



# SSL2115X

## Low-cost non-dimmable LED driver IC

Rev. 2 — 7 June 2012

Product data sheet

## 1. General description

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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

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- 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 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**

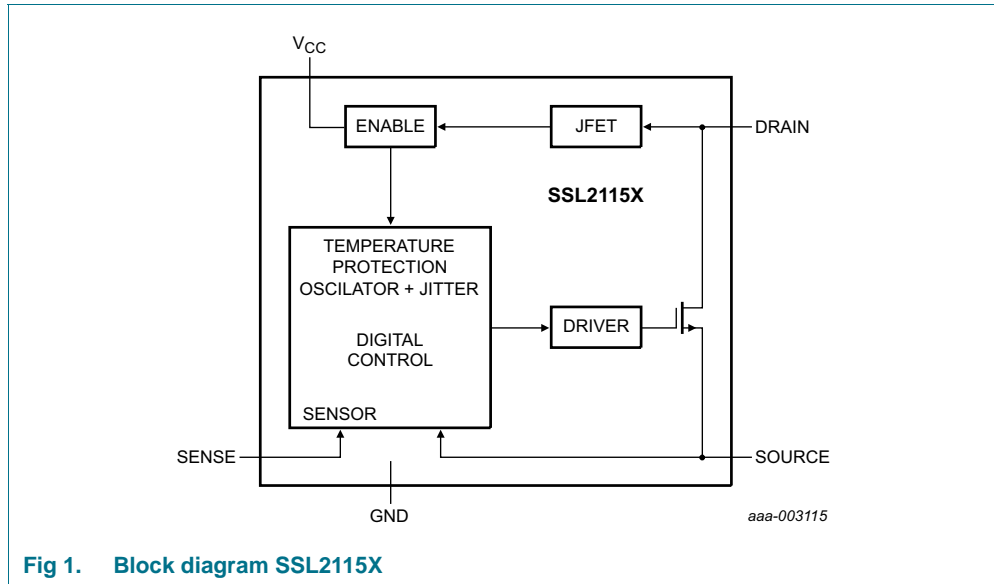
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage	operating range	-0.3	-	35	V
$R_{DSon}$	drain-source on-state resistance	SSL21151; $T_j = 25\text{ }^{\circ}\text{C}$	13	15.5	17	$\Omega$
		SSL21153; $T_j = 25\text{ }^{\circ}\text{C}$	3.5	4.8	6	$\Omega$
$f_{sw(high)}$	high switching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

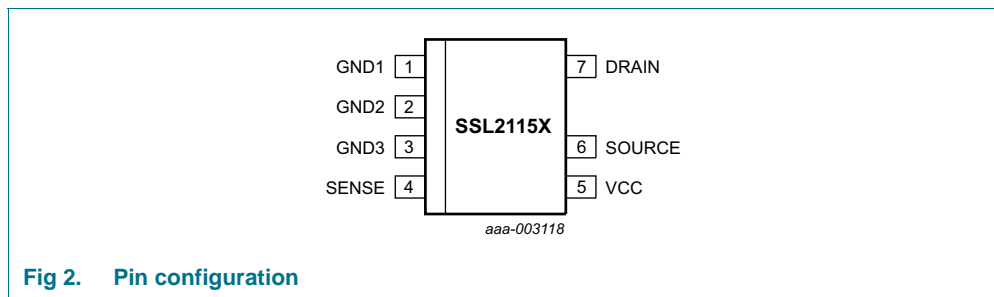
Type number	Package		Version
	Name	Description	
SSL21151T	SO7	plastic small package outline body; 7 leads; body width 3.9 mm	SOT1175-1
SSL21153T			

