UBA2212

Half-bridge power IC family for CFL lamps

Rev. 3 — 27 February 2012 Product data sheet

1. General description

The UBA2212 family of integrated circuits are a range of high voltage monolithic ICs for driving Compact Fluorescent Lamps (CFL) in half-bridge configurations. The family is designed to provide easy integration of lamp loads across a range of burner power and mains voltages.

2. Features and benefits

2.1 System integration

- Integrated half-bridge power transistors
  - UBA2212C: 120 V; 2 Ω; 3.5 A maximum ignition current
- Integrated bootstrap diode
- Integrated high-voltage supply

2.2 General

- RMS lamp current control

2.3 Fast and smooth light out

- Boost with externally controlled timing
- Temperature controlled timing during boost state
- Smooth transition from boost to steady state

2.4 Burner lifetime

- Fixed frequency preheat with adjustable preheat time
- Minimum glow time control to support cold start
- Lamp power independent from mains voltage variations
- Lamp inductor saturation protection during ignition

2.5 Safety

- Saturation Current Protection (SCP)
- OverTemperature Protection (OTP)
- Capacitive Mode Protection (CMP)

2.6 Ease of use

- Adjustable operating frequency for easy fit with various burners

3. Applications

- Compact Fluorescent Lamps up to 23 W for 120 V (AC) indoor and outdoor applications

4. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
UBA2212CP/1	DIP14	plastic dual inline package; 14 leads (300 mil)	SOT27-1
UBA2212CT/1	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1

