

## White LED power supply for large display backlight

### Features

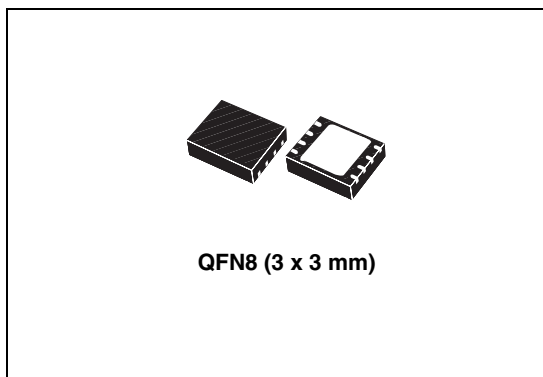
- Inductor switches boost controller
- PFM mode control
- High efficiency over wide range of input voltage from 3.0 V to 5.5 V
- Over voltage protection with automatic restart
- Adjustable peak current limit
- Enable pin with possibility of PWM dimming control
- Low shutdown current < 1  $\mu$ A
- Small external component
- Good load and line regulation
- QFN8 3 x 3 mm

### Applications

- White LED supply for LCD backlight
- Mobile phone
- PDA and organizers
- Any handsets powered from 3.0 V to 5.5 V

### Description

STLD40D is a boost converter that operates from 3.0 V to 5.5 V. It can provide an output voltage as high as 37 V and can drive up to 10 white LEDs in series. The converter is a PFM (pulse frequency modulation) inductor switch that can work in discontinuous (DCM) mode operation. A minimum OFF time of the embedded boost switch  $T_{SW}$  is fixed internally and allows limiting the switching frequency. The output current capability is 20 mA with an output voltage of 37 V. The regulation is done by sensing the LED current through the



resistor  $R_{LED}$ . The device can be turned ON/OFF through the logic enable signal pin EN. By applying a low frequency PWM signal the LEDs can be dimmed. The maximum peak inductor current can be programmed by connected a resistor  $R_{SET}$  to the pin  $R_{SET}$ .

**Table 1. Device summary**

Order code	Package	Packaging
STLD40DPUR	QFN8 (3 x 3 mm)	3000 parts per reel

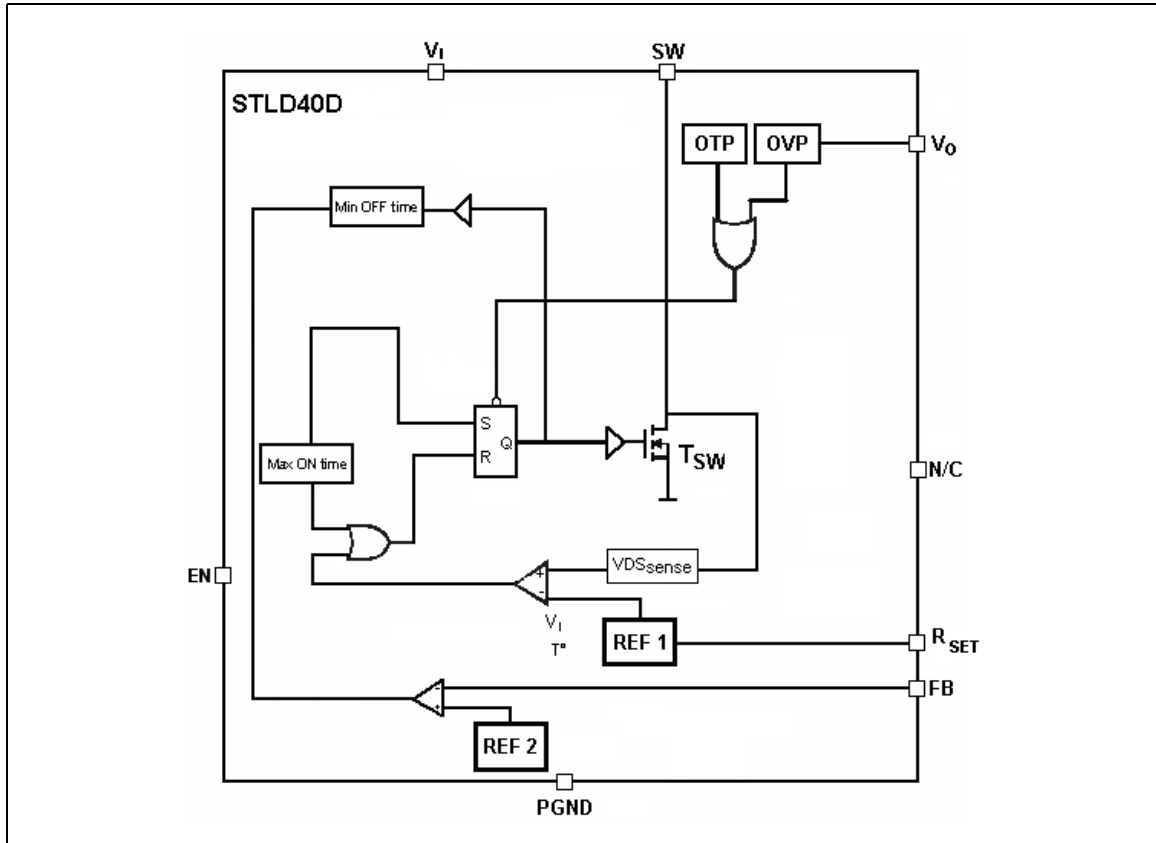
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# 1 Block diagram

