

# UBA2024

## Half-bridge power IC for CFL lamps

Rev. 6.2 — 1 November 2010

Product data sheet

### 1. General description

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The UBA2024 is a family of high-voltage monolithic Integrated Compact Fluorescent Lamp (CFL) drivers for a large range of lamp powers. Specific versions are optimized for 230 V and 110 V mains supplies. The product family integrates full CFL controller functionality with high voltage half-bridge transistors. All products in the UBA2024 family are pin-to-pin compatible enabling a single application design covering a wide range of power ratings.

The IC features a soft start function, an adjustable internal oscillator and an internal drive function with a high-voltage level shifter for driving the half-bridge.

To guarantee an accurate 50 % duty cycle, the oscillator signal is passed through a divider before being fed to the output drivers.

### 2. Features and benefits

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- The common feature set includes:
  - ◆ high power efficiency
  - ◆ a high integration level with low component counts enabling small form factor electronic ballast
  - ◆ integrated bootstrap diode
  - ◆ soft start function
  - ◆ minimum glow time control
  - ◆ integrated low-voltage supply
  - ◆ adjustable operating frequency as a result of the embedded oscillator
  - ◆ an accurate 50 % duty cycle provided by an embedded oscillator signal
  - ◆ integrated half-bridge power transistors
  - ◆ an internal drive function with a high-voltage level shifter up to 550 V (300 V for the UBA2024BP and UBA2024BT)

### 3. Applications

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- Driver for any kind of half-bridge configured load up to 23 W, provided that the maximum junction temperature is not exceeded
- Designed for electronically self-ballasted CFL lamps



### 4. Ordering information

Table 1. Ordering information

| Type number              | Package |  | Version  |
|--------------------------|---------|--|----------|
|                          | Name    | Description  |          |
| UBA2024P <sup>[1]</sup>  | DIP8    | plastic dual in-line package; 8 leads (300 mil)            | SOT97-1  |
| UBA2024T <sup>[1]</sup>  | SO14    | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |
| UBA2024AP <sup>[2]</sup> | DIP8    | plastic dual in-line package; 8 leads (300 mil)            | SOT97-1  |
| UBA2024AT <sup>[3]</sup> | SO14    | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |
| UBA2024BP <sup>[4]</sup> | DIP8    | plastic dual in-line package; 8 leads (300 mil)            | SOT97-1  |
| UBA2024BT <sup>[4]</sup> | SO14    | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |

- [1] For this type number,  $R_{DS(on)} = 9 \Omega$  and  $I_{SAT} = 900 \text{ mA}$ .
- [2] For this type number,  $R_{DS(on)} = 6 \Omega$  and  $I_{SAT} = 1350 \text{ mA}$ .
- [3] For this type number,  $R_{DS(on)} = 6.4 \Omega$  and  $I_{SAT} = 1200 \text{ mA}$ .
- [4] For this type number,  $R_{DS(on)} = 2 \Omega$  and  $I_{SAT} = 2500 \text{ mA}$ .

