REFERENCE DESIGN NOTE

LED Driver with MagI³C Power Module

MagI³C Power Modules

VDRM - LED Driver Application

DNS001: BY ROLAND KRATZ

7 - 24V INPUT / 0 – 1.5A LED CURRENT

1. Introduction

The DNS14 is a reference design for the WLMDU9456008T LED driver capable of driving up to 1.5 A output current using a voltage regulated module and an external secondary regulation loop to establish current regulation. The external loop regulates a DC output current which results in a constant photon flow. Compared to other solutions with PWM, this solution is less harmful to the eyes due to the constant photon flow, allowing the pupil opening to be the proper size for the light intensity emitted. Depending on the LED flux voltage up to 4 LEDs in series can be connected.

2. Features

- Input voltage range from 7 V to 24 V
- Output current up to 1.5 A
- Adjustable current from 10 mA to 1.5 A
- Dimming voltage 0 V (10 mA) to 5 V (1.5 A)
- Current regulation
- Output current ripple typ. < 10 mA
- Output power up to 22.5 W
- Series connected LEDs up to 15 V total flux voltage

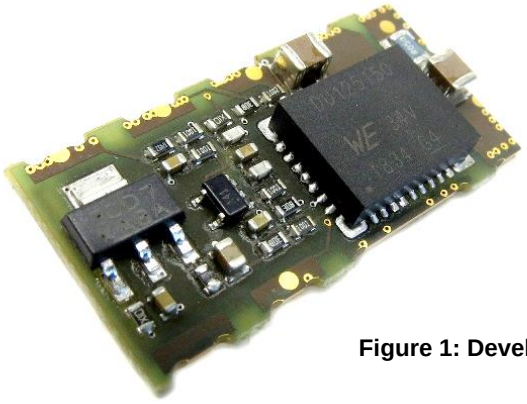

Figure 1: Development Example

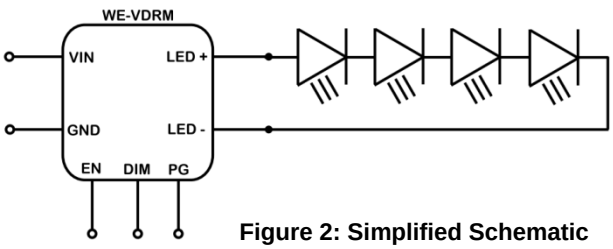

Figure 2: Simplified Schematic

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3. Description

The power consumption of LEDs on the lighting market is constantly increasing. LEDs require currents of 700 mA, 1 A or higher. High output currents are supported commonly with voltage regulated modules. Constant high current led drivers are uncommon on the market. This design note describes how to convert a voltage regulated module to a current regulated module. Typical supplies for LEDs are modules operating as current sources. They include dual protection against output short circuits. A current regulated circuit is - if designed properly - short circuit protected by itself due to its nature of forcing a defined current into the load regardless if the load is an LED or a low resistance like a short circuit. The second overcurrent protection circuit is integrated in the module commonly through a cycle by cycle current limit.

A MagI³C VDRM module is used in this application. Natively it is voltage regulated. The current through a specific number of LEDs will flow from LED+ pin through the LEDs to the LED- pin. The LED current flows through a shunt resistor, R3, and the voltage across R3 is compared with a dimming voltage. A 5 V dimming voltage at the DIM terminal results in a voltage of 75 mV at the regulation loop amplifier (IC3, pin4) with which the shunt voltage (IC3, pin 3) is compared. IC3 is used for an outer and slower regulation circuit which drives the feedback pin of the VDRM module. The compensation network consists of C8, C9 and R6, which may be trimmed by the design engineer depending on the customer PCB layout if modified from the reference design PCB layout.

An external dimming (adjusting) voltage is always required. This can be derived directly from V_{IN} if stable or from a resistor divider from the 3.3 V of the linear regulator (IC2).

