

DATA SHEET

UBA2021

630 V driver IC for CFL and TL
lamps

Product specification
Supersedes data of 2000 Jul 24
File under Integrated Circuits, IC11

2001 Jan 30

630 V driver IC for CFL and TL lamps

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FEATURES

- Adjustable preheat and ignition time
- Adjustable preheat current
- Adjustable lamp power
- Lamp temperature stress protection at higher mains voltages
- Capacitive mode protection
- Protection against a too-low drive voltage for the power MOSFETs.

GENERAL DESCRIPTION

The UBA2021 is a high-voltage IC intended to drive and control Compact Fluorescent Lamps (CFL) or fluorescent TL-lamps. It contains a driver circuit for an external half-bridge, an oscillator and a control circuit for starting up, preheating, ignition, lamp burning and protection.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
High voltage supply						
V_{FS}	high side supply voltage	$I_{FS} < 15 \mu A$; $t < 0.5 \text{ s}$	–	–	630	V
Start-up state						
$V_{VS(start)}$	oscillator start voltage		–	11.95	–	V
$V_{VS(stop)}$	oscillator stop voltage		–	10.15	–	V
$I_{VS(standby)}$	standby current	$V_{VS} = 11 \text{ V}$	–	200	–	μA
Preheat mode						
f_{start}	start frequency		–	108	–	kHz
t_{ph}	preheat time	$C_{CP} = 100 \text{ nF}$	–	666	–	ms
$V_{RS(ctrl)}$	control voltage at pin RS		–	–600	–	mV
Frequency sweep to ignition						
f_B	bottom frequency		–	42.9	–	kHz
t_{ign}	ignition time		–	625	–	ms
Normal operation						
f_B	bottom frequency		–	42.9	–	kHz
t_{no}	non-overlap time		–	1.4	–	μs
I_{tot}	total supply current	$f_B = 43 \text{ kHz}$	–	1	–	mA
$R_{G1(on)}, R_{G2(on)}$	high and low side on resistance		–	126	–	Ω
$R_{G1(off)}, R_{G2(off)}$	high and low side off resistance		–	75	–	Ω
Feed-forward						
f_{ff}	feed-forward frequency	$I_{RHV} = 0.75 \text{ mA}$	–	63.6	–	kHz
		$I_{RHV} = 1.0 \text{ mA}$	–	84.5	–	kHz
$I_{i(RHV)}$	operating range of input current at pin RHV		0	–	1000	μA

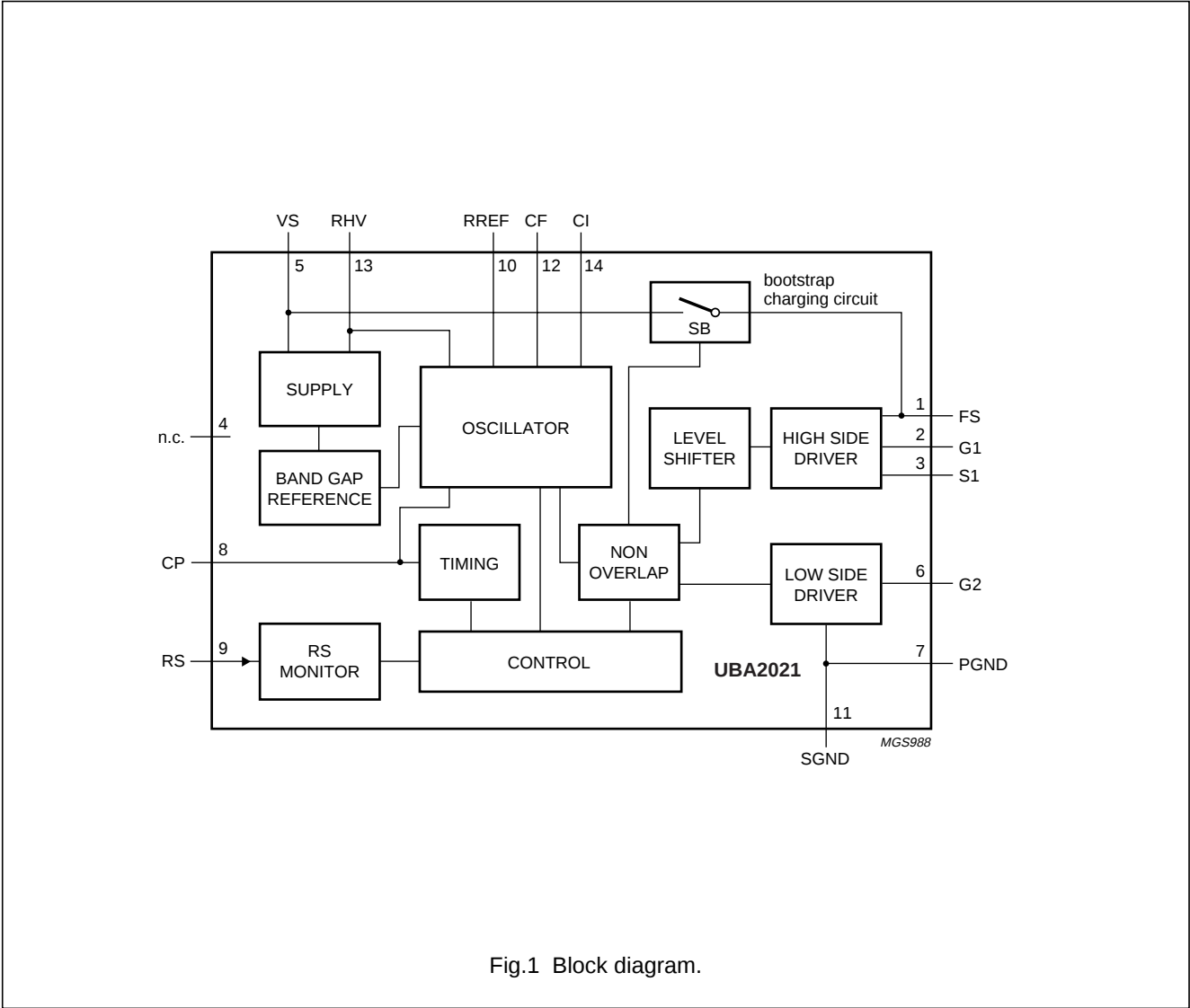
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ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
UBA2021T	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
UBA2021P	DIP14	plastic dual in-line package; 14 leads (300 mil)	SOT27-1