### 5. Block diagram

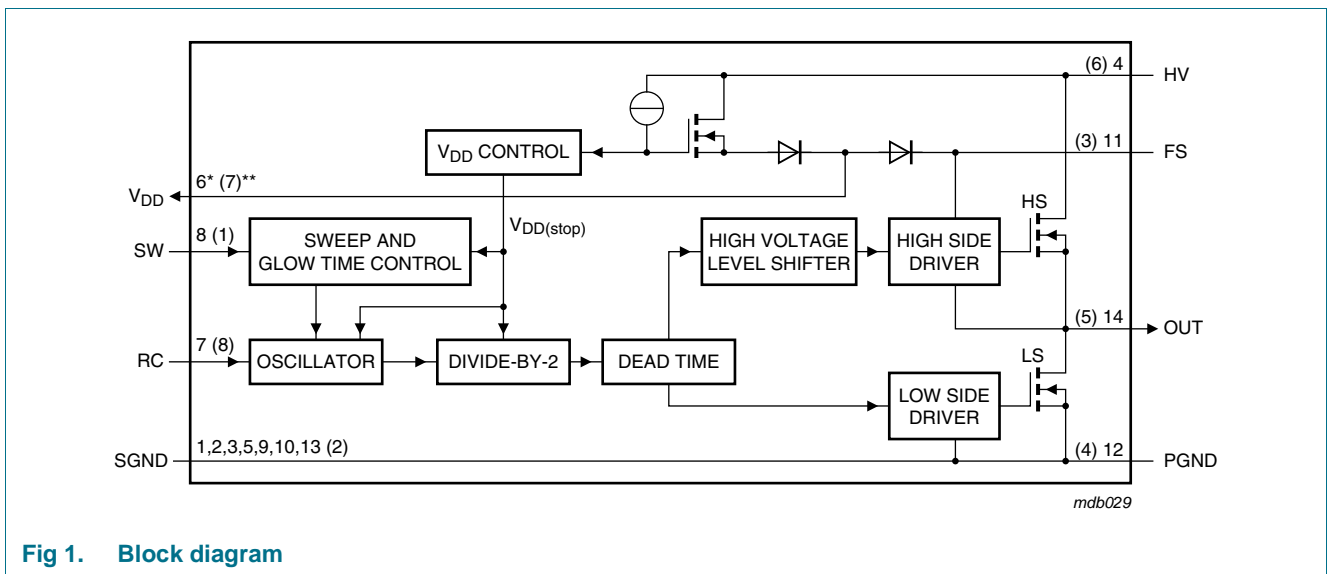


Fig 1. Block diagram

## 6. Pinning information

### 6.1 Pinning

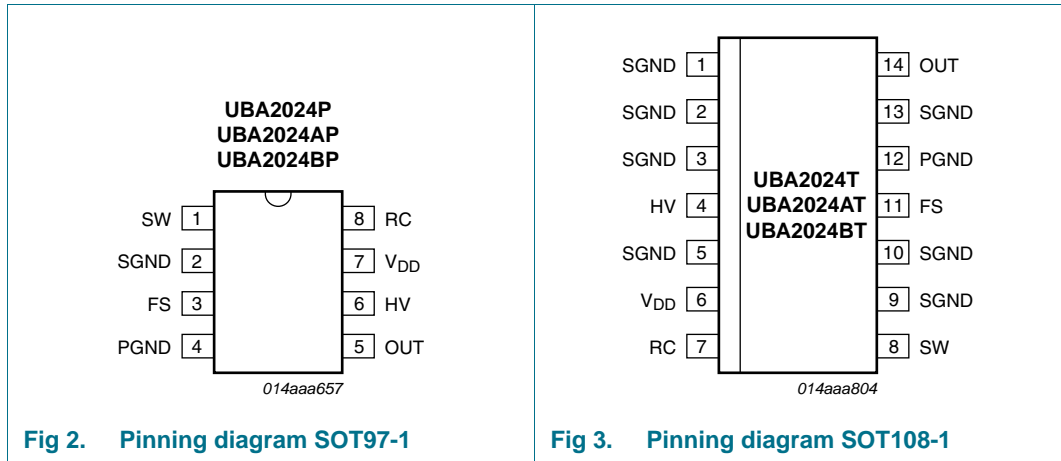


Fig 2. Pinning diagram SOT97-1

Fig 3. Pinning diagram SOT108-1

### 6.2 Pin description

Table 2. Pin description

| Symbol          | Pin SOT97-1 | Pin SOT108-1          | Description                        |
|-----------------|-------------|-----------------------|------------------------------------|
| SW              | 1           | 8                     | sweep timing input                 |
| SGND            | 2           | 1, 2, 3, 5, 9, 10, 13 | signal ground                      |
| FS              | 3           | 11                    | high-side floating supply output   |
| PGND            | 4           | 12                    | power ground                       |
| OUT             | 5           | 14                    | half-bridge output                 |
| HV              | 6           | 4                     | high-voltage supply                |
| V <sub>DD</sub> | 7           | 6                     | internal low-voltage supply output |
| RC              | 8           | 7                     | internal oscillator input          |

## 7. Functional description

### 7.1 Supply voltage

The UBA2024 does not require an external low-voltage supply as the mains supply voltage applied to pin HV powers it. The IC derives its own low supply voltage from this for its internal circuitry.

### 7.2 Start-up state

With an increase of the supply voltage on pin HV, the IC enters the start-up state. In the start-up state the high-side power transistor is not conducting and the low-side power transistor is switched on. The internal circuit is reset and the capacitors on the bootstrap pin FS and low-voltage supply pin V<sub>DD</sub> are charged. Pins RC and SW are switched to ground. The start-up state is defined until V<sub>DD</sub> = V<sub>DD(startup)</sub>.

### 7.3 Sweep mode

The IC enters the sweep mode when the voltage on pin V<sub>DD</sub> > V<sub>DD(startup)</sub>. The capacitor on pin SW is charged by I<sub>SW</sub> and the half-bridge circuit starts oscillating. The circuit enters the start-up state again when the voltage on pin V<sub>DD</sub> < V<sub>DD(stop)</sub>.

The sweep time (t<sub>sweep</sub>) is determined by the charge current (I<sub>ch(sw)</sub>) and the external capacitor (C<sub>SW</sub>). Typical the total sweep time set by C<sub>SW</sub> is:

$$t_{sweep} = C_{SW} (nF) \times 10.3 \text{ ms} \quad (1)$$

During the sweep time the current flowing through the lamp electrodes performs some preheating of the filaments. See [Figure 5](#).

### 7.4 Reset

A DC reset circuit is incorporated in the high-side driver. The high-side transistor is switched off when the voltage on pin FS is below the high-side lockout voltage V<sub>float(UVLO)</sub>.

### 7.5 Oscillation

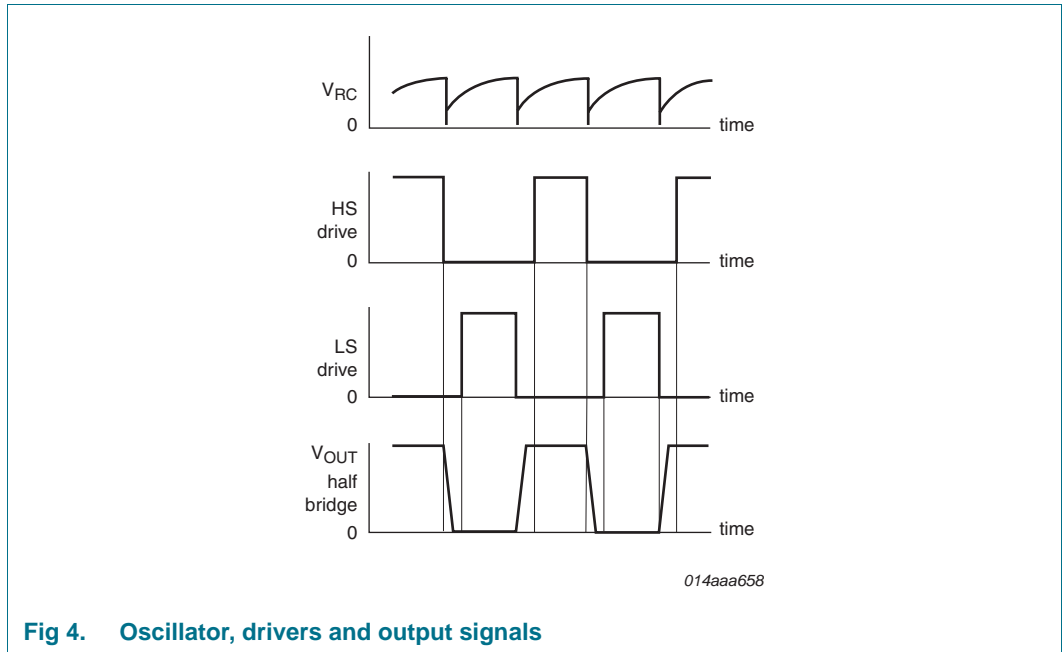
The oscillation is based upon the 555-timer function. A self oscillating circuit is made with the external resistor R<sub>OSC</sub> and the capacitor C<sub>OSC</sub> (see [Figure 4](#)).

