SSL2115X

Low-cost non-dimmable LED driver IC

Rev. 2 — 7 June 2012 **Product data sheet**

1. General description

The SSL2115X is a low-cost non-dimmable LED driver IC. It is designed to drive LEDs in isolated flyback or non-isolated buck-boost topologies. The device includes a high-voltage power switch and a circuit enabling start-up directly from the rectified mains voltage. It has a good controlled output current.

2. Features and benefits

- Compact solution with a small form factor and a low component count
- Ease of integration
- Primary side sensing (no optocoupler required)
- True current source behavior:
  - LED current independent of mains voltage, LED voltage and temperature variation
  - LED current accuracy (10 %)
  - Line regulation: ±3 % at 230 V ±10 %
  - Load regulation: ±3 % between 0.5 × U_{max} and 0.85 × U_{max}
- Efficiency up to 86 % depending on the application
- Power Factor 0.6 or ~0.9 using valley fill
- Low ripple current < 1 %
- Internal protections:
  - OverTemperature Protection (OTP)
  - LED short protection (I_{OUT} (0 V – V maximum) at a constant level)
  - LED open protection
  - UnderVoltage LockOut (UVLO)
- Internal supply voltage generation enabling start-up from the rectified mains voltage
- SO7 package

3. Applications

- SSL21151 is suitable for applications up to 5 W mains power
- SSL21153 is suitable for applications up to 10 W mains power
- SSL retrofit lamps (small-sized light bulbs or LED spots)
- LED module, mains AC/DC converter (down-lights)
- LED strings (retail displays)

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	operating range	–0.3	-	35	V
R_{DSon}	drain-source on-state resistance	SSL21151; T_j = 25 °C	13	15.5	17	Ω
		SSL21153; T_j = 25 °C	3.5	4.8	6	Ω
$f_{sw(high)}$	high switching frequency	normal operation	48	50.5	53	kHz
$I_{M(DRAIN)}$	peak current on pin DRAIN	SSL21151	–0.7	-	+0.7	A
		SSL21153	–1.5		+1.5	A
V_{DRAIN}	voltage on pin DRAIN		–2	-	+700	V
T_j	junction temperature		–40		+150	°C

5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
SSL21151T	SO7	plastic small package outline body; 7 leads; body width 3.9 mm	SOT1175-1
SSL21153T			

