming from the power switch. A great importance has the ground metal. It is mandatory to start all the GND patterns from the same point, in this case we can avoid the noise due to the drop on the power GND metal.

The minimum input capacitor is 4.7 μ F ceramic X7R or X5R, this value can be increased without any limitation.

The minimum suggested output capacitor is 22 μ F X7R or X5R. It is possible to obtain the minimum output capacitor value connecting several capacitors in parallel, in this case the ESR is minimized and the output ripple is reduced. Even if the device has excellent dynamic performances it is possible to improve the load transient just increasing the output capacitor value.

3. INDUCTOR CHOICE

The ST1S03 is a PWM voltage regulator with a typical working frequency of 1.5MHz. The very high frequency allows the use of small inductor values. The device is able to work with a minimum of 1 μ H inductor. We suggest using 3.3 μ H or higher values in order to cover all the parameters specified in the datasheet. Another important parameter to take into account in the inductor choice is the saturation current. Normally the device does not exceed a peak current of 2.3A @ Vin=5V.

4. SCHOTTKY DIODE

During the Toff the current in the inductor can continue to flow thanks to the schottky diode. It is very important the use of a diode with a very low threshold, in order to have high efficiency, and with a good current capability. In our application good results are obtained using the STPS2L30A diode.

In some applications, where the switching noise must be reduced, it could be useful to add a snubber circuit in parallel with the schottky diode. If necessary, we suggest to connect a 10 Ω resistor in series with a 680pF capacitor.

5. CONCLUSIONS

The device can be used in all the applications where a low supply voltage, starting from 0.8V, is needed. The low inductor and capacitors value allows the use of the ST1S03 in all the boards where space saving and power dissipation control is recommended. The high frequency makes the device compatible with the new HDD generation, where the rotation plate is 7200rpm or 10000rpm.

6. REVISION HISTORY**Table 2: Revision History**

| Date | Revision | Description of Changes |
|-------------|-----------------|---|
| 10-Dec-2004 | 1 | First Release |
| 15-Dec-2004 | 2 | In figure 2 the zener diode has been replaced by a Schottky diode |

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