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5. Block diagram

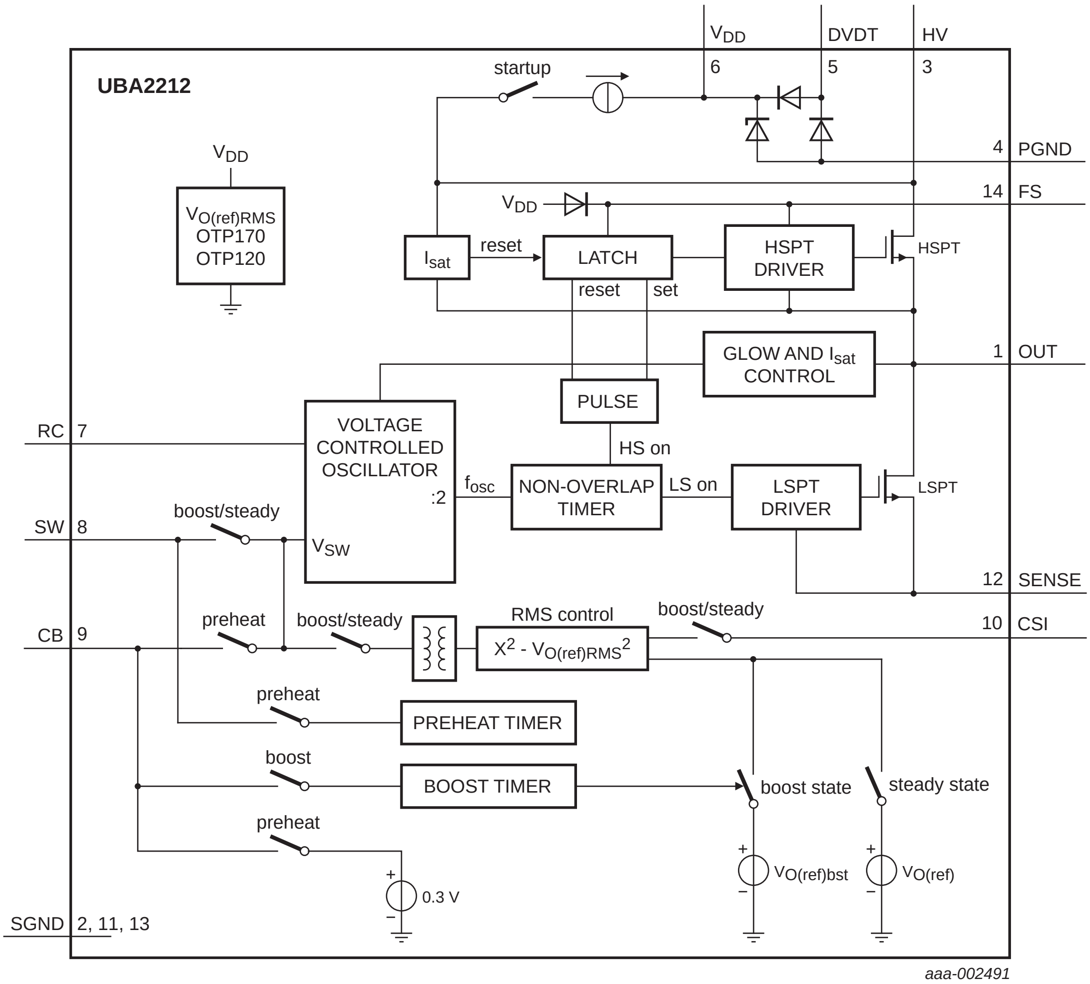

Fig 1. Block diagram

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6. Pinning information

6.1 Pinning

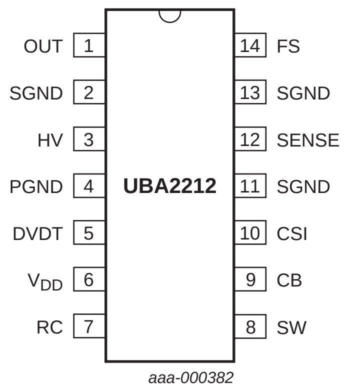

Fig 2. Pin configuration for UBA2212CP (SOT27-1)

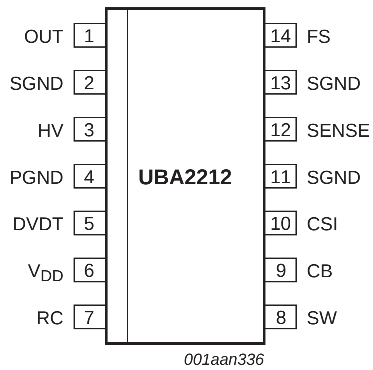

Fig 3. Pin configuration for UBA2212CT (SOT108-1)

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
OUT	1	half-bridge output
SGND	2, 11, 13	signal ground
HV	3	high-voltage supply
PGND	4	DVDT supply ground
DVDT	5	DVDT supply input
V_{DD}	6	internal low-voltage supply output
RC	7	internal oscillator input
SW	8	sweep timing and VCO input
CB	9	boost timing capacitor/preheat integrating capacitor
CSI	10	current feedback sense input
SENSE	12	current sense of LS MOSFET
FS	14	high-side floating supply output

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7. Functional description

7.1 Supply voltage

The UBA2212 family is powered using a start-up current source and a DVDT supply. When the voltage on pin HV increases, the V_{DD} capacitor (C_{VDD}) is charged using the internal Junction gate Field-Effect Transistor (JFET) current source. The voltage on pin V_{DD} rises until V_{DD} equals $V_{DD(start)}$. The start-up current source is then disabled. The half-bridge starts switching causing the charge pump to generate the required V_{DD} supply.

The amount of current flowing towards V_{DD} equals $V_{HV} \times C_{DVDT} \times f$ where f represents the momentary frequency. The charge pump consists of an external half-bridge capacitor (C_{DVDT}). The IC contains two internal diodes with an internal Zener diode. The Zener diode ensures the V_{DD} voltage cannot rise above the maximum V_{DD} rating.

The DVDT supply has its own ground pin (PGND) to prevent large peak currents from flowing through the external small signal ground pin (SGND).

The start-up current source is enabled when the voltage on pin V_{DD} is below $V_{DD(stop)}$.

7.2 Start-up state

When the supply voltage on pin V_{DD} increases, the IC enters the start-up state. In the start-up state, the High-Side Power Transistor (HSPT) is switched off and the Low-Side Power Transistor (LSPT) is switched on. The circuit is reset and the capacitors on the bootstrap pin FS (C_{bs}) and the low-voltage supply pin V_{DD} (C_{VDD}) are charged. Pins RC and SW are switched to ground.

When pin V_{DD} is above $V_{DD(start)}$, the start-up state is exited and the preheat state is entered. If the voltage on pin V_{DD} falls below $V_{DD(stop)}$, the system returns to the start-up state.

Remark: If OTP is active, the IC remains in the start-up state for as long as this is the case. The V_{DD} voltage slowly oscillates between $V_{DD} = V_{DD(stop)}$ and $V_{DD} = V_{DD(start)}$.

