



# 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:  $\pm 3\%$  at  $230\text{ V} \pm 10\%$
  - ◆ Load regulation:  $\pm 3\%$  between  $0.5 \times U_{\max}$  and  $0.85 \times U_{\max}$
- Efficiency up to 86 % depending on the application
- Power Factor 0.6 or  $\sim 0.9$  using valley fill
- Low ripple current  $< 1\%$
- Internal protections:
  - ◆ OverTemperature Protection (OTP)
  - ◆ LED short protection ( $I_{\text{OUT}}$  (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**

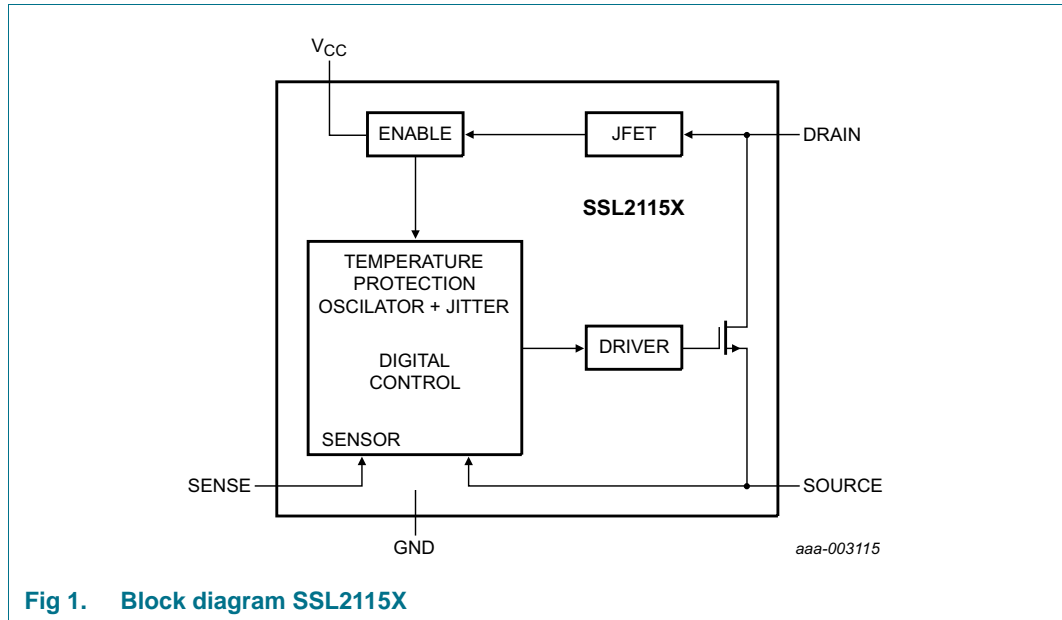
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage	operating range	-0.3	-	35	V
$R_{DSon}$	drain-source on-state resistance	SSL21151; $T_j = 25\text{ }^\circ\text{C}$	13	15.5	17	$\Omega$
		SSL21153; $T_j = 25\text{ }^\circ\text{C}$	3.5	4.8	6	$\Omega$
$f_{sw(high)}$	high switching frequency	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	$^\circ\text{C}$

### 5. Ordering information

**Table 2. Ordering information**

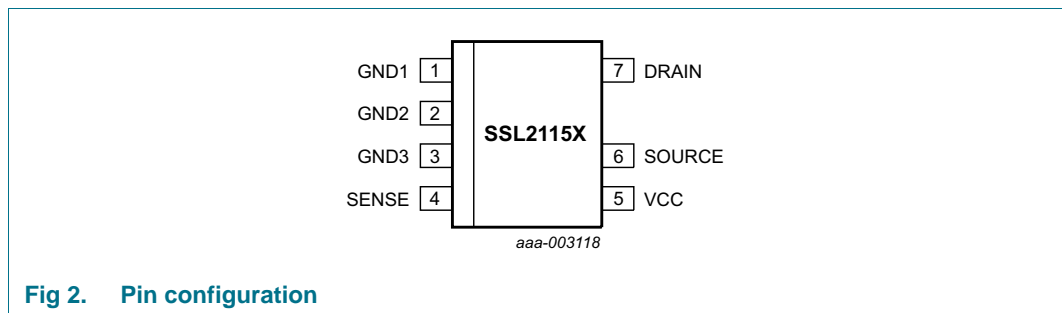
Type number	Package		
	Name	Description	Version
SSL21151T	SO7	plastic small package outline body; 7 leads; body width 3.9 mm	SOT1175-1
SSL21153T			