To realize an accurate 50 % duty cycle, an internal divider is used. This reduces the bridge frequency to half the oscillator frequency.

The output voltage of the bridge will change at the falling edge of the signal on pin RC. The design equation for the half-bridge frequency is:

$$f_{osc} = \frac{I}{k \times R_{OSC} \times C_{OSC}} \quad (2)$$

An overview of the oscillator signal, internal LS and HS drive signals and the output is given in [Figure 4](#).



**Fig 4. Oscillator, drivers and output signals**

When entering the sweep mode ( $V_{SW} = 0\text{ V}$ ), the bridge oscillator starts at 2.5 times the nominal bridge frequency and sweeps down to the nominal frequency (bridge), set by  $R_{OSC}$  and  $C_{OSC}$ . During the sweep mode the amplitude of the RC oscillator on pin RC, will swing between  $V_{trip(osc)low}$  and  $V_{SW} + 0.4V_{trip(osc)high}$ . The amplitude of the RC oscillator will continue to increase until  $V_{SW} + 0.4V_{trip(osc)high} = V_{trip(osc)high}$ , this determines the end of the sweep time. The voltage on pin SW however will continue to rise until it reaches supply voltage level.

During this continuous decrease in frequency, the circuit approaches the resonance frequency of the load, and this causes a high voltage across the load, which ignites the lamp. The sweep to resonance time should be much larger than the settling time of the supply voltage on pin HV, to guarantee that the full high-voltage is present at the moment of ignition. See [Figure 5](#).

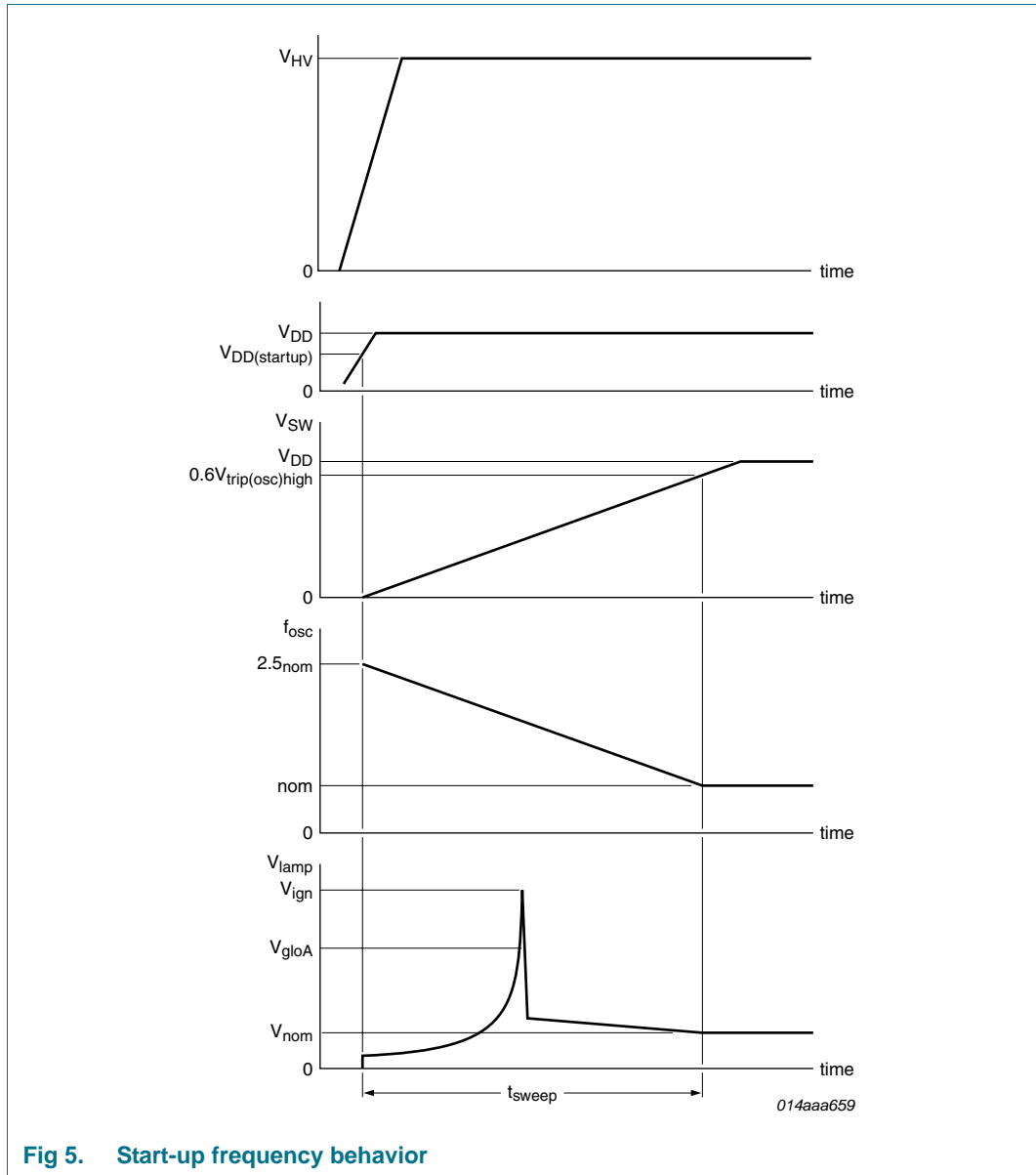


Fig 5. Start-up frequency behavior

### 7.6 Non-overlap time

The non-overlap time is defined as the time when both MOSFETs are not conducting. The non-overlap time is fixed internally.