BLOCK DIAGRAM



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PINNING

SYMBOL	PIN	DESCRIPTION
FS	1	high side floating supply voltage
G1	2	gate high transistor (T1)
S1	3	source high transistor (T1)
n.c.	4	high-voltage spacer, not to be connected
VS	5	low voltage supply
G2	6	gate low transistor (T2)
PGND	7	power ground
CP	8	timing/averaging capacitor
RS	9	current monitoring input
RREF	10	reference resistor
SGND	11	signal ground
CF	12	oscillator capacitor
RHV	13	start-up resistor/feed-forward resistor
CI	14	integrating capacitor

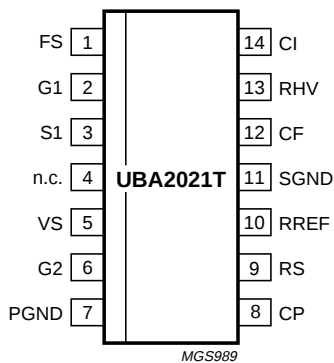


Fig.2 Pin configuration (SO14).

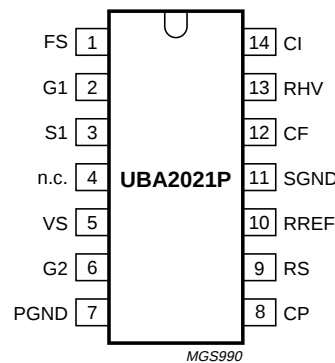


Fig.3 Pin configuration (DIP14).

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FUNCTIONAL DESCRIPTION

Introduction

The UBA2021 is an integrated circuit for electronically ballasted compact fluorescent lamps and their derivatives operating with mains voltages up to 240 V (RMS). It provides all the necessary functions for preheat, ignition and on-state operation of the lamp. In addition to the control function, the IC provides level shift and drive functions for the two discrete power MOSFETs, T1 and T2 (see Fig.7).

Initial start-up

Initial start-up is achieved by charging capacitor CS9 with the current applied to pin RHV. At start-up, MOSFET T2 conducts and T1 is non-conducting, ensuring C_{boot} becomes charged. This start-up state is reached for a supply voltage $V_{VS(reset)}$ (this is the voltage level at pin VS at which the circuit will be reset to the initial state) and maintained until the low voltage supply (V_{VS}) reaches a value of $V_{VS(start)}$. The circuit is reset in the start-up state.

Oscillation

When the low voltage supply (V_{VS}) has reached the value of $V_{VS(start)}$ the circuit starts oscillating in the preheat state. The internal oscillator is a current-controlled circuit which generates a sawtooth waveform. The frequency of the sawtooth is determined by the capacitor C_{CF} and the current out of pin CF (mainly set by R_{RREF}). The sawtooth frequency is twice the frequency of the signal across the load. The IC brings MOSFETs T1 and T2 alternately into conduction with a duty factor of approximately 50%. Figure 4 represents the timing of the IC. The circuit block 'non-overlap' generates a non-overlap time t_{no} that ensures conduction periods of exclusively T1 or T2. Time t_{no} is dependent on the reference current I_{RREF} .

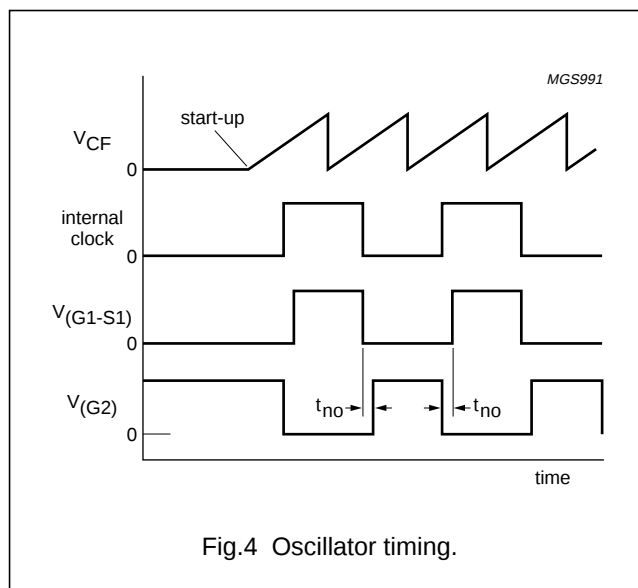


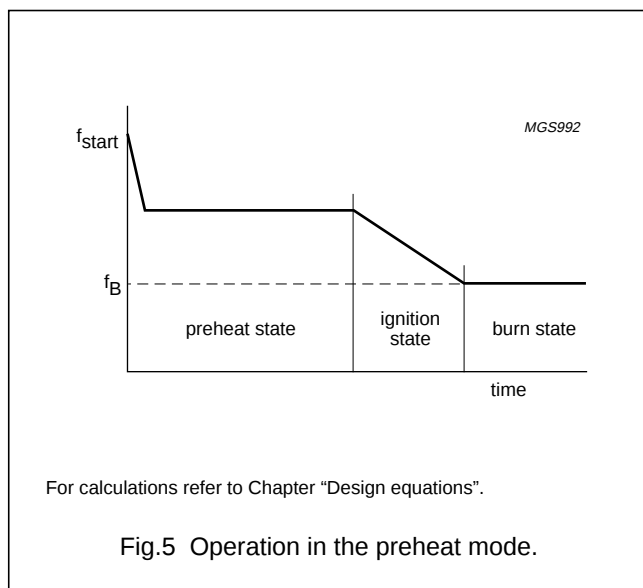
Fig.4 Oscillator timing.

