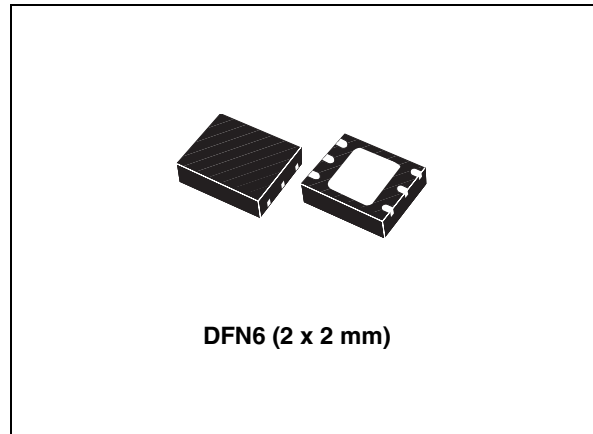# STLA02

## White LED driver for display backlight

## Features

- Boost DC-DC converter
- Drives up to 6 LEDs with a total current up to 20 mA
- Output power capability up to 500 mW
- Input voltage range 2.5 V to 18 V
- Output current control
- 2.3 MHz switching frequency
- PWM input for the output current dimming with 300:1 dimming range
- 350 mA integrated switch
- Overvoltage protection
- Chip overtemperature detection and protection
- Soft-start implemented
- Package DFN6 2 x 2 mm

## Applications

- PDA and handheld devices
- Cellular phones
- MP3 players

## Description

STLA02 is a boost converter that operates from 2.5 V to 18 V and can provide an output voltage as high as 27 V and can drive up to 6 white LEDs connected in series. The total output current capability is 20 mA at an output voltage of 24 V. The total output power capability is up to 500 mW. The regulation is done by the internal error amplifier which works with the feedback voltage from the sensing resistor connected in high side sensing configuration. The device can be turned
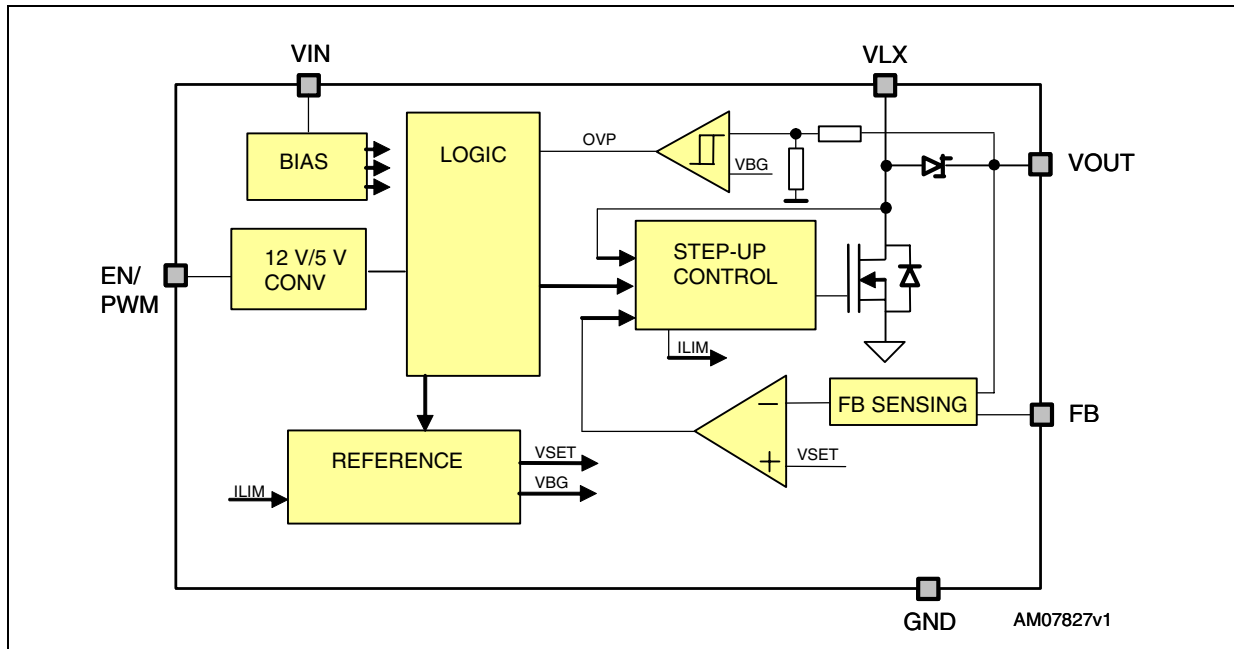
**DFN6 (2 x 2 mm)**

on/off by the logic signal connected to the EN pin and this pin is also dedicated for the PWM dimming of the output current. Current mode control of the regulation allows a fast response to a change of the enable pin voltage level.

**Table 1.    Device summary**

| Part number | Order code | Package |
|---|---|---|
| STLA02 | STLA02PUR | DFN6 (2 x 2 mm) |

# Contents

# 1        Diagram

**Figure 1.      Block diagram**

# 2 Pin configuration

**Figure 2. Pin connections (top view)**



CS26800
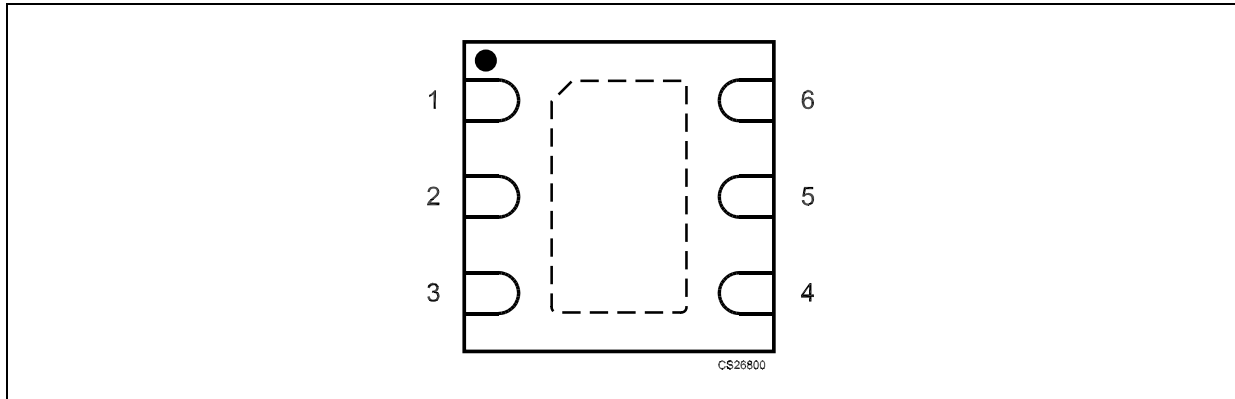
**Table 2. Pin description**

| Pin n° | Symbol | Name and function |
|--------|--------|-------------------|
| 1 | $V_{IN}$ | Supply voltage pin |
| 2 | GND | Ground |
| 3 | LX | Switching pin |
| 4 | $V_{OUT}$ | Output voltage pin |
| 5 | FB | Feedback voltage |
| 6 | EN/PWM | Enable pin or PWM control input for dimming |
| Exposed pad | GND | Ground |

# 3 Maximum ratings

**Table 3.    Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{IN}$ | Signal supply voltage | - 0.3 to 19 | V |
| $V_{LX}$ | Inductor connection | - 0.3 to 30 | V |
| FB | Feedback connection[1] | - 0.3 to 30 | V |
| EN/PWM | Logic pin/PWM input | - 0.3 to 12 | V |
| $V_{OUT}$ | Output voltage connection | - 0.3 to 30 | V |
| $P_{TOT}$ | Continuous power dissipation (at $T_A$ = 70 °C)[1] | 530 | mW |
| $T_{OP}$ | Operating ambient temperature range | - 40 to 85 | °C |
| $T_J$ | Junction temperature | - 40 to 150 | °C |
| $T_{STG}$ | Storage temperature range | - 65 to 150 | °C |

1.   The maximum acceptable difference between the $V_{OUT}$ pin potential and feedback pin potential is 5 V.

*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 |
|---|---|---|---|
| $R_{thJA}$ | Thermal resistance junction-ambient [1] | 102 | °C/W |

1.   Power dissipation is dependent on PCB. The recommended PCB design is included in this document (TBD).

**Table 5.    ESD**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| HBM | Human body model | 2 | kV |
| MM | Machine model | 200 | V |

