Offline Primary Side Regulation LED Flyback Controller with PWM Dimming

Features

- Primary Side Regulation (PSR); No Opto-isolator Required
- Primary Side Supply Chip Power, Simplified Transformer Design
- Universal Input Voltage Range (85V – 265V)
- Constant Current Output (+/- 3%)
- Excellent PWM Dimming
- High Line & Load Regulation (+/-2%)
- High Efficiency (>85%)
- Open & Short LED Protection
- Primary Side OCP
- VCC Over Voltage Protection (OVP)
- VCC Under Voltage Lockout (UVLO)
- ZCD Short Protection
- CS Sense Resistor Open Protection
- Over Temperature Protection (OTP)
- Cycle by Cycle Current Limit
- Patent Pending Sense Architecture
- SOP-8 Package Available

Applications

- Isolated LED driver with PWM Dimming
- LED Lighting

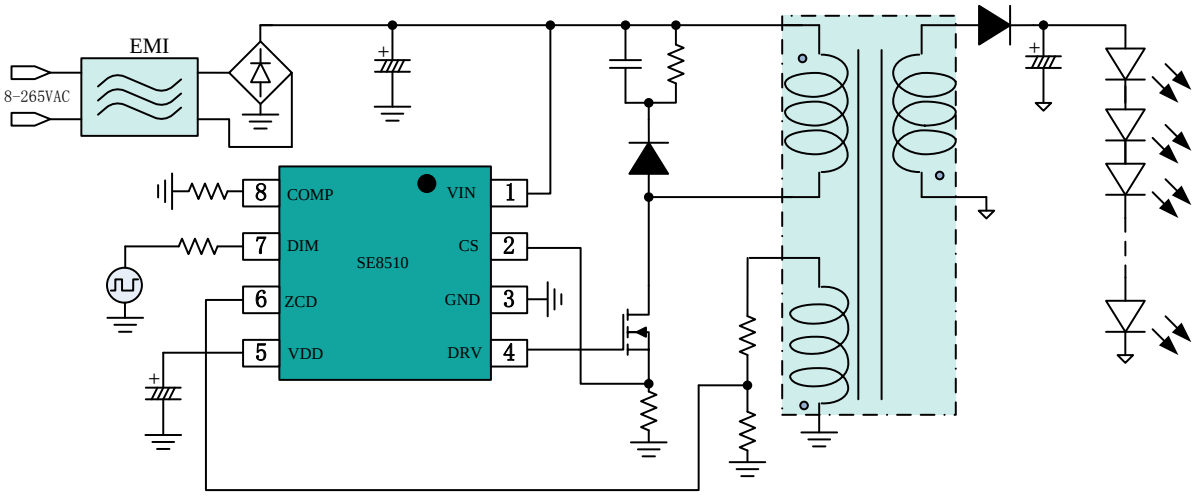
Description

SE8510 is an offline isolated flyback led controller with primary side control IC. Boundary mode operation provides a small magnetic solution with excellent load regulation. Using a patent pending current sensing scheme, the controller is able to deliver a well regulated current to the secondary side without using an opto-coupler.

SE8510 uses a rugged high voltage junction isolated process that can withstand an input voltage surge of up to 450V. Then SE8510 can be powered directly by main line input voltage source, this simplify the design of transformer for wide output voltage. Also the total application design becomes simpler than before.

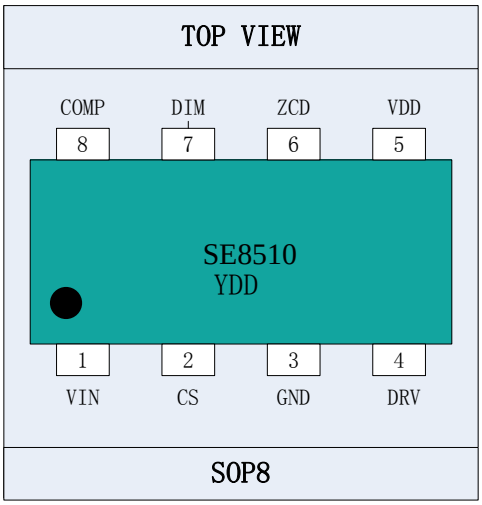
SE8510 has PWM dimming control feature. Additional features include thermal shutdown, current limit, open & short LED load and VDD under-voltage lockout.