## 6. Block diagram



## 7. Pinning information

### 7.1 Pinning



### 7.2 Pin description

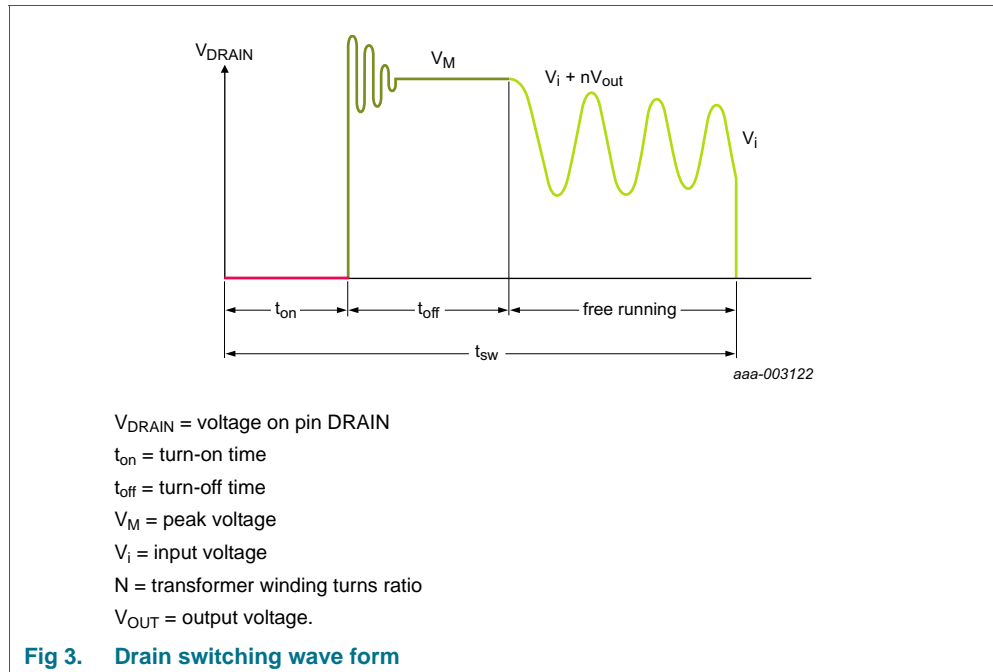
**Table 3. Pin description**

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:

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

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

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

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 <a href="#">[1]</a>	-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)	<a href="#">[1]</a> -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**

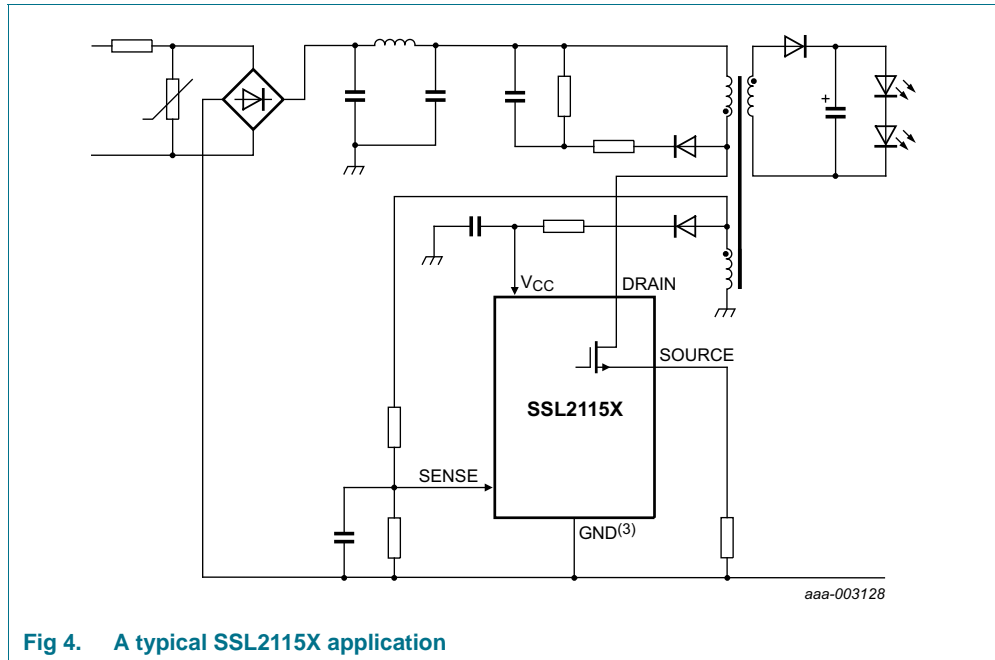
$T_{amb} = 25\text{ }^{\circ}\text{C}$ ,  $V_{CC} = 20\text{ V}$ ;  $V_{SENSE} = 0\text{ V}$ ;  $R_{SOURCE} = 1.5\ \Omega$ ; all voltages referenced to GND, positive currents flow into the IC, unless otherwise specified.