# 4 Application

**Figure 3. Application schematic**
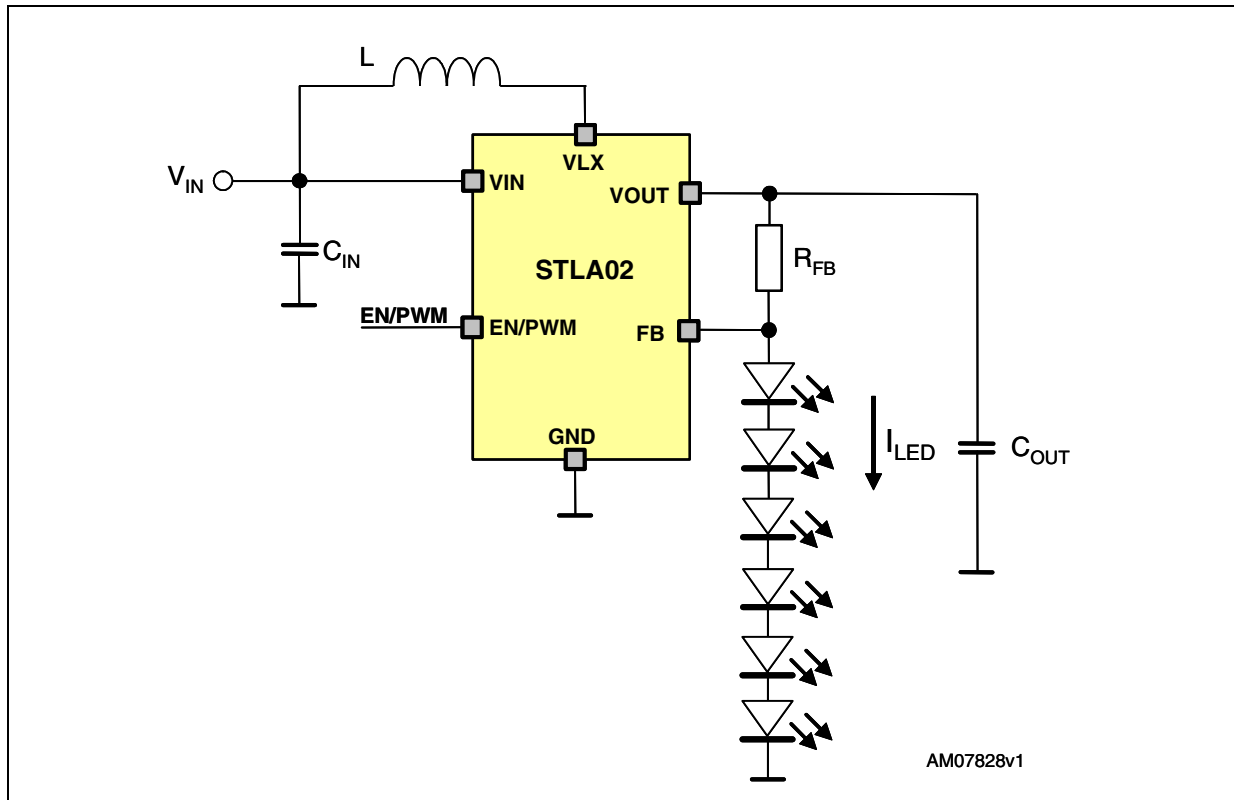


**Table 6. List of external components**

| Component | Manufacturer | Part number | Value | Size |
|---|---|---|---|---|
| $C_{IN}$ | MURATA | GRM216R61E105KA12 | 1 µF / 25 V | 0805 |
| $C_{OUT}$ | MURATA | GRM216R61E105KA12 | 1 µF / 25 V | 0805 |
| L | MURATA | LQH3NPN100NJ0L | 10 µH | 3x3x0.9 mm |
| | TDK | VLF3012ST-100MR59 | 10 µH | 3x2.8x1.2 mm |
| $R_{FB}$ | TYCO | CPF0402B10RE | 10 Ω | 0402 |
| LED | OSRAM | LWL283-Q1R2-3K8L-1-Z | 20 mA / 3.1 V | 0603 |

*Note:* *Above listed components refer to a typical application with maximum performance settings. Operation of the STLA02 is not limited to the choice of these external components.*

# 5 Electrical characteristics

$V_{EN}$ = $V_{IN}$ = 3 V $T_A$ = - 40 °C to 85 °C unless otherwise specified. Typical values are at $T_A$ = 25 °C, unless otherwise specified.

**Table 7. Electrical characteristics**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input operating supply voltage | | 2.5 | | 18 | V |
| $I_S$ | Supply current | $V_{EN}$ = $V_{IN}$, $V_{OUT}$ = 24 V, $V_{FB}$ = 23 V | | 2 | 4 | mA |
| | | $V_{EN}$ = GND | | 10 | | µA |
| $I_O$ | Output current adjustment | $V_{IN}$ = 2.5 V to 18 V, $R_{FB}$ = 10 $\Omega$ | | | 20 | mA |
| $V_{OUT}$ | Regulated voltage range | $V_{IN}$ = 2.5 V to 18 V | $V_{IN}$+1 | | 27 | V |
| $I_{PEAK}$ | Inductor peak current | $V_{IN}$ = 2.5 V | 300 | 400 | 550 | mA |
| $V_{FB}$ | Feedback voltage ($V_{OUT}$ - $V_{FB}$) | $V_{EN}$ = $V_{IN}$, $R_{FB}$ = 10 $\Omega$ | 190 | 200 | 210 | mV |
| $I_{FB}$ | FB bias current | $V_{EN}$ = $V_{IN}$, $V_{OUT}$ = 24 V, $V_{FB}$ = 24 V | | 6 | | µA |
| $I_{LX(leak)}$ | N-MOS leakage current | $V_{EN}$ = 0, $V_{LX}$ = $V_{OUT}$ = 24 V | | | 0.1 | µA |
| $\Delta I_O$ | Output current tolerance | $V_{IN}$ = 3 V, $I_{OUT}$ = 0.2 V / $R_{FB}$ | -5 | | 5 | % |
| $f_s$ | Switching frequency | $V_{IN}$ = 2.5 V, $T_A$ = 25 °C | 1.7 | 2 | 2.3 | MHz |
| $D_{MAX}$ | Maximum duty cycle | $V_{EN}$ = $V_{IN}$, $V_{OUT}$ = 24 V, $V_{FB}$ = 24 V | 88 | 92 | | % |
| $R_{DSon}$-N | Internal N-channel $R_{DSon}$ | $I_{LX}$ = 20 mA | | 0.8 | | $\Omega$ |
| $\nu$ | Efficiency of the chip itself | $V_{IN}$ = 10 V, $I_O$ = 20 mA, $V_O$ = 6 x $V_{FLED\_max}$ + $V_{RSENSE}$ = 24 V [1] | | 85 | | % |
| $\nu$ | Efficiency of the whole application | $V_{IN}$ = 10 V, $I_O$ = 20 mA, $V_O$ = 6 x $V_{FLED\_max}$ + $V_{RSENSE}$ = 24 V [1] | | 83 | | % |
| OVP | Output overvoltage protection | $V_{IN}$ = 3 V, no load | | 28 | | V |
| $T_{SHDN}$ | Thermal shutdown | | 130 | 150 | | °C |
| $T_{HYS}$ | Thermal shutdown hysteresis | | | 15 | | °C |
| $V_{IL}$ | Low and high level input logic signal on EN pin | $V_{IN}$ = 2.5 V to 18 V, $V_{ENMAX}$ = 12 V | 0 | | 1.5 | V |
| $V_{IH}$ | | | 1.8 | | $V_{IN}$ | |
| $T_{EN}$ | LED current rise time $I_{LED}$ = 0 to $I_{LED}$ = 20 mA | $V_{IN}$ = 9 V, $V_{EN}$ = 0 V to 3 V 6 LEDs in series [1] | | 0.2 | | ms |
| $T_{RESPONSE}$ | LED current rise time $I_{LED}$ = 0 mA to $I_{LED}$ = 20 mA | $V_{IN}$ = 9 V, $V_{EN}$ = 0 V to 3 V, 6 LEDs in series [1], $V_{OUT}$ precharged | | 60 | | µs |