## 8. Limiting values

**Table 3. Limiting values**
*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol            | Parameter            | Conditions  | Min             | Max                  | Unit |  |
|-------------------|----------------------|---|-----------------|----------------------|------|--|
| V <sub>HV</sub>   | voltage on pin HV    | normal operation  |                 |                      |      |  |
|                   |                      | UBA2024P  | -               | 373                  | V    |  |
|                   |                      | UBA2024AP   | -               | 373                  | V    |  |
|                   |                      | UBA2024T  | -               | 373                  | V    |  |
|                   |                      | UBA2024AT   | -               | 373                  | V    |  |
|                   |                      | UBA2024BP   | -               | 187                  | V    |  |
|                   |                      | UBA2024BT   | -               | 187                  | V    |  |
|                   |                      | mains transients during 0.5 s   |                 |                      |      |  |
|                   |                      | UBA2024P  | -               | 550                  | V    |  |
|                   |                      | UBA2024AP   | -               | 550                  | V    |  |
|                   |                      | UBA2024T  | -               | 550                  | V    |  |
|                   |                      | UBA2024AT   | -               | 550                  | V    |  |
|                   |                      | UBA2024BP   | -               | 300                  | V    |  |
|                   |                      | UBA2024BT   | -               | 300                  | V    |  |
| V <sub>FS</sub>   | voltage on pin FS    |   | V <sub>HV</sub> | V <sub>HV</sub> + 14 | V    |  |
| V <sub>DD</sub>   | supply voltage       | low voltage; DC supply  | 0               | 14                   | V    |  |
| I <sub>DD</sub>   | supply current       | low voltage; peak value is internally limited; T <sub>amb</sub> = 25 °C | 0               | 5                    | mA   |  |
| V <sub>PGND</sub> | voltage on pin PGND  | referenced to SGND  | -1              | +1                   | V    |  |
| V <sub>RC</sub>   | voltage on pin RC    | I <sub>RC</sub> < 1 mA  | 0               | V <sub>DD</sub>      | V    |  |
| V <sub>SW</sub>   | voltage on pin SW    | I <sub>SW</sub> < 1 mA  | 0               | V <sub>DD</sub>      | V    |  |
| SR                | slew rate            | pin OUT; repetitive   | -4              | +4                   | V/ns |  |
| T <sub>j</sub>    | junction temperature |   | [1] -40         | +150                 | °C   |  |
| T <sub>amb</sub>  | ambient temperature  |   | -40             | +150                 | °C   |  |
| T <sub>stg</sub>  | storage temperature  |   | -55             | +150                 | °C   |  |

[1] The maximum junction temperature must not be exceeded.

## 9. Thermal characteristics

**Table 4. Thermal characteristics**

| Symbol               | Parameter                                   | Conditions   | Typ | Unit |
|----------------------|---|--------------|-----|------|
| R <sub>th(j-a)</sub> | thermal resistance from junction to ambient | in free air  | [1] |      |
|                      |   | SO14 package | 95  | K/W  |
|                      |   | DIP8 package | 95  | K/W  |
| R <sub>th(j-c)</sub> | thermal resistance from junction to case    | in free air  | [1] |      |
|                      |   | SO14 package | 8   | K/W  |
|                      |   | DIP8 package | 16  | K/W  |

[1] In accordance with IEC 60747-1

## 10. Characteristics

**Table 5. Characteristics**

$T_j = 25\text{ °C}$ ; all voltages are measured with respect to SGND; positive currents flow into the IC.

| Symbol                     | Parameter                    | Conditions  | Min  | Typ  | Max  | Unit |
|----------------------------|------------------------------|---|------|------|------|------|
| <b>High-voltage supply</b> |                              |   |      |      |      |      |
| $V_{HV}$                   | voltage on pin HV            | mains transients during 0.5 s; $I_{HV} < 30\text{ }\mu\text{A}$                             |      |      |      |      |
|                            |                              | UBA2024P  | 0    | -    | 550  | V    |
|                            |                              | UBA2024AP   | 0    | -    | 550  | V    |
|                            |                              | UBA2024T  | 0    | -    | 550  | V    |
|                            |                              | UBA2024AT   | 0    | -    | 550  | V    |
|                            |                              | UBA2024BP   | 0    | -    | 250  | V    |
|                            |                              | UBA2024BT   | 0    | -    | 250  | V    |
| $V_{FS}$                   | voltage on pin FS            | mains transients during 0.5 s; $I_{HV} < 30\text{ }\mu\text{A}$                             |      |      |      |      |
|                            |                              | UBA2024P  | 0    | -    | 564  | V    |
|                            |                              | UBA2024AP   | 0    | -    | 564  | V    |
|                            |                              | UBA2024T  | 0    | -    | 564  | V    |
|                            |                              | UBA2024AT   | 0    | -    | 564  | V    |
|                            |                              | UBA2024BP   | 0    | -    | 264  | V    |
|                            |                              | UBA2024BT   | 0    | -    | 264  | V    |
| <b>Low-voltage supply</b>  |                              |   |      |      |      |      |
| $V_{DD}$                   | supply voltage               | $V_{HV} = 100\text{ V}$ ; $R_{osc} = \infty$ ; $V_{SW} = V_{DD}$ ;<br>$V_{RC} = 0\text{ V}$ | 11.4 | 12.5 | 13.3 | V    |
| <b>Start-up state</b>      |                              |   |      |      |      |      |
| $I_{HV}$                   | current on pin HV            | $V_{HV} = 100\text{ V}$ ; $R_{osc} = \infty$ ; $V_{SW} = V_{DD}$ ;<br>$V_{RC} = 0\text{ V}$ | -    | -    | 0.39 | mA   |
| $V_{DD(\text{startup})}$   | start-up supply voltage      |   | 10   | 11   | 12   | V    |
| $V_{DD(\text{stop})}$      | stop supply voltage          |   | 8    | 8.5  | 9    | V    |
| $V_{DD(\text{hys})}$       | hysteresis of supply voltage |   | 2    | 2.5  | 3    | V    |