7.3 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.

7.4 Oscillation control

The oscillation frequency is based on the 555-timer function. A self oscillating circuit is created comprising the external components: resistors R_{osc}, R_{SENSE} and capacitor C_{osc}. R_{osc} and C_{osc} determine the nominal oscillating frequency.

An internal divider $0.5 \times f_{osc(int)}$ is used to generate the accurate 50 % duty cycle. The divider sets the bridge frequency at half the oscillator frequency.

The input on pin SW generates signal V_{SW}. The V_{SW} signal is used to determine the frequency in all states except preheat. Signal V_{CB} is an internally generated signal used to determine the frequency during the preheat state.

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The output voltage of the bridge changes with the falling edge of the signal on pin RC. The nominal half-bridge frequency is shown in Equation 1:

$$f_{osc(nom)} = \frac{1}{k_{osc} \times R_{osc} \times C_{osc}} \quad (1)$$

The maximum frequency is 2.5 × $f_{osc(nom)}$ and is set at V_{SW}. An overview of the oscillator, internal LSPT and HSPT drive signals and the output is shown in Figure 4.

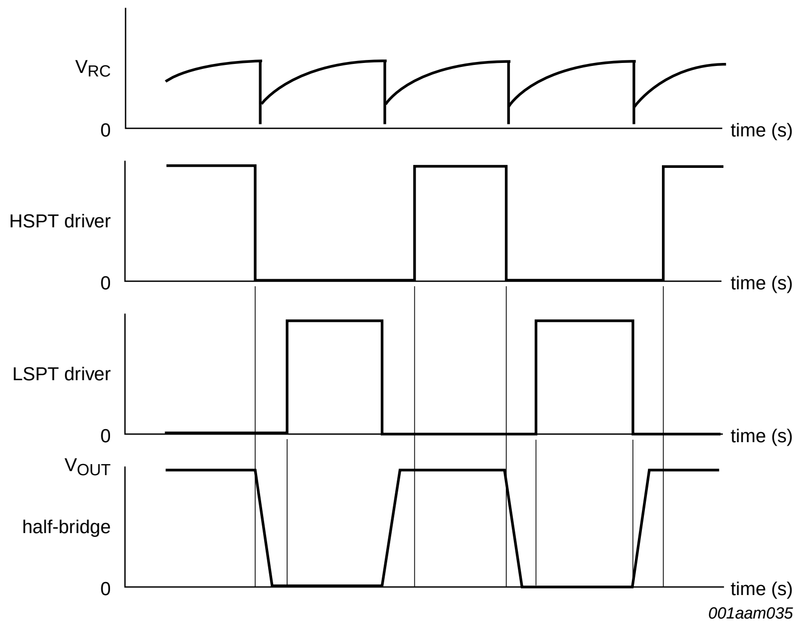

Fig 4. Oscillator, HSPT/LSPT drivers and output signals

7.5 Preheat state

The VCO input is directly connected to a fixed DC voltage of 0.3 V in the preheat state. The frequency is set to about 0.94 f_{max} to ensure voltage mode preheat. The preheat state is finished when V_{SW} drops to 0.3 V.

7.6 Ignition state

The ignition state is entered after the preheat state has finished. Current I_{SW} charges the capacitor on pin SW (C_{SW}) and the frequency continuously drops.

During this frequency sweep (f_{SW}), the resonance frequency is reached resulting in the ignition of the lamp (see Figure 5). The lamp inductor (L_{lamp}) and lamp capacitor (C_{lamp}) set the resonance frequency.

