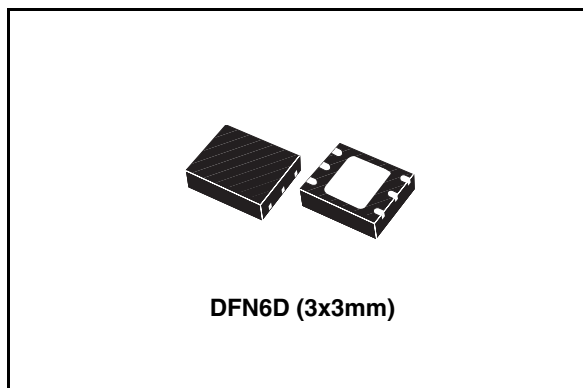


### Features

- Step-down current mode PWM (1.5 MHz) DC-DC converter
- 2 % DC output voltage tolerance
- Internal soft start for START-UP current limitation and power on delay of 50-100  $\mu$ s
- Typical efficiency: > 70 % over all operating conditions
- 1.5 A output current capability
- Not switching quiescent current: max 2.5 mA over temperature range
- Switch  $V_{DS}$ : max 350 mV @  $I_{SW} = 750$  mA
- Uses tiny capacitors and inductors
- Available in DFN 3x3 mm exposed pad

### Description

The ST1S03 is a step down DC-DC converter optimized for powering low-voltage digital core in HDD applications and, generally, to replace the high current linear solution when the power dissipation may cause an high heating of the application environment. It provides up to 1.5 A



over an input voltage range of 3 V to 16 V. An high switching frequency (1.5 MHz) allows the use of tiny surface-mount components: as well as the 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 ESR 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.

**Table 1. Device summary**

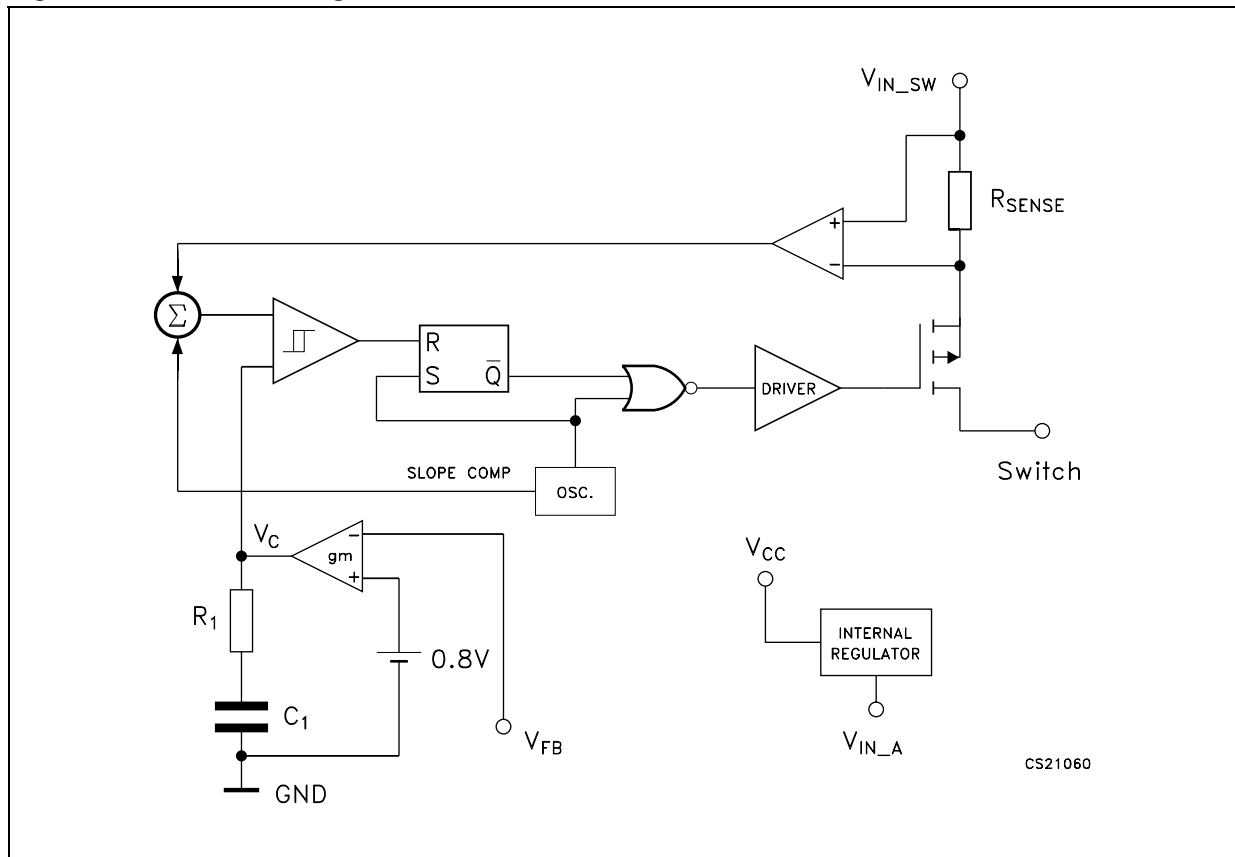
| Order code | Packaging | Package        |
|------------|-----------|----------------|
| ST1S03PU   | ST1S03PUR | DFN6D (3x3 mm) |

# Contents

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# 1 Diagram

Figure 1. Schematic diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)