**Table 5. Characteristics ...continued**

$T_j = 25\text{ °C}$ ; all voltages are measured with respect to SGND; positive currents flow into the IC.

| Symbol              | Parameter                             | Conditions  | Min  | Typ      | Max  | Unit          |
|---------------------|---------------------------------------|---|------|----------|------|---------------|
| <b>Output stage</b> |                                       |   |      |          |      |               |
| $R_{on}$            | on-state resistance                   | HS transistor; $V_{HV} = 310\text{ V}$ ; $I_D = 100\text{ mA}$                  |      |          |      |               |
|                     |                                       | UBA2024P  | -    | 9.7      | 11   | $\Omega$      |
|                     |                                       | UBA2024T  | -    | 9.7      | 11   | $\Omega$      |
|                     |                                       | UBA2024AP   | -    | 6.5      | 7.4  | $\Omega$      |
|                     |                                       | UBA2024AT   | -    | 7.0      | 8.0  | $\Omega$      |
|                     |                                       | HS transistor; $V_{HV} = 160\text{ V}$ ; $I_D = 100\text{ mA}$                  |      |          |      |               |
|                     |                                       | UBA2024BP   | -    | 2.0      | 2.35 | $\Omega$      |
|                     |                                       | UBA2024BT   | -    | 2.0      | 2.35 | $\Omega$      |
|                     |                                       | LS transistor; $I_D = 100\text{ mA}$  |      |          |      |               |
|                     |                                       | UBA2024P  | -    | 8.5      | 9.4  | $\Omega$      |
|                     |                                       | UBA2024T  | -    | 8.5      | 9.4  | $\Omega$      |
|                     |                                       | UBA2024AP   | -    | 5.7      | 6.3  | $\Omega$      |
|                     |                                       | UBA2024AT   | -    | 6.2      | 6.9  | $\Omega$      |
|                     |                                       | UBA2024BP   | -    | 2.3      | 2.55 | $\Omega$      |
| UBA2024BT           | -                                     | 2.3   | 2.55 | $\Omega$ |      |               |
| $V_F$               | forward voltage                       | HS; $I_F = 200\text{ mA}$   | -    | -        | 2.0  | V             |
|                     |                                       | LS; $I_F = 200\text{ mA}$   | -    | -        | 2.0  | V             |
|                     |                                       | bootstrap diode; $I_F = 1\text{ mA}$  | 0.7  | 1.0      | 1.3  | V             |
| $I_{Dsat}$          | drain saturation current              | HS; $V_{DS} = 30\text{ V}$ ; $T_j \leq 125\text{ °C}$ ; $V_{HV} = 310\text{ V}$ |      |          |      |               |
|                     |                                       | UBA2024P  | 900  | -        | -    | mA            |
|                     |                                       | UBA2024AP   | 1350 | -        | -    | mA            |
|                     |                                       | UBA2024T  | 900  | -        | -    | mA            |
|                     |                                       | UBA2024AT   | 1200 | -        | -    | mA            |
|                     |                                       | HS; $V_{DS} = 30\text{ V}$ ; $T_j \leq 125\text{ °C}$ ; $V_{HV} = 160\text{ V}$ |      |          |      |               |
|                     |                                       | UBA2024BP   | 2500 | -        | -    | mA            |
|                     |                                       | UBA2024BT   | 2500 | -        | -    | mA            |
|                     |                                       | LS; $V_{DS} = 30\text{ V}$ ; $T_j \leq 125\text{ °C}$                           |      |          |      |               |
|                     |                                       | UBA2024P  | 900  | -        | -    | mA            |
|                     |                                       | UBA2024AP   | 1350 | -        | -    | mA            |
|                     |                                       | UBA2024T  | 900  | -        | -    | mA            |
|                     |                                       | UBA2024AT   | 1200 | -        | -    | mA            |
|                     |                                       | UBA2024BP   | 2500 | -        | -    | mA            |
| UBA2024BT           | 2500                                  | -   | -    | mA       |      |               |
| $t_{no}$            | non-overlap time                      |   | 1    | 1.35     | 1.7  | $\mu\text{s}$ |
| $V_{float(UVLO)}$   | undervoltage lockout floating voltage |   | 3.6  | 4.2      | 4.8  | V             |

**Table 5. Characteristics ...continued**

$T_j = 25\text{ °C}$ ; all voltages are measured with respect to SGND; positive currents flow into the IC.

