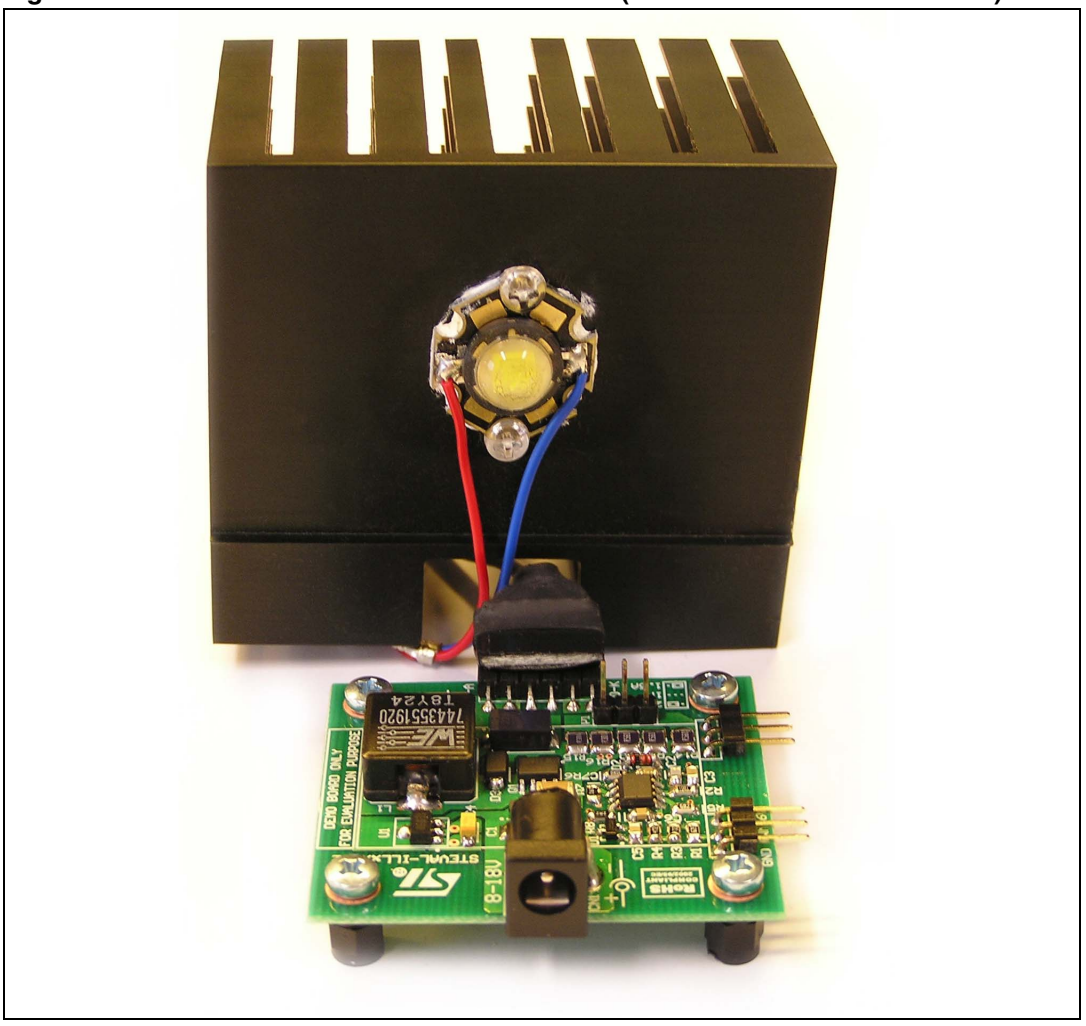
UM0677
User manual

High-efficiency switching LED driver for high-current LEDs

1 Introduction

The progress made in the field of LEDs has led to rapid and impressive results in output current capabilities. A short time ago the most advanced LEDs had current at 0.350 A, soon followed by 0.7 A and then 1 A devices. Nowadays even LEDs with several amps of output are present on the market. These high currents are increasing the requirements on the driving circuitry for both efficiency and features. This document presents the demonstration board designed for 2.8 A LEDs (1-3 in a series string) focusing on easy dimming and high efficiency.