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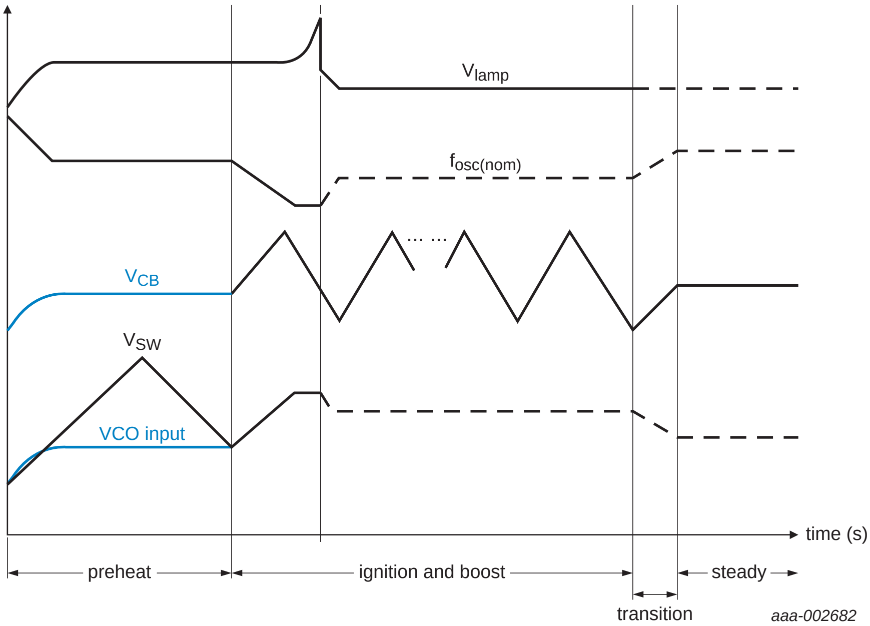

Fig 5. V_{lamp}, $f_{osc(int)}$, V_{CB} and V_{SW} plotted against time

7.7 Boost state and transition to steady state

The boost state is entered after ignition. The output of RMS current control circuit and the input of VCO are switched to capacitor C_{SW}. At the same time, the input of RMS current control circuit is switched to pin CSI to sense lamp current. On pin CB, capacitor C_{CB} is connected to the boost timer input to control the boost time. V_{SW} changes to a given voltage to set the lamp current to the level pre-defined by the internal boost reference and resistor R_{CSI}. The calculation is shown in Equation 2:

$$Boost\ I_{lamp} = \frac{V_{ref(bst)}}{R_{CSI}} \qquad (2)$$

When boost timer gives a signal to indicate that boost state is ended, the transition from boost to steady state starts to avoid flicker. In this state, the boost transition timer is active to define the transition time, which is also realized with capacitor C_{CB} on CB pin.

7.8 Steady state

When the RMS current control circuit leaves the system operating at the normal lamp current, it enters the steady state. In this state, the voltage on pin CB is fixed and the voltage on pin SW is controlled by a feedback loop. This feature enables the lamp current to be independent of the mains or lamp voltage.

The same analysis as with the boost state can be used to express lamp current (Equation 3):

$$Steady\ I_{lamp} = \frac{V_{ref(steady)}}{R_{CSI}} \qquad (3)$$

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Therefore, the boost-steady ratio can be found as shown in Equation 4:

$$Boost\ to\ steady\ ratio = \frac{V_{ref(bst)}}{V_{ref(steady)}} \tag{4}$$

7.9 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 and is fixed at the t_{no} value (see Table 5).

7.10 OverTemperature Protection (OTP)

OTP is active in all states except boost. When the die temperature reaches the OTP activation threshold ($T_{th(act)otp}$), the oscillator is stopped and the power switches (LSPT/HSPT) are set to the start-up state. When the oscillator is stopped, the DVDT supply no longer generates the supply current I_{DVDT}. Voltage V_{DD} gradually decreases and the start-up state is entered as described in Section 7.2 on page 5. OTP is reset when the temperature < $T_{th(rel)otp}$.

During boost state, the threshold of temperature is $T_{j(end)bst}$ which is lower than $T_{th(otp)}$. When the die temperature has reached $T_{j(end)bst}$, the boost state ends, the IC enters steady state and OTP is enabled.

7.11 Saturation Current Protection (SCP)

A critical parameter in the design of the lamp inductor is its saturation current. When the momentary inductor exceeds its saturation current, the inductance drops significantly. The inductor current and the current flowing through the LSPT and HSPT power switches increases rapidly if this happens. The increase can cause the current to exceed the half-bridge power transistors maximum ratings.

Saturation of the lamp inductor is likely to occur in cost-effective and miniaturized CFLs. The UBA2212 family internally monitors the power transistor current. When this current exceeds the momentary rating of the internal half-bridge power transistors, the conduction time is reduced and the frequency is slowly increased (by discharging C_{SW}). This function causes the system to balance at the edge of the current rating of the power switches.