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>						
$f_{\text{jitter}}/f_{\text{sw}}$	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



### 13. Package outline

S07: plastic small outline package; 7 leads; body width 3.9 mm

SOT1175-1

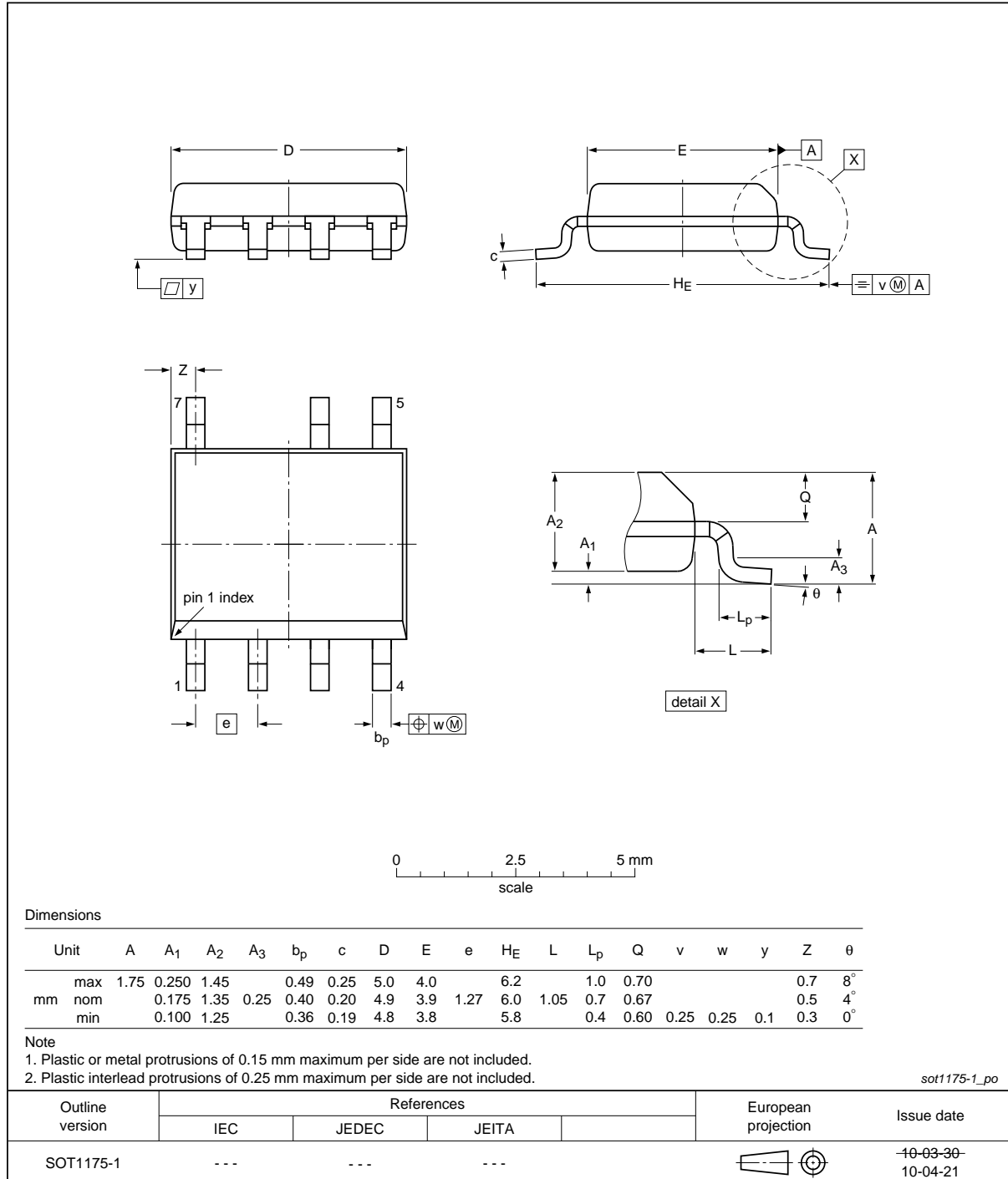


Fig 5. Package outline SOT1175-1 (S07)

## 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	-	-

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### 16.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	Definition
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[2] The term 'short data sheet' is explained in section "Definitions".

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## 18. Contents

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<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>

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