Figure 1. STEVAL-ILL023V1 - 2.8 A LED driver (LED is not included in the kit)



Contents

List of tables

List of figures

2 Description of reference design

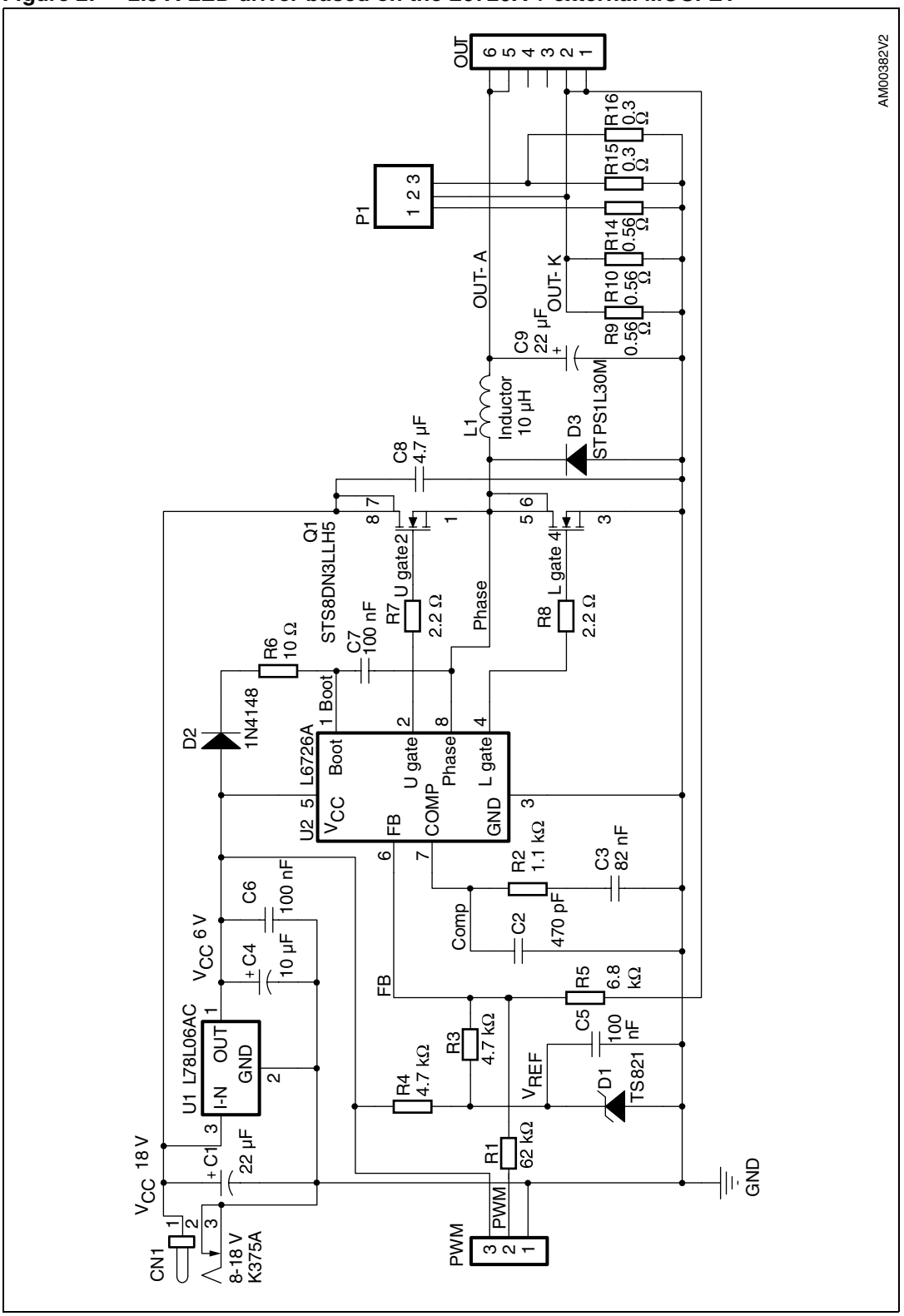
This solution uses the L6726A controller with two external MOSFETs for synchronous rectification. The main advantage is very good efficiency. Future scalability for even higher currents could be seen as another advantage. This solution is much safer concerning the border conditions as the current limit is defined only by the selection of the MOSFET.