Figure 1. Block diagram



## 2 Pin configuration

Figure 2. Pin connections (top through view)

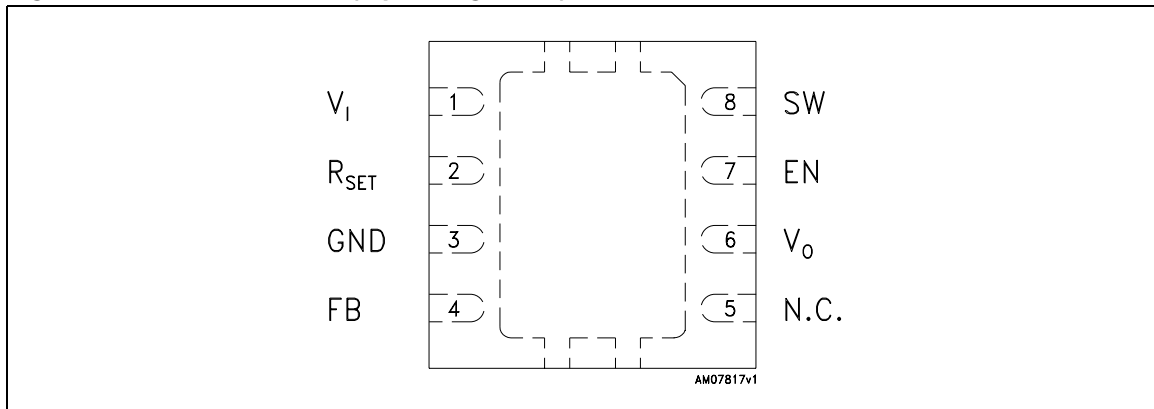


Table 2. Pin description

Pin n°	Symbol	Note
1	$V_I$	Supply voltage
2	$R_{SET}$	Peak inductor current adjust
3	GND	Analog ground
4	FB	Feedback for the LED current regulation
5	N.C.	Not connected
6	$V_O$	Output voltage for LED supply
7	EN	IC enable signal
8	SW	Boost switch drain
	PGND	Power ground

### 3 Maximum ratings

**Table 3. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{BSW}, V_{BO}$	Breakdown voltage at $V_O$ and SW pin	44	V
EN	Maximum voltage applied on pin EN	$V_I$	V
$V_I$	Supply voltage range	6	V
$V_{ESD}$	ESD ratings - (HBM MIL STD 883C)	2	kV
$T_{OP}$	Operating temperature	- 40 to 85	°C
$T_{STG}$	Storage temperature range	- 65 to 150	°C

**Table 4. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJA}$	Thermal resistance junction-ambient	52	°C/W

## 4 Electrical characteristics

$T_J = -40\text{ }^\circ\text{C}$  to  $85\text{ }^\circ\text{C}$ ,  $V_I = 3.6\text{ V}$ ,  $V_{EN} = 3\text{ V}$ ,  $C_I = 2.2\text{ }\mu\text{F}$ ,  $C_O = 4.7\text{ }\mu\text{F}$ ,  $L = 4.7\text{ }\mu\text{H}$ ,  $R_{LED} = 8\text{ }\Omega$   
 $V_O = 32\text{ V}$ , typ. values @  $25\text{ }^\circ\text{C}$ , unless otherwise specified.

