



SSL2103

Dimmable Greenchip controller for LED lighting

Rev. 2.2 — 5 December 2011

Product data sheet

1. General description

The SSL2103 is a Switched Mode Power Supply (SMPS) controller IC that operates in combination with a phase cut dimmer directly from the rectified mains. It is designed to drive LED devices. The device includes a circuit to allow direct start-up from the rectified mains voltage.

For dimmer applications, an integrated dedicated circuitry optimizes the dimming curve.

- SSL2101: fully integrated LED driver for lamps up to 10 W
- SSL2102: fully integrated LED driver for lamps up to 25 W
- SSL2103: gives the application designer flexibility to:
 - Use an external power switch to allow the IC to provide any power
 - Use an external bleeder transistors to provide extended dimmer interoperability

2. Features and benefits

- Easy migration to existing lighting control infrastructure
- Supports most available dimming solutions
- Optimized efficiency with valley switching managed by a built-in circuitry
- Demagnetization detection
- OverTemperature Protection (OTP)
- Short-Winding Protection (SWP) and OverCurrent Protection (OCP)
- Internal V_{CC} generation allowing start-up from the rectified mains voltage
- Natural dimming curve by logarithmic correction, down to 1 %
- Suitable for flyback and buck applications

3. Applications

- SSL applications with various power requirements
- LED modules such as LED spots and down-lights
- LED strings suitable for retail displays, etc.



4. Quick reference data

Table 1. Quick reference data

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|----------------|----------------------|---|--------|-----|------|--------------------|
| V_{CC} | supply voltage | $V_{DRAIN} > 60\text{ V}$ | [1] 12 | 20 | 28 | V |
| f_{osc} | oscillator frequency | | 10 | 100 | 130 | kHz |
| I_{DRAIN} | current on pin DRAIN | $V_{DRAIN} > 60\text{ V}$; with auxiliary supply | - | 30 | 125 | μA |
| δ_{min} | minimum duty factor | | - | 0 | - | % |
| δ_{max} | maximum duty cycle | PWMLIMIT= 3 V | - | 75 | - | % |
| T_{amb} | ambient temperature | | -40 | - | +100 | $^{\circ}\text{C}$ |

[1] $V_{CC} = 20\text{ V}$ minimum to meet all characteristics.

5. Ordering information

Table 2. Ordering information

| Type number | Package | | |
|-------------|---------|--|----------|
| | Name | Description | Version |
| SSL2103T | SO14 | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |

6. Block diagram

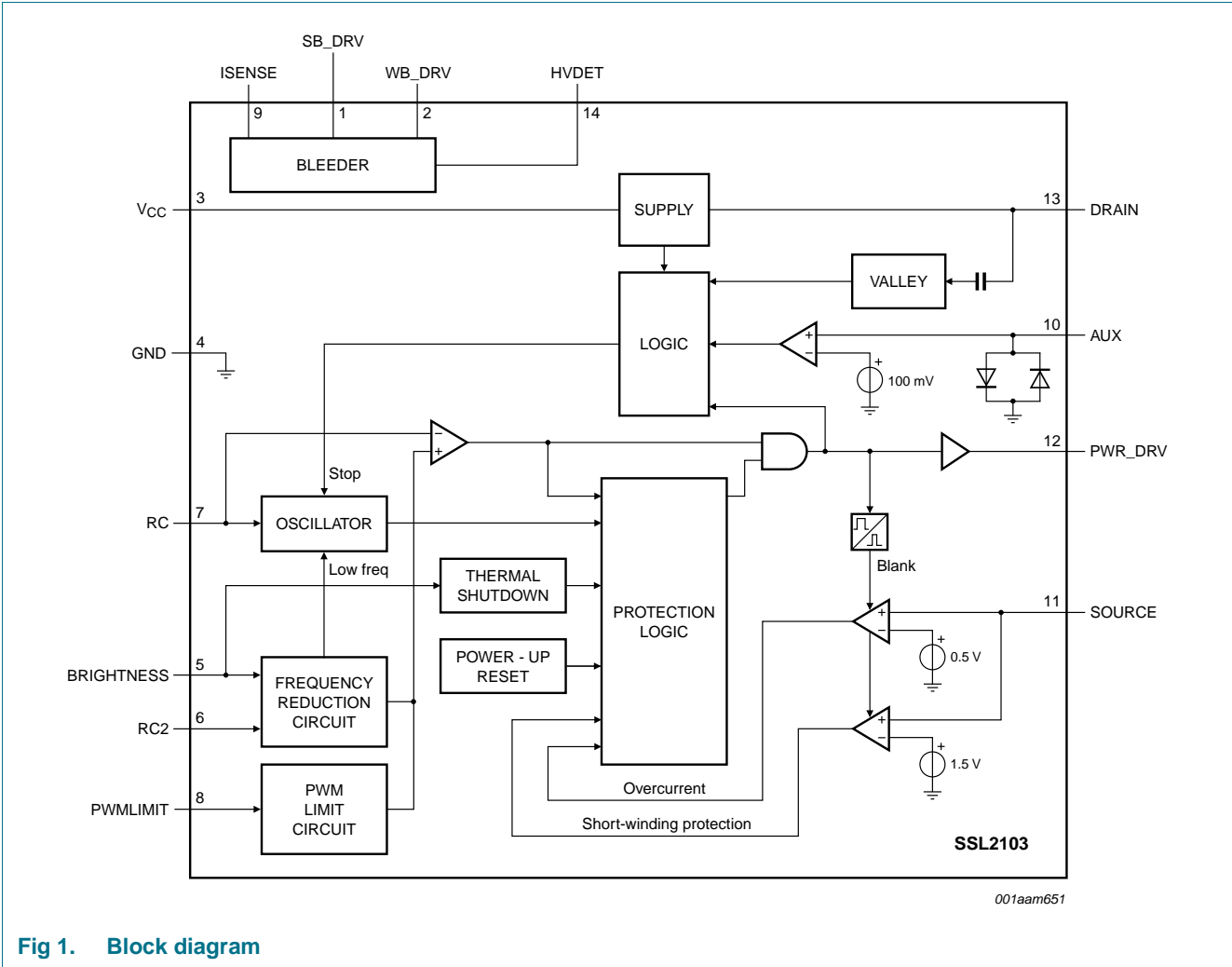
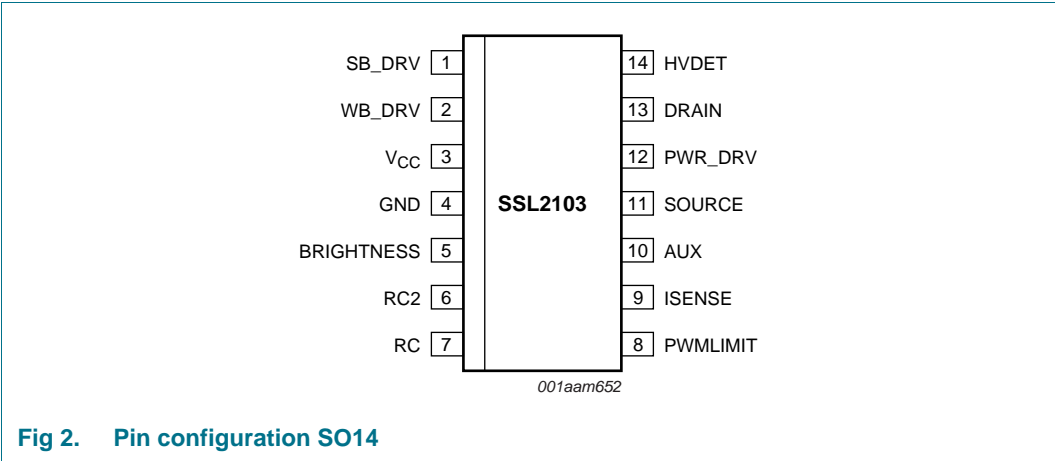