Operation in the preheat mode

The circuit starts oscillating at approximately $2.5 \times f_B$ (108 kHz). The frequency gradually decreases until a defined value of current I_{shunt} is reached (see Fig.5). The slope of the decrease in frequency is determined by capacitor C_{CI} . The frequency during preheating is approximately 90 kHz. This frequency is well above the resonant frequency of the load, which means that the lamp is off; the load consists of L2, C5 and the electrode resistance only. The preheat time is determined by capacitor C_{CP} . The circuit can be locked in the preheat state by connecting pin CP to ground. During preheating, the circuit monitors the load current by measuring the voltage drop over external resistor R_{shunt} at the end of conduction of T2 with decision level $V_{RS(ctrl)}$. The frequency is decreased as long as $V_{RS} > V_{RS(ctrl)}$. The frequency is increased for $V_{RS} < V_{RS(ctrl)}$.

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Ignition state

The RS monitoring function changes from $V_{RS(ctr)}$ regulation to capacitive mode protection at the end of the preheat time. Normally this results in a further frequency decrease down to the bottom frequency f_B (approximately 43 kHz). The rate of change of frequency in the ignition state is less than that in the preheat mode. During the downward frequency sweep, the circuit sweeps through the resonant frequency of the load. A high voltage then appears across the lamp. This voltage normally ignites the lamp.

Failure to ignite

Excessive current levels may occur if the lamp fails to ignite. The IC does not limit these currents in any manner.

Transition to the burn state

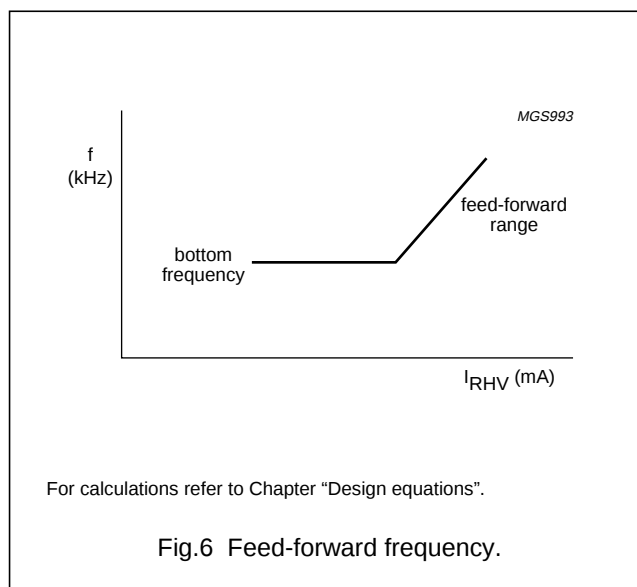
Assuming that the lamp has ignited during the downward frequency sweep, the frequency normally decreases to the bottom frequency. The IC can transit to the burn state in two ways:

1. In the event that the bottom frequency is not reached, transition is made after reaching the ignition time t_{ign} .
2. As soon as the bottom frequency is reached.

The bottom frequency is determined by R_{REF} and C_{CF} .

Feed-forward frequency

Above a defined voltage level the oscillation frequency also depends on the supply voltage of the half-bridge (see Fig.6). The current for the current-controlled oscillator is in the feed-forward range derived from the current through R_{RHV} . The feed-forward frequency is proportional to the average value of the current through R_{RHV} within the operating range of $I_{i(RHV)}$, given the lower limit set by f_B . For currents beyond the operating range (i.e. between 1.0 and 1.6 mA) the feed-forward frequency is clamped. In order to prevent feed-forward of ripple on V_{in} , the ripple is filtered out. The capacitor connected to pin CP is used for this purpose. This pin is also used in the preheat state and the ignition state for timing (t_{ph} and t_{ign}).



Capacitive mode protection

When the preheat mode is completed, the IC will protect the power circuit against losing the zero voltage switching condition and getting too close to the capacitive mode of operation. This is detected by monitoring voltage V_{RS} at pin RS. If the voltage is below $V_{RS(cap)}$ at the time of turn-on of T2, then capacitive mode operation is assumed. Consequently the frequency increases as long as the capacitive mode is detected. The frequency decreases down to the feed-forward frequency if no capacitive mode is detected. Frequency modulation is achieved via pin CI.

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IC supply

Initially, the IC is supplied from V_{in} by the current through R_{RHV} . This current charges the supply capacitor CS9 via an internal diode. As soon as V_{VS} exceeds $V_{VS(start)}$, the circuit starts oscillating. After the preheat phase is finished, pin RHV is connected to an internal resistor $R_{i(RHV)}$; prior to this, pin RHV is internally connected to pin VS. The voltage level at pin RHV thus drops from $V_{VS} + V_{diode}$ to $I_{RHV} \times R_{i(RHV)}$. The capacitor CS9 at pin VS will now be charged via the snubber capacitor CS7. Excess charge is drained by an internal clamp that turns on at voltage $V_{VS(clamp)}$.

Minimum gate-source voltage of T1 and T2

The high side driver is supplied via capacitor C_{boot} . Capacitor C_{boot} is charged via the bootstrap switch during the on-periods of T2. The IC stops oscillating at a voltage level $V_{VS(stop)}$. Given a maximum charge consumption on the load at pin G1 of 1 nC/V, this safeguards the minimum drive voltages $V_{(G1-S1)}$ for the high side driver; see Table 1.