**Table 5. Electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_I$	Input voltage range		3.0		5.5	V
$V_O$	Output voltage range		$V_I$		37	V
$I_O$	Regulated output current	$V_O = 36\text{ V}$ (10 white LEDs)	20			mA
$I_{SD}$	Stand-by current	$V_{EN} = \text{Low}$ , $V_I = 3.6\text{ V}$ , $T_J = 25\text{ }^\circ\text{C}$		1	3	$\mu\text{A}$
		$V_{EN} = \text{Low}$ , $V_I = 3\text{ V}$ to $4.2\text{ V}$			10	
$I_Q$	Quiescent current	$V_I = 3\text{ V}$ to $4.2\text{ V}$ , $T_J = 25\text{ }^\circ\text{C}$		0.4	0.8	mA
		$V_I = 5.5\text{ V}$ , $T_J = 25\text{ }^\circ\text{C}$		0.8	1.2	
$R_{DSON}$	Boost switch $R_{DSON}$	$V_I = 5.5\text{ V}$ , $I = 100\text{ mA}$		0.4		$\Omega$
		$V_I = 4.2\text{ V}$ , $I = 100\text{ mA}$		0.4		
		$V_I = 3.0\text{ V}$ , $I = 100\text{ mA}$		0.5		
	BVDS breakdown voltage		38			V
$I_{LIM-ADJ}$	Maximum peak inductor limit adjust range <sup>(1)</sup>	$R_{SET} = 12\text{ k}\Omega$ to $100\text{ k}\Omega$	0.2		1	A
$I_{LIM}$	Maximum peak inductor limit when $R_{SET} = V_I$ <sup>(1)</sup>	$V_I = 3\text{ V}$ to $5.5\text{ V}$	0.75		1.1	A
$V_{FB}$	Feedback voltage	$V_I = 3.6\text{ V}$	130	165	200	mV
Line FB	Line feedback voltage	$V_I = 3\text{ V}$ to $5.5\text{ V}$		5	35	mV
$T_{ON\_MAX}$	Maximum ON time	$V_I = 4.2\text{ V}$		5.5		$\mu\text{s}$
$T_{OFF\_MIN}$	Minimum OFF time	$V_I = 4.2\text{ V}$		250		ns
$\eta$	Efficiency at $V_I = 3.0\text{ V}_{DC}$ <sup>(1)</sup>	$I_O = 20\text{ mA}$ , $V_O = 36\text{ V}_{DC}$	75			%
	Efficiency at $V_I = 5.5\text{ V}_{DC}$ <sup>(1)</sup>	$I_O = 20\text{ mA}$ , $V_O = 36\text{ V}_{DC}$	80			
OVP	Over voltage protection		36		42	V
$OV_{HYS}$	Over voltage hysteresis			1.5		V
$V_{EN}$	Enable input logic low	Disable Low $V_{IL}$			0.3	V
	Enable input logic high	Enable High $V_{IH}$	1.2			

1. Guaranteed by design.

## 5 Functional description

### 5.1 Boost controller

The STLD40D is a boost converter operating in PFM (pulsed frequency modulation) mode.

The converter monitors the LED current through the resistor  $R_{LED}$  and when the feedback voltage falls below the reference voltage REF2, the boost switch  $T_{SW}$  turns ON and the current ramps up. The inductor current is measured by sensing the temperature compensated drain voltage of the boost MOSFET. The boost turns off when its drain voltage reaches the internally reference REF1, the main switch remains off until the minimum off time (250 ns typical) has passed and the feedback voltage is below the reference again. A maximum ON time of 4  $\mu$ s typical prevents the switch  $T_{SW}$  to stay ON during a too long period of time.

### 5.2 Adjustable peak inductor current limit

The peak inductor current is monitored by sensing the drain voltage of the switch  $T_{SW}$ . Since it exceeds the temperature compensated and supply voltage compensated reference REF1, the RS flip flop is reset and  $T_{SW}$  is turned OFF. By connecting a resistance to the pin  $R_{SET}$  the peak current limit can be adjusted from 200 mA to 1 A. When  $R_{SET}$  resistor value is about 12 k $\Omega$  is connected directly to GND, the default value is 1 A.

### 5.3 Enable

The ENABLE pin is a high logic input signal and allows turning on/off the controller without cutting the input voltage from the boost regulator circuit. The pin ENABLE can be used to dim the LED by applying a low frequency PWM signal.

### 5.4 OVP

If the regulation loop is cut, there is no signal at the feedback pin, the PFM controller will then continue to switch without control and generate an output voltage at the SW, and  $V_O$  pin exceeding the breakdown value  $V_{BSW}$ , and  $V_{BO}$ .

The over voltage protection (OVP) senses the voltage at the  $V_O$  pin. When the voltage exceed 38 V min. the controller is automatically turned OFF.

A hysteresis control allows the device restarting automatically since the output voltage drops down of 1.5 V.