Typical Application



Typical SE8510 LED Driver Application Circuit

Pin Configuration



Pin Descriptions

Name	SOP8	Description
VIN	1	Input voltage 8V to 400V DC
CS	2	Senses primary current
GND	3	Device ground
DRV	4	Drives the gate of the external MOSFET
VDD	5	Internally regulated supply voltage
ZCD	6	feedback terminal to detect zero current
DIM	7	PWM dimming pin
COMP	8	power compensation

Order Information

Type	Package	Logo	Temp	Tape and Reel
SE8510	SOP-8	SE8510 YDD	-40℃ to 85℃	2,500

SE8510, SE- Company Logo，8510 - Chip Type，Y - Year，DD - Production Code

Absolute Maximum Ratings

VIN to GND	-0.3V to +450V
CS，VID, DRV, ZCD, LD, DIM, COMP to GND	-0.3V to (VDD+0.3V)
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C

Note: Absolute maximum ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions for which the device is intended to be functional, but device parameter specifications may not be guaranteed.

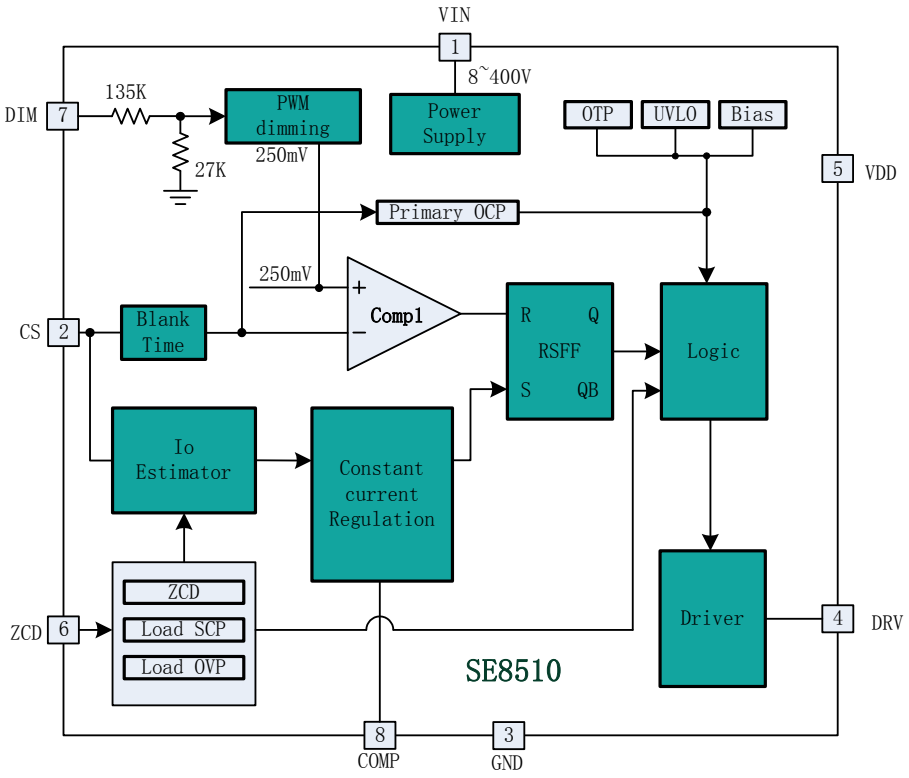
Electrical Characteristics

（TA = 25°C, Vdd = 7.5V, Vin=12V unless noted otherwise）

Symbol	Parameter	Min	Typical	Max	Unit	Condition
V_{IN}	Input DC supply voltage range [1]	8		400	V	DC input voltage
I_{IN}	supply current	-	2	3	mA	
V_{DD}	Internally regulated voltage	7.0	7.5	8.0	V	V_{IN}= 8-400V, pin DRV open
I_{DD}	VDD current for external circuitry	-	-	0.5	mA	V_{IN} = 8 - 100V
UVLO	VDD under voltage lockout threshold	4.5	5.0	6.5	V	V_{IN} rise
ΔUVLO	VDD under voltage lockout hysteresis	-	1.5	-	V	V_{IN} fall
V_{CS}	Current sense threshold voltage	225	250	275	mV	Temp=-40℃ to +85℃
V_{DRV}(hi)	DRV high output voltage	V_{DD}-0.3	-	V_{DD}	V	I_{OUT} = 5mA
V_{DRV}(lo)	DRV low output voltage	0	-	0.3	V	I_{OUT} = -5mA
R_{DIM}	Pin DIM pull-down resistance		165.0		KΩ	For SE8510
V_{DIM}	Pin DIM voltage range	0	-	5	V	TEMP ≤ 85°C, for SE8510
V_{DIM-th}	Pin DIM threshold voltage range	1.35	1.50	1.65	V	TEMP ≤ 85°C, for SE8510
T_{BLANK}	Current sense blanking interval	300	450	600	ns	V_{CS} ≥ 300mV,V_{LD}=V_{DD}
T_{RISE}	DRV rise time	-	30	50	ns	C_{GATE} = 500pF
T_{FALL}	DRV fall time	-	30	50	ns	C_{GATE} = 500pF
V_{ZCD}	ZCD feedback comparator threshold		350		mV	
V_{OVP}	ZCD over voltage threshold		1.2		V	
I_{OCP}	primary side over current threshold		4.8*I_{PK}		A	I_{PK}=primary peak current