| Symbol                     | Parameter                               | Conditions   | Min   | Typ   | Max   | Unit          |
|----------------------------|---|--|-------|-------|-------|---------------|
| $I_{FS}$                   | current on pin FS                       | $V_{HV} = 310\text{ V}$ ; $V_{FS} = 12.2\text{ V}$   |       |       |       |               |
|                            |   | UBA2024P, UBA2024T   | 10    | 14    | 18    | $\mu\text{A}$ |
|                            |   | UBA2024AP, UBA2024AT   | 10    | 14    | 18    | $\mu\text{A}$ |
|                            |   | $V_{HV} = 160\text{ V}$ ; $V_{FS} = 12.2\text{ V}$   |       |       |       |               |
|                            |   | UBA2024BP, UBA2024BT   | 10    | 14    | 18    | $\mu\text{A}$ |
| <b>Internal oscillator</b> |   |  |       |       |       |               |
| $f_{osc}$                  | oscillator frequency                    | $V_{SW} = 0\text{ V}$  | -     | 150   | -     | kHz           |
|                            |   | $V_{SW} = V_{DD}$  | -     | -     | 60    | kHz           |
|                            |   | operating; nominal; $R_{OSC} = 100\text{ k}\Omega$ ;<br>$C_{OSC} = 220\text{ pF}$ ; $V_{SW} = V_{DD}$        | 40.05 | 41.32 | 42.68 | kHz           |
| $\Delta f_{osc}/f_{osc}$   | relative oscillator frequency variation | $R_{OSC} = 100\text{ k}\Omega$ ; $C_{OSC} = 220\text{ pF}$ ;<br>$-20\text{ °C} \leq T_j \leq +150\text{ °C}$ | -     | 2     | -     | %             |
| $k_H$                      | high-level trip point factor            |  | 0.382 | 0.395 | 0.408 |               |
| $V_{trip(osc)high}$        | high oscillator trip voltage            | $V_{trip(osc)high} = k_H \times V_{DD}$  | 4.58  | 4.94  | 5.29  | V             |
| $k_L$                      | low-level trip point factor             |  | 0.030 | 0.033 | 0.038 |               |
| $V_{trip(osc)low}$         | low oscillator trip voltage             | $V_{trip(osc)low} = k_L \times V_{DD}$   | 0.367 | 0.413 | 0.483 | V             |
| $K_{osc}$                  | oscillator constant                     | $R_{OSC} = 100\text{ k}\Omega$ ; $C_{OSC} = 220\text{ pF}$   | 1.065 | 1.1   | 1.35  | V             |
| <b>Sweep function</b>      |   |  |       |       |       |               |
| $I_{ch(sweep)}$            | sweep charge current                    | $V_{SW} = 0\text{ V}$  | 215   | 280   | 345   | nA            |
| $t_{sweep}$                | sweep time                              | $C_{SW} = 33\text{ nF}$ ; $V_{DD} = 12.2\text{ V}$   | 0.28  | 0.35  | 0.45  | s             |

## 11. Electrostatic discharge

**Table 6. ElectroStatic Discharge (ESD) overview**

| Model                       | Class | JEDEC classification criteria                               |
|-----------------------------|-------|---|
| ESDH (human body model)     | 1C    | pass at ESD pulse 1000 V                                    |
|                             |       | fail at ESD pulse 2000 V                                    |
| ESDC (charged device model) | C2    | pass at ESD pulse 200 V                                     |
|                             |       | fail at ESD pulse 500 V                                     |
| ESDM (machine model)        | B     | pass at $200\text{ V} \geq \text{ESD pulse} < 400\text{ V}$ |

## 12. Application information

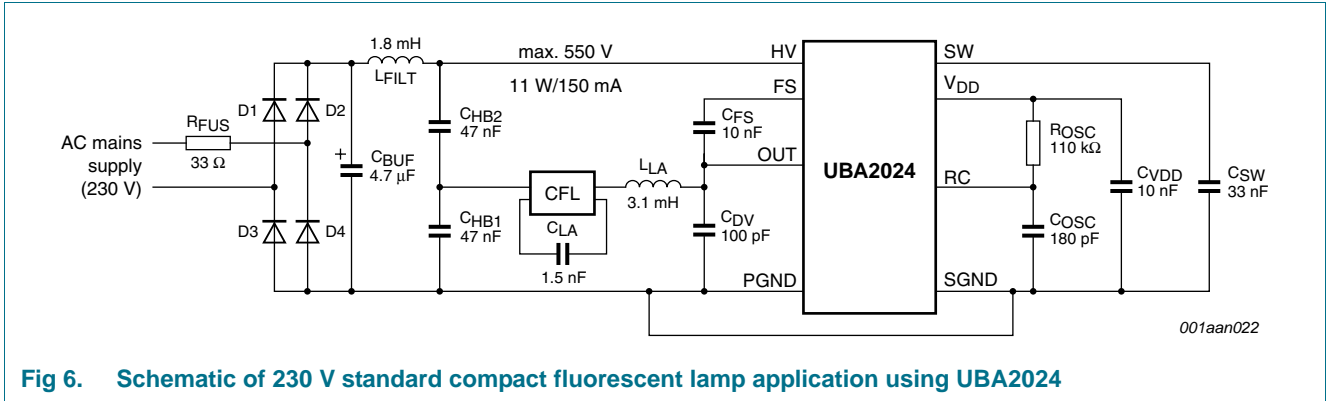


Fig 6. Schematic of 230 V standard compact fluorescent lamp application using UBA2024