## 6 Typical application

Figure 3. Application circuit

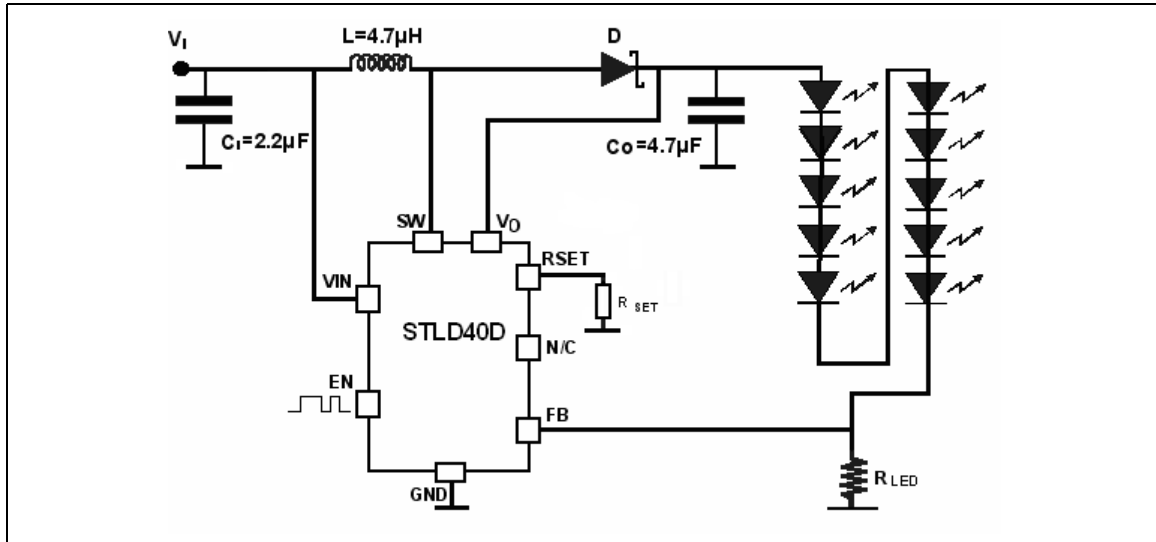


Table 6. External component proposal (see [Figure 3](#))

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
D	Boost schottky diode	VRRM	40			V
		$V_F$ at $I_F = 300 \text{ mA}$ , $T_J = 25 \text{ }^\circ\text{C}$			0.5	V
		$I_R$ at $V_R = 10 \text{ V}$ , $T_J = 25 \text{ }^\circ\text{C}$			30	$\mu\text{A}$
	STPS1L40M	VRRM	40			V
		$V_F$ at $I_F = 1 \text{ A}$ , $T_J = 25 \text{ }^\circ\text{C}$			0.46	V
		$I_R$ at $V_R = 20 \text{ V}$ , $T_J = 25 \text{ }^\circ\text{C}$			21	$\mu\text{A}$
$R_{LED}$	Feedback LED current regulation resistor	$I_{LED} = 20 \text{ mA}$		8		$\Omega$
$R_{SET}$	Current peak setting resistor	$I_{PEAK} = 0.2 \text{ A to } 1 \text{ A}$	12		100	$\text{k}\Omega$
$C_1$	Input filtering capacitor	Ceramic Type		2.2		$\mu\text{F}$
$C_O$	Output capacitance: ceramic low ESR	Capacitance	4.7			$\mu\text{F}$
		Voltage	35			V
		ESR			1.6	$\Omega$
L	Boost inductor (height < 2 mm)	Inductance			4.7	$\mu\text{H}$
		DCR			1	$\Omega$
		$I_{SATRSET} = \text{GND}$			1	A

Note: The external components proposal should be considered as a design reference guide. The performances mentioned in the electrical characteristics table are not guaranteed for all the possible electrical parameters of the components included in this list. On an other hand the operation of STL40D is not limited with the use of components included in this list.



## 7 Typical performance characteristics

$V_I = 3.6\text{ V}$ ,  $V_{EN} = 3\text{ V}$ ,  $C_I = 2.2\text{ }\mu\text{F}$ ,  $C_O = 4.7\text{ }\mu\text{F}$ ,  $L = 4.7\text{ }\mu\text{H}$ ,  $R_{LED} = 8\text{ }\Omega$ ,  $V_O = 32\text{ V}$ , 10 W LEDs load ( $V_O = 32\text{ V}$ ) typ. values @  $25\text{ }^\circ\text{C}$ , unless otherwise specified.