T_{SD}	Thermal shutdown temperature		160		°C	
T_{hy}	Thermal shutdown hysteresis		70		°C	

1. Also limited by package power dissipation limit, whichever is lower.

SIMPLIFIED INTERNAL BLOCK DIAGRAM



Detailed Description

SE8510 is an offline isolated flyback LED controller with primary side control IC. It combines a high performance low voltage PWM controller chip and an input high voltage MOSFET that can withstand an input voltage surge of up to 450V. Using a patent pending current sensing scheme, the controller is able to deliver a well regulated current to the secondary side without using an opto-coupler. Moreover it guarantees a safe operation when short circuit of LEDs occurs, or open load circuit.

Supply Power

As shown in block diagram, chip current is internally generated in SE8510 without using bulky startup resistors typically required in the offline applications. Moreover, in many applications the SE8510 can be continuously powered using its internal linear regulator that provides a regulated voltage of 7.5V for all internal circuits.

Its supply is from the main line source. By this way the design of application system becomes simpler than before.

Discontinuous Conduction Mode

Critical conduction mode is a variable frequency switching scheme that always returns the secondary current to zero with every cycle. The SE8510 relies on boundary mode or discontinuous mode to calculate the critical current because the sensing scheme assumes the secondary current returns to zero with every cycle. The ZCD pin uses a patented schematic to determine the zero current point.

Primary-Side Current Control

When the voltage at CS pin exceeds a peak current sense voltage threshold, the gate drive signal terminates, and the power MOSFET turns off. The threshold is internally set to 250mV. The primary peak current can be calculated as:

$$I_{pk1} = \frac{250mV}{R_{cs}} \quad \text{.....(1)}$$

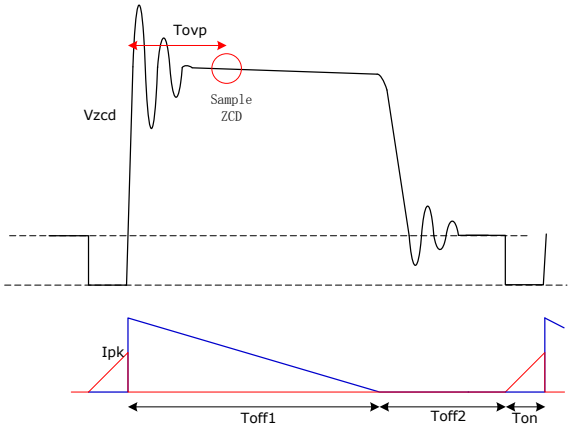


Figure 1. Discontinuous Conduction Mode

Secondary-Side(load) Current Control

SE8510 controls the secondary side LED current from the primary side information. The output LED mean current can be calculated approximately as:

$$I_{out} = \frac{62.5m \times N}{R_{cs}} \quad \text{.....(2)}$$

or,

$$I_{out} = \frac{I_{pk1} \times N}{4} \quad \text{.....(3)}$$

N — Turn ratio of primary side to secondary side

R_{CS} — primary side current sense resistor

I_{PK1} — primary side peak current

Switching Frequency

The Switching Frequency of SE8510 can be calculate as:

$$F_{osc} = \frac{V_{out}}{2NL_{sec}I_{pk1}} \quad \text{.....(4)}$$

or,

$$F_{osc} = \frac{V_{out}}{8L_{sec}I_{out}} \quad \text{.....(5)}$$

V_{OUT} — output load voltage

N — Turn ratio of primary side to secondary side

L_{SEC} — secondary side inductance

I_{PK1} — primary side peak current

It is better to set the frequency lower than 70KHz. The recommend value is 45KHz.

PWM dimming Feature (pin DIM)

PWM dimming can be achieved by driving the DIM pin with a low frequency square wave signal. When the PWM signal is zero, the GATE driver is turned off and when the PWMD signal is high(>1.5V), the GATE driver is enabled. The LED current is proportional to the duty cycle of PWM wave.

Output Over Voltage & Open Load Protection (OVP)

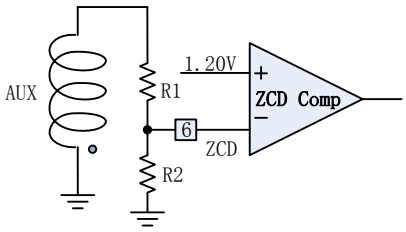


Figure 2. Over Voltage Protection

After the MOSFET turns off, the ZCD comparator detects the level of pin ZCD. Once its level is larger than 1.2v the gate driver will be turned off. To avoid mis-trigger OVP the ZCD OVP function does not work until the blank time Tzcd (fig.1), the typical interval is 1us.

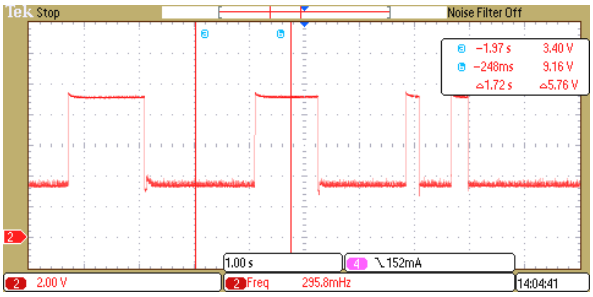
The OVP threshold is:

$$V_{ovp} = 1.2 \times \left(1 + \frac{R_1}{R_2}\right)\frac{N_{sec}}{N_{aux}} \quad \text{.....(6)}$$

N_{SEC}—The secondary winding turns

N_{AUX}—The auxiliary winding turns

The below wave records four OVP events.



Primary-Side Current Limit

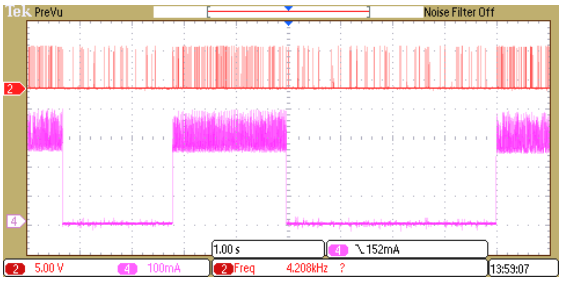
When the primary current exceeds a limit, the chip will shut down, and then wait for a moment to restart. The limit is 4.8*I_{PK}.

Output short Circuit Protection (OSCP)

Chip can control the output current, but

when OSCP the better way is to disable PWM signal. SE8510 will trigger OSCP after short LED series. After a fixed time the chip will restart to try whether the OSCP is still here. If so, the chip will re-disable PWM signal.

The below wave records two output short events.