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

# 6 Typical performance characteristics

**Figure 4.    Efficiency at 20 mA current load**
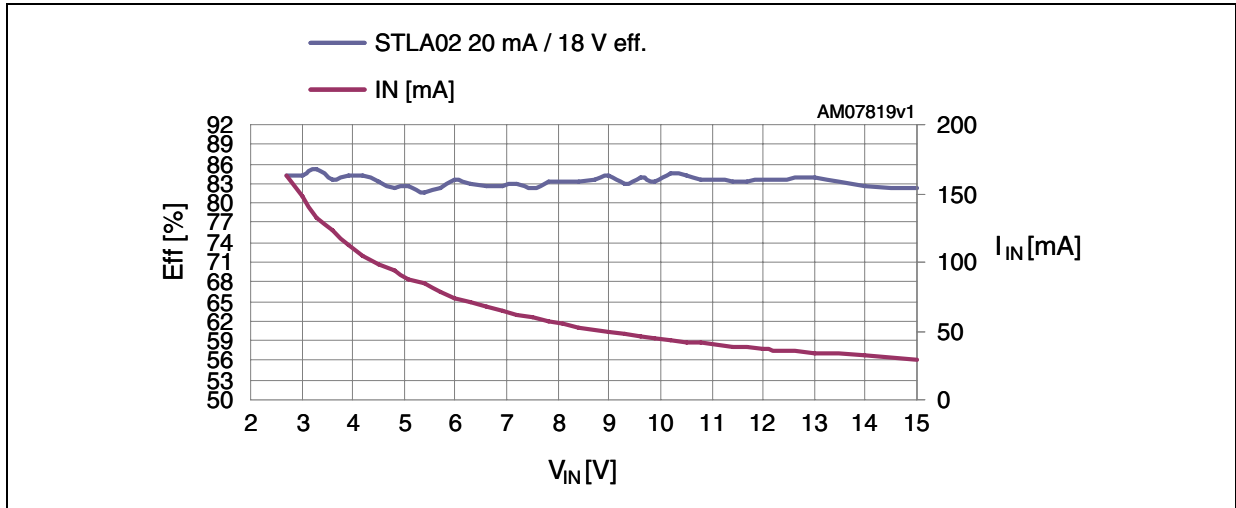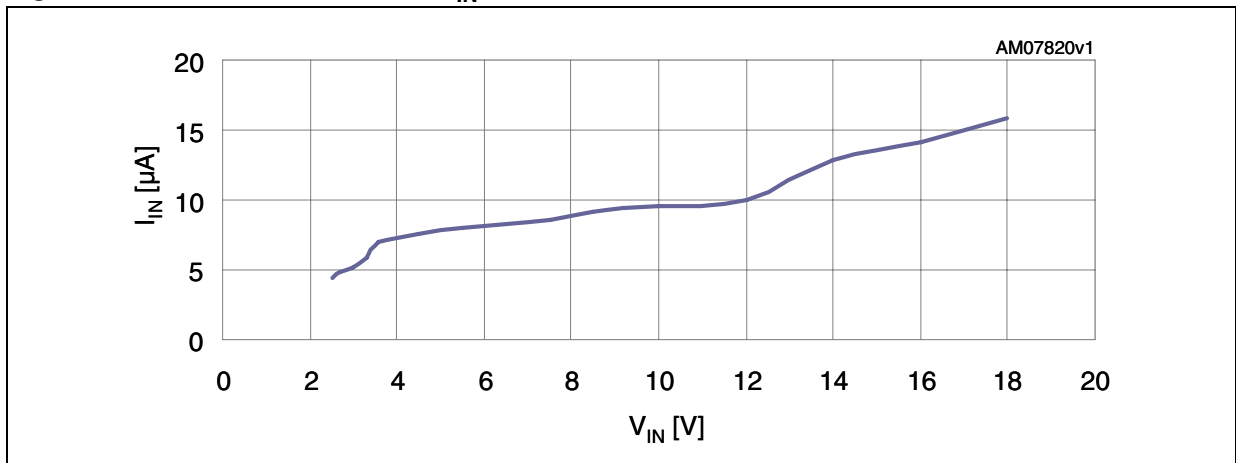


**Figure 5.    Quiescent current vs. V$_{IN}$**

**Figure 6.**     **STLA02 driver current consumption vs. V$_{IN}$**



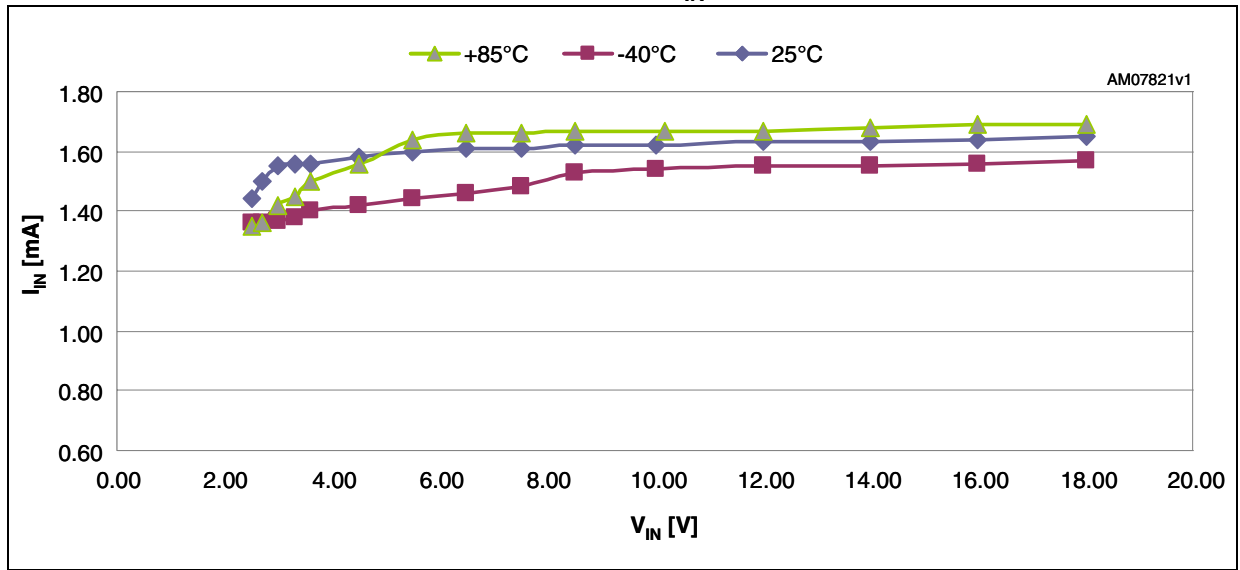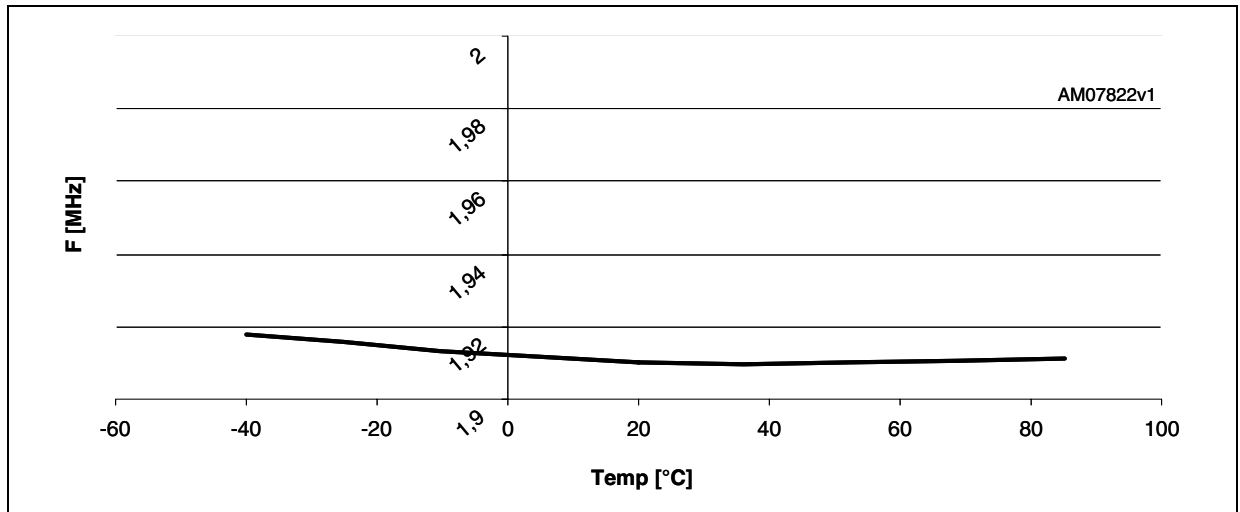**Figure 7.**     **Switching frequency vs. temperature**