Figure 4.  $I_{LED}$  vs.  $R_{LED}$

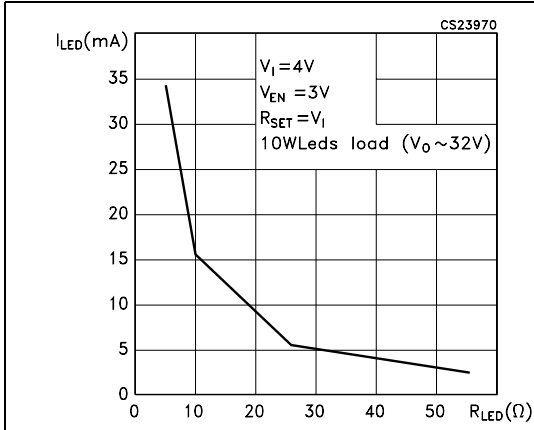


Figure 5.  $I_{LED}$  vs.  $V_I$

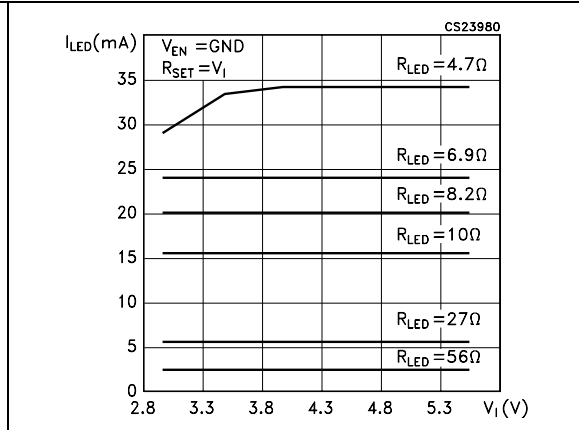


Figure 6.  $I_Q$  vs. temperature

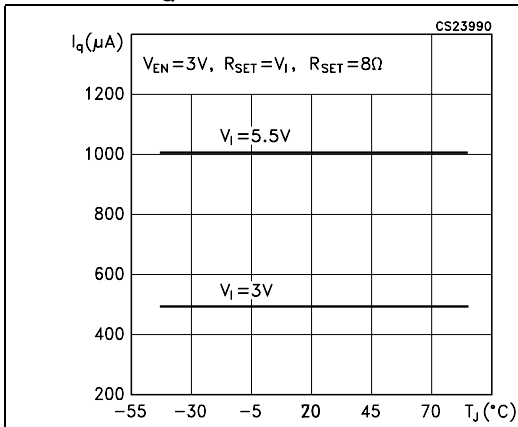


Figure 7.  $I_{SD}$  vs.  $V_I$

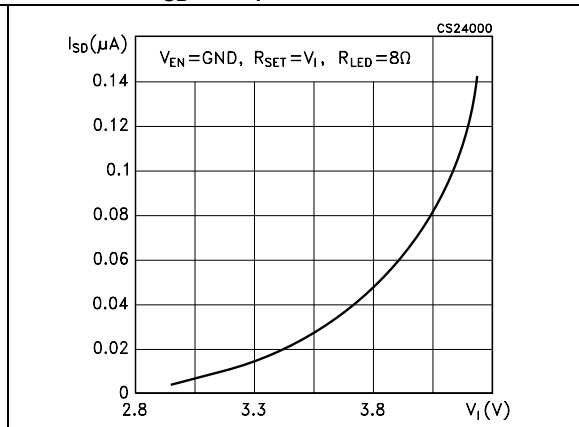


Figure 8.  $R_{DS(on)}$  vs.  $V_I$