6. Block diagram

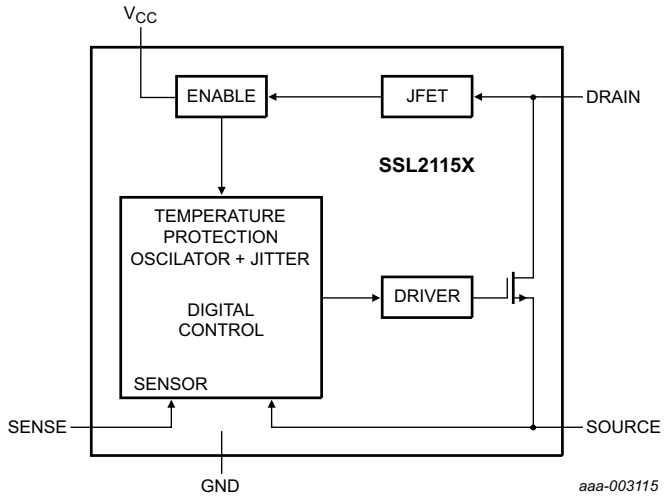


Fig 1. Block diagram SSL2115X

7. Pinning information

7.1 Pinning

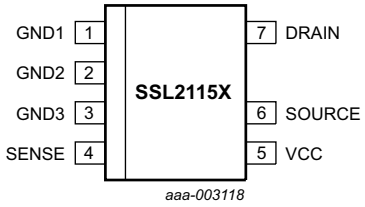


Fig 2. Pin configuration

7.2 Pin description

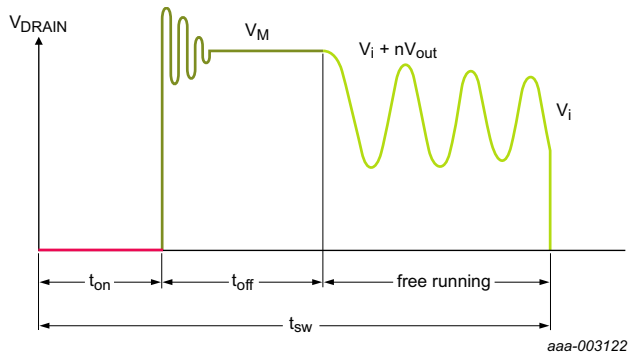
Table 3. Pin description

Symbol	Pin	Description
GND1	1	ground
GND2	2	ground
GND3	3	ground
SENSE	4	transformer status sensing
VCC	5	supply voltage
SOURCE	6	source of the internal power switch
DRAIN	7	drain of the internal power switch

8. Functional description

8.1 Introduction

The SSL2115X is an integrated circuit intended for retrofit small form factor SSL lamps. It provides a controller with an internal high-voltage switch to drive LEDs. It operates directly from the rectified mains.



V_{DRAIN} = voltage on pin DRAIN
t_{on} = turn-on time
t_{off} = turn-off time
V_M = peak voltage
V_i = input voltage
N = transformer winding turns ratio
V_{OUT} = output voltage.

Fig 3. Drain switching wave form

8.2 Current source operation

A flyback inductor is calculated using Equation 1:

$$L = \frac{(I_{LED} \cdot U_{max})}{0.85 \cdot \eta \cdot f_{sw(high)} \cdot 0.5 \cdot {I_{pk}}^2} \quad (1)$$

Where

- η is the efficiency of the complete flyback converter
- $f_{sw(high)}$ is the high switching frequency
- U_{max} the maximum combined voltage of the connected LEDs and the voltage drop of the output rectifier
- L is the primary inductance of the flyback transformer
- I_{pk} is the peak current through of the flyback transformer

$$I_{pk} = \frac{V_{ref(high)pk}}{R_{SOURCE}} \quad (2)$$

Where

- $V_{ref(high)pk}$ is the peak high reference voltage
- R_{SOURCE} is the value of the resistor connected to the SOURCE pin

8.3 Leading-Edge Blanking (LEB)

The controller has a fixed LEB of 325 ns to avoid wrong detection of the primary peak current.

8.4 dV/dt detection

The end of demagnetization is detected when the voltage on the sense pin is <50 mV.

8.5 Turn-off-time (t_{off})

A blanking time is applied at the beginning of t_{off} during t_{blank} time to observe the demagnetization.

8.6 Supply concepts VCC and UnderVoltage LockOut (UVLO)

An integrated Junction gate Field-Effect Transistor (JFET), connected to the drain voltage, provides the start-up current.

The IC starts switching when the voltage on pin VCC exceeds the $V_{CC(startup)}$ level. After start-up, an external supply is required, which an auxiliary winding connection can provide. When the voltage on pin VCC drops below the $V_{CC(UVLO)}$ level, the IC stops switching and is reset.

Design the voltage of the auxiliary winding to ensure that the VCC supply voltage has a U_{max} value of $\leq$ 29 V

8.7 Peak current detection

The cycle-by-cycle peak drain current limit circuit uses the external source resistor R_{SOURCE} to measure the primary peak current. The circuit is activated after the leading edge blanking time. The protection circuit limits the source voltage over resistor R_{SOURCE} to $V_{th(det)SOURCE}$, thus limiting the primary peak current.

8.8 LED OverTemperature Protection (OTP)

An external temperature dependent resistor can be applied for LED over temperature protection.

8.9 LED Output Short-circuit Protection (OSP)

When the output short-circuit protection is activated, the IC enters shutdown mode. Only a power-on reset (switching off the mains voltage) activates normal operation.

8.10 Output LED open-circuit protection

If an open circuit occurs on the LEDs, the output voltage increases at each cycle of the AC/DC converter. Energy is no longer transferred to the LEDs. The energy accumulated at the primary side is transferred to the supply of the IC via the auxiliary winding. The IC

limits the V_{LED} when VCC reaches the $V_{prot(VCC)}$ value. A non-latched application can be created depending on implementation of a small preload. Without the small preload, the protection latches.