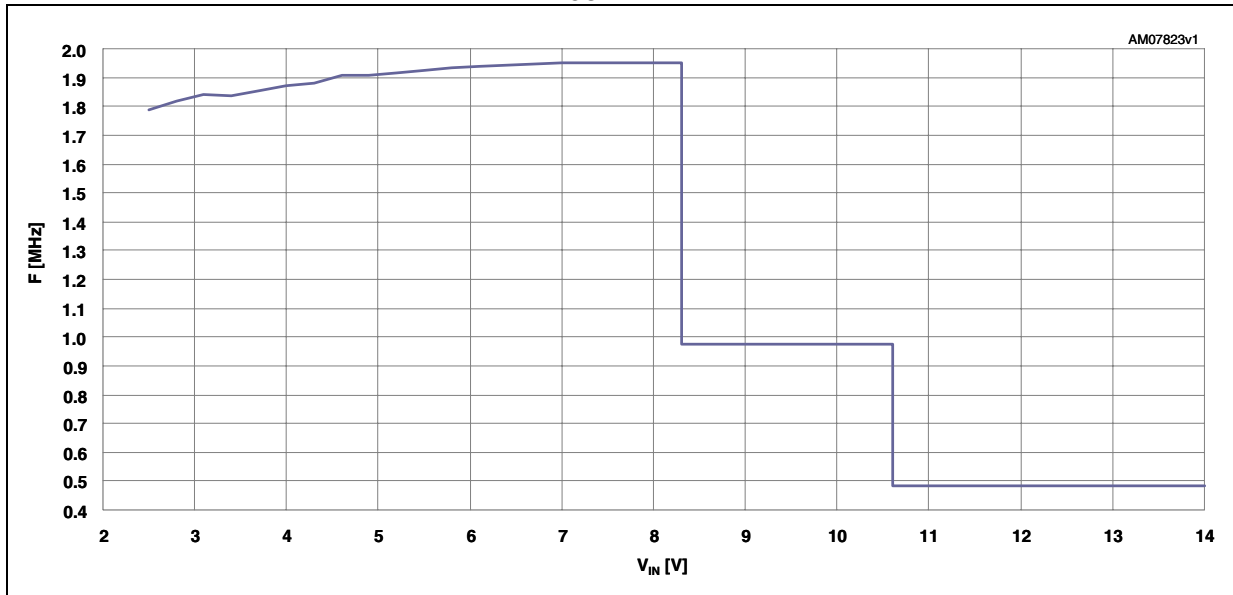**Figure 8. Switching frequency vs. $V_{IN}$ @ $P_{OUT}$ = 0.36 W**



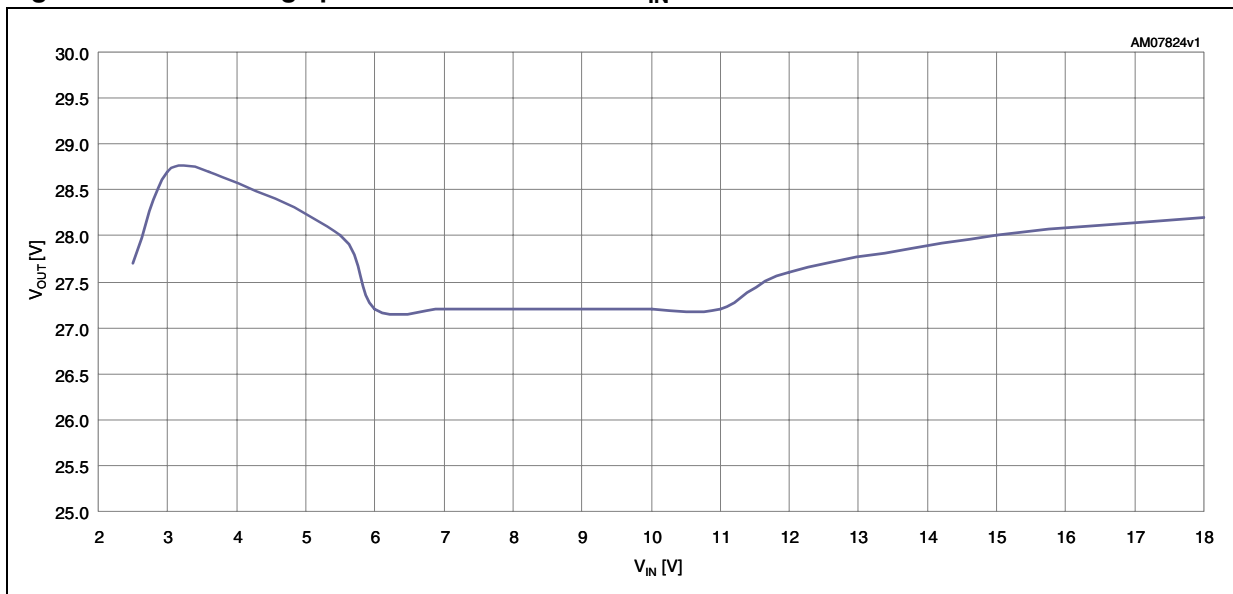**Figure 9. Overvoltage protection threshold vs. $V_{IN}$**

**Figure 10. Overvoltage protection threshold vs. temp**



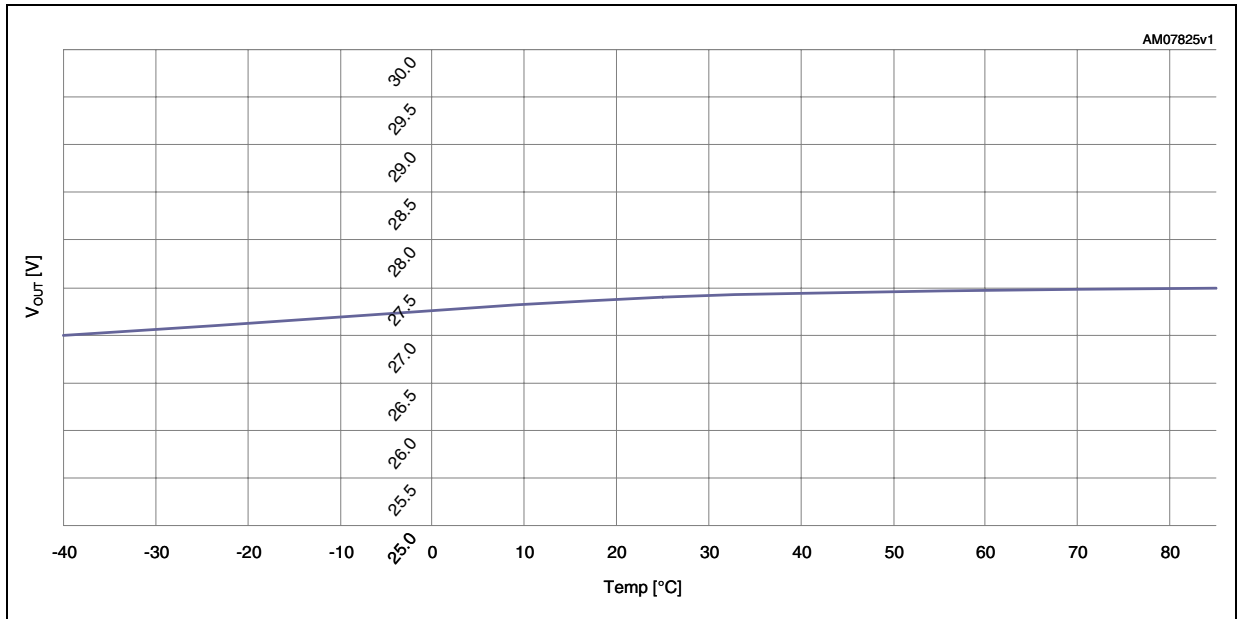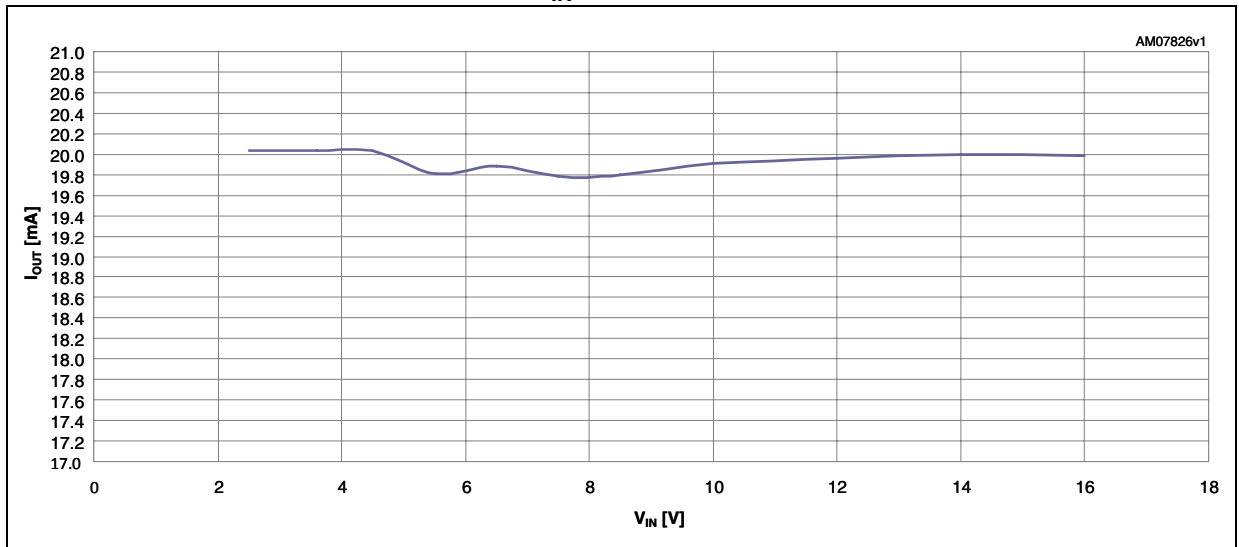**Figure 11. Output current regulation vs. V$_{IN}$**
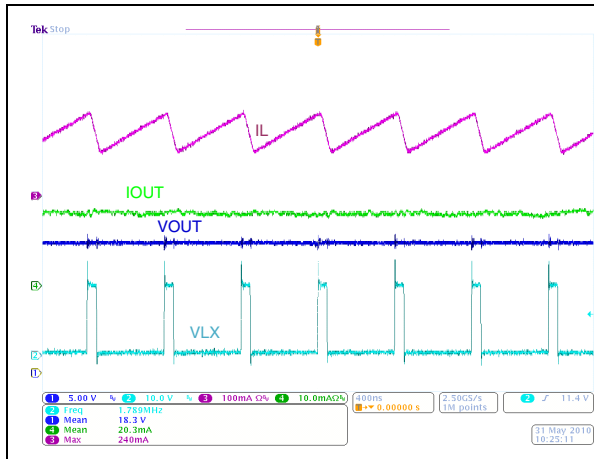
**Figure 12. Switching waveform at V_IN = 2.5 V**