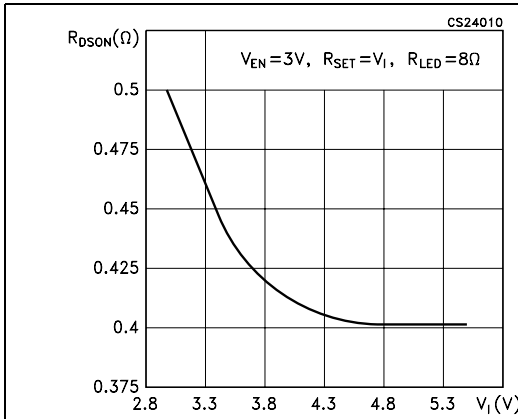


Figure 9.  $I_{LIMIT}$  vs.  $R_{SET}$

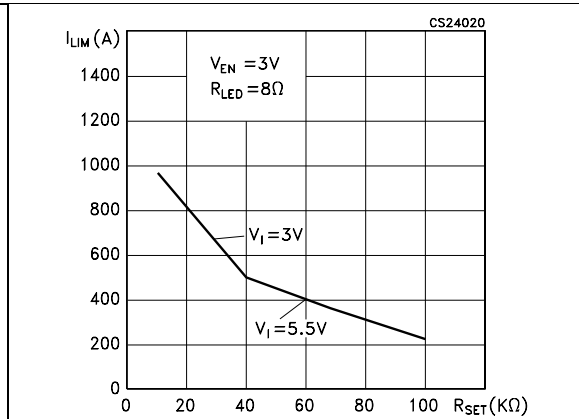


Figure 10.  $V_{FB}$  vs. temperature

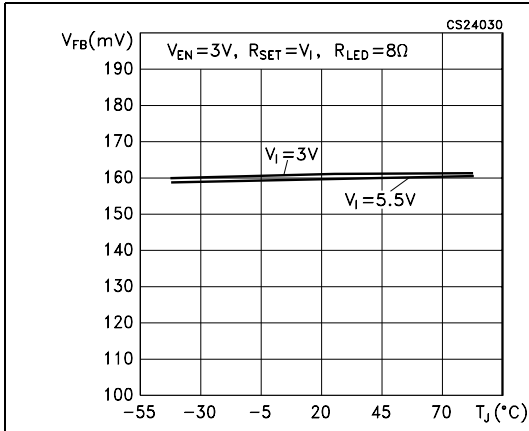


Figure 11.  $V_{EN}$  vs. temperature

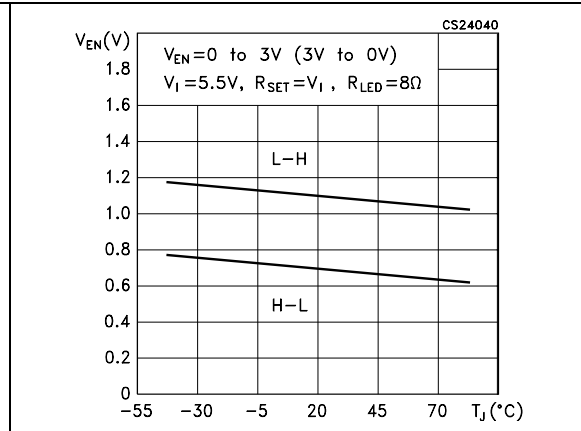


Figure 12. Efficiency vs.  $V_I$