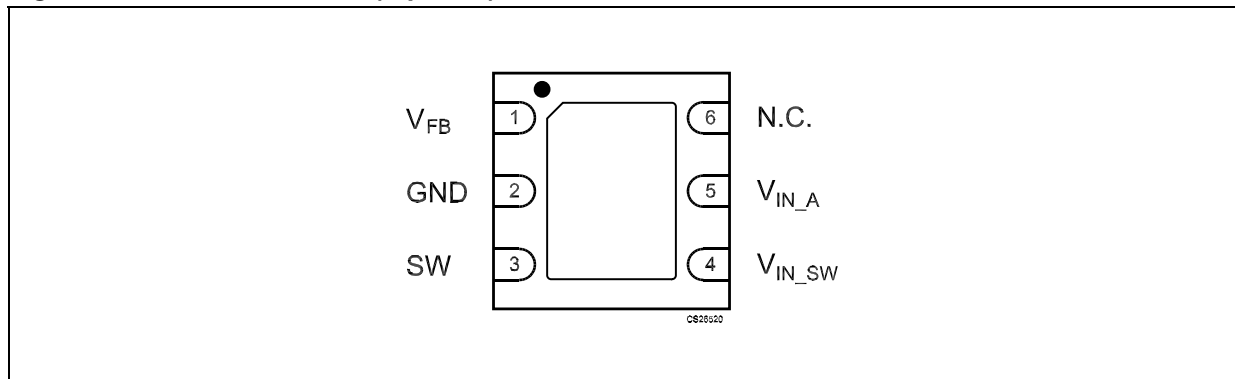


Table 2. Pin description

| Pin n° | Symbol       | Name and function                   |
|--------|--------------|-------------------------------------|
| 1      | $V_{FB}$     | Voltage of feedback                 |
| 2      | GND          | System ground                       |
| 3      | SW           | Output of the internal power switch |
| 4      | $V_{IN\_SW}$ | Power supply for the MOSFET switch  |
| 5      | $V_{IN\_A}$  | Power supply for the analog circuit |
| 6      | N.C.         | Not connected                       |

### 3 Maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol         | Parameter                            | Value      | Unit        |
|----------------|--------------------------------------|------------|-------------|
| $V_{IN\_SW}$   | Positive power supply voltage        | -0.3 to 16 | V           |
| $V_{IN\_A}$    | Positive power supply voltage        | -0.3 to 16 | V           |
| SWITCH voltage | Max voltage of output pin            | -0.3 to 16 | V           |
| $V_{FB}$       | Feedback voltage                     | 2.5        | V           |
| $I_{VFB}$      | Common mode input voltage            | $\pm 1$    | mA          |
| $T_J$          | Max junction temperature             | 150        | $^{\circ}C$ |
| $T_{STG}$      | Storage temperature range            | -25 to 150 | $^{\circ}C$ |
| $T_{LEAD}$     | Lead temperature (Soldering) 10 Sec. | 300        | $^{\circ}C$ |

*Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.*

**Table 4. Thermal data**

| Symbol     | Parameter                           | Value | Unit          |
|------------|-------------------------------------|-------|---------------|
| $R_{thJC}$ | Thermal resistance junction-case    | 10    | $^{\circ}C/W$ |
| $R_{thJA}$ | Thermal resistance junction-ambient | 55    | $^{\circ}C/W$ |

## 4 Electrical characteristics

**Table 5. Electrical characteristics** ( $V_{IN\_SW} = V_{IN\_A} = 5\text{ V}$ ,  $C_1 = 4.7\ \mu\text{F}$ ,  $C_O = 22\ \mu\text{F}$ ,  $L_1 = 3.3\ \mu\text{H}$ ,  $T_J = 0\text{ to }125\text{ }^\circ\text{C}$ , unless otherwise specified. Typical values are referred to  $25\text{ }^\circ\text{C}$ )

| Symbol                                     | Parameter                                     | Test conditions  | Min. | Typ.   | Max.  | Unit                  |
|--|---|--|------|--------|-------|-----------------------|
| FB   | Feedback voltage                              | $I_O = 100\text{mA}$   | 784  | 800    | 816   | mV                    |
| $I_{FB}$                                   | $V_{FB}$ pin bias current                     |  |      |        | 600   | nA                    |
| $I_Q$                                      | Quiescent current                             | No Switching   |      |        | 2.5   | mA                    |
| $I_O$                                      | Output current                                | $V_{IN} = 3\text{V to }16\text{V}$   | 1.5  |        |       | A                     |
| $I_{MIN}$                                  | Minimum output current                        |  | 1    |        |       | mA                    |
| $\%V_O/\Delta V_{IN}$                      | Reference line regulation                     | $V_{IN} = 3\text{V to }16\text{V}$   |      | 0.032  | 0.06  | $\%V_O/\Delta V_{IN}$ |
| $\%V_O/\Delta I_O$                         | Reference load regulation                     | $I_O = 10\text{mA to }1.2\text{A}$   |      | 0.0014 | 0.003 | $\%V_O/\text{mA}$     |
| PWM $f_S$                                  | PWM switching frequency <sup>(1)</sup>        | $V_{FB} = 0.8\text{V}$ , $T_A = 25^\circ\text{C}$  | 1.2  | 1.5    | 1.8   | MHz                   |
| $D_{MAX}$                                  | Maximum duty cycle                            |  |      | 87     |       | %                     |
| $I_{SWL}$                                  | Switching current limitation                  |  | 1.65 |        |       | A                     |
| $V_{DS}$                                   | Switch $V_{DS}$                               | $I_{SW} = 750\text{ mA}$   |      | 200    | 350   | mV                    |
| E  | Efficiency                                    | $I_O = 10\text{mA to }1.2\text{A}$   | 70   |        |       | %                     |
| $T_{SHDN}$                                 | Thermal shut down <sup>(1)</sup>              |  | 130  | 150    |       | $^\circ\text{C}$      |
| $T_{HYS}$                                  | Thermal shut down hysteresis <sup>(1)</sup>   |  |      | 15     |       | $^\circ\text{C}$      |
| $\Delta V_O/\Delta I_O$                    | Load transient response <sup>(1)</sup>        | $I_O = 100\text{mA to }700\text{mA}$<br>$t_R = t_F \geq 100\text{ns}$ , $T_A = 25^\circ\text{C}$ | -5   |        | +5    | $\%V_O$               |
| $\Delta V_O/\Delta I_O @ I_O=\text{short}$ | Short circuit removal response <sup>(1)</sup> | $I_O = 10\text{mA to short}$ , $T_A = 25^\circ\text{C}$  |      |        | +5    | $\%V_O$               |