The supply of the operational amplifier is derived from V_{IN} with a linear regulator (IC2) with a capability of abs. max. 40V or 60V input voltage. Its output voltage is set to 3.3V. The Input voltage of the design ranges from 7 V to 50 V (only with the 60 V version of the LM2936, which is not available in this small package) and the output current ranges from 0 A to 2.5 A. Note that the output power shall not exceed 22.5 W. The compensation may be adapted for various operating points.

This Reference Design is developed using the following specification:

V_{in} = 7 V - 24 V V_{out} = 0 V - 15 V I_{out} = 10 mA - 1.5 A

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4. Bill of Material

Index	Description	Size	Value	Order Code	Supplier
IC1	MagI³C power module	BQFN-41	WPMDU1251501N	171 021 501	Würth Elektronik eiSos
IC2	Linear regulator	SOT-223	LM2936(HV)	LM2936MP-3.3 (40V)	Texas Instruments
IC3	Operational amplifier	SOT-23	OPA364	OPA364	Texas Instruments
R5,R6,R8,R13		0603 1% TK100 125mW	1K00		
R10,R11,R12		0603 1% TK100 125mW	2K00		
R1		0603 5% TK100 125mW	10R0		
R2		0603 5% TK100 125mW	0R02		
R4,R9	Change R9 to your UVLO needs	0603 1% TK100 125mW	10K0		
R7	Defines max current at 5 V at DIM pin/pad (5 V = 1.5 A)	0603 1% TK100 125mW	64K9		
R3	Shunt resistor	1210 0,5% 250mW	0R05		
C2,C3		X5R or X7R 1210 10%	10µ/50V		
C5,C10,C11		X7R 0603 10%	100n/50V	885 012 206 095	Würth Elektronik eiSos
C7,C9		COG,NP0 0603 10%	22p/50V	885 012 006 053	Würth Elektronik eiSos
C8		X7R 0603 10%	22n/50V	885 012 206 091	Würth Elektronik eiSos
C6		X5R 0805 20%	10µ/10V	885 012 107 010	Würth Elektronik eiSos