## 6. Block diagram



## 7. Pinning information

### 7.1 Pinning



### 7.2 Pin description

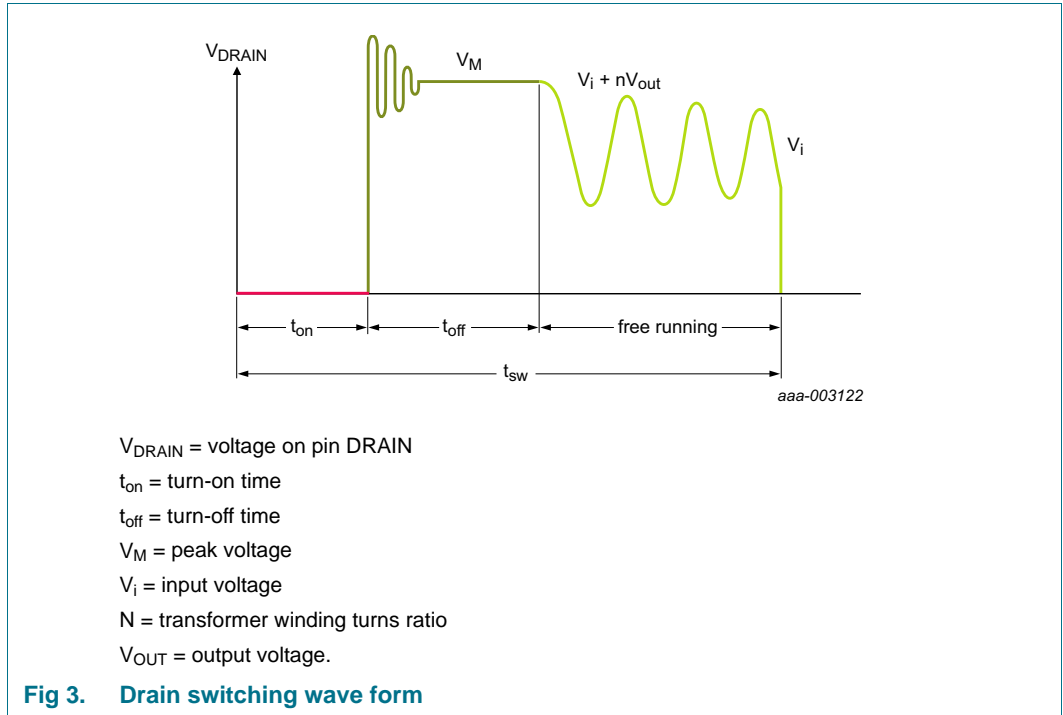
**Table 3. Pin description**

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.



### 8.2 Current source operation

A flyback inductor is calculated using Equation 1:

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

Where

- $\eta$  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

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

Where

- $V_{\text{ref(high)pk}}$  is the peak high reference voltage
- $R_{\text{SOURCE}}$  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 ( $t_{\text{off}}$ )

A blanking time is applied at the beginning of  $t_{\text{off}}$  during  $t_{\text{blank}}$  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  $V_{\text{CC(startup)}}$  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  $V_{\text{CC(UVLO)}}$  level, the IC stops switching and is reset.

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

### 8.7 Peak current detection

The cycle-by-cycle peak drain current limit circuit uses the external source resistor  $R_{\text{SOURCE}}$  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  $R_{\text{SOURCE}}$  to  $V_{\text{th(det)SOURCE}}$ , 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
<b>General</b>					
$T_{amb}$	ambient temperature		-40	+85	°C
$T_j$	junction temperature		-40	+150	°C
$T_{stg}$	storage temperature		-55	+150	°C
<b>Voltages</b>					
$V_{CC}$	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
<b>Currents</b>					
$I_{M(DRAIN)}$	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**