7.12 Capacitive Mode Protection (CMP)

In boost and steady state, V_{SW} determines the operating frequency. The RMS current control circuit and the CMP circuit control this frequency. When Capacitive mode is detected, capacitor C_{SW} is mainly controlled by the CMP circuit. Capacitor C_{SW} is discharged by a current source, which is also dependent on the hard switching voltage level. The operating frequency f_{osc}, increases until CMP is no longer detected.

Remark: CMP always controls the operation. If the lamp current is lower than the defined value before CMP is detected, the system moves to the edge of hard switching (~25 V). The set value cannot be achieved. Change the LC tank to get a higher resonant gain, which enables the required lamp current to be obtained.

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8. Limiting values

Table 3. Limiting values

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

Symbol	Parameter	Conditions		Min	Max	Unit
V_{HV}	voltage on pin HV	operating		-	202	V
		mains transients during 0.5 s		-	250	V
V_{FS}	voltage on pin FS			V_{HV}	V_{HV} + 14	V
V_{DD}	supply voltage	DC supply		0	14	V
V_{SENSE}	voltage on pin SENSE			–5	+5	V
V_{RC}	voltage on pin RC	I_{RC} < 1 mA		0	V_{DD}	V
V_{SW}	voltage on pin SW	I_{SW} < 1 mA		0	V_{DD}	V
I_{OUT}	current on pin OUT	T_j < 125 °C		–3.5	+3.5	A
I_{DVDT}	current on pin DVDT	T_j < 125 °C		–2.5	+2.5	A
$V_{i(CSI)}$	input voltage on pin CSI	T_j > –40 °C		–3.5	+3.5	V
SR	slew rate	repetitive output on pin OUT		–4	+4	V/ns
T_j	junction temperature			–40	+150	°C
T_{amb}	ambient temperature			–40	+150	°C
T_{stg}	storage temperature			–55	+150	°C
V_{ESD}	electrostatic discharge voltage	Human Body Model (HBM):	[1]			
		pins HV, FS, OUT		-	800	V
		pins SW, RC, V_{DD}, DVDT		-	2.5	kV
		Charged Device Model (CDM):				
		pins SW, RC, V_{DD}, DVDT, CSI and CB		-	400	V

[1] In accordance with the Human Body Model (HBM): equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

9. Thermal characteristics

Table 4. Thermal characteristics

Symbol	Parameter	Conditions		Typ	Unit
DIP14 package					
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	70	K/W
$R_{th(j-c)}$	thermal resistance from junction to case	in free air	[1]	16	K/W
SO14 package					
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	95	K/W
$R_{th(j-c)}$	thermal resistance from junction to case	in free air	[1]	16	K/W

[1] In accordance with IEC 60747-1

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10. Characteristics

Table 5. Characteristics

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Low-voltage supply						
Start-up state						
I_{HV}	current on pin HV	V_{HV} = 60 V	-	1.5	-	mA
$V_{DD(start)}$	start supply voltage	oscillation start	11.5	12.5	13.5	V
$V_{DD(stop)}$	stop supply voltage	oscillation stop	8.5	9	9.5	V
$V_{DD(hys)}$	hysteresis of supply voltage	start − stop	3	3.5	4	V
$V_{DD(reg)}$	regulation supply voltage		-	12.5	-	V
I_{sink}	sink current	capability of VDD regulator	6	-	-	mA
Output stage						
R_{on}	on-state resistance	HS; V_{HV} = 170 V; I_D = 200 mA	-	2	-	Ω
		LS; V_{HV} = 170 V; I_D = 200 mA	-	2	-	Ω
$R_{on(150)}$/ $R_{on(25)}$	on-state resistance ratio (150 °C to 25 °C)		-	1.4	-	
V_{Fd}	diode forward voltage	HS; I_F = 320 mA	-	1.1	-	V
		LS; I_F = 320 mA	-	1.2	-	V
		bootstrap diode; I_F = 1 mA	0.7	1	1.3	V
t_{no}	non-overlap time		0.9	1.2	1.5	μs
V_{FS}	voltage on pin FS	UnderVoltage LockOut with respect to pin OUT	3.9	4.5	5.1	V
I_{FS}	current on pin FS	V_{HV} = 170 V; V_{FS} = 12 V	10	14	18	μA
I_{sat}	saturation current	HS; V_{DS} = 14 V; $T_j \leq$ 125 °C	3.5	-	-	A
		LS; V_{DS} = 14 V; $T_j \leq$ 125 °C	3.5	-	-	A
Internal oscillator						
$f_{osc(min)}$	minimum oscillator frequency	R_{osc} = 100 kΩ; C_{osc} = 220 pF; V_{SW} = V_{DD}	-	36	-	kHz
$f_{osc(max)}$	maximum oscillator frequency	R_{osc} = 100 kΩ; C_{osc} = 220 pF; V_{SW} = 0 V	-	104	-	kHz
$\Delta f_{osc(nom)}/\Delta T$	nominal oscillator frequency variation with temperature	R_{osc} = 100 kΩ; C_{osc} = 220 pF; ΔT = −20 to +150 °C	-	2	-	%
k_H	high-level trip point factor		0.36	0.38	0.50	
k_L	low-level trip point factor		0.018	0.029	0.040	
$V_{H(RC)}$	HIGH-level voltage on pin RC	trip point; $V_{H(RC)} = k_H \times V_{DD}$	4.45	4.78	5.20	V
$V_{L(RC)}$	LOW-level voltage on pin RC	trip point; $V_{L(RC)} = k_L \times V_{DD}$	0.255	0.362	0.455	V
K_{osc}	oscillator constant	R_{osc} = 100 kΩ; C_{osc} = 220 pF	1.065	1.1	1.135	
Preheat function						
t_{ph}	preheat time	C_{SW} = 47 nF	-	0.55	-	s
f_{ph}	preheat frequency	R_{osc} = 100 kΩ; C_{osc} = 220 pF	-	90	-	kHz
V_{RC}	voltage on pin RC	trip point during preheat state	-	0.3	-	V