Table 1. Board parameters

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input voltage		8		18	V
V_{OUT}	Output voltage	V_{IN} = 18 V	2.5		14	V
I_{LED}	Output current			1 / 1.5 / 2.8		A
Dimm	Analog dimming	I_{LED} - 0 A	0		2.5	V
	PWM signal	Low level		0		V
		High level	2.8	3.3	3.8	V
	Duty cycle(1)	f_{DIM} = 200 Hz	0		99	%
η	Efficiency	V_{IN} = 18 V; V_{OUT} = 12.6 V		94.8		%

1. PWM signal has inverted characteristics (0% = full power).

Figure 2. 2.8 A LED driver based on the L6726A + external MOSFET



2.1 Current sensing

Adapting the voltage step-down regulator as a constant current source requires few external components (as indicated in *Figure 3*). Basically only a sense resistor would be necessary, but that results in high losses on the sense resistors (feedback reference is 0.8 V). When voltage reference TS821 is used, the losses are almost three times lower.

The application depicted allows setting three different values of the output current. The options are 1 A, 1.5 A and 2.8 A. The output currents are chosen by the jumper on the header P1 as indicated in *Table 2*.

Figure 3. Part of schematics with highlighted components for efficient current sensing

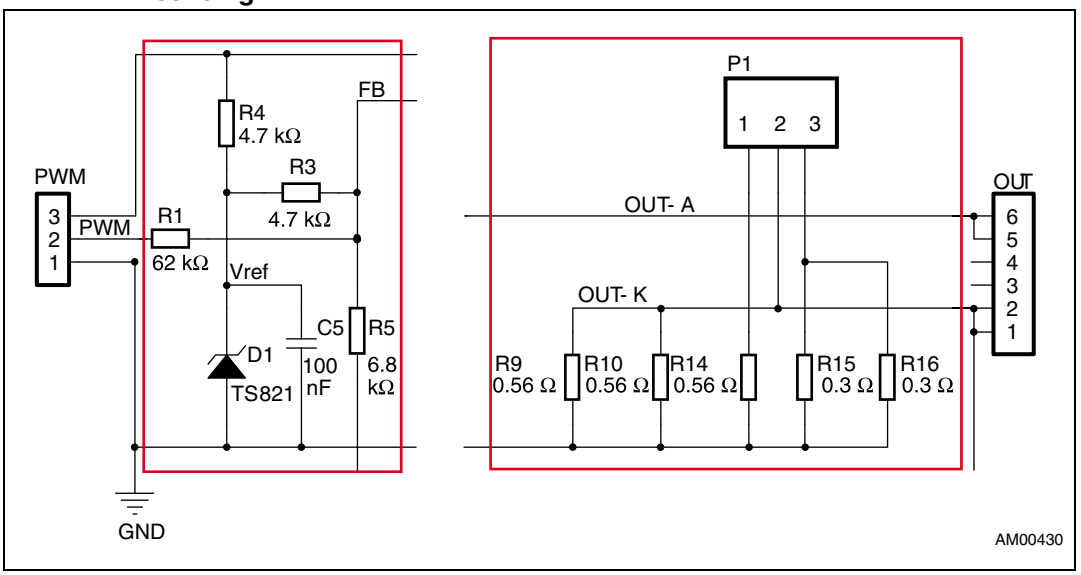


Table 2. Nominal output current settings

Header P1 1 2 3	Output current
 AM00386	1 A
 AM00387	1.5 A
 AM00388	2.8 A

2.2 Dimming interface