Hysteretic Thermal Shutdown

The thermal shutdown circuitry senses the controller die temperature. The threshold is set at 160 °C typical with a 70 °C hysteresis.

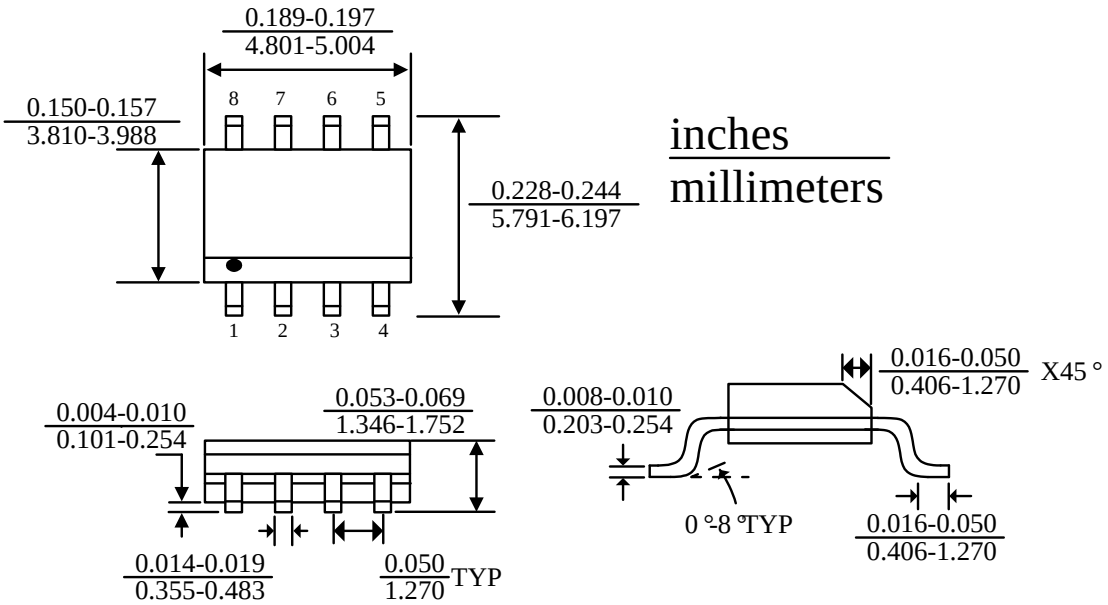
Application Example

Please refer to document AN26 which has one detailed design example, or contact someone of the company.

The final application is shown in figure 3.

Package Information

SOP8



Version

Version	Date	Note
V4.0	2013.10.31	Pin DIM spec modified

IMPORTANT NOTICE

“Preliminary” product information describes products that are in production, but for which full characterization data is not yet available. SMET Ltd. believes that the information contained in this document is accurate and reliable. However, the information is subject to change without notice and is provided “AS IS” without warranty of any kind (express or implied). Customers are advised to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability. No responsibility is assumed by SMET for the use of this information, including use of this information as the basis for manufacture or sale of any items, or for infringement of patents or other rights of third parties. This document is the property of SMET and by furnishing this information, SMET grants no license, express or implied under any patents, mask work rights, copyrights, trademarks, trade secrets or other intellectual property rights. SMET owns the copyrights associated with the information contained herein and gives consent for copies to be made of the information only for use within your organization with respect to SMET integrated circuits or other products of SMET. This consent does not extend to other copying such as copying for general distribution, advertising or promotional purposes, or for creating any work for resale. An export permit needs to be obtained from the competent authorities of the Japanese Government if any of the products or technologies described in this material and controlled under the “Foreign Exchange and Foreign Trade Law” is to be exported or taken out of Japan. An export license and /or quota needs to be obtained from the competent authorities of the Chinese Government if any of the products or technologies described in this material is subject to the PRC Foreign Trade Law and is to be exported or taken out of the PRC. CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE (“CRITICAL APPLICATIONS”). SMET PRODUCTS ARE NOT DESIGNED, AUTHORIZED OR WARRANTED FOR USE IN AIRCRAFT SYSTEMS, MILITARY APPLICATIONS, PRODUCTS SURGICALLY IMPLANTED INTO THE BODY, LIFE SUPPORT PRODUCTS OR OTHER CRITICAL APPLICATIONS (INCLUDING MEDICAL DEVICES, AIRCRAFT SYSTEMS OR COMPONENTS AND PERSONAL OR AUTOMOTIVE SAFETY OR SECURITY DEVICES). INCLUSION OF SMET PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER’S RISK AND SMET DISCLAIMS AND MAKES NO WARRANTY, EXPRESS, STATUTORY OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, WITH REGARD TO ANY SMET PRODUCT THAT IS USED IN SUCH A MANNER. IF THE CUSTOMER OR CUSTOMER’S CUSTOMER USES OR PERMITS THE USE OF SMET PRODUCTS IN CRITICAL APPLICATIONS, CUSTOMER AGREES, BY SUCH USE, TO FULLY INDEMNIFY SMET, ITS OFFICERS, DIRECTORS, EMPLOYEES, DISTRIBUTORS AND OTHER AGENTS FROM ANY AND ALL LIABILITY, INCLUDING ATTORNEYS’ FEES AND COSTS, THAT MAY RESULT FROM OR ARISE IN CONNECTION WITH THESE USES.