Table 1 Minimum gate-source voltages

FREQUENCY	VOLTAGE
<75 kHz	8 V (min.)
75 kHz to 85 kHz	7 V (min.)
≥85 kHz	6 V (min.)

The drive voltage at G2 will exceed the drive voltage of the high side driver.

Frequency and change in frequency

At any point in time during oscillation, the circuit will operate between f_B and f_{start} . Any change in frequency will be gradual, no steps in frequency will occur. Changes in frequency caused by a change in voltage at pin CI show a rather-constant df/dt over the entire frequency range. The following rates are realised (at a frequency of 85 kHz and with a 100 nF capacitor connected to pin CI):

- For any increase in frequency: df/dt is between 15 and 37.5 kHz/ms
- During preheat and normal operation: df/dt for a decrease in frequency is between –6 and –15 kHz/ms
- During the ignition phase: df/dt for a decrease in frequency is between –150 and –375 Hz/ms.

Ground pins

Pin PGND is the ground reference of the IC with respect to the application. As an exception, pin SGND provides a local ground reference for the components connected to pins CP, CI, RREF and CF. For this purpose pins PGND and SGND are short-circuited internally. External connection of pins PGND and SGND is not preferred. The sum of currents flowing out of the pins CP, CI, RREF, CF and SGND must remain zero at any time.

Charge coupling

Due to parasitic capacitive coupling to the high voltage circuitry, all pins are burdened with a repetitive charge injection. Given the typical application in Fig.7, pins RREF and CF are sensitive to this charge injection. For the rating Q_{couple} a safe functional operation of the IC is guaranteed, independent of the current level. Charge coupling at current levels below 50 μ A will not interfere with the accuracy of the $V_{RS(cap)}$ and $V_{RS(ctrl)}$ levels. Charge coupling at current levels below 20 μ A will not interfere with the accuracy of any parameter.

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); all voltages referenced to ground.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V _{FS}	high side floating supply voltage	operating	–	570	V
		$t \leq 0.5$ s	–	630	V
I _{VS(clamp)}	clamp current	$t \leq 0.5$ s	–	35	mA
V _{RS}	input voltage pin RS		–2.5	+2.5	V
		transient of 50 ns	–15.0	+2.5	V
SR	slew rate at pins S1, G1 and FS (with respect to ground)		–4	+4	V/ns
P	power dissipation		–	500	mW
T _{amb}	ambient temperature		–40	+150	°C
T _j	junction temperature		–40	+150	°C
T _{stg}	storage temperature		–55	+150	°C
Q _{couple}	charge coupling at pins RREF and CF	operating	–8	+8	pC
V _{es}	electrostatic handling voltage	human body model; note 1	–	3000	V
		machine model; note 2	–	300	V

Notes

- Human body model: all pins are 3000 V maximum, except pins FS, G1, S1 and VS which are 1500 V maximum and pin G2 which is 1000 V maximum.
- Machine model: all pins are 300 V maximum, except pin G2 which is 125 V maximum.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
R _{th(j-a)}	thermal resistance from junction to ambient	in free air		
	SO14		100	K/W
	DIP14		60	K/W
R _{th(j-pin)}	thermal resistance from junction to pcb	in free air		
	SO14		50	K/W
	DIP14		30	K/W

QUALITY SPECIFICATION

In accordance with “SNW-FQ-611-E”.

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CHARACTERISTICS

$V_{VS} = 11\text{ V}$; $V_{FS} - V_{S1} = 11\text{ V}$; $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$; all voltages referenced to ground; see Fig.7; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
High voltage supply						
I_L	leakage current on high voltage pins	V_{FS} , V_{G1} and $V_{S1} = 630\text{ V}$	–	–	15	μA
Start-up state						
$V_{VS(\text{reset})}$	reset voltage	T1 off; T2 on	4.0	5.5	6.5	V
$V_{VS(\text{start})}$	oscillator start voltage		11.35	11.95	12.55	V
$V_{VS(\text{stop})}$	oscillator stop voltage		9.55	10.15	10.75	V
$V_{VS(\text{hys})}$	supply voltage hysteresis		1.5	1.8	2.0	V
$I_{VS(\text{standby})}$	standby supply current at pin VS	$V_{VS} = 11\text{ V}$; note 1	150	200	250	μA
$\Delta V_{(\text{RHV}-\text{VS})}$	voltage difference between pins RHV and VS	$I_{\text{RHV}} = 1.0\text{ mA}$	0.7	0.8	1.0	V
$V_{VS(\text{clamp-start})}$	clamp margin $V_{VS(\text{clamp})}$ to $V_{VS(\text{start})}$	note 2	0.2	0.3	0.4	V
$I_{VS(\text{clamp})}$	clamp current	$V_{VS} < 17\text{ V}$	–	14	35	mA
Preheat mode						
f_{start}	starting frequency	$V_{CI} = 0\text{ V}$	98	108	118	kHz
t_g	conducting time T1 and T2	$f_{\text{start}} = 108\text{ kHz}$	–	3.2	–	μs
$I_{CI(\text{charge})}$	charge current at pin CI	$V_{CI} = 1.5\text{ V}$; $V_{RS} = -0.3\text{ V}$	38	44	50	μA
$I_{CI(\text{discharge})}$	discharge current at pin CI	$V_{CI} = 1.5\text{ V}$; $V_{RS} = -0.9\text{ V}$	79	93	107	μA
t_{ph}	preheat time		599	666	733	ms
$I_{CP(\text{charge})}$	charge current at pin CP	$V_{CP} = 1\text{ V}$	–	6.0	–	μA
$I_{CP(\text{discharge})}$	discharge current at pin CP	$V_{CP} = 1\text{ V}$	–	5.95	–	μA
$\Delta V_{CP(\text{pk})}$	peak voltage difference at pin CP	when timing	–	2.5	–	V
$V_{RS(\text{ctrl})}$	control voltage at pin RS	note 3	–636	–600	–564	mV
Frequency sweep to ignition						
$I_{CI(\text{charge})}$	charge current at pin CI	$V_{CI} = 1.5\text{ V}$; $f \approx 85\text{ kHz}$	0.8	1.0	1.2	μA
f_B	bottom frequency	V_{CI} at clamp level	–	42.9	–	kHz
t_{ign}	ignition time		–	625	–	ms
Normal operation						
f_B	bottom frequency		42.21	42.90	44.59	kHz
t_g	conducting time T1 and T2	$f_B = 43\text{ kHz}$	–	10.2	–	μs
t_{no}	non-overlap conductance time		1.05	1.4	1.75	μs
I_{tot}	total supply current	$f_B = 43\text{ kHz}$; note 4	0.85	1.0	1.1	mA
$V_{RS(\text{cap})}$	capacitive mode control voltage	note 5	0	20	40	mV
V_{RREF}	reference voltage	note 6	2.425	2.5	2.575	V
$V_{G1(\text{on})}$	on voltage at pin G1	$ I_{G1} = 1\text{ mA}$	10.5	–	–	V
$V_{G1(\text{off})}$	off voltage at pin G1	$ I_{G1} = 1\text{ mA}$	–	–	0.3	V
$V_{G2(\text{on})}$	on voltage at pin G2	$ I_{G2} = 1\text{ mA}$	10.5	–	–	V
$V_{G2(\text{off})}$	off voltage at pin G2	$ I_{G2} = 1\text{ mA}$	–	–	0.3	V
$R_{G1(\text{on})}$	high side driver on resistance	$V_{(G1-S1)} = 3\text{ V}$; note 7	100	126	152	Ω