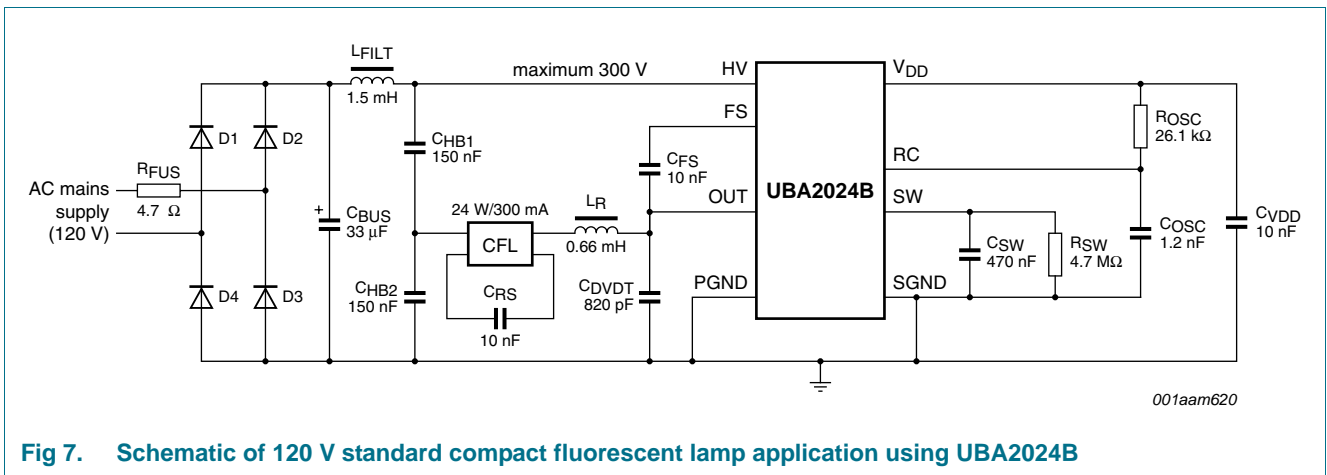


Fig 7. Schematic of 120 V standard compact fluorescent lamp application using UBA2024B

### 13. Package outline

DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1

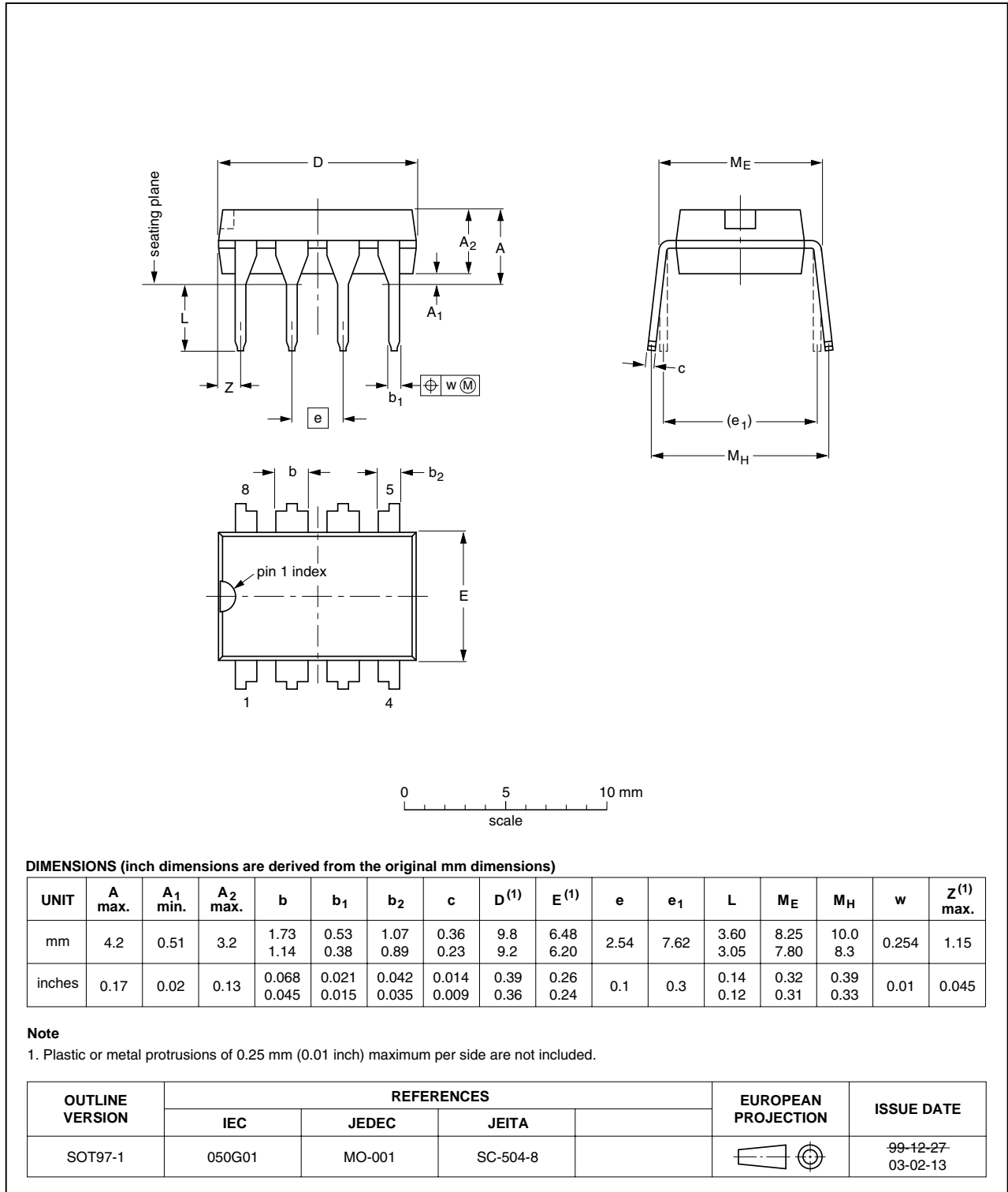


Fig 8. Package outline SOT97-1 (DIP8)