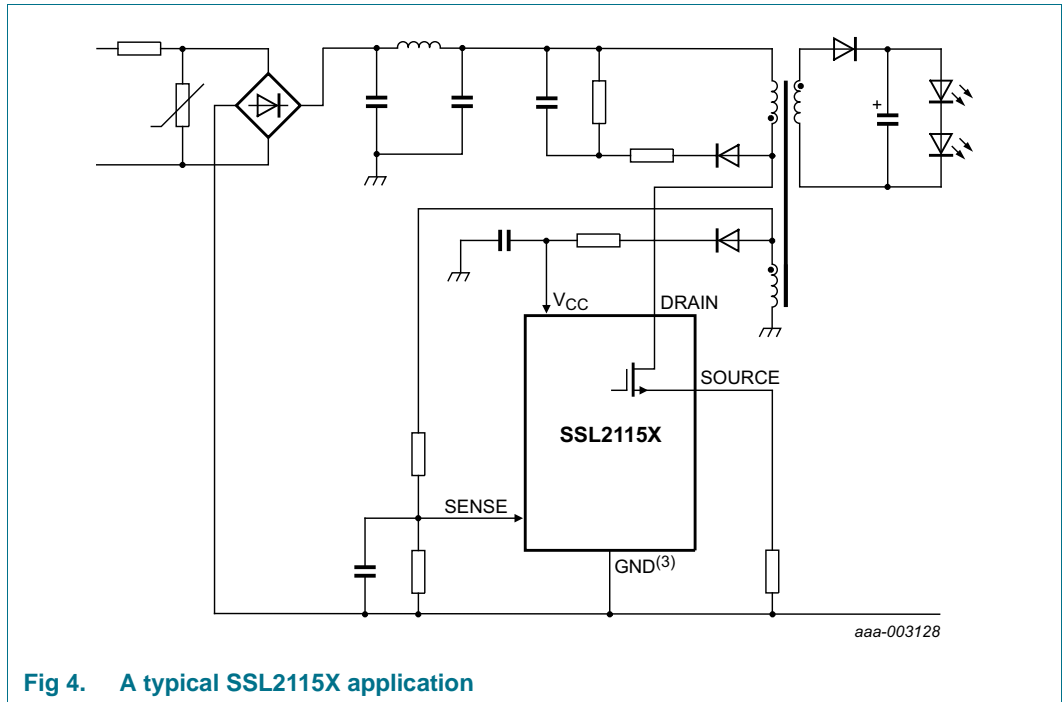
$T_{amb} = 25\text{ }^{\circ}\text{C}$ ,  $V_{CC} = 20\text{ V}$ ;  $V_{SENSE} = 0\text{ V}$ ;  $R_{SOURCE} = 1.5\text{ }\Omega$ ; all voltages referenced to GND, positive currents flow into the IC, unless otherwise specified.