Fig 1. Block diagram

7. Pinning information

7.1 Pinning



7.2 Pin description

Table 3. Pin description

| Symbol | Pin | Description |
|-----------------|-----|---|
| SB_DRV | 1 | strong bleeder switch drive |
| WB_DRV | 2 | weak bleeder switch drive |
| V _{CC} | 3 | supply voltage |
| GND | 4 | ground |
| BRIGHTNESS | 5 | brightness input |
| RC2 | 6 | setting for frequency reduction |
| RC | 7 | frequency setting |
| PWMLIMIT | 8 | PWM limit input |
| ISENSE | 9 | current sense input for WBLEED |
| AUX | 10 | input for voltage from auxiliary winding for timing (demagnetization) |
| SOURCE | 11 | current sense input of external power switch |
| PWR_DRV | 12 | power switch drive |
| DRAIN | 13 | drain of external power switch; input for start-up current and valley sensing |
| HVDET | 14 | input for high voltage sensing |

8. Functional description

The SSL2103 is an LED driver IC that operates directly from the rectified mains. The SSL2103 uses on-time mode control and frequency control to control the LED brightness. The BRIGHTNESS and PWMLIMIT input of the IC can be used to control the LED light output in combination with an external dimmer. The PWMLIMIT input can also be used for Thermal Lumen Management (TLM) and for precision LED current control.

8.1 Start-up and Under Voltage Lock Out (UVLO)

Initially, the IC is self-supplying from the rectified mains voltage. The IC starts switching as soon as the voltage on pin V_{CC} passes the $V_{CC(startup)}$ level. The supply can be taken over by the auxiliary winding of the transformer as soon as V_{CC} is high enough and the supply from the line is stopped for high efficiency operation. Alternatively the IC can be supplied via a bleeder resistor connected to a high voltage.

Remark: The maximum V_{CC} voltage rating of the IC must be considered.

8.2 Oscillator

An oscillator inside the IC provides the timing for the switching converter logic.

The frequency of the oscillator is set by the external resistors and the capacitor on pin RC and pin RC2. The external capacitor is charged rapidly to the $V_{RC(max)}$ level and, starting from a new primary stroke, discharges to the $V_{RC(min)}$ level. Because the discharge is exponential, the relative sensitivity of the duty factor to the regulation voltage at low duty factor, is almost equal to the sensitivity at high duty factors. This results in a more constant gain over the duty factor range, compared to Pulse Width Modulated (PWM) systems with a linear sawtooth oscillator. Stable operation at low duty factors is easily achieved. The frequency of the converter when $V_{BRIGHTNESS}$ is high can be calculated using [Equation 1](#):

$$RC = \frac{1}{3.5} \cdot \left(\frac{1}{f_{osc}} - t_{charge} \right) \quad (1)$$

R equals the parallel resistance of both oscillator resistors. C is the capacitor connected at the RC pin (pin 7).

The BRIGHTNESS input controls the frequency reduction mode. [Figure 3](#) shows that the oscillator switches over from an RC curve with R1/R2, to R1 only. A low BRIGHTNESS voltage will reduce the switching frequency.

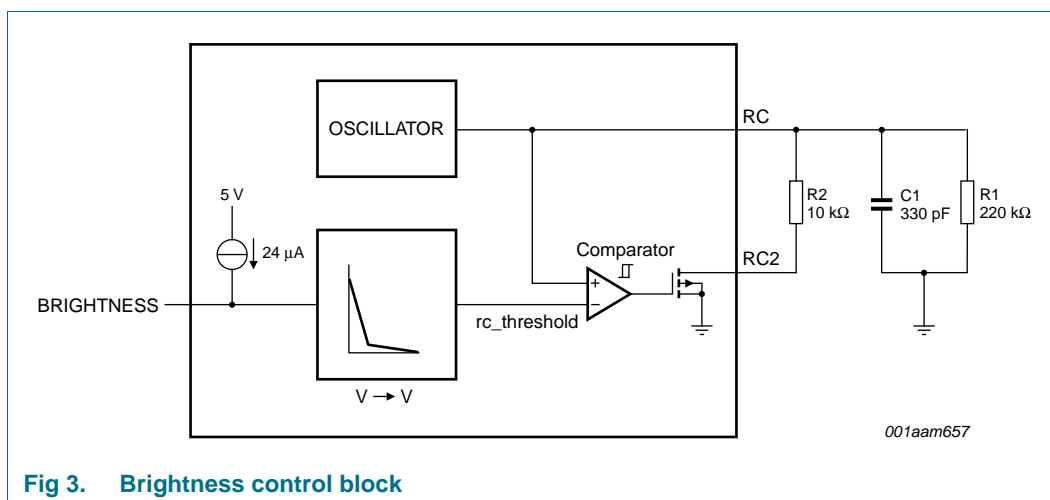


Fig 3. Brightness control block

A typical RC waveform is shown in [Figure 4](#). The RC switch-over threshold is controlled by the BRIGHTNESS pin.

To ensure that the capacitor can be charged within the charge time, the value of the oscillator capacitor should be limited to 1 nF. Due to leakage current, the value of the resistor connected between the RC pin and the ground should be limited to a maximum of 220 kΩ.