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

SOT108-1

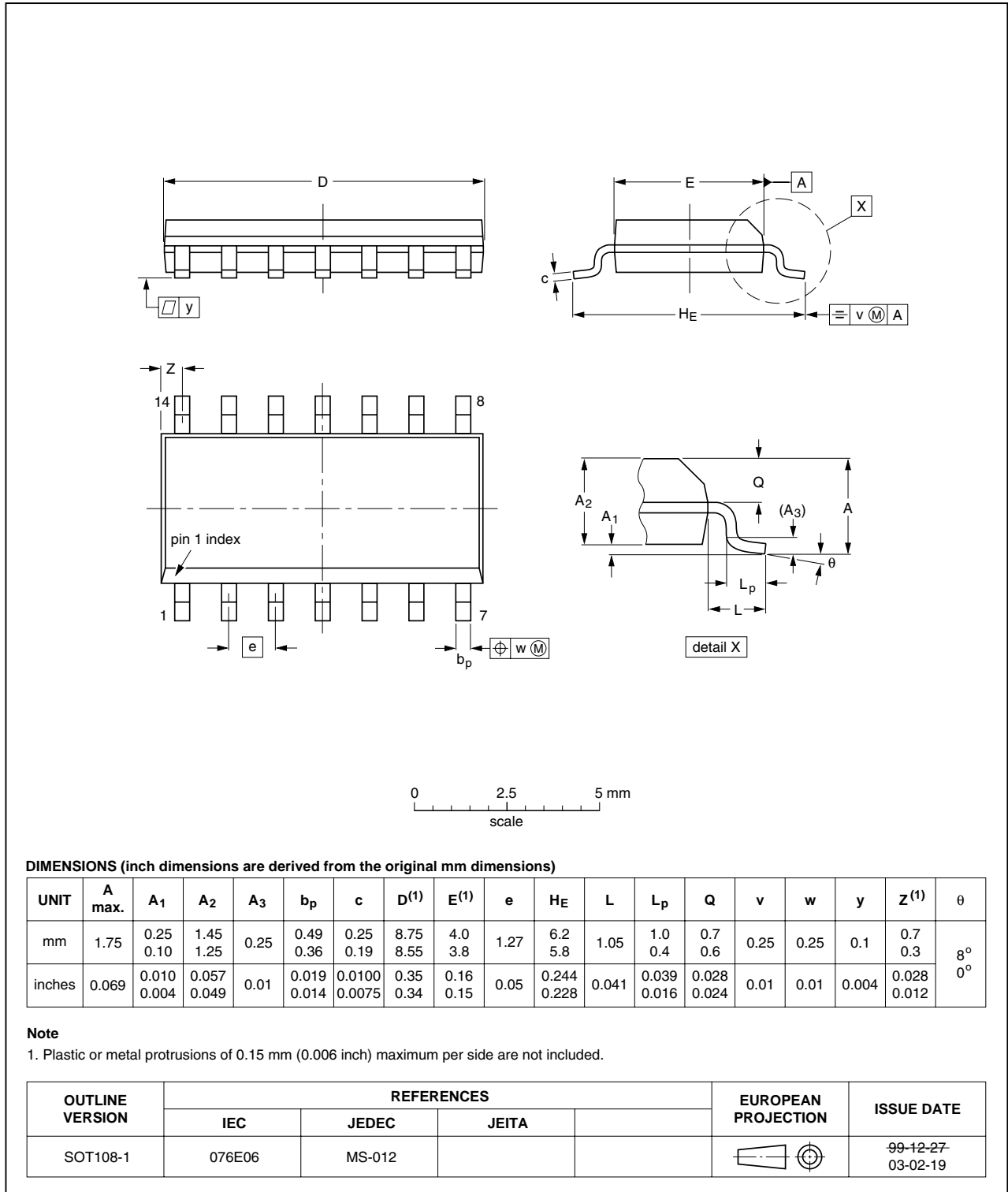


Fig 9. Package outline SOT108-1 (SO14)

## 14. Revision history

Table 7. Revision history

| Document ID    | Release date | Data sheet status   | Change notice | Supersedes  |
|----------------|--------------|---|---------------|-------------|
| UBA2024 v.6.2  | 20101101     | Product data sheet  | -             | UBA2024 v.5 |
| Modifications: |              | <ul style="list-style-type: none"> <li>• <a href="#">Figure 5 on page 6</a> has been changed.</li> <li>• The glow time section has been removed.</li> <li>• ESD values have been removed from <a href="#">Table 3 “Limiting values” on page 7</a>, added in to <a href="#">Table 6 “ElectroStatic Discharge (ESD) overview” on page 10</a> and one error corrected.</li> <li>• <a href="#">Table 3 “Limiting values” on page 7</a>: table notes 2 and 3 have been removed.</li> <li>• <a href="#">Table 5 “Characteristics” on page 8</a>: <ul style="list-style-type: none"> <li>– <math>V_{DD}</math> supply voltage minimum value has been changed.</li> <li>– <math>V_F</math> forward voltage HS maximum value has been changed.</li> <li>– <math>K_L</math> low-level trip point factor maximum value has been changed.</li> <li>– <math>V_{trip(osc)low}</math> low oscillator trip voltage maximum value has been changed.</li> </ul> </li> <li>• <a href="#">Figure 6 on page 11</a> have been changed.</li> </ul> |               |             |
| UBA2024 v.5    | 20100916     | Product data sheet  | -             | UBA2024 v.4 |
| UBA2024 v.4    | 20090917     | Product data sheet  | -             | UBA2024 v.3 |
| UBA2024 v.3    | 081016       | Product data sheet  | -             | UBA2024 v.2 |
| UBA2024 v.2    | 040203       | Product data sheet  | -             | UBA2024 v.1 |
| UBA2024 v.1    | 030813       | Product data sheet  | -             | -           |

## 15. Legal information

### 15.1 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>.

### 15.2 Definitions

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