Star Micro Electronic Technology Co.Ltd
Room 602 UESTC Industrial Building
NO.159, 1st Ring Rd, Chengdu, China
Tel: (86) 28 8113 1361
Fax: (86) 28 8113 1841
Email: sales@star-micro.com
Website: www.star-micro.com

Application Schematic

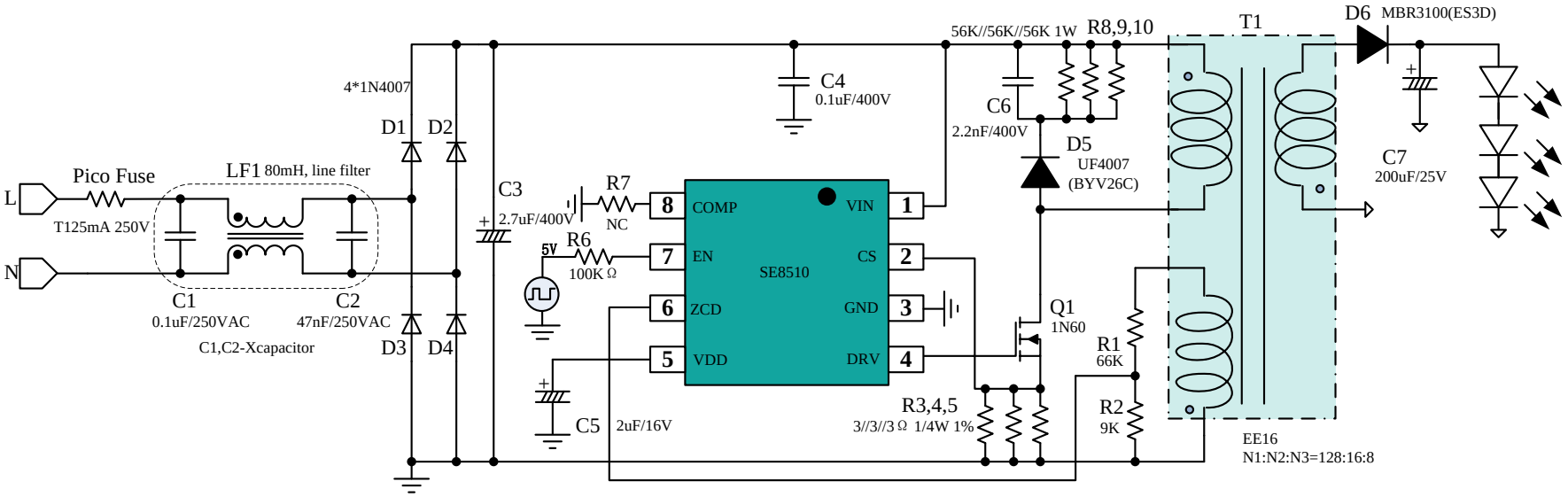


Figure 3. Application Schematic 9.6V/500mA LED driver