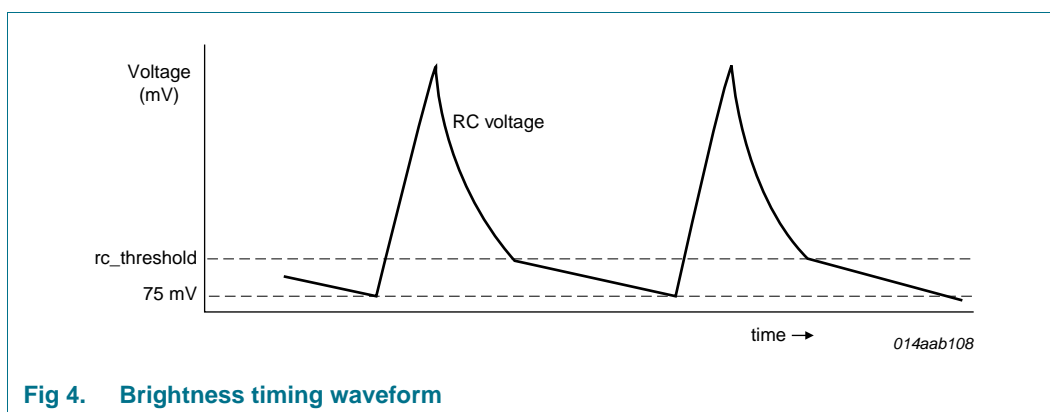


Fig 4. Brightness timing waveform

8.3 Duty factor control

The duty factor is controlled by an internally regulated voltage and the oscillator signal on pin RC. The internal regulation voltage is set by the voltage on the PWMLIMIT pin.

A low PWMLIMIT voltage will result in a low on-time for the external power switch. The minimum duty factor of the switched mode power supply can be set to 0 %. The maximum duty factor is set to 75 %.

8.4 Bleeder for dimming applications

The SSL2103 IC contains some circuitry intended for mains dimmer compatibility. This circuitry can drive two external current sinks, called bleeders. A strong bleeder is used for zero-cross reset of the dimmer and TRIAC latching. A weak bleeder is added to maintain the hold current through the dimmer.

The SB_DRV output is activated when the maximum voltage on pin HVDET is below the $V_{th(SBLEED)}$ level (52 V typically). The WB_DRV output is activated as soon as the voltage on pin ISENSE exceeds the $V_{th(high)(ISENSE)}$ level (−100 mV typically). The WB_DRV output is deactivated when the ISENSE voltage drops below the $V_{th(low)(ISENSE)}$ level (−250 mV typically). The WB_DRV output is also deactivated when the strong bleeder switch is switched on. See [Figure 5](#).

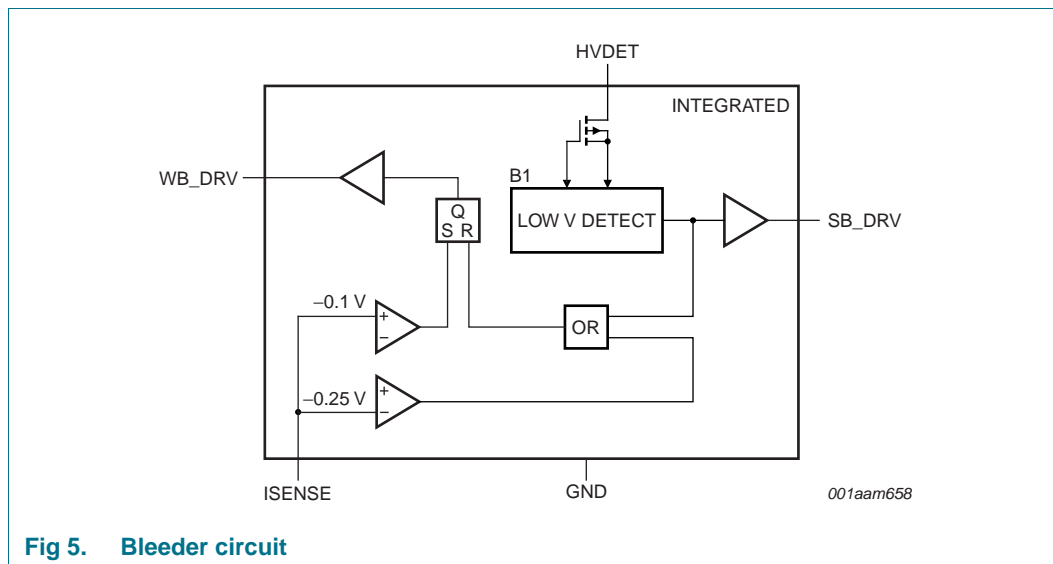


Fig 5. Bleeder circuit

8.5 Valley switching

A new cycle is started when the primary switch is switched on (see [Figure 6](#)). After a time determined by the oscillator voltage, RC and the internal regulation level, the switch is turned off and the secondary stroke starts. The internal regulation level is determined by the voltage on pin PWMLIMIT.

After the secondary stroke, the drain voltage shows an oscillation with a frequency of approximately:

$$\frac{I}{2 \times \pi \times \sqrt{(L_p \times C_p)}} \quad (2)$$

where:

L_p = primary self inductance

C_p = parasitic capacitance on drain node

As soon as the oscillator voltage is high again and the secondary stroke has ended, the circuit waits for a low drain voltage before starting a new primary stroke.

[Figure 6](#) shows the drain voltage together with the valley signal, the signal indicating the secondary stroke and the RC voltage.

The primary stroke starts some time before the actual valley at low ringing frequencies, and some time after the actual valley at high ringing frequencies.