8.11 Operational limits

The application must stay in Current Control Mode (CCM) for normal functionality. During normal operation, the switching frequency can reach $0.85 \times f_{sw(high)}$. This requirement must be met for the highest specified LED voltage.

On the other hand, the converter must be capable to handle the lowest specified LED voltage. The auxiliary winding of the transformer generates the IC's VCC supply voltage. As the minimum and maximum requirements for the supply voltage of the IC have a given ratio, the ratio of the lowest and highest LED voltage is also determined.

Choose the auxiliary voltage carefully if a large LED voltage ratio is required. An LED voltage ratio up to three can be realized with this IC.

The open output protection limits the output voltage to U_{max} / 0.85 when the circuit is designed according to the guidelines contained in this data sheet.

9. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
General					
T_{amb}	ambient temperature		–40	+85	°C
T_j	junction temperature		–40	+150	°C
T_{stg}	storage temperature		–55	+150	°C
Voltages					
V_{CC}	supply voltage	continuous [1]	–0.3	+35	V
V_{DRAIN}	voltage on pin DRAIN		–2	+700	V
V_{SENSE}	voltage on pin SENSE	current limited	–20	+5	V
Currents					
$I_{M(DRAIN)}$	peak current on pin DRAIN	SSL21151	–0.7	+0.7	A
		SSL21153	–1.5	+1.5	A
I_{DRAIN}	current on pin DRAIN	SSL21151	–0.1	+0.7	A
		SSL21153	–0.1	+1.5	A
I_{SOURCE}	current on pin SOURCE	SSL21151	–0.7	+0.1	A
		SSL21153	–1.5	+0.1	
V_{ESD}	electrostatic discharge voltage	human body model; all pins (except DRAIN) [1]	–2	+2	kV
		pin DRAIN	–1	+1	kV
		charged device model	–500	+500	V

[1] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

10. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air; SO7 package, PCB: 475 mm, 2-layer, 70 μm Cu per layer	136	K/W
		in free air; SO7 package, PCB: 1750 mm, 1-layer, 35 μm Cu per layer	136	K/W

11. Characteristics

Table 6. Characteristics

T_{amb} = 25 °C, VCC = 20 V; V_{SENSE} = 0 V; R_{SOURCE} = 1.5 Ω; all voltages referenced to GND, positive currents flow into the IC, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply						
I_{CC}	supply current	operating	0.53	0.75	0.97	mA
$V_{CC(startup)}$	start-up supply voltage		15	17	19	V
$V_{CC(UVLO)}$	undervoltage lockout supply voltage		7.5	8.5	9.5	V
$I_{startup(DRAIN)}$	start-up current on pin DRAIN		0.2	0.7	1.6	mA
$V_{BR(DRAIN)}$	breakdown voltage on pin DRAIN		700	-	-	V
Output stage						
R_{DSon}	drain-source on-state resistance	SSL21151; T_j = 25 °C	13	15.5	17	Ω
		SSL21153; T_j = 25 °C	3.5	4.8	6	Ω
$I_{DRAIN(off)}$	off-state drain current	V_{DRAIN} = 325 V	-	1	-	μA
Temperature protection						
$T_{th(otp)}$	overtemperature protection threshold temperature	junction temperature	140	150	160	°C
$T_{otp(hys)}$	overtemperature protection trip hysteresis	junction temperature	-	50		°C
Peak current comparator (SOURCE pin)						
$t_{d(ocp)}$	overcurrent protection delay time	dV/dt = 0.2 V/μs	-	100	-	ns
t_{leb}	leading edge blanking time		290	325	360	ns
$V_{ref(high)pk}$	high peak reference voltage	maximum peak voltage without jitter	0.525	0.555	0.585	V
$V_{ref(low)pk}$	low peak reference voltage	in LED open output mode	0.085	0.1	0.115	V
V_{ref-0V}	reference voltage at start-up or 0 V feedback voltage	in CC mode with V_{FBS} = 0 V	0.18	0.21	0.24	V
Sense input (SENSE pin)						
$V_{th(ovp)sence}$	sense overvoltage protection threshold voltage		3.1	3.2	3.3	V
$V_{ref(sense)}$	sense reference voltage	LED overvoltage mode	2.5	-	2.6	V
$V_{th(det)demag(sense)}$	demagnetization detection voltage level on Sense pin		25	50	75	mV
Frequency switching						
f_{jit}/f_{sw}	jitter frequency to switching frequency ratio	in all operation modes except in burst mode	5	7	9	%
$f_{sw(high)}$	high switching frequency	maximum switching, without jitter	48	50.5	53	kHz
$f_{sw(low)}$	low switching frequency	minimum switching, without jitter.	21	22.5	24	kHz
δ_{max}	maximum duty cycle		72	75	78	%