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Table 5. Characteristics *…continued*

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Boost function						
$V_{O(ref)bst}$	boost reference output voltage	V_{DD} = 12 V; H_V = 30 V; V_{SW} = 3 V	-	450	-	mV
$T_{j(end)bst}$	boost end junction temperature		-	90	-	°C
t_{bst}	boost time	C_{SW} = 220 nF	-	48	-	s
t_t	transition time	C_{SW} = 220 nF	-	2	-	s
Steady function						
$V_{O(ref)}$	steady reference output voltage	V_{DD} = 12 V; H_V = 30 V; V_{SW} = 3 V	-	300	-	mV
N_{LCBR}	lamp current boost ratio	boost and steady state	-	1.5	-	
OTP function						
$T_{th(act)otp}$	overtemperature protection activation threshold temperature		-	170	-	°C
$T_{th(rel)otp}$	overtemperature protection release threshold temperature		-	100	-	°C

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11. Application information

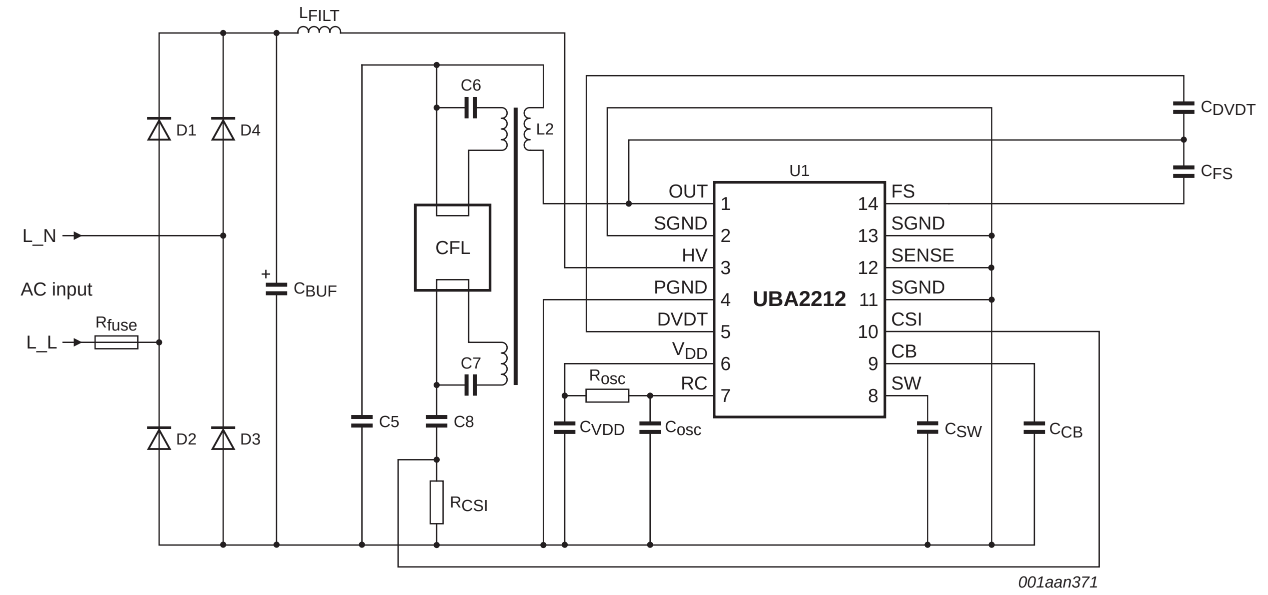

Fig 6. Application diagram

Table 6. Bill of materials