For more advanced applications, the reference design also includes an interface for dimming. The board itself does not include any signal generator, but to keep universality with different control schemes (analog or digital dimming) a three-pin connector was built in as depicted in *Figure 3*. A supply voltage of 6 V V_{CC} can serve as an external PWM generator (implemented by either the microcontroller or by comparators). The PWM pin is an universal dimming input, working with both analog and digital dimming. Any voltage above 2.5 V is considered as 0% power, i.e. the analog dimming works in the range from 0 V to 2.5 V, where 0 V (grounding the pin) results in full power. The standard 3.3 V logic levels can be used as a PWM control signal for digital dimming. In this case the brightness changes from 0% (full power) to 99% (minimum power) duty cycle. If the driver is used without the PWM generator, pins 1 (GND) and 2 (PWM) on the PWM connector must be connected together.

3 Application

The PCB layout (top and bottom side) of the application displayed in the schematic of *Figure 2* is shown in the two figures below. The two layers of the PCB (35 µm thickness of Cu) are used, when the size of the circuit itself (including several sense resistors for different versions of output current) is 40 mm x 23 mm.

Figure 4. PCB layout - top side

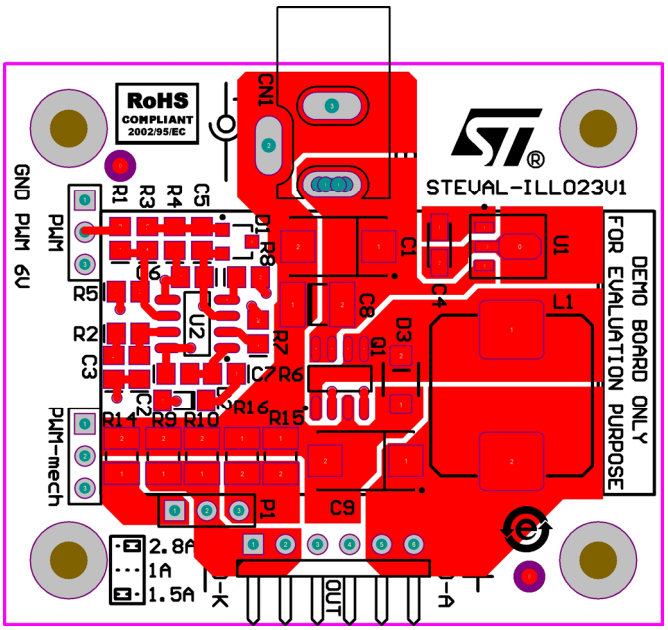


Figure 5. PCB layout - bottom side

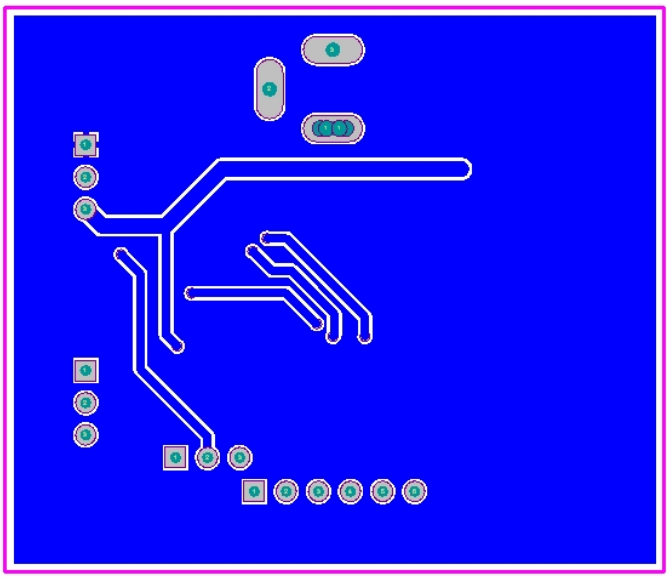
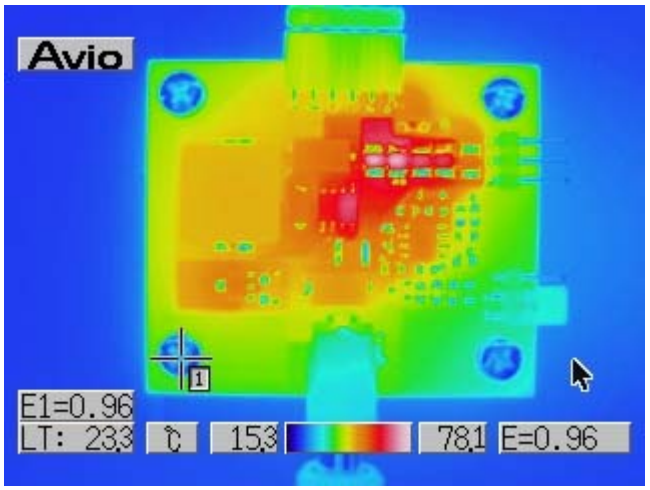