1. Guaranteed by design, but not tested in production.

## 5 Application notes

The ST1S03 is an adjustable current mode PWM step-down DC-DC converter with internal 1.5 A power switch, packaged in 6-lead DFN 3x3 mm.

It's a complete 1.5 A switching regulator with its internal compensation eliminating additional component.

The constant frequency, current mode, PWM architecture and stable operation with ceramic capacitors results in low, predictable output ripple. However, in order to keep the output regulated, the device goes in pulse skipping mode when a very light load is required.

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  $50 = 100 \mu\text{s}$  ensure the proper operation when switching on the power supply. Other circuits fitted to the device protection are the thermal shut down block which turn off the regulator when the junction temperature exceeds  $150 \text{ }^\circ\text{C}$  typically and the cycle-by-cycle current limiting that provides protection against shorted outputs.

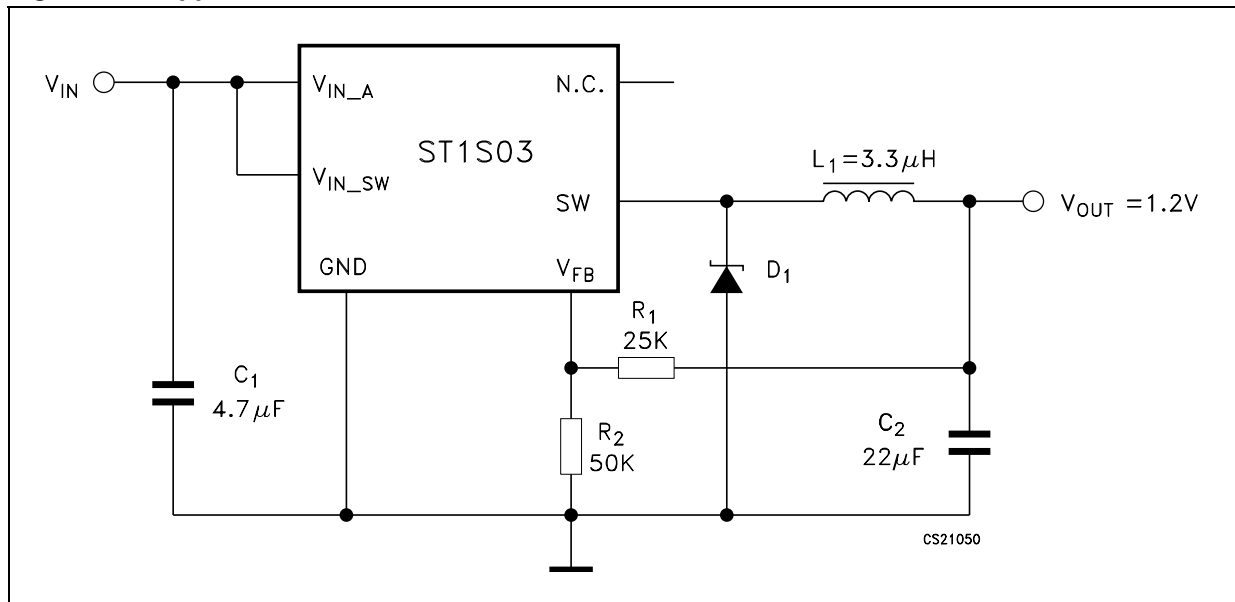
Being the ST1S03 an adjustable regulator, the output voltage is determined by an external resistor divider. The desired value is given by the following equation:

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

To make the device working, only other four external components are required: a Schottky diode, an inductor and two capacitors. The chosen inductor must be able to not saturate at the peak current level. Besides, its value can be selected keeping in 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 invalidating the right functioning of the device. 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.