Table 1: Bill of Material

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5. Schematic and Layout

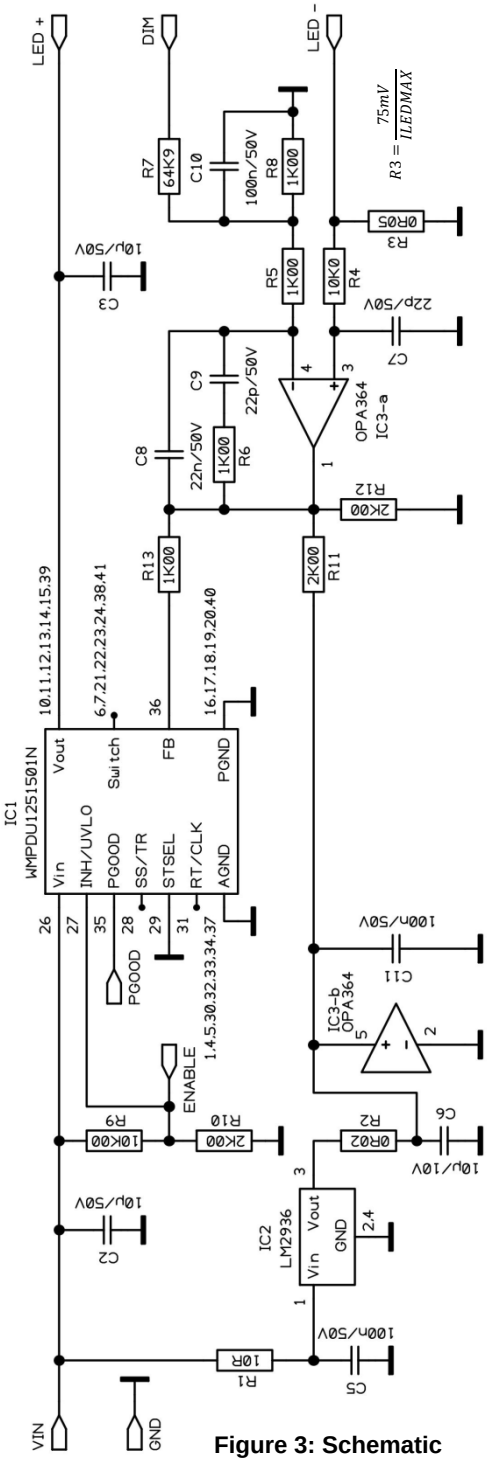

Figure 3: Schematic

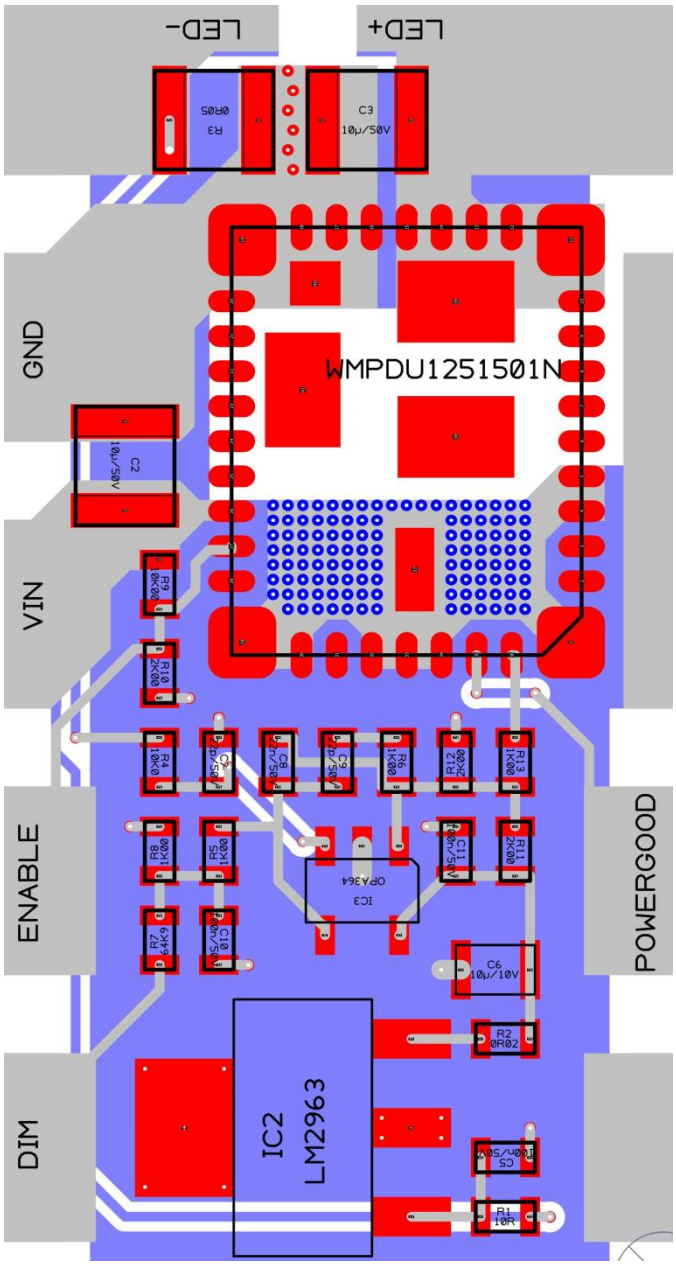

Figure 4: Layout

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6. Suitable Würth Elektronik eiSos High power LEDs

WL-SWTC

SMD White Top View Ceramic LED

Size 3535, waterclear dome lens

Characteristics

- Fast switching
- No IR radiation
- High brightness
- Minimal side emission
- Waterclear silicone lens
- Top view
- Flexible coupling with secondary optic
- Various color temperatures
- Compact footprint
- Thermal resistance junction to solder point: 8 °C/W
- LED junction temperature: 150 °C

Applications

- Indoor lighting: Spot light, Down light
- Outdoor lighting: Street light, Security light, Tunnel light, Parking lots light
- Industrial lighting: High-bay light, Low-bay light
- Consumer lighting: Torch light
- Agricultural equipment lighting
- Signal and symbol luminaries

QR-Code

Electrical & Optical Characteristics @ 0.35 A (typ.)