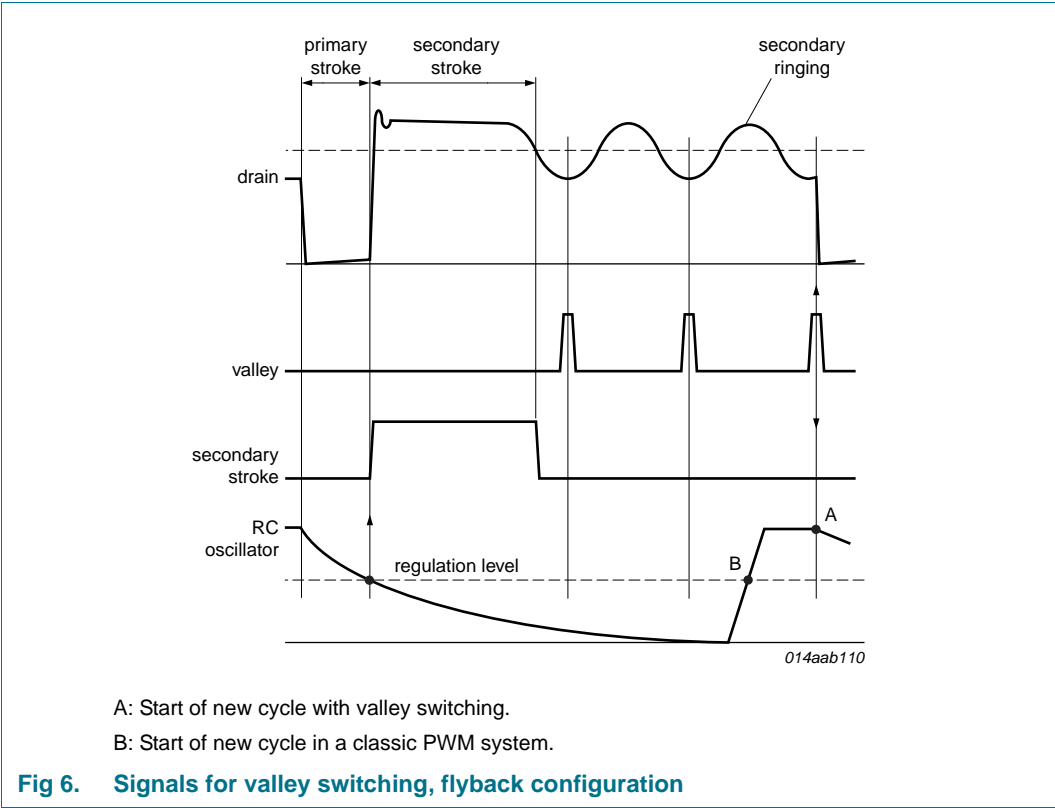
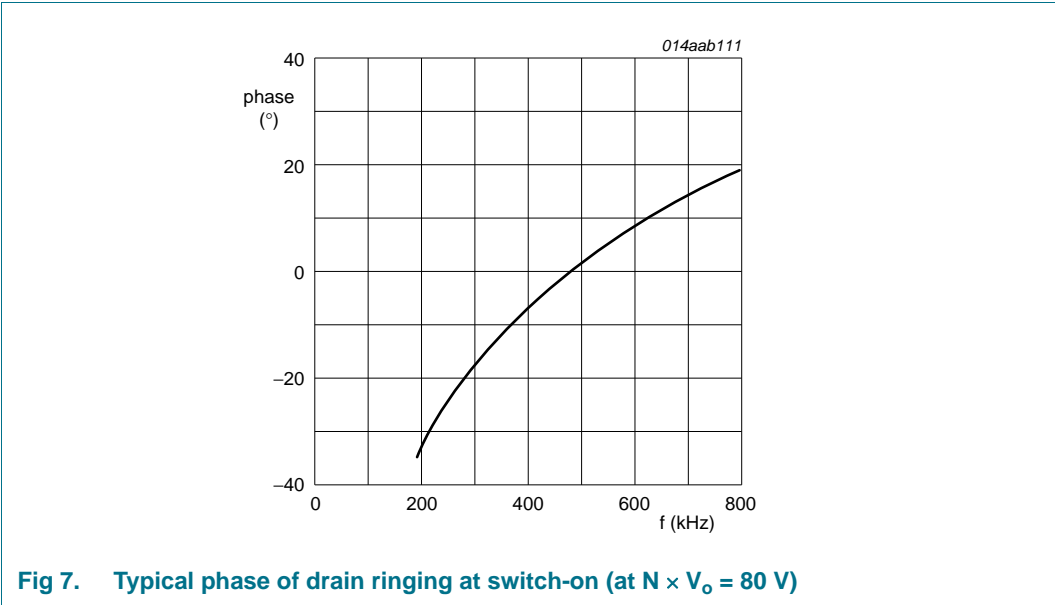


Figure 7 shows a typical curve for a reflected output voltage N at an output voltage of 80 V. This voltage is the output voltage transferred to the primary side of the transformer with the factor N (determined by the turns ratio of the transformer). It shows that the system switches exactly at minimum drain voltage for ringing frequencies of 480 kHz, thus reducing the switch-on losses to a minimum. At 130 kHz, the next primary stroke is started at 33° before the valley. The switch-on losses are still reduced significantly.



8.6 Demagnetization

The system operates in discontinuous conduction mode if the AUX pin is connected. As long as the secondary stroke has not ended, the oscillator will not start a new primary stroke. During the first $t_{\text{sup(xfmr_ring)}}$ seconds, demagnetization recognition is suppressed. This suppression may be necessary in applications where the transformer has a large leakage inductance and at low output voltages.

8.7 Overcurrent protection

The cycle-by-cycle peak drain current limit circuit uses the external source resistor R_{SENSE} to measure the current. The circuit is activated after the leading edge blanking time t_{leb} . The protection circuit limits the source voltage over the R_{SENSE}^1 resistor to $V_{\text{th(ocp)SOURCE}}$, and thus limits the primary peak current.

8.8 Short-winding protection

The short-winding protection circuit is also activated after the leading edge blanking time. If the source voltage exceeds the short-winding protection threshold voltage $V_{\text{th(swp)SOURCE}}$, the IC stops switching. Only a power-on reset will restart normal operation. The short-winding protection also protects in case of a secondary diode short circuit.

8.9 Overtemperature protection

Accurate temperature protection is provided in the device. When the junction temperature exceeds the thermal shut-down temperature, the IC stops switching. During thermal protection, the IC current is lowered to the start-up current. The IC continues normal operation as soon as the overtemperature situation has disappeared.

1. R_{SENSE} is the resistor between the SOURCE pin and GND

9. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). All voltages are measured with respect to ground; positive currents flow into the device.

| Symbol | Parameter | Conditions | Min | Max | Unit |
|------------------|---------------------------------|--------------------------|----------|-------|------|
| Voltages | | | | | |
| V_{CC} | supply voltage | continuous | [1] -0.4 | +28 | V |
| V_{RC} | voltage on pin RC | | [1] -0.4 | +3 | V |
| V_{RC2} | voltage on pin RC2 | | -0.4 | +3 | V |
| $V_{BRIGHTNESS}$ | voltage on pin BRIGHTNESS | | -0.4 | +5 | V |
| $V_{PWMLIMIT}$ | voltage on pin PWMLIMIT | | -0.4 | +5 | V |
| V_{SOURCE} | voltage on pin SOURCE | | -0.4 | +5 | V |
| V_{DRAIN} | voltage on pin DRAIN | $T_{amb} = 25\text{ °C}$ | -0.4 | +600 | V |
| V_{HVDET} | voltage on pin HVDET | $T_{amb} = 25\text{ °C}$ | -0.4 | +600 | V |
| Currents | | | | | |
| I_{SENSE} | current on pin ISENSE | | [2] -20 | +5 | mA |
| I_{AUX} | current on pin AUX | | [2] -10 | +5 | mA |
| I_{SB_DRV} | current on pin SB_DRV | | | +3.6 | mA |
| I_{WB_DRV} | current on pin WB_DRV | | | +3.6 | mA |
| General | | | | | |
| P_{tot} | total power dissipation | $T_{amb} = 70\text{ °C}$ | - | 250 | mW |
| T_{stg} | storage temperature | | -55 | +150 | °C |
| T_{amb} | ambient temperature | | -40 | +100 | °C |
| T_j | junction temperature | | -40 | +150 | °C |
| V_{ESD} | electrostatic discharge voltage | human body model; | [3] | | |
| | | Pins 13 and 14 | -1000 | +1000 | V |
| | | All other pins | -2000 | +2000 | V |
| | | charged device model | [4] -500 | +500 | V |

[1] Pins V_{CC} and RC cannot be current driven.