## 6 Typical application

Figure 3. Application circuits

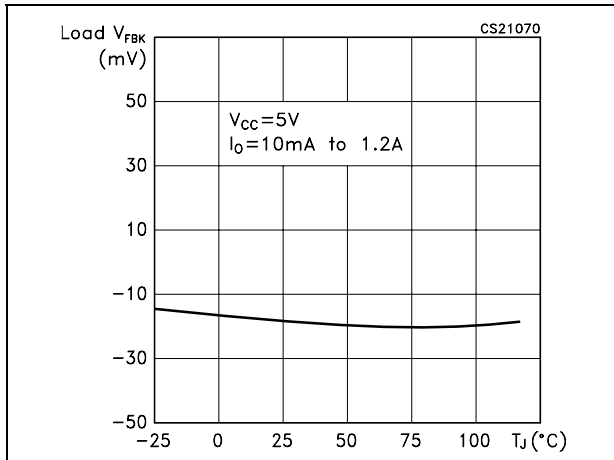




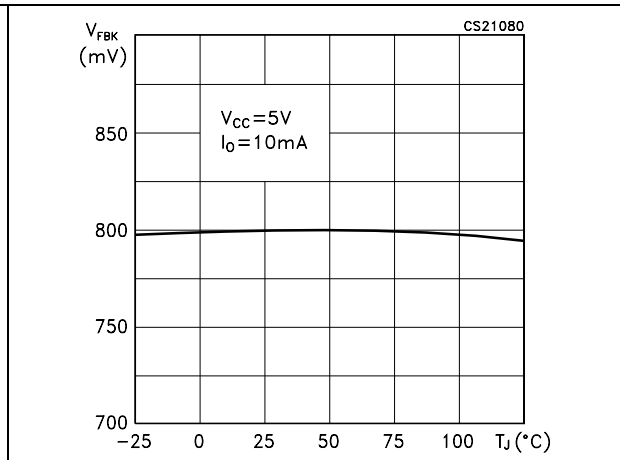
# 7 Typical performance characteristics

( $L_1 = 3.3 \mu\text{H}$ ,  $C_1 = 4.7 \mu\text{F}$ ,  $C_O = 22 \mu\text{F}$ , unless otherwise specified)

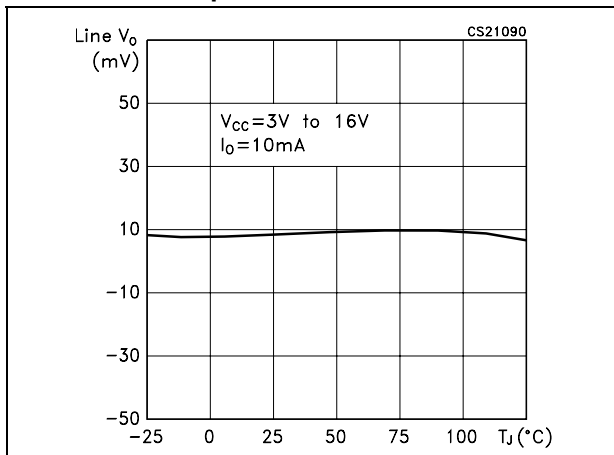
**Figure 4. Load voltage feedback vs temp.**



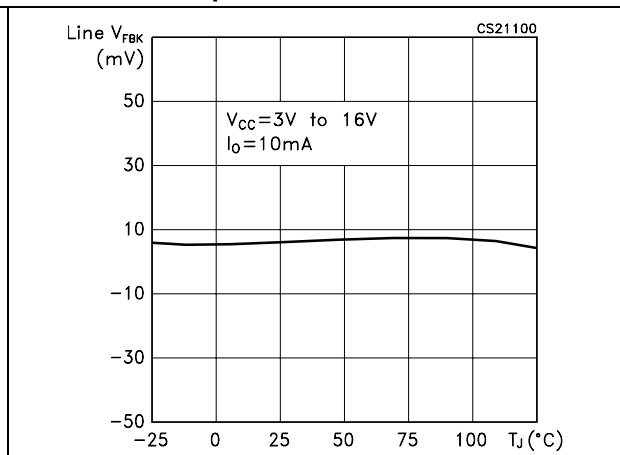
**Figure 5. Voltage feedback vs temperature**



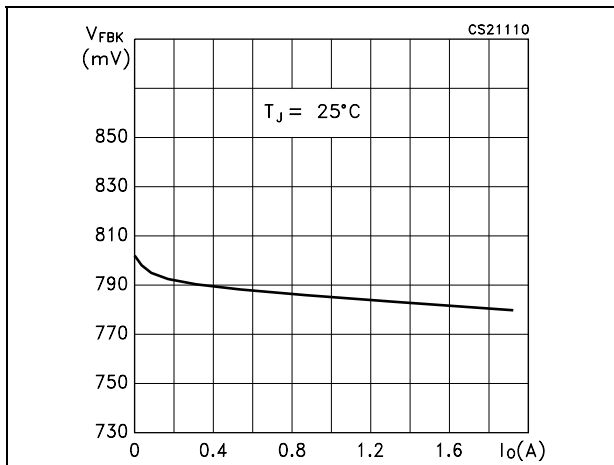
**Figure 6. Line output voltage regulation vs temperature**