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

SOT7: plastic small outline package; 7 leads; body width 3.9 mm

SOT1175-1

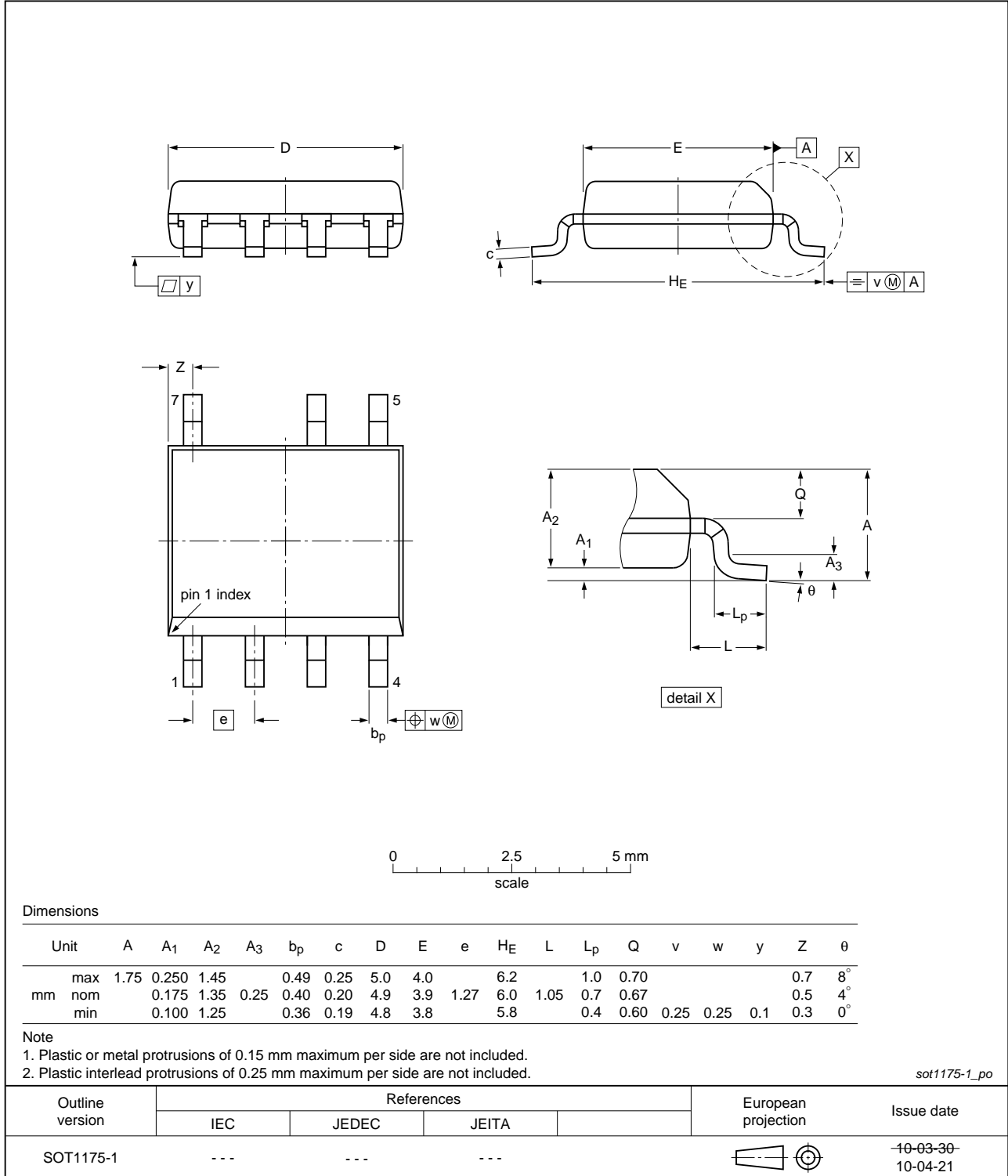


Fig 5. Package outline SOT1175-1 (SOT7)

## 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		<ul style="list-style-type: none"><li>• Data sheet title changed</li><li>• Minor text changes to <a href="#">Section 1 "General description" on page 1.</a></li><li>• Minor text changes to <a href="#">Section 2 "Features and benefits" on page 1.</a></li><li>• Minor text changes to <a href="#">Section 4 "Quick reference data" on page 2.</a></li></ul>		
SSL2115X v.1	20120529	Objective data sheet	-	-

## 16. Legal information

### 16.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

### 16.2 Definitions

**Draft** — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

**Short data sheet** — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

**Product specification** — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

### 16.3 Disclaimers

**Limited warranty and liability** — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the *Terms and conditions of commercial sale* of NXP Semiconductors.

**Right to make changes** — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

**Suitability for use** — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

**Applications** — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

**Limiting values** — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

**Terms and conditions of commercial sale** — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

**No offer to sell or license** — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

**Export control** — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

**Quick reference data** — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

**Non-automotive qualified products** — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the

product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

## 16.4 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

**GreenChip** — is a trademark of NXP B.V.

## 17. Contact information

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

## 18. Contents

<b>1</b>	<b>General description</b> .....	<b>1</b>
<b>2</b>	<b>Features and benefits</b> .....	<b>1</b>
<b>3</b>	<b>Applications</b> .....	<b>2</b>
<b>4</b>	<b>Quick reference data</b> .....	<b>2</b>
<b>5</b>	<b>Ordering information</b> .....	<b>2</b>
<b>6</b>	<b>Block diagram</b> .....	<b>3</b>
<b>7</b>	<b>Pinning information</b> .....	<b>3</b>
7.1	Pinning .....	3
7.2	Pin description .....	3
<b>8</b>	<b>Functional description</b> .....	<b>4</b>
8.1	Introduction .....	4
8.2	Current source operation .....	4
8.3	Leading-Edge Blanking (LEB) .....	5
8.4	dV/dt detection .....	5
8.5	Turn-off-time ( $t_{off}$ ) .....	5
8.6	Supply concepts VCC and UnderVoltage LockOut (UVLO) .....	5
8.7	Peak current detection .....	5
8.8	LED OverTemperature Protection (OTP) .....	5
8.9	LED Output Short-circuit Protection (OSP) .....	5
8.10	Output LED open-circuit protection .....	5
8.11	Operational limits .....	6
<b>9</b>	<b>Limiting values</b> .....	<b>7</b>
<b>10</b>	<b>Thermal characteristics</b> .....	<b>7</b>
<b>11</b>	<b>Characteristics</b> .....	<b>8</b>
<b>12</b>	<b>Application information</b> .....	<b>9</b>
<b>13</b>	<b>Package outline</b> .....	<b>10</b>
<b>14</b>	<b>Abbreviations</b> .....	<b>11</b>
<b>15</b>	<b>Revision history</b> .....	<b>12</b>
<b>16</b>	<b>Legal information</b> .....	<b>13</b>
16.1	Data sheet status .....	13
16.2	Definitions .....	13
16.3	Disclaimers .....	13
16.4	Trademarks .....	14
<b>17</b>	<b>Contact information</b> .....	<b>14</b>
<b>18</b>	<b>Contents</b> .....	<b>15</b>

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP B.V. 2012.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

Date of release: 7 June 2012

Document identifier: SSL2115X