**Figure 13. Switching waveform at V_IN = 7 V**



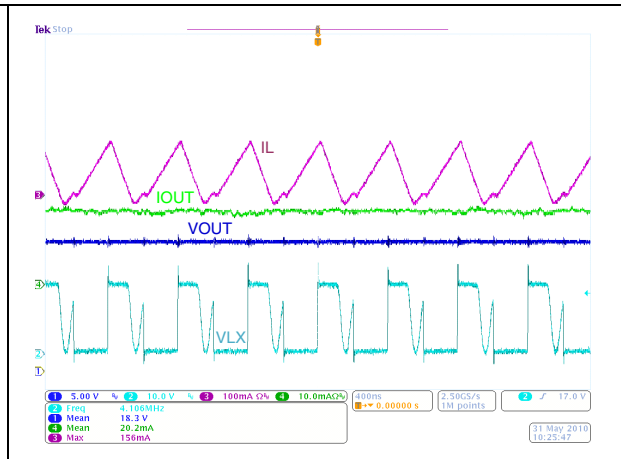**Figure 14. Switching waveform at V_IN = 12 V**



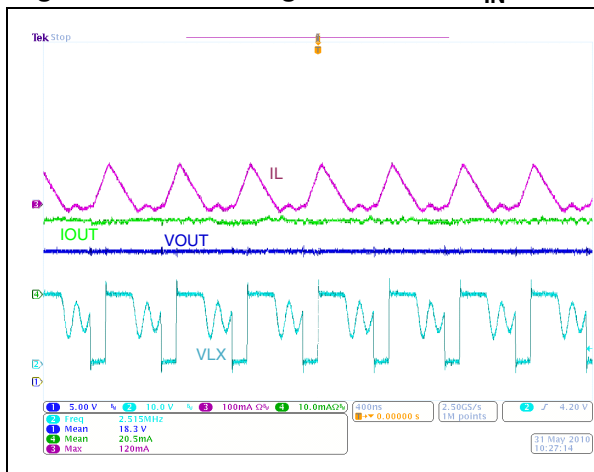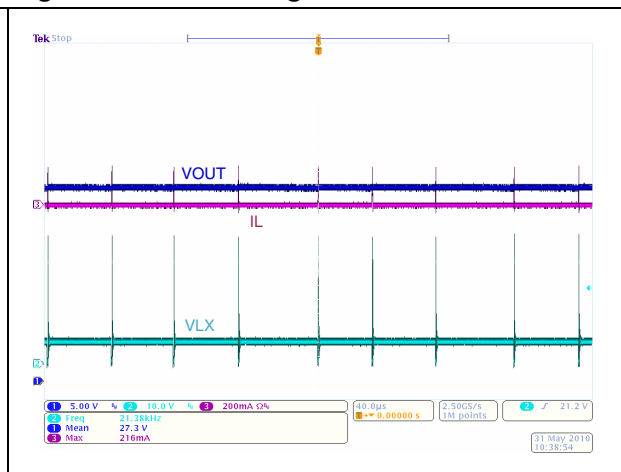**Figure 15. Overvoltage function**



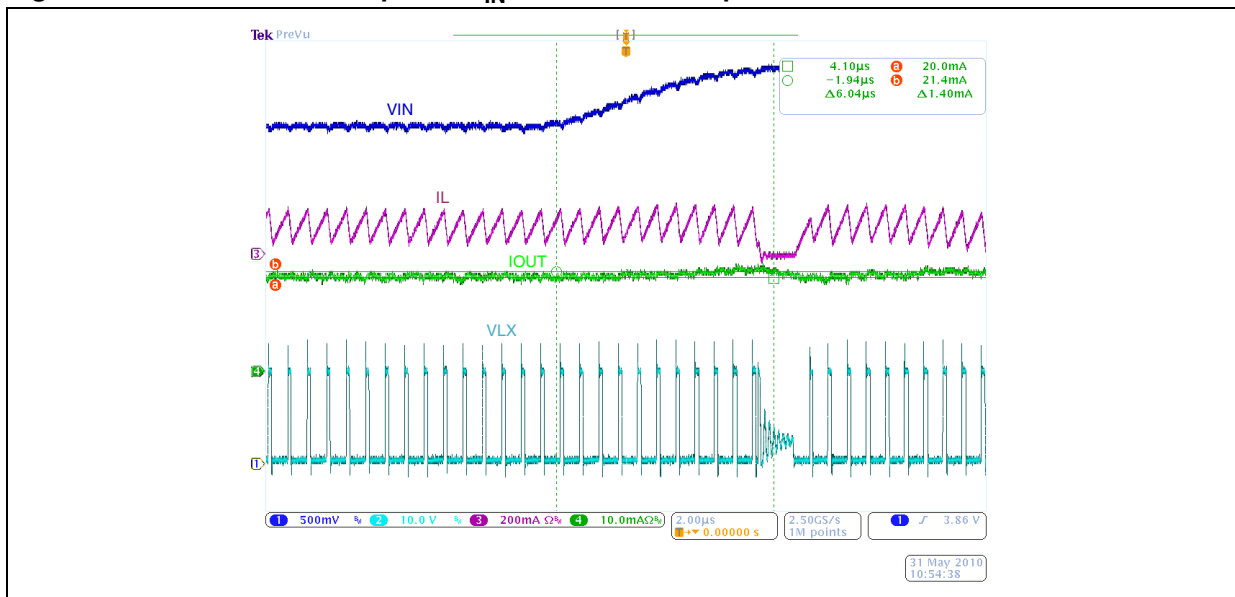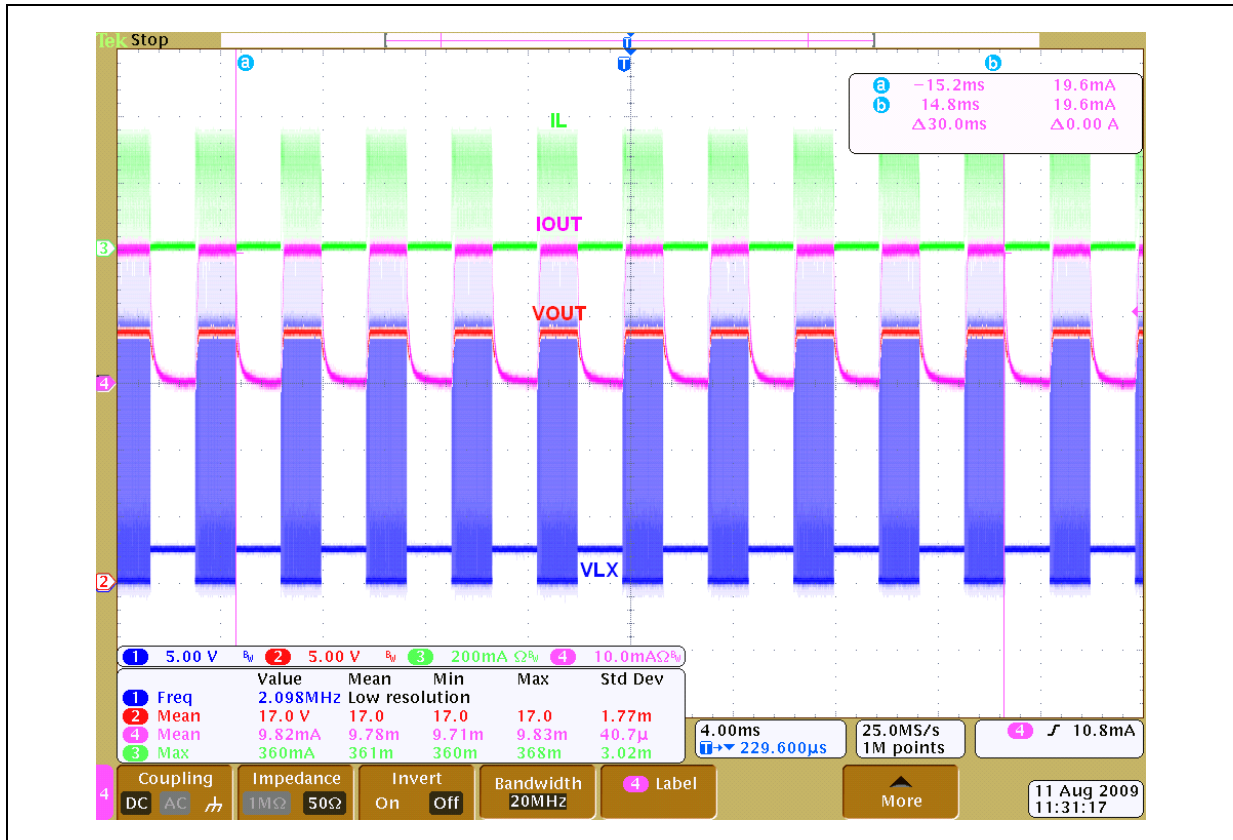**Figure 16. Line transient response V_IN = 3.4 V to 4 V step**