[2] Pins ISENSE and AUX cannot be voltage driven.

[3] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 k Ω series resistor.

[4] Charged device model: equivalent to charging the IC up to 1 kV and the subsequent discharging of each pin down to 0 V over a 1 Ω 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, on JESD51-3 board | 123 | K/W |
| Ψ_{j-top} | thermal characterization parameter from junction to top | in free air, on JESD51-3 board | 7 | K/W |

11. Characteristics

Table 6. Characteristics

$T_{amb} = 25\text{ }^{\circ}\text{C}$; no overtemperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; $V_{CC} = 20\text{ V}$ and PWMLIMIT and BRIGHTNESS pins are disconnected unless otherwise specified. Typical frequency 100 kHz.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------------|--------------------------------------|--|---------|-------|-----|---------------|
| Supply | | | | | | |
| I_{CC} | supply current | normal operation; bleeders disconnected; $V_{DRAIN} = 60\text{ V}$; | - | 1.8 | - | mA |
| $I_{CC(ch)}$ | charge supply current | $V_{DRAIN} > 60\text{ V}$; $V_{CC} = 0\text{ V}$ | -6 | -4.5 | - | mA |
| V_{CC} | supply voltage | $V_{DRAIN} > 60\text{ V}$ | [1] 12 | 20 | 28 | V |
| $V_{CC(startup)}$ | start-up supply voltage | | - | 10.25 | - | V |
| $V_{CC(UVLO)}$ | undervoltage lockout supply voltage | | - | 8.2 | - | V |
| I_{DRAIN} | current on pin DRAIN | $V_{DRAIN} > 60\text{ V}$; with auxiliary supply | - | 30 | 125 | μA |
| V_{DRAIN} | voltage on pin DRAIN | | 40 | - | 600 | V |
| Pulse width modulator | | | | | | |
| δ_{min} | minimum duty factor | | - | 0 | - | % |
| δ_{max} | maximum duty cycle | PWMLIMIT= 3 V | - | 75 | - | % |
| SOPS | | | | | | |
| $V_{det(demag)}$ | demagnetization detection voltage | | 50 | 100 | 150 | mV |
| $t_{sup(xfmr_ring)}$ | transformer ringing suppression time | at start of secondary stroke | 1.0 | 1.5 | 2.0 | μs |
| RC oscillator | | | | | | |
| $V_{RC(min)}$ | minimum voltage on pin RC | | 60 | 75 | 90 | mV |
| $V_{RC(max)}$ | maximum voltage on pin RC | | 2.4 | 2.5 | 2.6 | V |
| $t_{ch(RC)}$ | charge time on pin RC | | - | 1 | - | μs |
| f_{osc} | oscillator frequency | | 10 | 100 | 130 | kHz |
| $I_{BRIGHTNESS}$ | current on pin BRIGHTNESS | $V_{BRIGHTNESS} = 0\text{ V}$ | -20 | -24 | -28 | μA |
| Driver bleeder | | | | | | |
| $V_{th(HVDET)}$ | threshold voltage on pin HVDET | | 46 | 52 | 56 | V |
| $V_{th(low)ISENSE}$ | low threshold voltage on pin ISENSE | | - | -250 | - | mV |
| $V_{th(high)ISENSE}$ | high threshold voltage on pin ISENSE | | - | -100 | - | mV |
| I_{SB_DRV} | current on pin SB_DRV | $V_{SB_DRV} < 9\text{ V}$ | - | 3.2 | 3.6 | mA |
| I_{WB_DRV} | current on pin WB_DRV | $V_{WB_DRV} < 9\text{ V}$ | - | 3.2 | 3.6 | mA |
| V_{SB_DRV} | voltage on pin SB_DRV | $I_{SB_DRV} = 0$ | - | - | 12 | V |
| | | $I_{SB_DRV} = 2.5\text{ mA}$ | - | 10 | - | V |
| | | during V_{CC} start-up; $I_{SB_DRV} = 2.5\text{ mA}$ | [2] 5.5 | - | - | V |
| V_{WB_DRV} | voltage on pin WB_DRV | $I_{WB_DRV} = 0$ | - | - | 12 | V |
| | | $I_{WB_DRV} = 2.5\text{ mA}$ | - | 10 | - | V |