Figure 6. Reference design detail

Figure 7. Thermal snapshot at full load



3.1 Measurement results

Several tests made on the reference design can be observed in *Figure 8* through *11*.

Figure 8. Output current with 1 LED (Seoul Semiconductor P7)

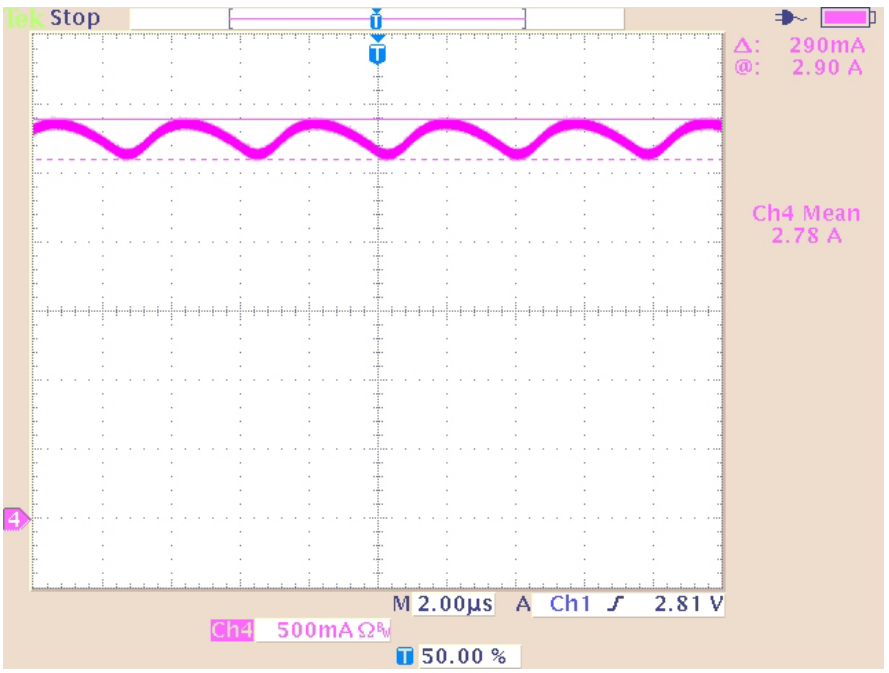


Figure 9. Dimming control curve (12 V input, 1 LED output)