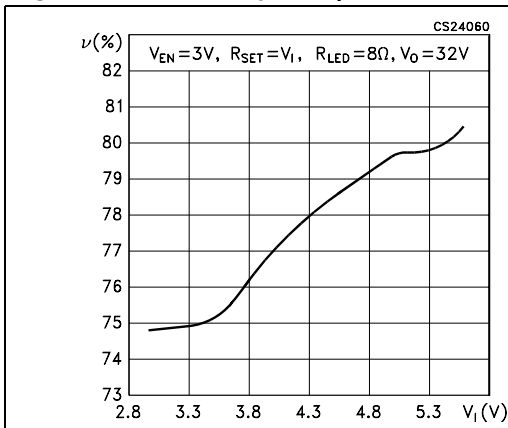


Figure 13.  $V_{OVP}$  vs. temperature

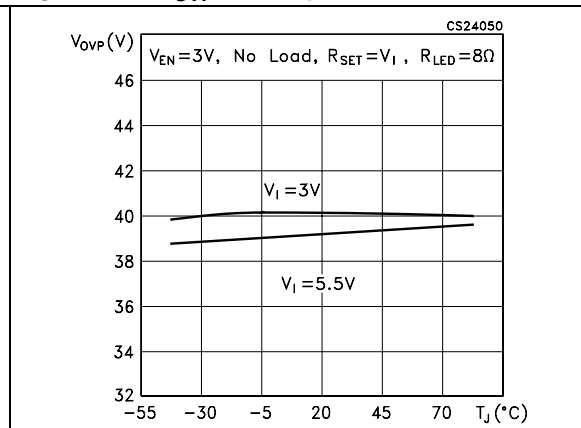
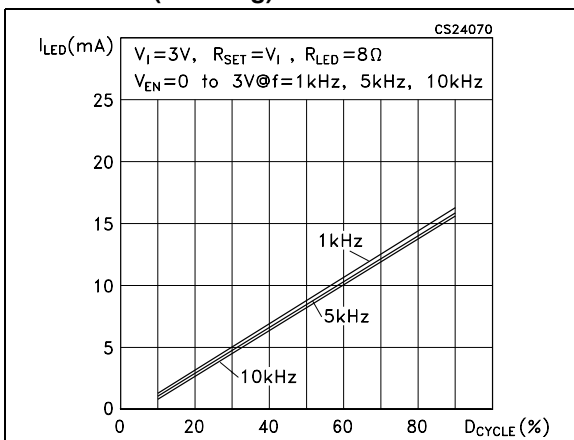


Figure 14.  $I_{LED}$  vs. duty cycle EN pin (dimming)



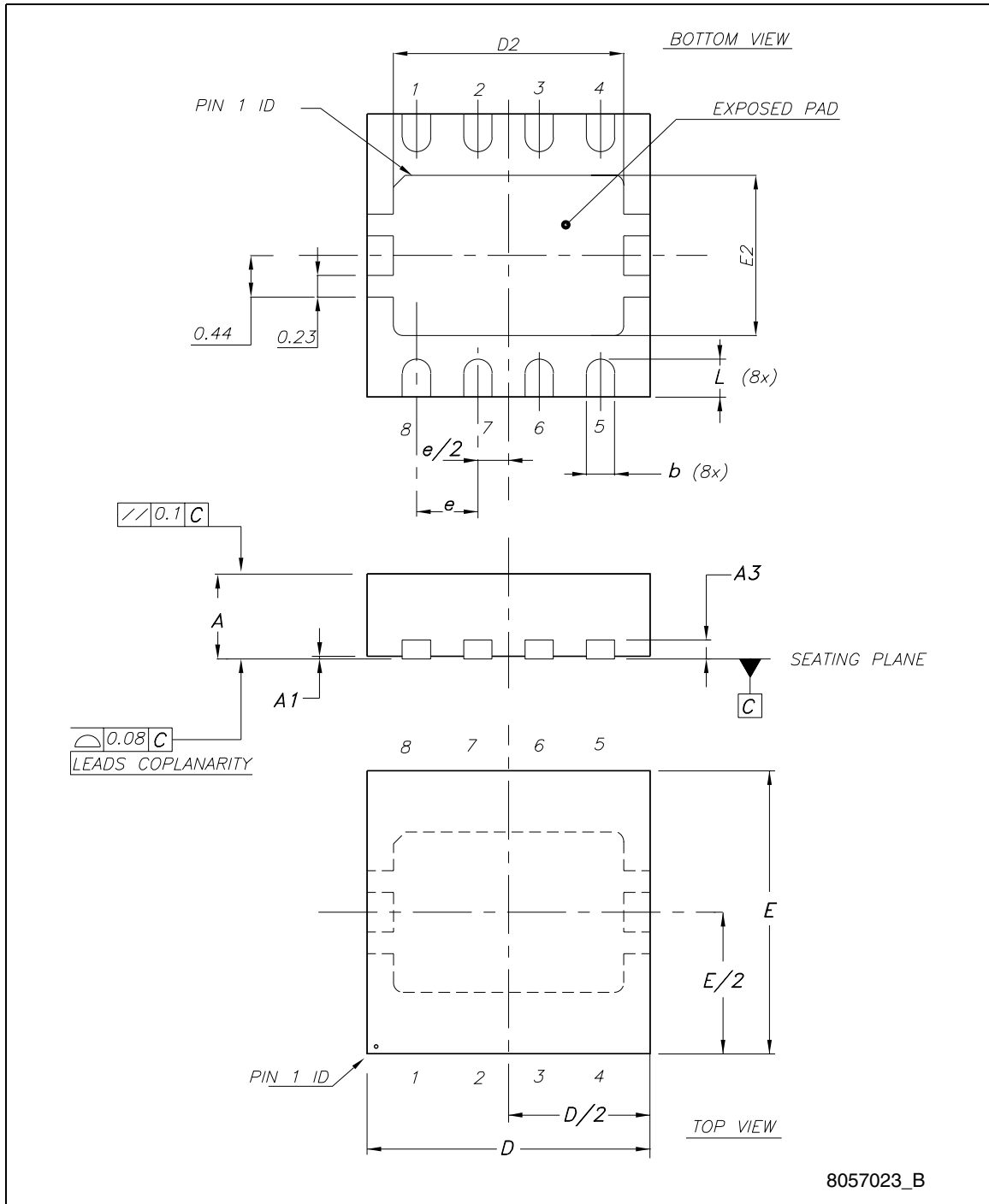
## 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