Table 6. Characteristics ...continued

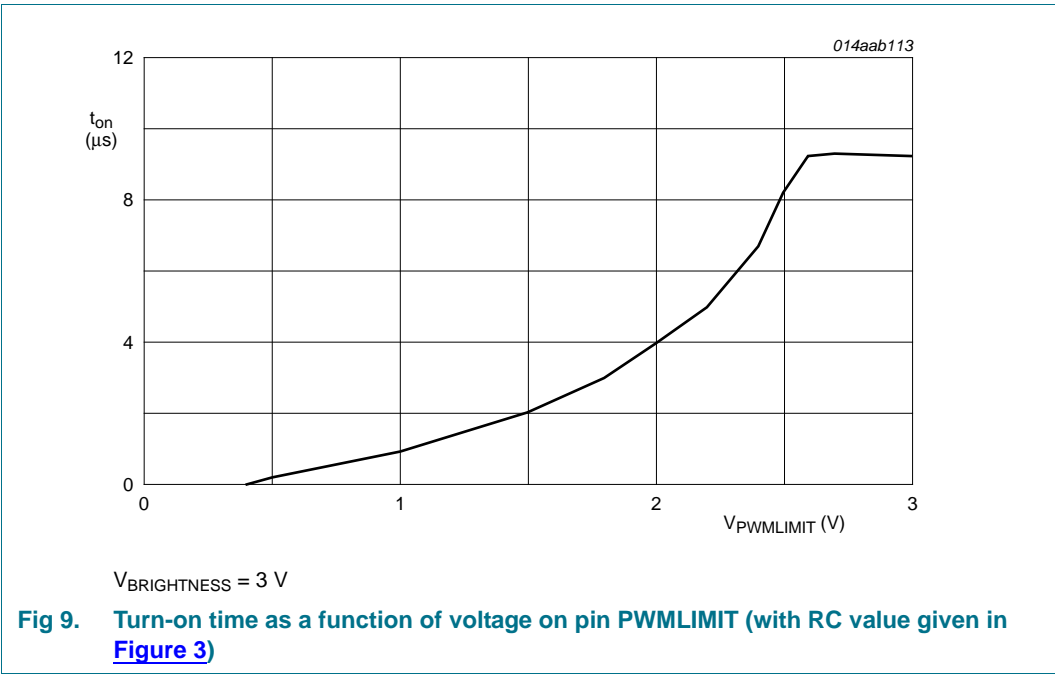
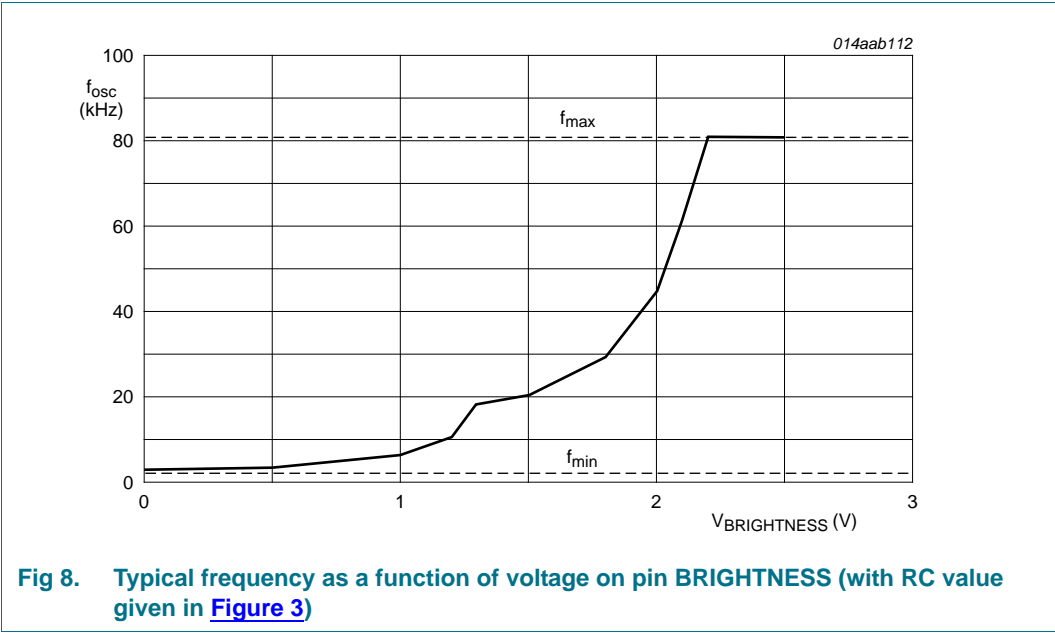
$T_{amb} = 25\text{ }^{\circ}\text{C}$; no overtemperature; all voltages are measured with respect to ground; currents are positive when flowing into the IC; $V_{CC} = 20\text{ V}$ and PWMLIMIT and BRIGHTNESS pins are disconnected unless otherwise specified. Typical frequency 100 kHz.

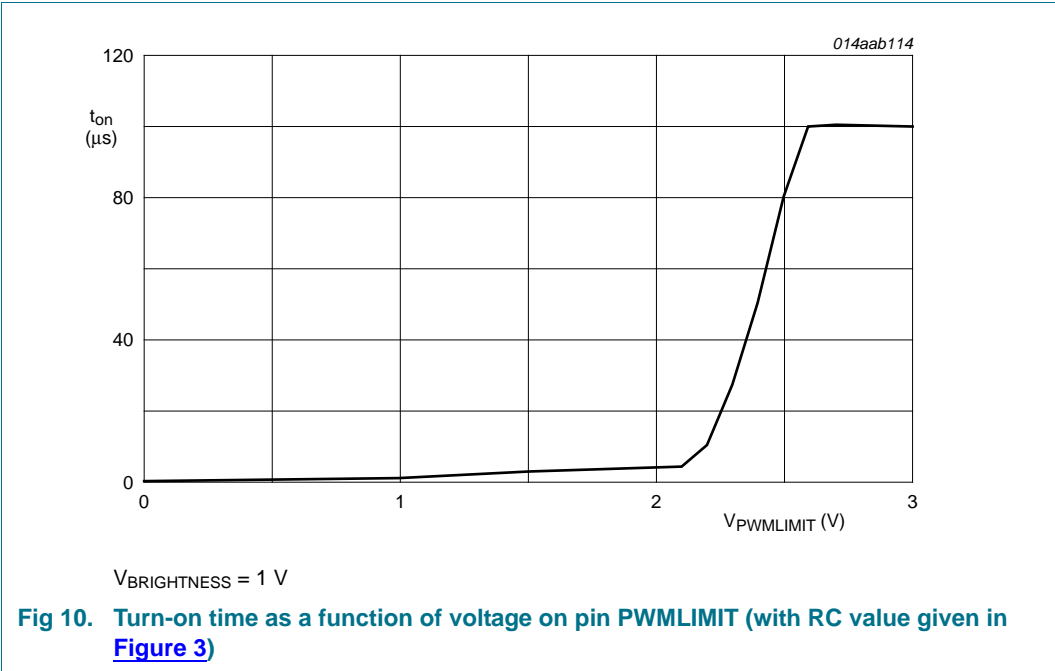
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit | |
|--|--|--|------|------|-----------------|------|------|
| Duty factor regulator: pin PWMLIMIT | | | | | | | |
| I _{PWMLIMIT} | current on pin PWMLIMIT | | −25 | - | −18 | μA | |
| V _{PWMLIMIT} | voltage on pin PWMLIMIT | maximum duty cycle threshold V _{BRIGHTNESS} = 3 V | - | 2.6 | - | V | |
| | | minimum duty cycle threshold V _{BRIGHTNESS} = 3 V | - | 0.45 | - | V | |
| Valley switching | | | | | | | |
| (ΔV/Δt) _{vrec} | valley recognition voltage change with time | minimum absolute value | [3] | - | 100 | - | V/μs |
| f _{ring} | ringing frequency | N × V _O = 100 V | 200 | 500 | 800 | kHz | |
| t _{d(vrec-swon)} | valley recognition to switch-on delay time | | - | 150 | - | ns | |
| Current and short circuit winding protection | | | | | | | |
| V _{th(ocp)SOURCE} | overcurrent protection threshold voltage on pin SOURCE | dV/dt = 0.1 V/μs | 0.46 | 0.50 | 0.53 | V | |
| V _{th(swp)SOURCE} | short-winding protection threshold voltage on pin SOURCE | dV/dt = 0.1 V/μs | - | 1.5 | - | V | |
| t _{d(ocp-swoff)} | delay time from overcurrent protection to switch-off | dV/dt = 0.5 V/μs | - | 160 | 185 | ns | |
| t _{leb} | leading edge blanking time | | 250 | 350 | 450 | ns | |
| FET driver output stage | | | | | | | |
| V _{O(PWR_DRV)} | output Voltage on pin PWR_DRV | | - | 12 | V _{CC} | V | |
| t _{r(PWR_DRV)} | rise time on pin PWR_DRV | With maximum input capacitance 4.7 nF on pin PWR_DRV; V _{CC} = 20 V | - | 210 | - | ns | |
| t _{f(PWR_DRV)} | fall time on pin PWR_DRV | With maximum input capacitance 4.7 nF on pin PWR_DRV; V _{CC} = 20 V | - | 210 | - | ns | |
| Temperature protection | | | | | | | |
| T _{otp} | overtemperature protection threshold | junction temperature | 150 | 160 | 170 | °C | |
| T _{otp(hys)} | overtemperature protection trip hysteresis | junction temperature | - | 7 | - | °C | |

[1] $V_{CC} = 20\text{ V}$ minimum to meet all characteristics.