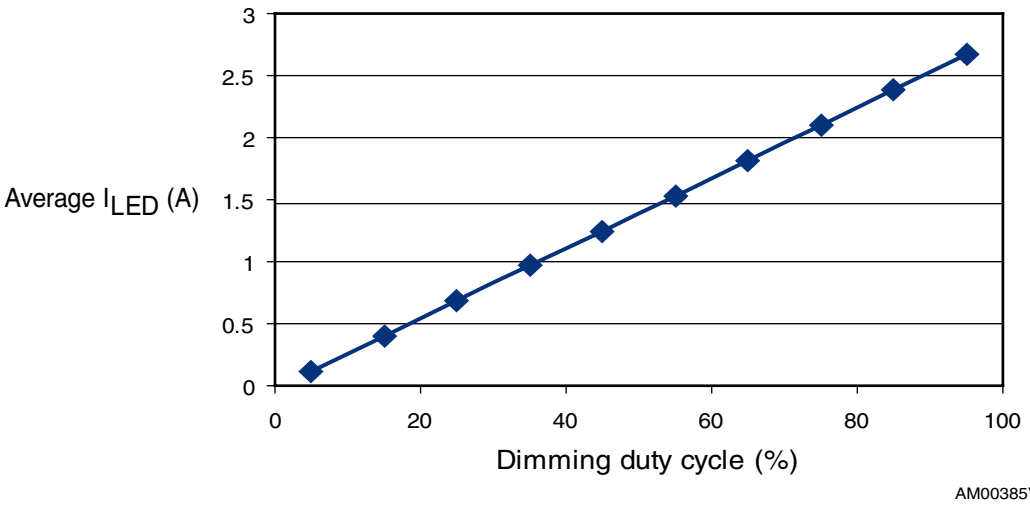


Figure 10. Variation in output currents with load change (number of LEDs in a string)