**Table 7. QFN8 (3 x 3 mm) mechanical data**

Dim.	mm.		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1	0	0.02	0.05
A3		0.20	
b	0.25	0.30	0.35
D	2.85	3.00	3.15
D2	2.49	2.64	2.74
E	2.85	3.00	3.15
E2	1.75	1.90	2.00
e		0.65	
L	0.30	0.40	0.50

Figure 15. Drawing dimension QFN8 (3 x 3 mm)



## Tape &amp; reel QFNxx/DFNxx (3x3) 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		3.3		0.130		
Bo		3.3		0.130		
Ko		1.1		0.043		
Po		4		0.157		
P		8		0.315		

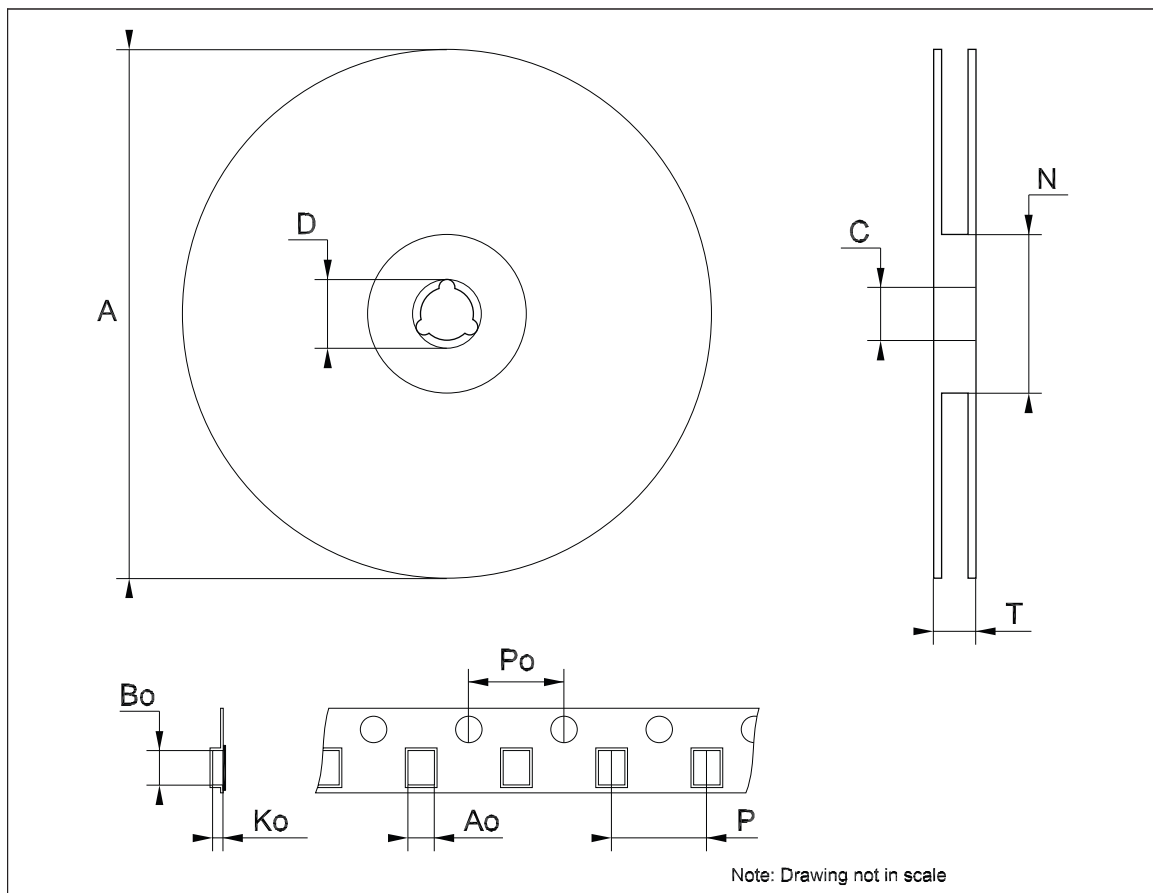
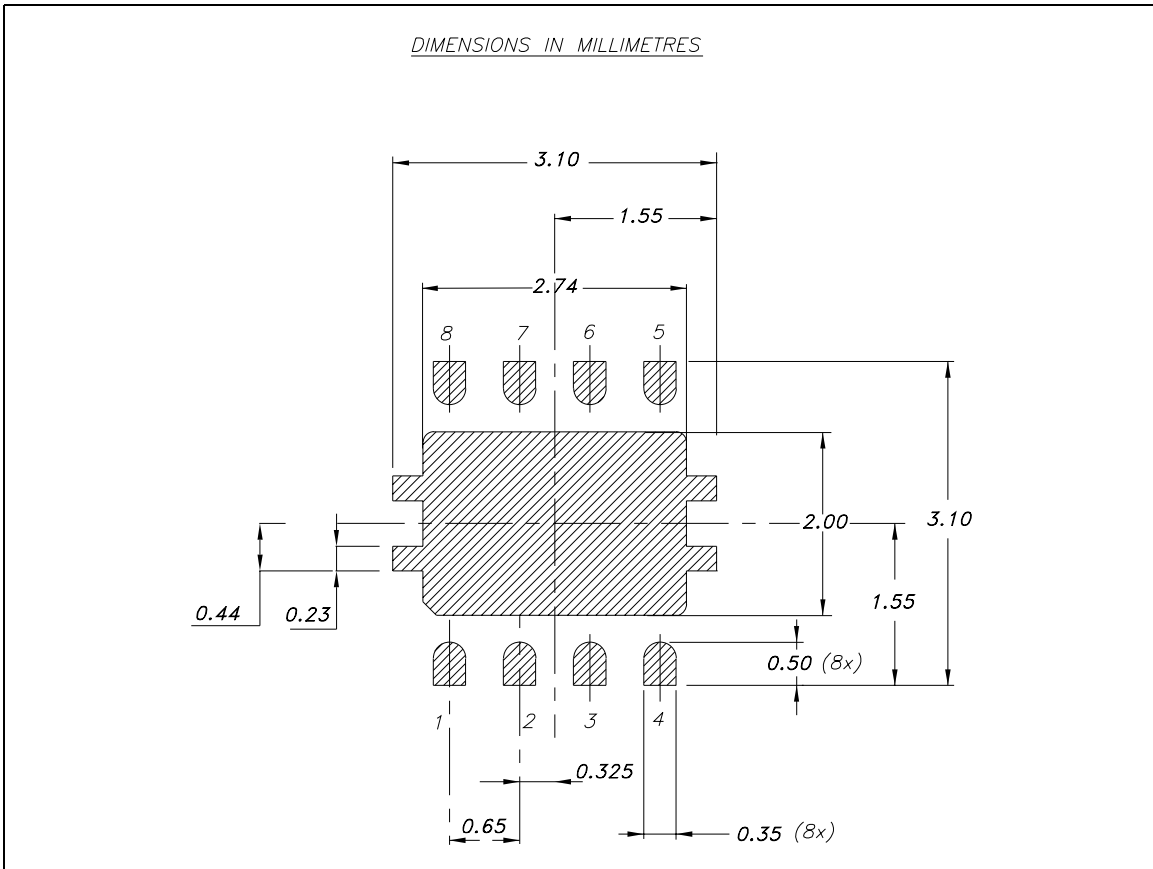


Figure 16. QFN8 (3x3) footprint recommended data



## 9 Revision history

**Table 8. Document revision history**

Date	Revision	Changes
20-Mar-2006	1	Initial release.
04-Apr-2006	2	Add R <sub>SET</sub> in table 4 and fig 2 has been updated.
27-Feb-2009	3	Modified mechanical data.
03-Mar-2009	4	Modified packaging <i>Table 1 on page 1</i> .
11-Mar-2009	5	Modified: <i>Figure 2 on page 4</i> and added <i>Figure 16 on page 14</i> .
01-Jul-2010	6	Modified: <i>Table 7 on page 11</i> , <i>Figure 15 on page 12</i> and <i>Figure 16 on page 14</i> .
31-May-2011	7	Modified: <i>Table 6 on page 8</i> .

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