Number	Reference	Typical value	Quantity
1	R_{fuse}	10 Ω; 1 W - no value for fuse resistor	1
2	D1, D2, D3, D4	diode, 1 A; 1000 V; 1N4007	4
3	C_{BUF}	electrolytic capacitor; 33 µF; 250 V; 105 °C	1
4	L_{FILT}	inductor; 3 mH; 0.5 A	1
5	C_{DVDT}	ceramic capacitor; 330 pF; 500 V; 1206	1
6	C_{FS}	ceramic capacitor; 22 nF; 50 V; 0805	1
7	C_B	ceramic capacitor; 220 nF; 50 V; 0805	1
8	C_{SW}	ceramic capacitor; 68 nF; 50 V; 0805	1
9	C_{osc}	ceramic capacitor; 220 pF; 50 V; 0805	1
10	C_{VDD}	ceramic capacitor; 100 nF; 50 V; 0805	1
11	R_{osc}	chip resistor; 100 kΩ; 5 %; 0805	1
12	C6; C7	film capacitor; 82 nF; 100 V	2
13	C5	film capacitor; 6.8 nF; 1 kV	1
14	C8	film capacitor; 8.2 nF; 400 V	1
15	R_{CSI}	chip resistor; 1.8 Ω; 1 %; 0.25 W	1
16	L2	PC40-EE16; 1.5 mH; 1 A; N = 180 : 6 : 6; diameter 0.23 mm	1
18	U1	UBA2213CT; SO14	1
19	Burner	burner; T3 Spiral 20 W	1

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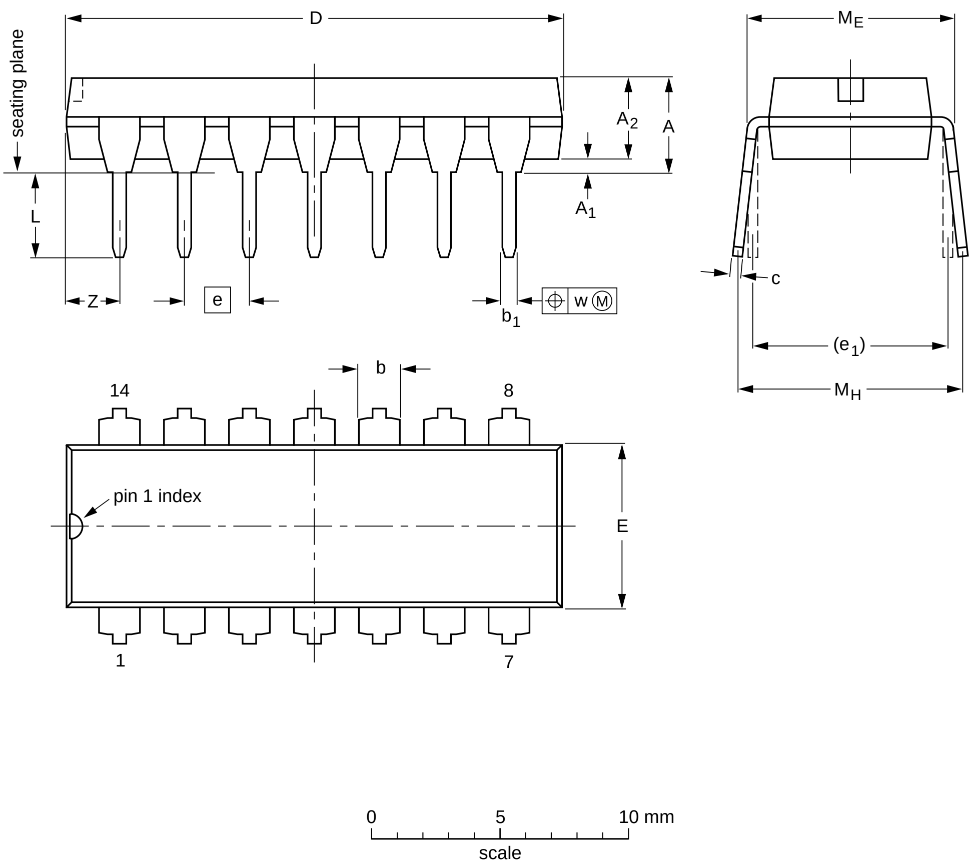
12. Package outline