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$R_{G1(off)}$	high side driver off resistance	$V_{(G1 - S1)} = 3 \text{ V}$; note 7	60	75	90	Ω
$R_{G2(on)}$	low side driver on resistance	$V_{G2} = 3 \text{ V}$; note 7	100	126	152	Ω
$R_{G2(off)}$	low side driver off resistance	$V_{G2} = 3 \text{ V}$; note 7	60	75	90	Ω
V_{drop}	voltage drop at bootstrap switch	$I_{FS} = 5 \text{ mA}$	0.6	1.0	1.4	V
Feed-forward						
$R_{i(RHV)}$	input resistance at pin RHV		1.54	2.2	2.86	k Ω
$I_{i(RHV)}$	operating range of input current at pin RHV	note 8	0	–	1000	μA
f_{ff}	feed-forward frequency	$I_{RHV} = 0.75 \text{ mA}$	60.4	63.6	66.15	kHz
		$I_{RHV} = 1 \text{ mA}$	80.3	84.5	88.2	kHz
SYM_{ff}	symmetry	$I_{RHV} = 1 \text{ mA}$; note 9	0.9	1.0	1.1	
RR	ripple rejection	$f_{Vin} = 100 \text{ Hz}$	–	6	–	dB
$R_{CP(sw)}$	CP switch series resistance	$I_{CP} = 100 \mu\text{A}$	0.75	1.5	2.25	k Ω
R_{AV}	averaging resistor	$I_{CP} = 10 \mu\text{A}$	22.4	32	41.6	k Ω

Notes

1. The start-up supply current is specified in a temperature (T_{vj}) range of 0 to 125 °C. For $T_{vj} < 0$ and $T_{vj} > 125$ °C the start-up supply current is $< 350 \mu\text{A}$.
2. The clamp margin is defined as the voltage difference between turn-on of the clamp and start of oscillation. The clamp is in the off-state at start of oscillation.
3. Data sampling of $V_{RS(ctrl)}$ is performed at the end of conduction of T2.
4. The total supply current is specified in a temperature (T_{vj}) range of –20 to +125 °C. For $T_{vj} < -20$ and $T_{vj} > 125$ °C the total supply current is $< 1.5 \text{ mA}$.
5. Data sampling of $V_{RS(cap)}$ is performed at the start of conduction of T2.
6. Within the allowed range of R_{RREF} , defined as $30 \text{ k}\Omega \pm 10\%$.
7. Typical values for the on and off resistances at $T_{vj} = 87.5$ °C are: $R_{G2(on)}$ and $R_{G1(on)} = 164 \Omega$, $R_{G2(off)}$ and $R_{G1(off)} = 100 \Omega$.
8. The input current at pin RHV may increase to $1600 \mu\text{A}$ during voltage transient at V_{in} . Only for currents I_{RHV} beyond approximately $550 \mu\text{A}$ is the oscillator frequency proportional to I_{RHV} .
9. The symmetry SYM_{ff} is calculated from the quotient $SYM_{ff} = T1_{tot}/T2_{tot}$, with $T1_{tot}$ the time between turn-off of G2 and turn-off of G1, and $T2_{tot}$ the time between turn-off of G1 and turn-off of G2.