[2] SB_DRV is active during V_{CC} start-up.

[3] Voltage change in time for valley recognition.





12. Application information

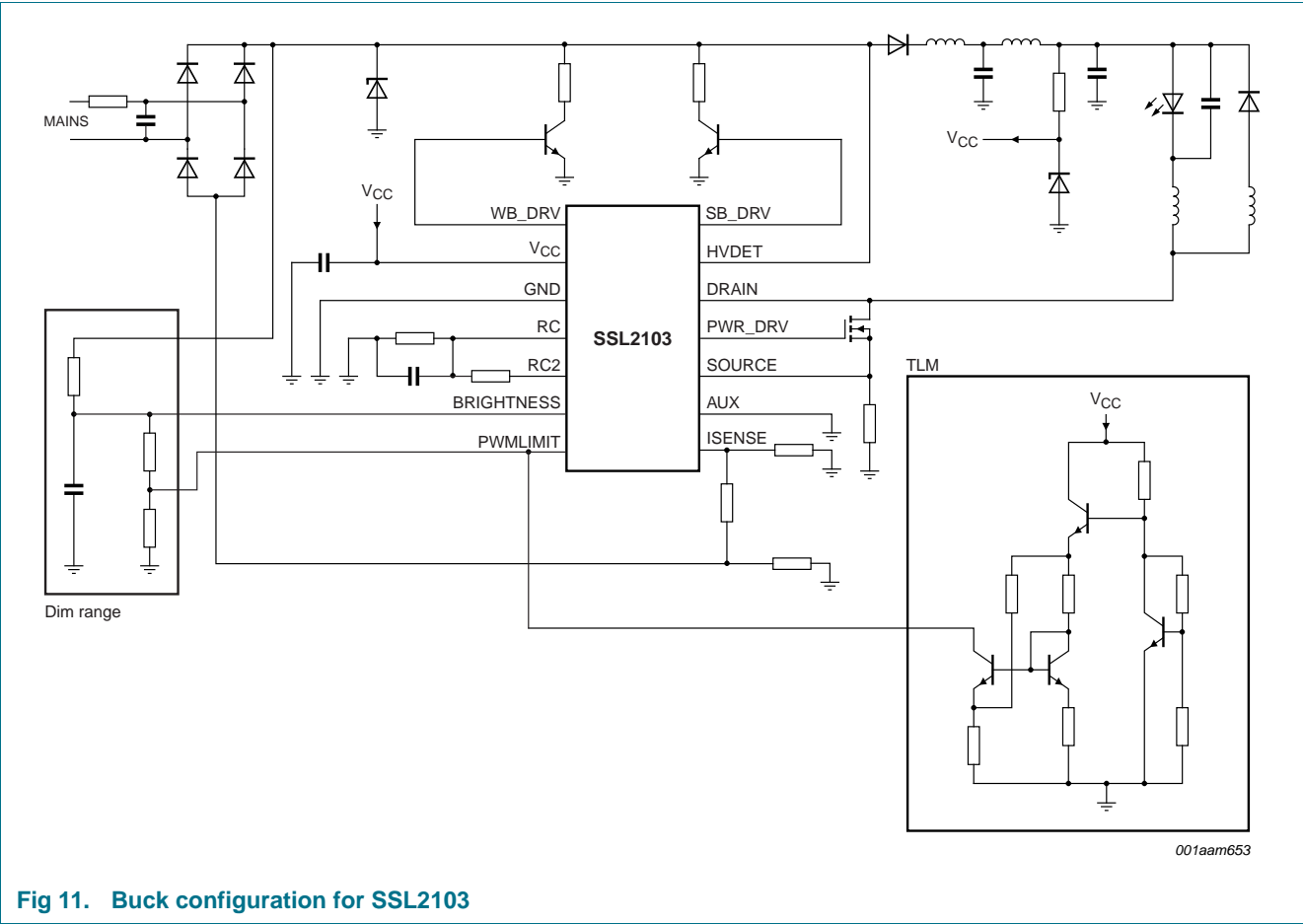


Fig 11. Buck configuration for SSL2103

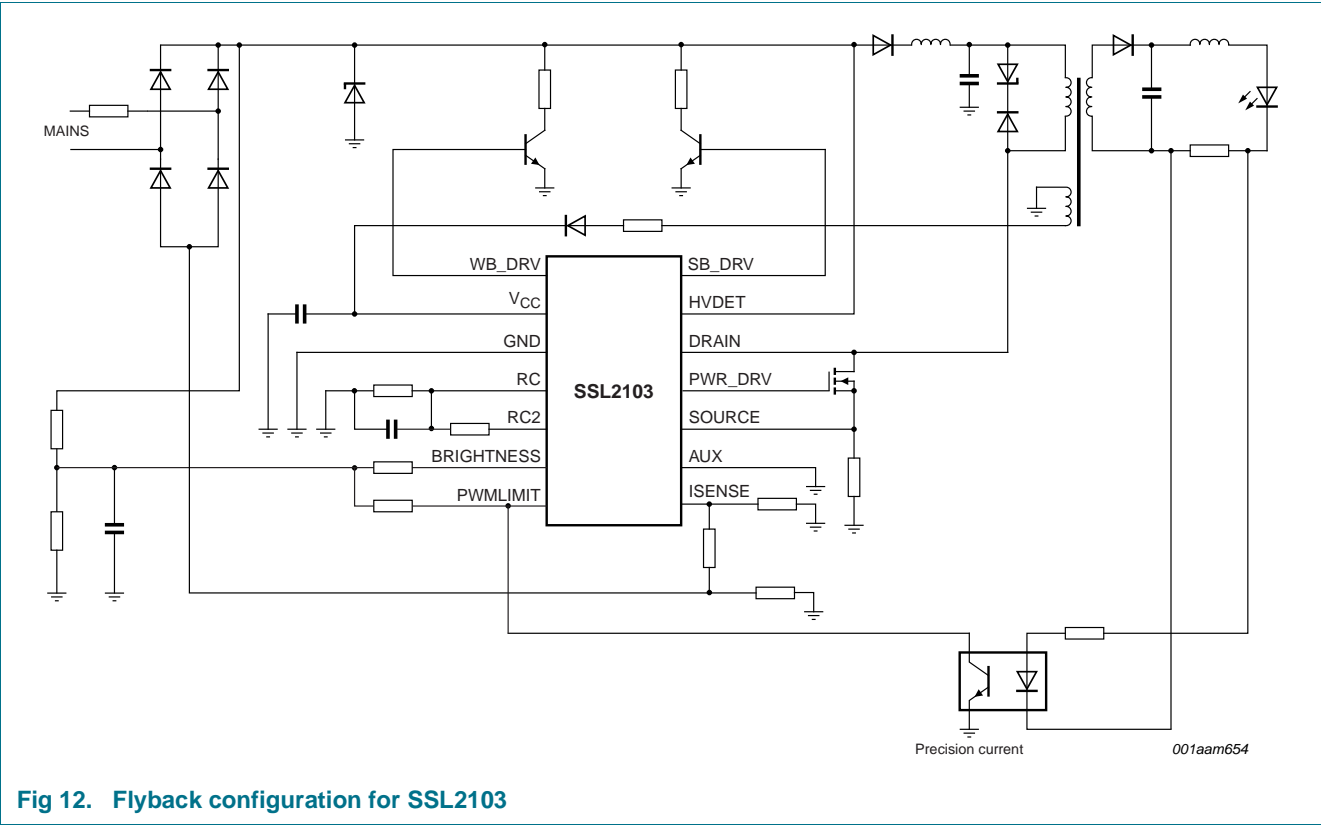


Fig 12. Flyback configuration for SSL2103

Further application information can be found in the SSL2103 application notes.

13. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1

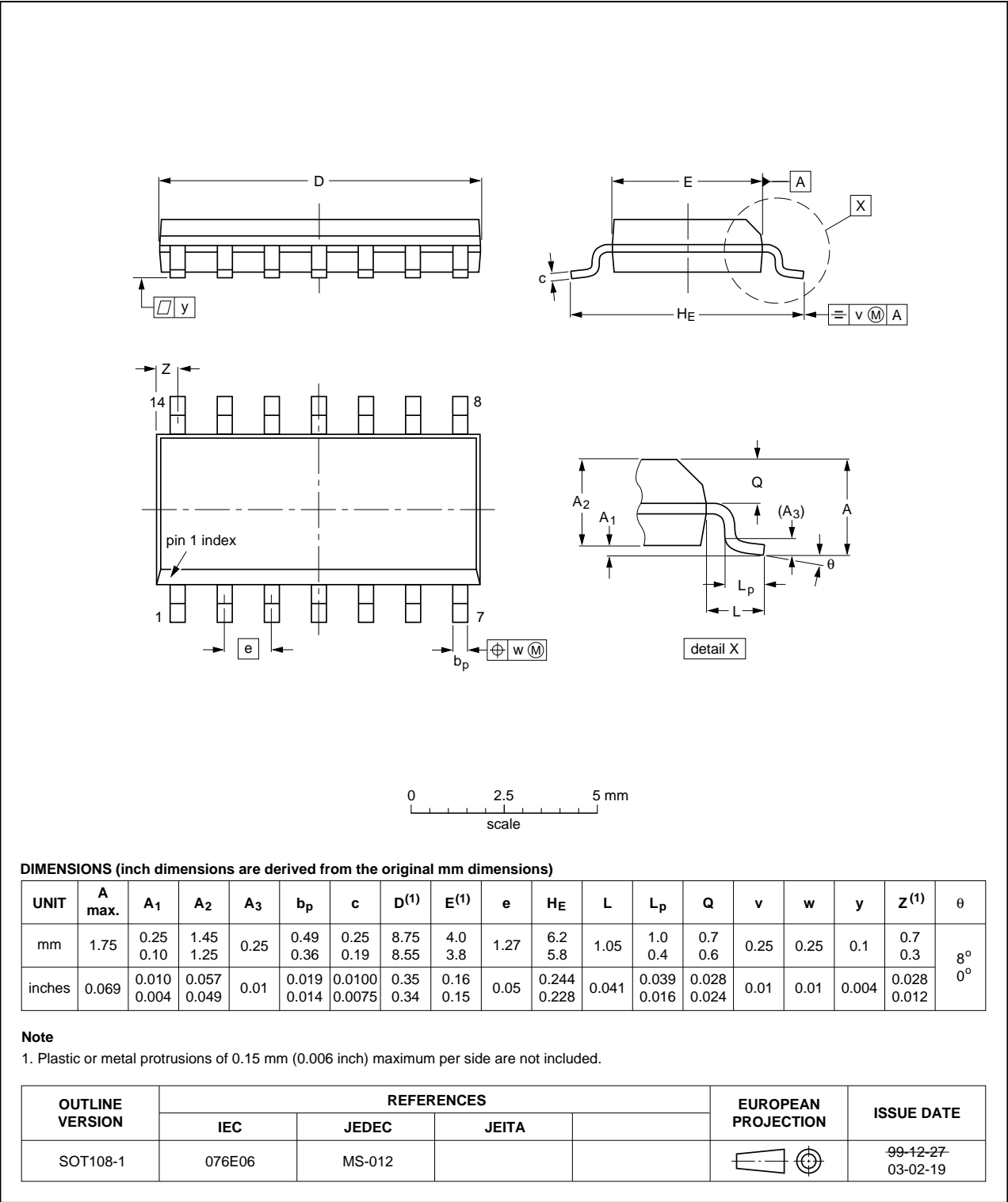


Fig 13. Package outline SOT108-1 (SO14)

14. Revision history

Table 7. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|----------------|--|------------------------|---------------|---------------|
| SSL2103 v.2.2 | 20111205 | Product data sheet | - | SSL2103 v.2.1 |
| Modifications: | <ul style="list-style-type: none">• GreenChip trademark has been added.• Section 1 "General description" has been updated.• Section 2 "Features and benefits" has been updated.• Section 3 "Applications" has been updated. | | | |
| SSL2103 v.2.1 | 20110825 | Product data sheet | - | SSL2103 v.2.0 |
| SSL2103 v.2 | 20101125 | Product data sheet | - | SSL2103 v.1 |
| SSL2103 v.1 | 20101011 | Preliminary data sheet | - | - |

15. Legal information

15.1 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".

[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>.

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Date of release: 5 December 2011

Document identifier: SSL2103

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