**Figure 17. Direct PWM dimming 300 Hz at V$_{BAT}$ = 2.5 V, V$_{EN}$ = 0 to 3 V step**

# 7 Introduction

The STLA02 is a boost converter dedicated to powering and controlling the current of white LEDs in an LCD backlight. The device operates at a typical constant switching frequency of 2.3 MHz. It steps an input voltage ranging from 2.5 V to 18 V, up to 27 V. The output current is adjustable by the resistor $R_{FB}$ connected between the $V_{OUT}$ and FB pins. The STLA02 device contains high side sensing to simplify the PCB layout in terms of connection of the LEDs.

The output current is dimmable by the PWM signal applied to the EN pin with minimum PWM frequency equal 100 Hz.

## 7.1 PWM input (EN)

Light intensity can be dimmed by a signal applied to the PWM (EN) input.

The PWM signal is directly connected to the enable pin of the STLA02. It is recommended to use the frequency of the PWM signal in the range of 100 Hz to 1 kHz and amplitude of the signal 1.8 V min. The result of the direct PWM dimming method (300 Hz PWM and $V_{EN}$ = 1.8 V) is shown in *Figure 17*.

*Note:* *When the device is required to operate in a constant current mode with the EN pin connected to the voltage higher than 1.8 V, then the delay between rise times of $V_{IN}$ voltage of the device and the EN voltage is mandatory to guarantee the proper internal reset of the logic of the device during ramping of the $V_{IN}$. It is recommended to delay the EN voltage rise time by 2 ms after the rise time on $V_{IN}$ appears.*

## 7.2 Selection of the external components

### $C_{IN}$ selection

It is recommended to use 1 µF as the input capacitor to achieve good stability of the device and low noise on the $V_{IN}$ track.

### $C_{OUT}$ selection

It is recommended to use 1 µF as the optimal value of output capacitor to get the best compromise between output voltage ripple and load transients response. The output ripple can be checked according to the equation for step-up architecture:

**Equation 1**

$$V_{PK-PK} = \frac{I_{OUT(MAX)} * (V_{OUT} - V_{IN(MIN)}) * 100}{C_{OUT} * V_{OUT}^2 * f} [V; A, V, F, Hz]$$

### Inductor selection

A thin shielded inductor with a low DC series winding resistance is recommended for this application. To achieve a good efficiency in step-up mode, it is recommended to use an inductor with a DC series resistance $R_{DCL} = R_D/10$ [$\Omega$; $\Omega$; 1], where $R_D$ is the dynamic resistance of the LED [$\Omega$; $\Omega$; 1].

For nominal operation, the peak inductor current can be calculated by the formula:

**Equation 2**

$$I_{PEAK} = \left\{ \left( \frac{I_{OUT}}{\nu} \right) + \frac{\left[ (V_{OUT} - V_{IN}) * V_{IN}{}^2 \right]}{2 * L * f * V_{OUT}{}^2} \right\} * \frac{V_{OUT}}{V_{IN}}$$

where:

| | |
|---|---|
| $I_{PEAK}$ | Peak inductor current |
| $I_{OUT}$ | Current sourced at the $V_{OUT}$ pin |
| $\nu$ | Efficiency of the STLA02 |
| $V_{OUT}$ | Output voltage at the $V_{OUT}$ pin |
| $V_{IN}$ | Input voltage at the $V_{IN}$ pin |
| L | Inductance value of the inductor |
| f | Switching frequency |

For the optimal function of the STLA02 device, it is recommended to use the inductor value 10 µH and higher with low serial resistance and relevant saturation current calculated from the equation above.

## $R_{FB}$ value

$R_{FB} = V_{FB} / I_{LED}$

In the case of a typical setting $I_{LED}$ = 20 mA, $V_{FB}$ = 200 mV, and $R_{SENSE}$ = 10 $\Omega$. The resistor must be rated for a power dissipation of 10 x 0.02² W = 0.004 W.

## PCB layout

STLA02 is a powerful switched device, the PCB must be designed in line with rules for designing switched supplies. It is recommended to use a two layer PCB. The power wirings must be as short as possible and wide. Place all external components close to the STLA02. High-energy switched loops should be as small as possible to reduce EMI. Most LEDs need cooling, which may be done by a defined area of copper on the PCB. Use the reference guide of each LED to design the heatsink. Place the $R_{FB}$ resistor as close as possible to pin 4 and 5. When a change of PCB layer is needed, use enough vias. During routing the PCB must be focused on the minimum area of the application ground - the smaller the ground area of the DC-DC converter [a], the better stability and lower noise issues are achieved. It is recommended to place the copper plate, connected through the vias to the Exposed pad, on the bottom layer to create the heatsink of the device.

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a. The application ground area is represented by the area which is created by the ground pins of the $C_{IN}$, $C_{OUT}$, ground of the DEVICE and GND connection of the load.
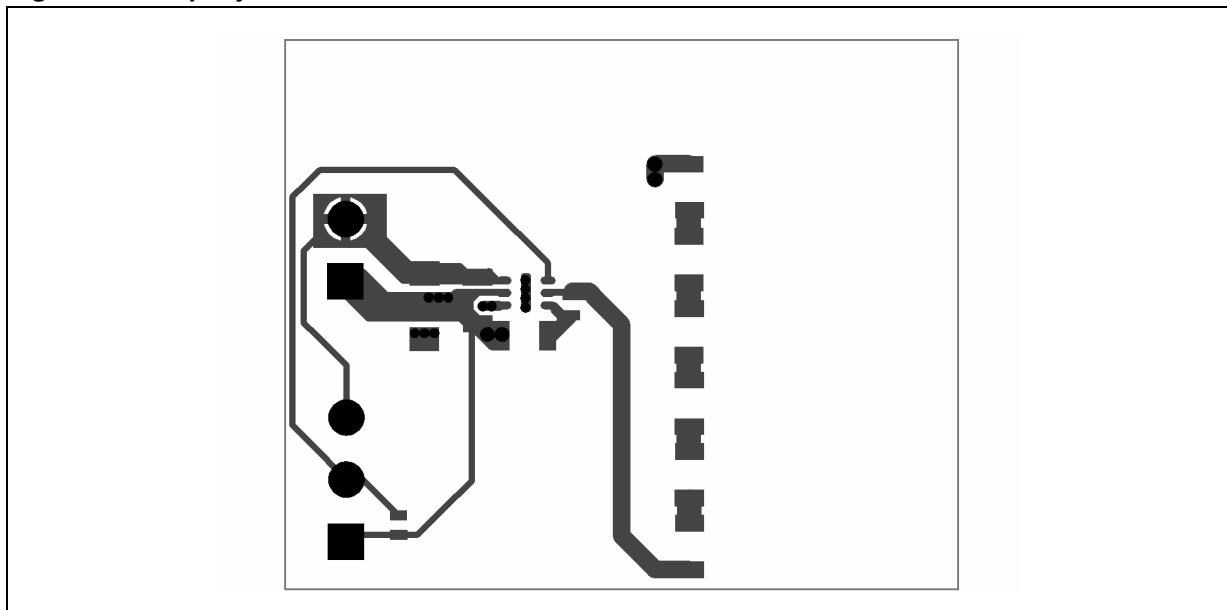
**Figure 18.    Top layer**