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DESIGN EQUATIONS

- Bottom frequency: $f_B = \frac{1}{2 \times \{[(C_{CF} + C_{par}) \times (X1 \times R_{RREF} - R_{int})] + \tau\}}$
- Feed-forward frequency: $f_{ff} = \frac{1}{2 \times \left\{ \left[(C_{CF} + C_{par}) \times \left(\frac{X2 \times V_{RREF}}{I_{i(RHV)}} - R_{int} \right) \right] + \tau \right\}}$

Where:

- $X1 = 3.68$
 - $X2 = 22.28$
 - $\tau = 0.4 \mu s$
 - $R_{int} = 3 k\Omega$
 - $C_{par} = 4.7 pF$
 - Operating frequency is the maximum of f_B , f_{ff} or f_{cm}
- Where:
- f_B = bottom frequency
 - f_{ff} = feed-forward frequency
 - f_{cm} = frequency due to capacitive mode detection

- Preheat time: $t_{ph} = \frac{C_{CP}}{150 nF} \times \frac{R_{RREF}}{30 k\Omega}$
- Ignition time: $t_{ign} = \frac{15}{16} \times t_{ph}$
- Non-overlap time: $t_{no} = 1.4 \mu s \times \frac{R_{RREF}}{30 k\Omega}$

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APPLICATION INFORMATION

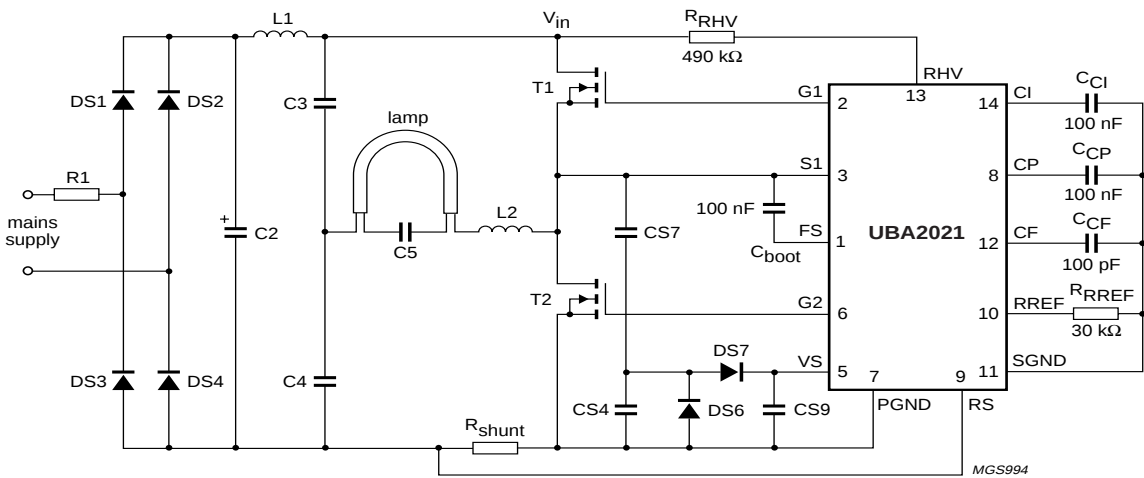


Fig.7 Application diagram.

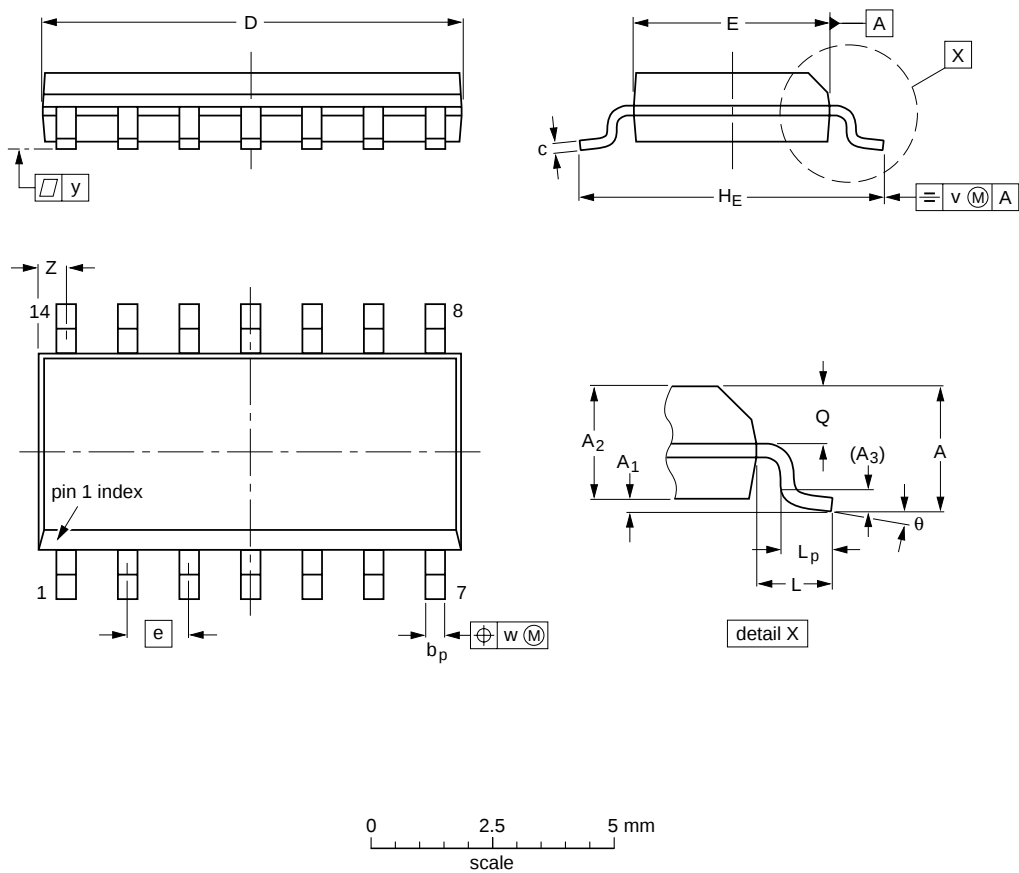
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PACKAGE OUTLINES

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

SOT108-1

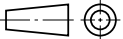


DIMENSIONS (inch dimensions are derived from the original mm dimensions)

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° 0°
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	0.050	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 maximum per side are not included.