Order Code	Emitting Color	CCT (K)	CRI	Φ_v (lm)	V_F (V)	Chip Technology	$2\theta_{50\%}$ (°)	Qty. Tape & reel
158353027	Sunrise	2700	80	95	3.2	InGaN	120	1000
158353030	Warm White	3000	80	95				
158353040	Moonlight	4000	75	110				
158353050	Daylight	5000	70	121				
158353060	Cool White	6000	70	121				

CCT = Correlated Color Temperature
CRI = Color Rendering Index
Φ_v = Luminous Flux
V_F = Forward Voltage
$2\theta_{50\%}$ = Viewing Angle

Figure 5: Recommended High Power White LEDs

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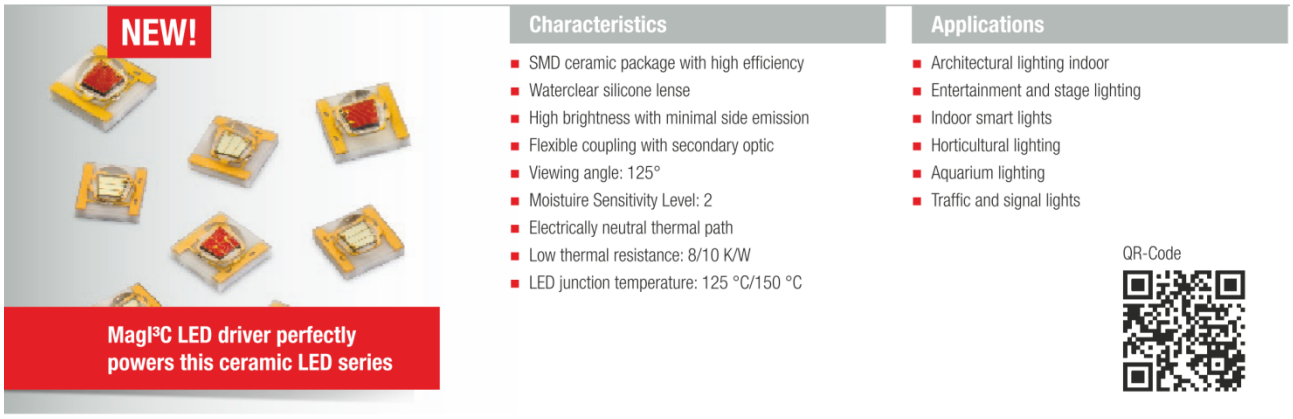
WL-SMDC

Ceramic mono-color High Power LED

Size 3535, waterclear



Electrical & Optical Characteristics @ 0.35 A (typ.)

Order Code	Emitting Color	λ_{Peak} (nm)	λ_{Dom} (nm)	Φ_v (lm)	V_F (V)	Chip Technology	$2\theta_{50\%}$ (°)	Qty. Tape & reel
150353RS74500	Red	635	625	55	2.2	AlInGaP	125	1000
150353YS74500	Yellow	593	590	50	2.2	AlInGaP		
150353GS74500	Green	520	525	85	3.4	InGaN		
150353BS74500	Blue	455	460	25	3.2	InGaN		

λ_{Peak} = Peak Wavelength
λ_{Dom} = Dominant Wavelength
I_v = Luminous Intensity
V_F = Forward Voltage
$2\theta_{50\%}$ = Viewing Angle

Figure 6: Recommended High Power Colored LEDs

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Application Notes:
http://www.we-online.com/app-notes

Component Selector:
http://www.we-online.com/component-selector

Toolbox:
http://www.we-online.com/toolbox

Product Catalog:
http://katalog.we-online.de/en/

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