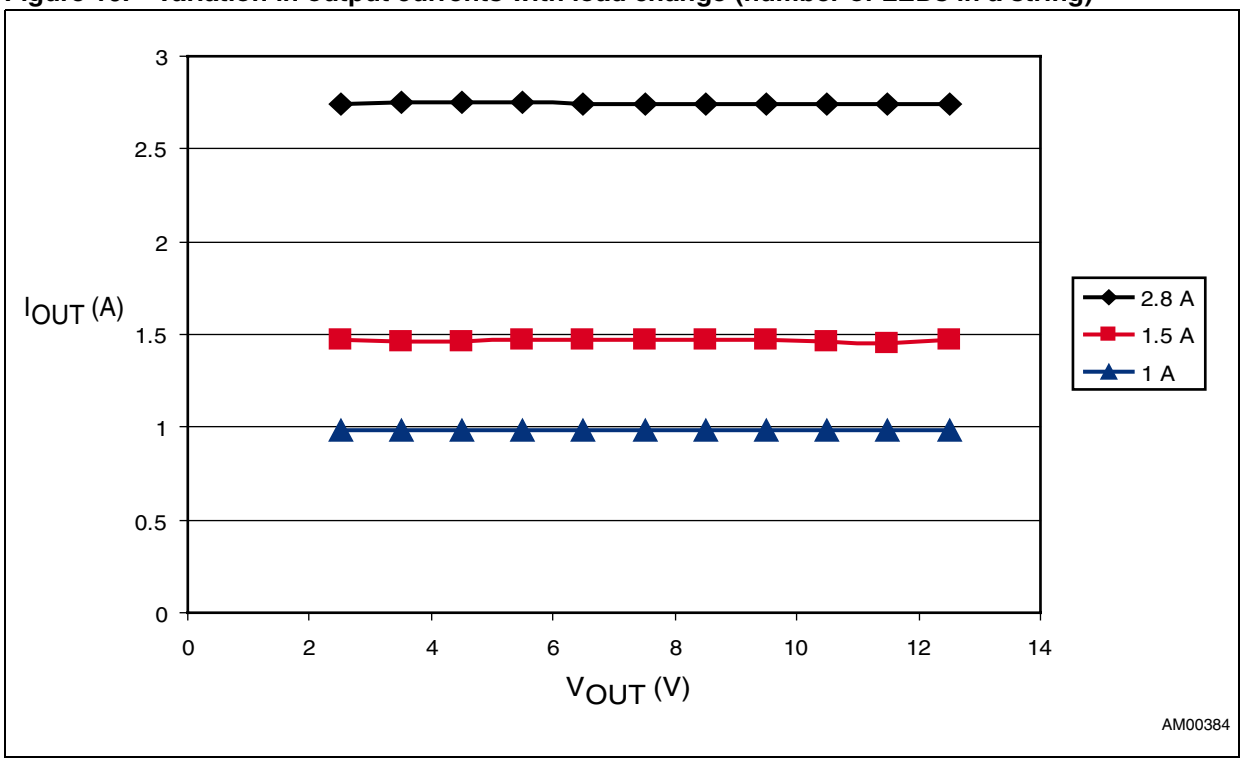
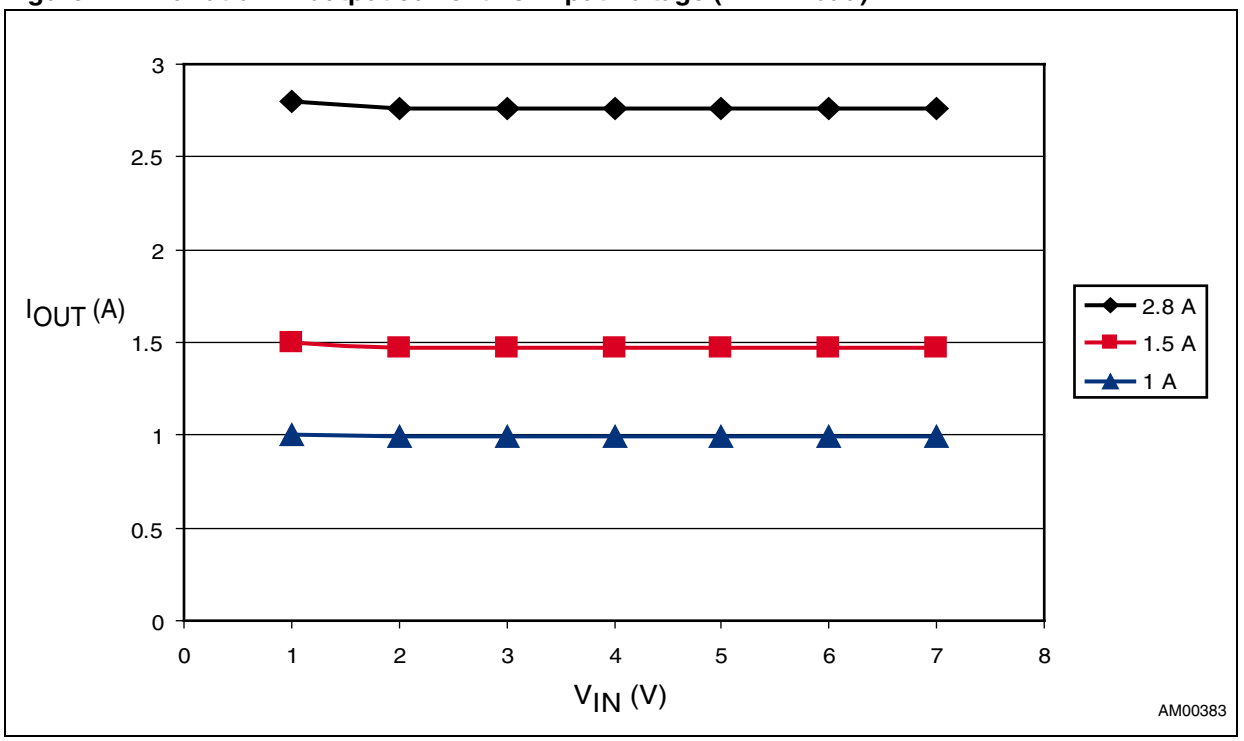


Figure 11. Variation in output current vs. input voltage (1 LED load)