**Figure 7. Line voltage feedback vs temperature**



**Figure 8. Voltage feedback vs output current**



**Figure 9. PWM Switching frequency vs temperature**

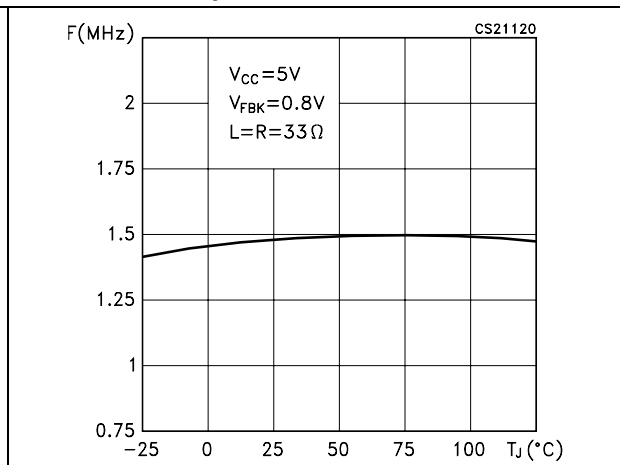


Figure 10. Quiescent current vs temperature

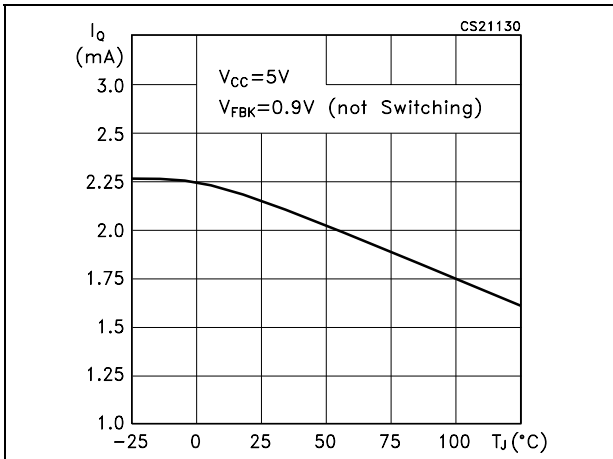


Figure 11. Quiescent current vs input voltage

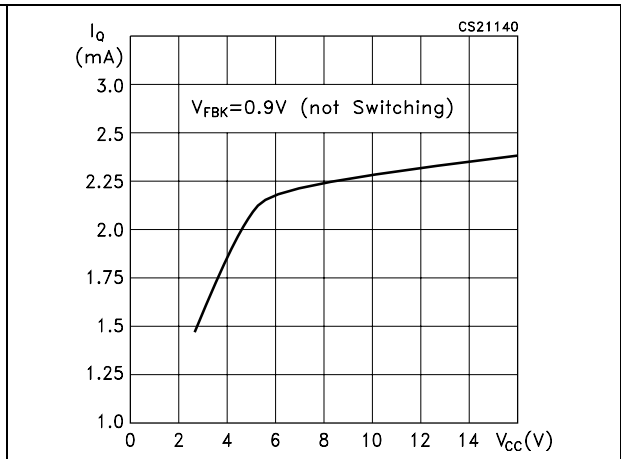


Figure 12. Minimum operating voltage vs output voltage

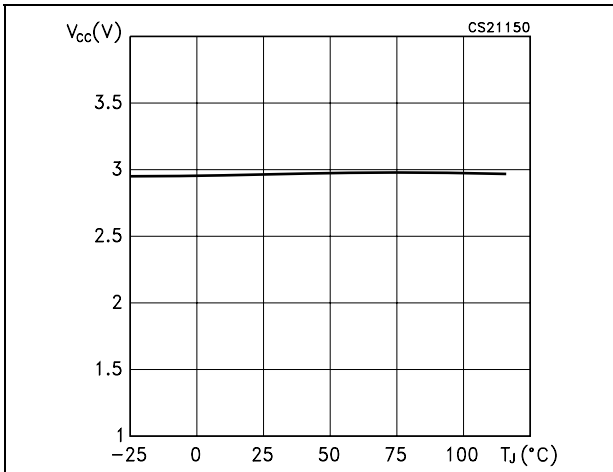