12. Application information

The application is shown in Figure 4. More information can be found in the application note for the SSL2115X

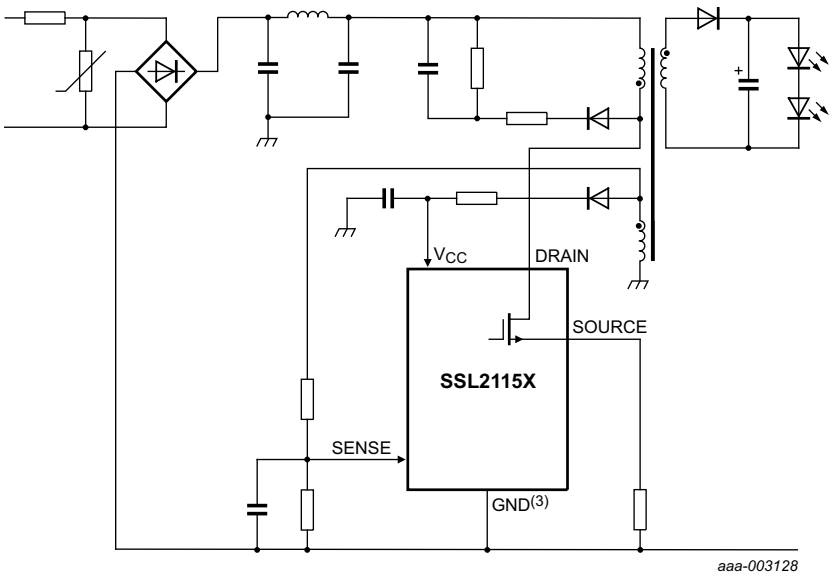
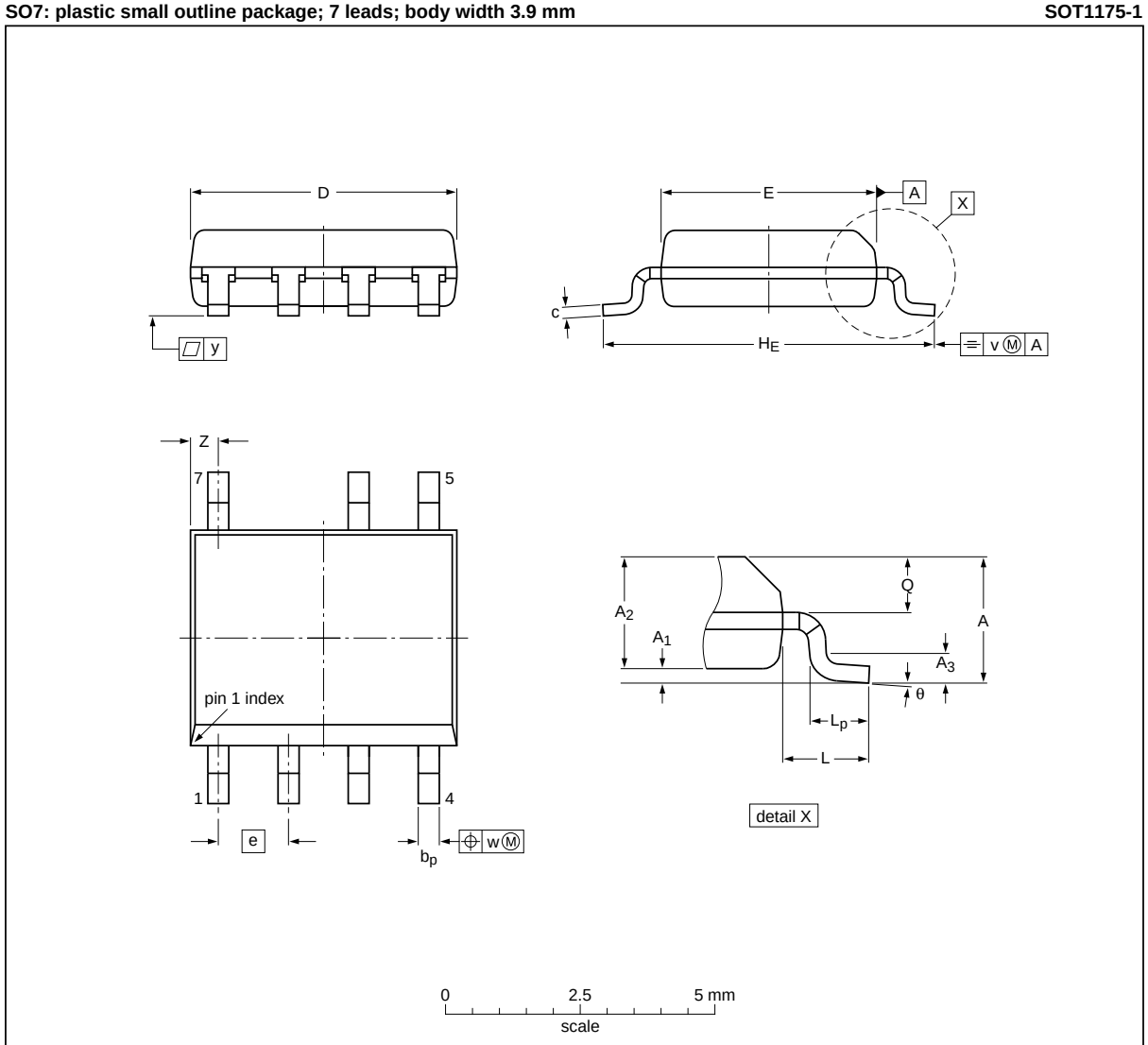