DIP14: plastic dual in-line package; 14 leads (300 mil) **SOT27-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.13	0.53 0.38	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.2
inches	0.17	0.02	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.087

Note

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT27-1	050G04	MO-001	SC-501-14			~~99-12-27~~ 03-02-13

Fig 7. Package outline SOT27-1 (DIP14)

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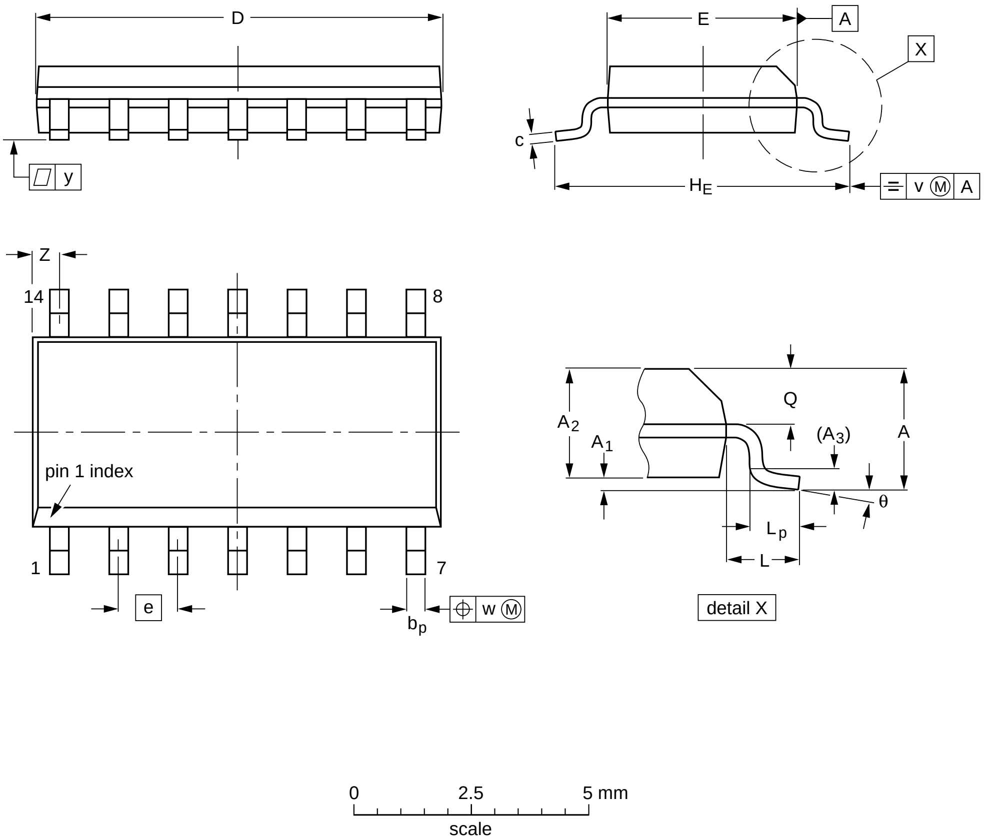
SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Fig 8. Package outline SOT108-1 (SO14)

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13. Revision history

Table 7. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
UBA2212 v.3	20120227	Product data sheet	-	UBA2212 v.2
Modifications:	• Data sheet status changed from Preliminary to Product. • Text and drawings updated throughout entire data sheet.			
UBA2212 v.2	20120209	Preliminary data sheet	-	UBA2212 v.1
UBA2212 v.1	20111209	Objective data sheet	-	-

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14. Legal information

14.1 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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