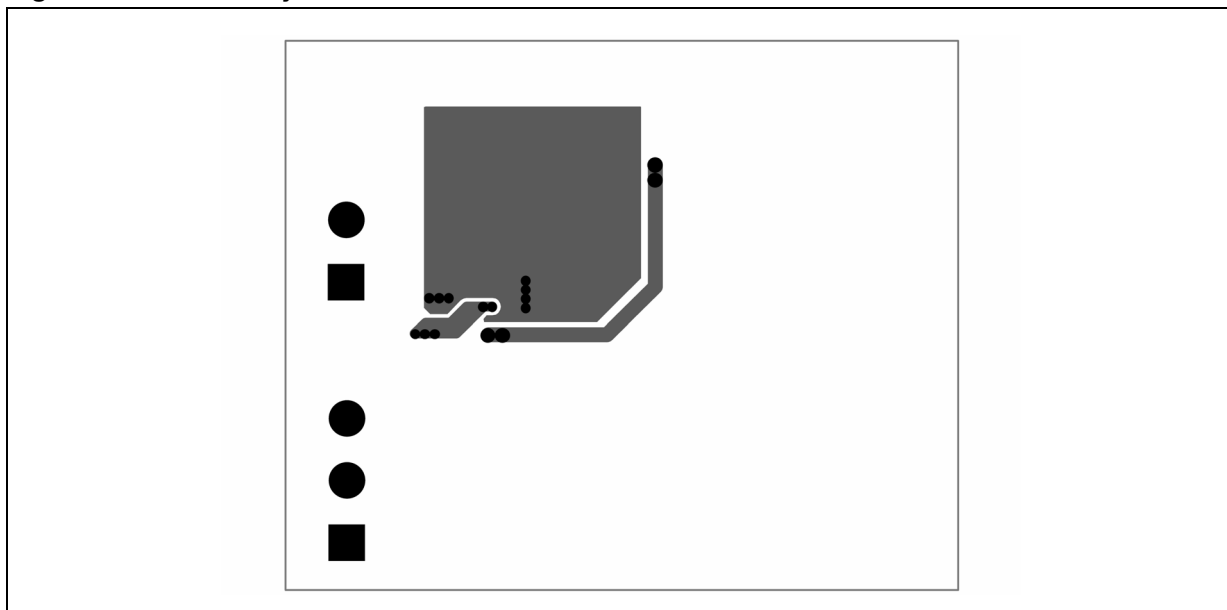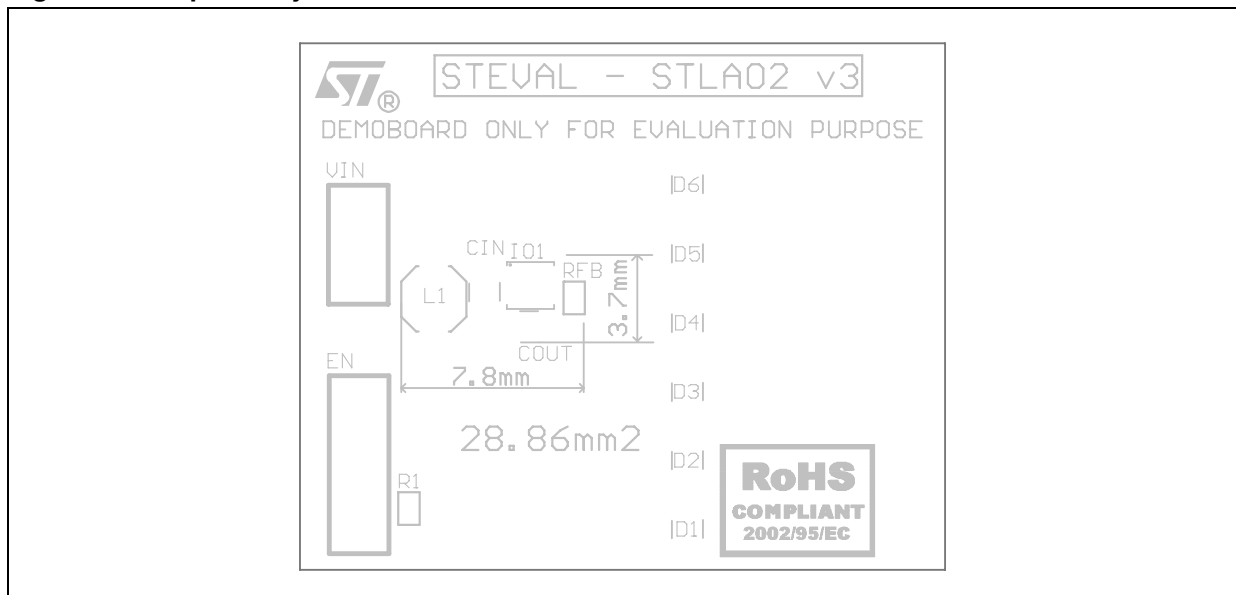**Figure 19.    Bottom layer**

**Figure 20. Top overlay**

# 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK$^{®}$ packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions, and product status are available at *www.st.com*. ECOPACK is an ST trademark.

**Table 8.     DFN6 (2 x 2 mm.) mechanical data**

| Dim. | mm. | | |
|:---:|:---:|:---:|:---:|
| | **Min.** | **Typ.** | **Max.** |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0 | 0.02 | 0.05 |
| A3 | | 0.20 | |
| b | 0.18 | 0.25 | 0.30 |
| D | 1.90 | 2.00 | 2.10 |
| D2 | 1.35 | 1.50 | 1.60 |
| E | 1.90 | 2.00 | 2.10 |
| E2 | 0.15 | 0.30 | 0.40 |
| e | | 0.50 | |
| L | 0.25 | 0.35 | 0.45 |

**Figure 21.   DFN6 (2 x 2 mm.) drawing**
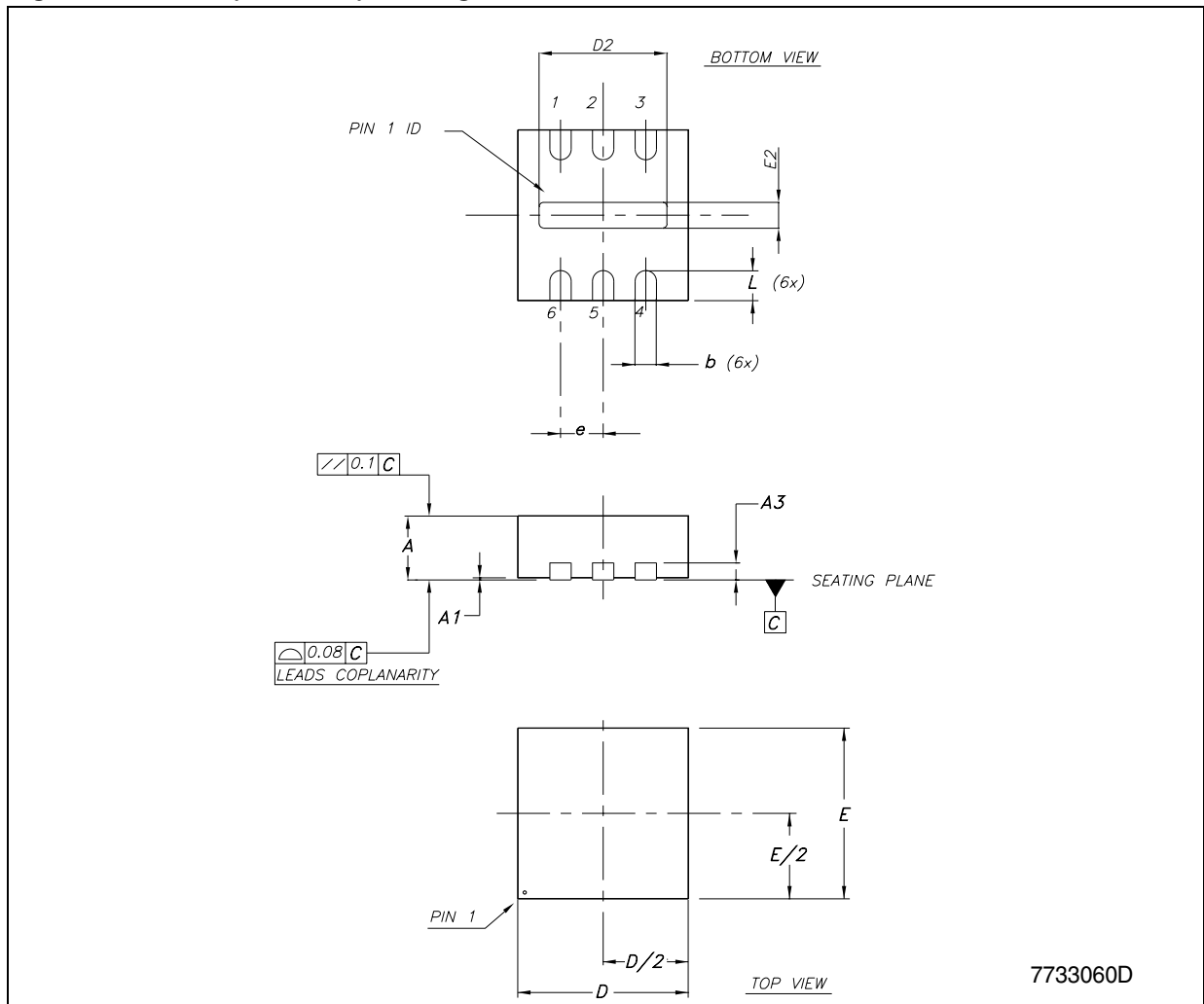
**Table 9.** DFN6 (2 x 2 mm.) tape and reel mechanical data