Figure 13. Efficiency vs temperature

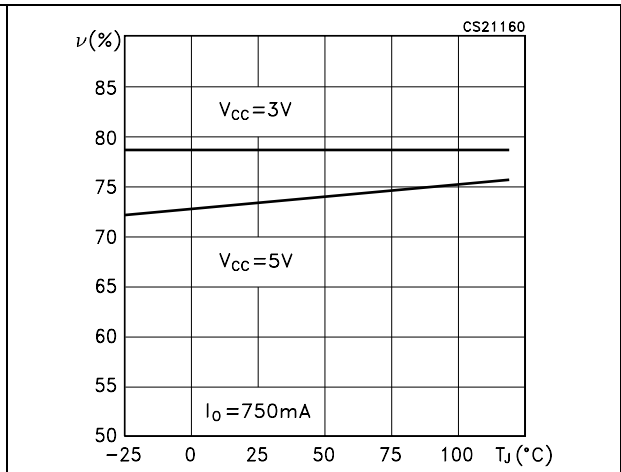


Figure 14. Efficiency vs output current

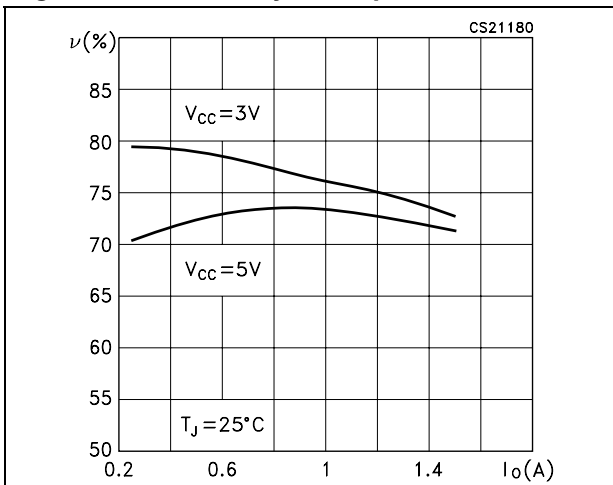


Figure 15. Switch VDS vs temperature

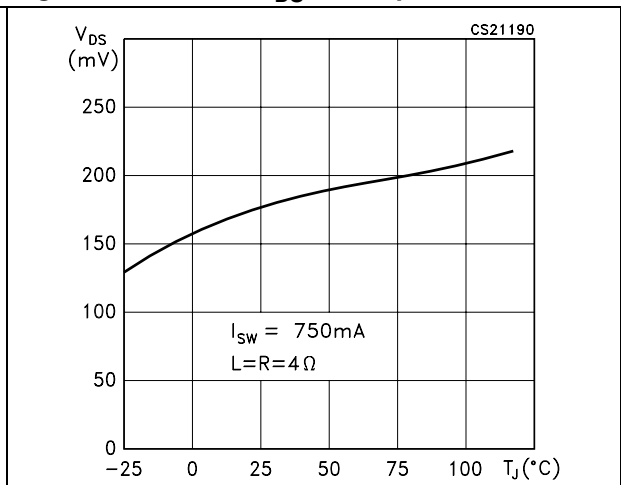


Figure 16. Switch RDS-ON vs temperature

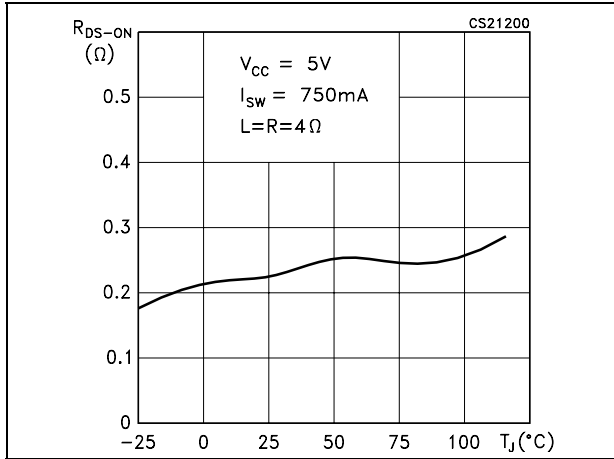


Figure 17. Switch current limitation vs temperature

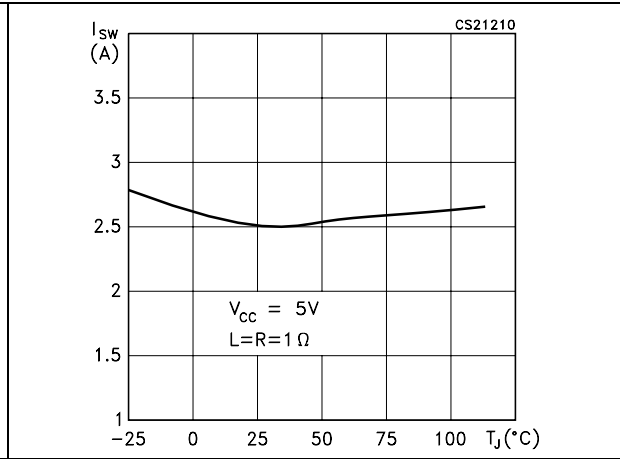


Figure 18. Load transient response