4 Bill of material

Table 3. Bill of material

Designator	Comment	Description	Footprint	Value
C1	Cap. pol.	Polarized capacitor (tantalum)	SMD D	22 µF / 25 V
C2	Cap.	Ceramic capacitor	0805	470 pF
C3	Cap.	Ceramic capacitor	0805	100 nF
C4	Cap. pol.	Polarized capacitor (tantalum)	SMD A	10 µF / 10 V
C5	Cap.	Ceramic capacitor	0805	100 nF
C6	Cap.	Ceramic capacitor	0805	100 nF
C7	Cap.	Ceramic capacitor	0805	100 nF
C8	Cap.	Ceramic capacitor	1812	4.7 µF / 25 V
C9	Cap. pol.	Polarized capacitor (tantalum)	SMD D	22 µF / 20 V
CN1	Connector	Low voltage DC power connector		Dia. 2.1 mm
D1	V_{REF}	Voltage reference 1.225 0.5%	SOT23-3	TS821B
D2	Diode	Diode SMD	MINI-MELF	1N4148
D3	Sch. diode	Schottky diode 1 A, 30 V	SMA_A	STPS1L30A
L1	Inductor	High current inductor	13.2 x 12.8 mm	9.2 µH
OUT	Header 6	Header, 6-pin, 90° female	1 x 6 2.54 mm	1 x 6 pin
P1	Header 3	Header, 3-pin, male	1 x 3 2.54 mm	1 x 3 pin
PWM	Header 3	Header, 3-pin, 90° male	1 x 3 2.54 mm	1 x 3 pin
Q1	MOSFET	Dual N-channel MOSFET 30 V, 10 A	SO-8	STS8DN3LLH5
R1	Res.	Resistor SMD 1%	0805	62 kΩ
R2	Res.	Resistor SMD	0805	1 kΩ
R3	Res.	Resistor SMD 1%	0805	4.7 kΩ
R4	Res.	Resistor SMD	0805	4.7 kΩ
R5	Res.	Resistor SMD 1%	0805	6.8 kΩ
R6	Res.	Resistor SMD	0805	10 Ω
R7	Res.	Resistor SMD	0805	2.2 Ω
R8	Res.	Resistor SMD	0805	2.2 Ω
R9	Res.	Resistor SMD 1%	1210	0.56 Ω
R10	Res.	Resistor SMD 1%	1210	0.56 Ω
R14	Res.	Resistor SMD 1%	1210	0.56 Ω
R15	Res.	Resistor SMD 1%	1210	0.3 Ω
R16	Res.	Resistor SMD 1%	1210	0.3 Ω
U1	Vreg.	Positive voltage regulator 6 V 5%	SOT-89	L78L06AC
U2	PWM cont.	Single-phase PWM controller	SO-8	L6726A

5 References and related materials

1. AN2129 - DIMMING OF SUPER HIGH BRIGHTNESS LEDS WITH L6902D - see www.st.com/stonline/products/literature/an/11247.pdf
2. AN1891 - APPLICATION IDEAS: DRIVING LEDS USING L497X, L597X,L692X DC-DC CONVERTERS FAMILIES - see www.st.com/stonline/products/literature/an/10232.pdf
3. ST1S10 - 3 A, 900 kHz, monolithic synchronous step-down regulator - see www.st.com/stonline/products/literature/ds/13844.pdf
4. L6726A - Single phase PWM controller - see www.st.com/stonline/products/literature/ds/12754.pdf
5. STS8DN3LLH5 - Dual N-channel 30 V, 0.0155 Ω, 10 A, SO-8 STripFET™ V Power MOSFET - see www.st.com/stonline/products/literature/ds/16967.pdf
6. STPS1L30M - LOW DROP POWER SCHOTTKY RECTIFIER - see www.st.com/stonline/products/literature/ds/8902.pdf
7. TS821- 1.225V micropower shunt voltage reference - see www.st.com/stonline/products/literature/ds/6877.pdf.

6 Revision history

Table 4. Document revision history

Date	Revision	Changes
07-May-2009	1	Initial release.
14-May-2010	2	STS8DNH3LL device replaced by STS8DN3LLH5 device - updated *Figure 2*, *Table 3*, *Section 5*, corrected typo in *Section 1*, *Table 1*, *Figure 9* and *Table 3*.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com