Fig 4. A typical SSL2115X application

13. Package outline

SO7: plastic small outline package; 7 leads; body width 3.9 mm **SOT1175-1**



Dimensions

Unit		A	A_1	A_2	A_3	b_p	c	D	E	e	H_E	L	L_p	Q	v	w	y	Z	θ
mm	max	1.75	0.250	1.45		0.49	0.25	5.0	4.0		6.2		1.0	0.70				0.7	8°
	nom		0.175	1.35	0.25	0.40	0.20	4.9	3.9	1.27	6.0	1.05	0.7	0.67				0.5	4°
	min		0.100	1.25		0.36	0.19	4.8	3.8		5.8		0.4	0.60	0.25	0.25	0.1	0.3	0°

Note
1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

sot1175-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1175-1	- - -	- - -	- - -			~~10-03-30~~ 10-04-21

Fig 5. Package outline SOT1175-1 (SO7)

14. Abbreviations

Table 7. Abbreviations

Acronym	Description
BCM	Boundary Conduction Mode
BOM	Bill Of Materials
JFET	Junction Field-Effect Transistor
LEB	Leading-Edge Blanking
LED	Light Emitting Diode
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
OCP	OverCurrent Protection
OSP	Output Short Protection
OTP	OverTemperature Protection
PCB	Printed-Circuit Board
PWM	Pulse-Width Modulation
SMPS	Switched Mode Power Supply
UVLO	UnderVoltage LockOut
ZCS	Zero-Current Switching

15. Revision history

Table 8. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SSL2115X v.2	20120607	Product data sheet	-	SSL2115X v.1
Modifications	• Data sheet title changed • Minor text changes to Section 1 “General description” on page 1. • Minor text changes to Section 2 “Features and benefits” on page 1. • Minor text changes to Section 4 “Quick reference data” on page 2.			
SSL2115X v.1	20120529	Objective data sheet	-	-

16. Legal information

16.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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18. Contents

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