| Dim. | mm. | | | inch. | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 180 | | | 7.087 |
| C | 12.8 | | 13.2 | 0.504 | | 0.519 |
| D | 20.2 | | | 0.795 | | |
| N | 60 | | | 2.362 | | |
| T | | | 14.4 | | | 0.567 |
| Ao | | 2.3 | | | 0.091 | |
| Bo | | 2.3 | | | 0.091 | |
| Ko | | 1.0 | | | 0.039 | |
| Po | | 4 | | | 0.157 | |
| P | | 8 | | | 0.315 | |

**Figure 22.** DFN6 (2 x 2 mm.) tape and reel drawing
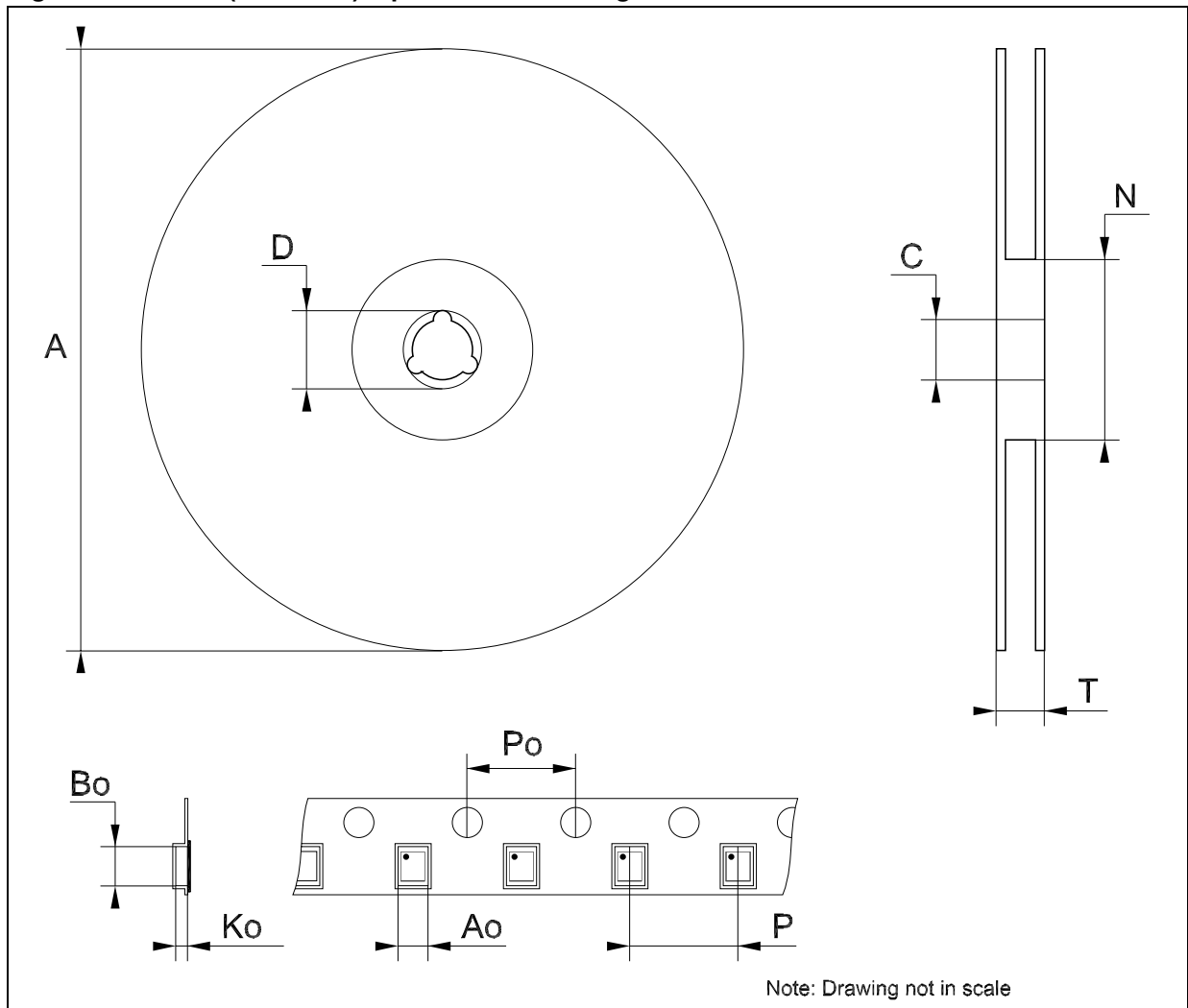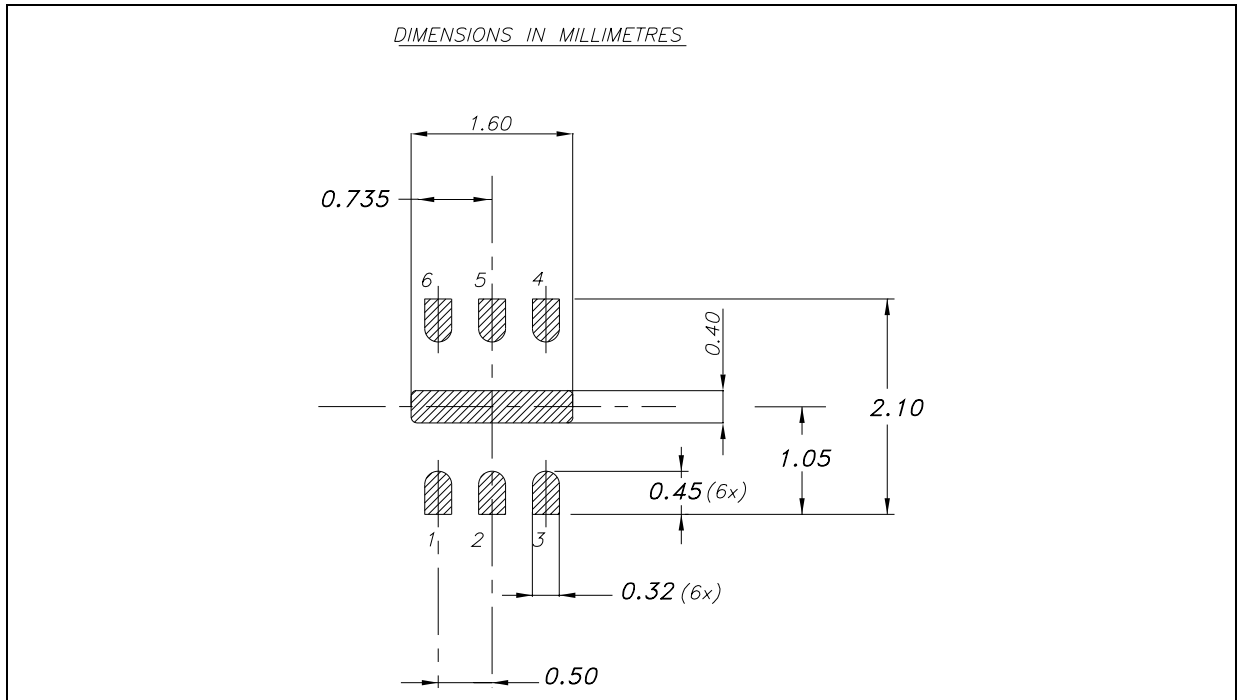


Note: Drawing not in scale

**Figure 23. DFN6 (2 x 2 mm) footprint recommended data**

# 9    Revision history

**Table 10.    Document revision history**

| Date | Revision | Changes |
|------|----------|---------|
| 22-Feb-2011 | 1 | Initial release |

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