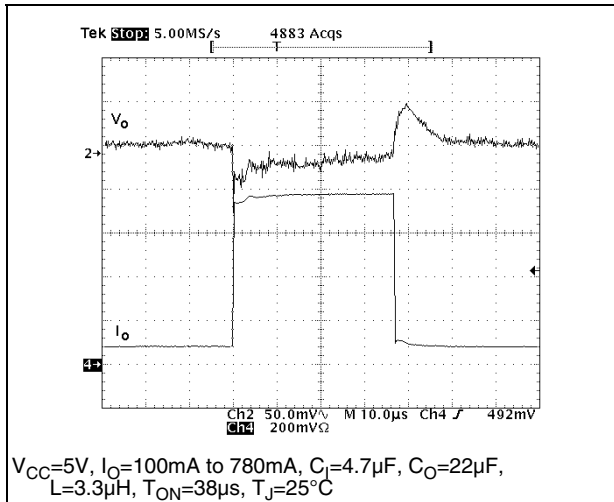


Figure 19. Load transient response

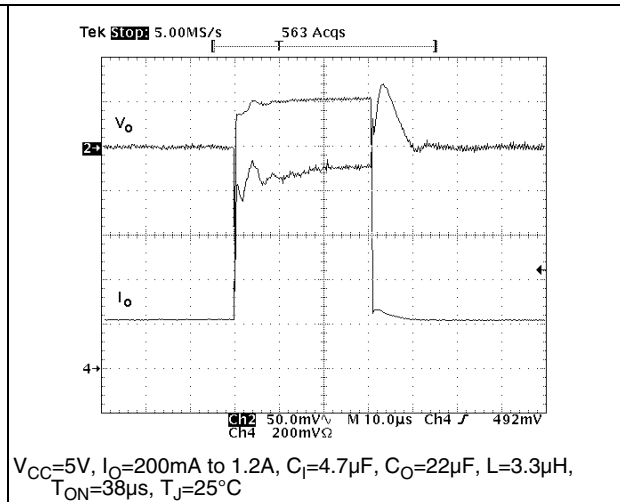


Figure 20. Start-Up transient

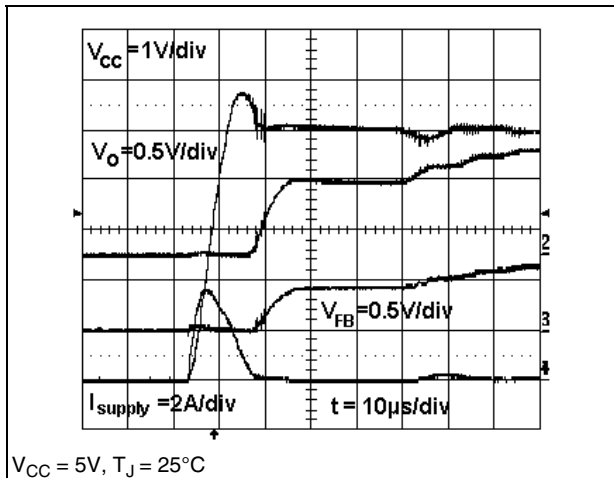
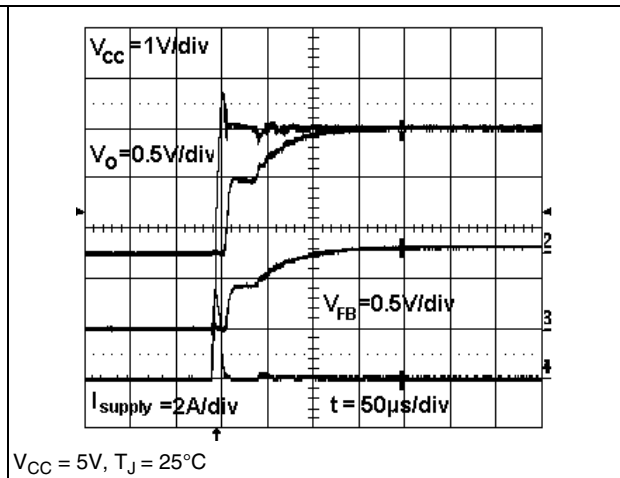


Figure 21. Start-Up transient

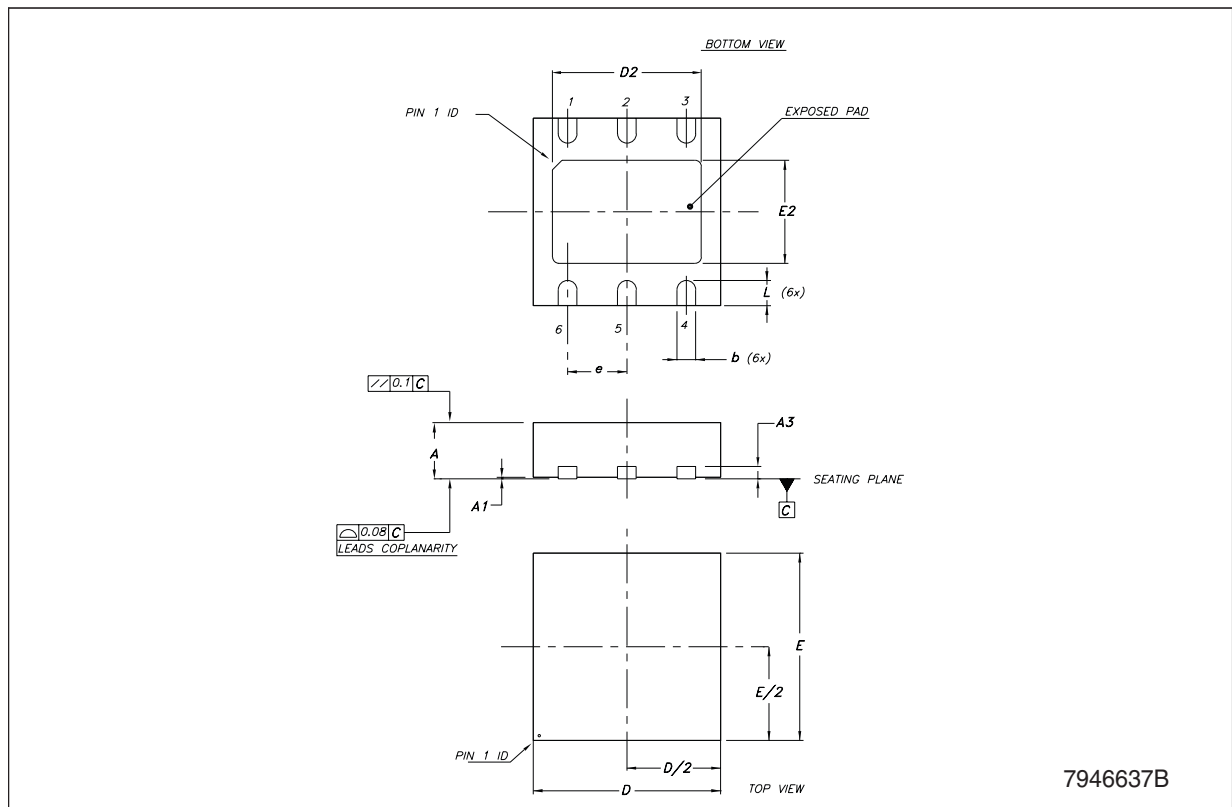


## 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. These packages have a lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