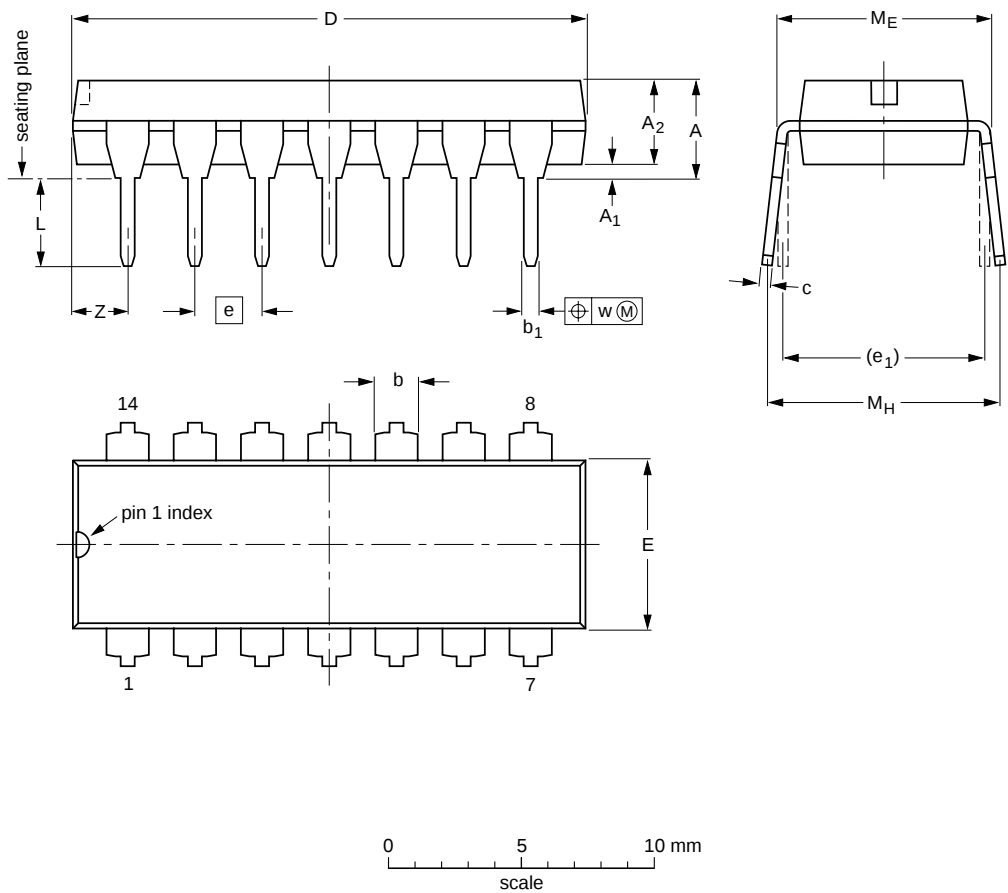
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT108-1	076E06	MS-012				97-05-22- 99-12-27

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

SOT27-1

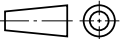


DIMENSIONS (inch dimensions are derived from the original mm dimensions)

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	0.020	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.10	0.30	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 maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT27-1	050G04	MO-001	SC-501-14			95-03-11- 99-12-27

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SOLDERING

Introduction

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mount components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Through-hole mount packages

SOLDERING BY DIPPING OR BY SOLDER WAVE

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joints for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ($T_{stg(max)}$). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

MANUAL SOLDERING

Apply the soldering iron (24 V or less) to the lead(s) of the package, either below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

Surface mount packages

REFLOW SOLDERING

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferably be kept below 230 °C.

WAVE SOLDERING

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

MANUAL SOLDERING

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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Suitability of IC packages for wave, reflow and dipping soldering methods

MOUNTING	PACKAGE	SOLDERING METHOD		
		WAVE	REFLOW ⁽¹⁾	DIPPING
Through-hole mount	DBS, DIP, HDIP, SDIP, SIL	suitable ⁽²⁾	–	suitable
Surface mount	BGA, LFBGA, SQFP, TFBGA	not suitable	suitable	–
	HBCC, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, SMS	not suitable ⁽³⁾	suitable	–
	PLCC ⁽⁴⁾ , SO, SOJ	suitable	suitable	–
	LQFP, QFP, TQFP	not recommended ⁽⁴⁾⁽⁵⁾	suitable	–
	SSOP, TSSOP, VSO	not recommended ⁽⁶⁾	suitable	–

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the “*Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods*”.
2. For SDIP packages, the longitudinal axis must be parallel to the transport direction of the printed-circuit board.
3. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
4. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
5. Wave soldering is only suitable for LQFP, QFP and TQFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
6. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

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DATA SHEET STATUS

DATA SHEET STATUS	PRODUCT STATUS	DEFINITIONS ⁽¹⁾
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product specification	Production	This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

Note

1. Please consult the most recently issued data sheet before initiating or completing a design.

DEFINITIONS

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Philips Semiconductors – a worldwide company

Argentina: see South America

Australia: 3 Figtree Drive, HOMEBUSH, NSW 2140,
Tel. +61 2 9704 8141, Fax. +61 2 9704 8139

Austria: Computerstr. 6, A-1101 WIEN, P.O. Box 213,
Tel. +43 1 60 101 1248, Fax. +43 1 60 101 1210

Belarus: Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6,
220050 MINSK, Tel. +375 172 20 0733, Fax. +375 172 20 0773

Belgium: see The Netherlands

Brazil: see South America

Bulgaria: Philips Bulgaria Ltd., Energoproject, 15th floor,
51 James Bourchier Blvd., 1407 SOFIA,
Tel. +359 2 68 9211, Fax. +359 2 68 9102