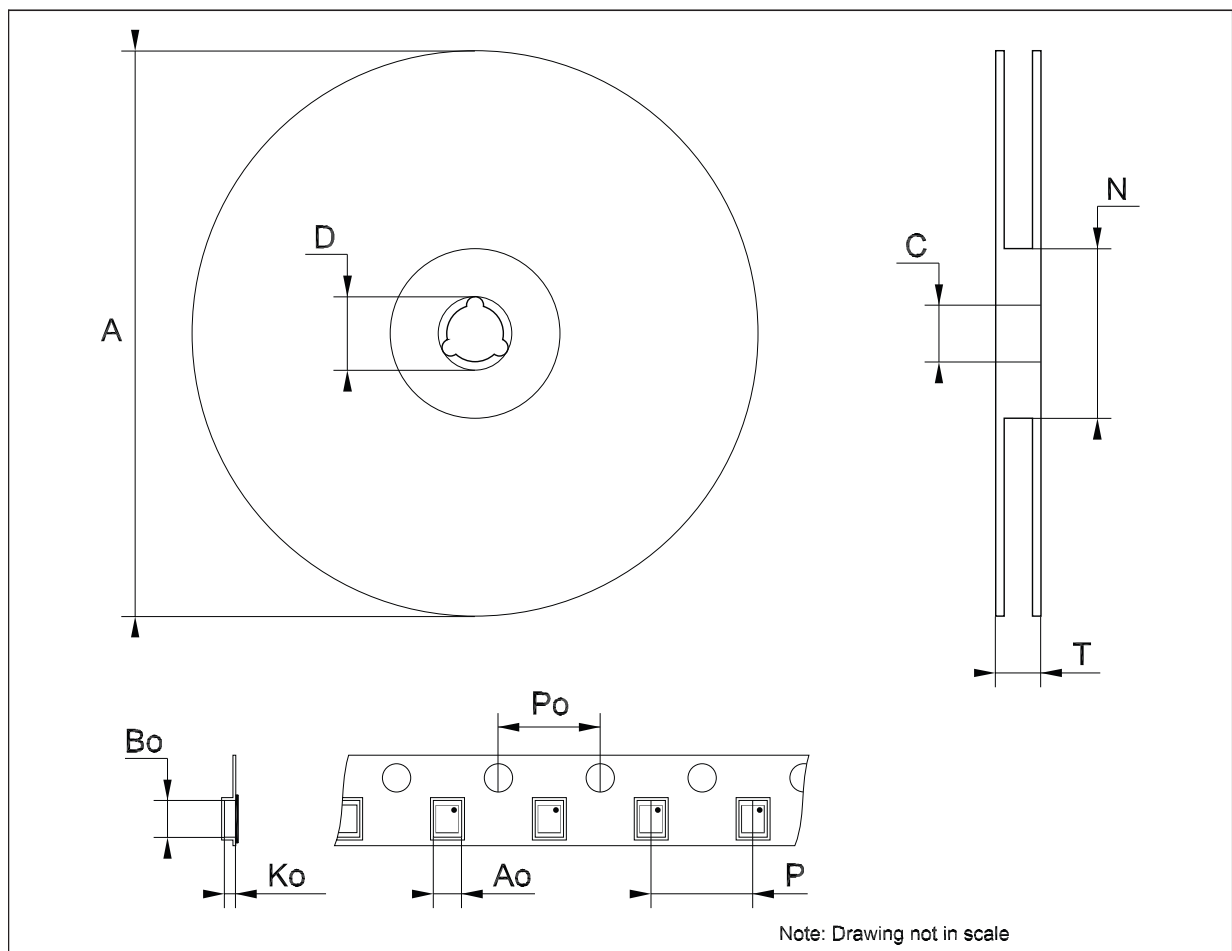
**DFN6D (3x3 mm) mechanical data**

| Dim. | mm.  |      |      | inch. |       |       |
|------|------|------|------|-------|-------|-------|
|      | Min. | Typ. | Max. | Min.  | Typ.  | Max.  |
| A    | 0.80 |      | 1.00 | 0.031 |       | 0.039 |
| A1   | 0    | 0.02 | 0.05 | 0     | 0.001 | 0.002 |
| A3   |      | 0.20 |      |       | 0.008 |       |
| b    | 0.23 |      | 0.45 | 0.009 |       | 0.018 |
| D    | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| D2   | 2.23 |      | 2.50 | 0.088 |       | 0.098 |
| E    | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E2   | 1.50 |      | 1.75 | 0.059 |       | 0.069 |
| e    |      | 0.95 |      |       | 0.037 |       |
| L    | 0.30 | 0.40 | 0.50 | 0.012 | 0.016 | 0.020 |



**Tape & Reel QFNxx/DFNxx (3x3) Mechanical Data**

| Dim. | mm.  |      |      | inch. |       |        |
|------|------|------|------|-------|-------|--------|
|      | Min. | Typ. | Max. | Min.  | Typ.  | Max.   |
| A    |      |      | 330  |       |       | 12.992 |
| C    | 12.8 |      | 13.2 | 0.504 |       | 0.519  |
| D    | 20.2 |      |      | 0.795 |       |        |
| N    | 60   |      |      | 2.362 |       |        |
| T    |      |      | 18.4 |       |       | 0.724  |
| Ao   |      | 3.3  |      |       | 0.130 |        |
| Bo   |      | 3.3  |      |       | 0.130 |        |
| Ko   |      | 1.1  |      |       | 0.043 |        |
| Po   |      | 4    |      |       | 0.157 |        |
| P    |      | 8    |      |       | 0.315 |        |



## 9 Revision history

**Table 6. Document revision history**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>  |
|-------------|-----------------|---|
| 11-Nov-2004 | 1               | First Release.  |
| 08-Feb-2005 | 2               | Maturity Change.  |
| 03-Mar-2005 | 3               | Mistake on Figure 1, $T_J$ is changed 125 ==> 150°C on Table 3. |
| 13-Jul-2005 | 4               | Add new package SO-8 exposed pad.                               |
| 29-Mar-2007 | 5               | Package SO-8 removed.   |
| 07-Mar-2008 | 6               | Removed: package mechanical data DFN6.                          |

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