Canada: PHILIPS SEMICONDUCTORS/COMPONENTS,
Tel. +1 800 234 7381, Fax. +1 800 943 0087

China/Hong Kong: 501 Hong Kong Industrial Technology Centre,
72 Tat Chee Avenue, Kowloon Tong, HONG KONG,
Tel. +852 2319 7888, Fax. +852 2319 7700

Colombia: see South America

Czech Republic: see Austria

Denmark: Sydhavnsgade 23, 1780 COPENHAGEN V,
Tel. +45 33 29 3333, Fax. +45 33 29 3905

Finland: Sinikalliontie 3, FIN-02630 ESPOO,
Tel. +358 9 615 800, Fax. +358 9 6158 0920

France: 51 Rue Carnot, BP317, 92156 SURESNES Cedex,
Tel. +33 1 4099 6161, Fax. +33 1 4099 6427

Germany: Hammerbrookstraße 69, D-20097 HAMBURG,
Tel. +49 40 2353 60, Fax. +49 40 2353 6300

Hungary: Philips Hungary Ltd., H-1119 Budapest, Fehervari ut 84/A,
Tel: +36 1 382 1700, Fax: +36 1 382 1800

India: Philips INDIA Ltd, Band Box Building, 2nd floor,
254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025,
Tel. +91 22 493 8541, Fax. +91 22 493 0966

Indonesia: PT Philips Development Corporation, Semiconductors Division,
Gedung Philips, Jl. Buncit Raya Kav.99-100, JAKARTA 12510,
Tel. +62 21 794 0040 ext. 2501, Fax. +62 21 794 0080

Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. +353 1 7640 000, Fax. +353 1 7640 200

Israel: RAPAC Electronics, 7 Kehilat Saloniki St, PO Box 18053,
TEL AVIV 61180, Tel. +972 3 645 0444, Fax. +972 3 649 1007

Italy: PHILIPS SEMICONDUCTORS, Via Casati, 23 - 20052 MONZA (MI),
Tel. +39 039 203 6838, Fax +39 039 203 6800

Japan: Philips Bldg 13-37, Kohnan 2-chome, Minato-ku,
TOKYO 108-8507, Tel. +81 3 3740 5130, Fax. +81 3 3740 5057

Korea: Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL,
Tel. +82 2 709 1412, Fax. +82 2 709 1415

Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR,
Tel. +60 3 750 5214, Fax. +60 3 757 4880

Mexico: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905,
Tel. +9-5 800 234 7381, Fax +9-5 800 943 0087

Middle East: see Italy

Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. +31 40 27 82785, Fax. +31 40 27 88399

New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. +64 9 849 4160, Fax. +64 9 849 7811

Norway: Box 1, Manglerud 0612, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

Pakistan: see Singapore

Philippines: Philips Semiconductors Philippines Inc.,
106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI,
Metro MANILA, Tel. +63 2 816 6380, Fax. +63 2 817 3474

Poland: Al.Jerozolimskie 195 B, 02-222 WARSAW,
Tel. +48 22 5710 000, Fax. +48 22 5710 001

Portugal: see Spain

Romania: see Italy

Russia: Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,
Tel. +7 095 755 6918, Fax. +7 095 755 6919

Singapore: Lorong 1, Toa Payoh, SINGAPORE 319762,
Tel. +65 350 2538, Fax. +65 251 6500

Slovakia: see Austria

Slovenia: see Italy

South Africa: S.A. PHILIPS Pty Ltd., 195-215 Main Road Martindale,
2092 JOHANNESBURG, P.O. Box 58088 Newville 2114,
Tel. +27 11 471 5401, Fax. +27 11 471 5398

South America: Al. Vicente Pinzon, 173, 6th floor,
04547-130 SÃO PAULO, SP, Brazil,
Tel. +55 11 821 2333, Fax. +55 11 821 2382

Spain: Balmes 22, 08007 BARCELONA,
Tel. +34 93 301 6312, Fax. +34 93 301 4107

Sweden: Kottbygatan 7, Akalla, S-16485 STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Switzerland: Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. +41 1 488 2741 Fax. +41 1 488 3263

Taiwan: Philips Semiconductors, 5F, No. 96, Chien Kuo N. Rd., Sec. 1,
TAIPEI, Taiwan Tel. +886 2 2134 2451, Fax. +886 2 2134 2874

Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd.,
60/14 MOO 11, Bangna Trad Road KM. 3, Bangna, BANGKOK 10260,
Tel. +66 2 361 7910, Fax. +66 2 398 3447

Turkey: Yukari Dudullu, Org. San. Blg., 2.Cad. Nr. 28 81260 Umraniye,
ISTANBUL, Tel. +90 216 522 1500, Fax. +90 216 522 1813

Ukraine: PHILIPS UKRAINE, 4 Patrice Lumumba str., Building B, Floor 7,
252042 KIEV, Tel. +380 44 264 2776, Fax. +380 44 268 0461

United Kingdom: Philips Semiconductors Ltd., 276 Bath Road, Hayes,
MIDDLESEX UB3 5BX, Tel. +44 208 730 5000, Fax. +44 208 754 8421

United States: 811 East Arques Avenue, SUNNYVALE, CA 94088-3409,
Tel. +1 800 234 7381, Fax. +1 800 943 0087

Uruguay: see South America

Vietnam: see Singapore

Yugoslavia: PHILIPS, Trg N. Pasica 5/v, 11000 BEOGRAD,
Tel. +381 11 3341 299, Fax. +381 11 3342 553

For all other countries apply to: Philips Semiconductors,
Marketing Communications, Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN,
The Netherlands, Fax. +31 40 27 24825

Internet: <http://www.semiconductors.philips.com>

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Printed in The Netherlands

613502/02/pp20

Date of release: 2001 Jan 30

Document order number: 9397 750 07752

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