照明电器专题

一种低成本23 W紧凑型荧光灯电子镇流器

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摘 要 UBA2025是一种将振荡器、控制电路、两个高/低端驱动器以及两个半桥功率开关MOSFET集成在同一芯片上的功率集成电路（IC），在应用中仅需外加少量元件，就可以组成简单、低成本5～25 W的紧凑型荧光灯（CFL）镇流器，并提供灯丝预热和保护功能，预热频率、预热时间、点灯时间和正常点燃频率可由IC外部元件设定。

关键词 功率集成电路（UBA2025） 紧凑型荧光灯（CFL） 镇流器 功率集成电路（IC） 预热 保护

0 概述

在上个世纪80年代问世的节能灯（如2U型、3U型、螺旋型等），都属于紧凑型荧光灯（Compact Fluoresceng Lamp，CFL）。所谓电子节能，是指节能型CFL与配套电子镇流器一体化的新型灯具。

早期的CFL电子镇流器采用分立元器件制作，典型电路如图1所示。该电路的直流/交流（DC/AC）逆变器，是半桥式拓结构。两个双极型功率晶体管（BJT），构成半桥功率开关。R_1、C_2和双向二极管VD2，是半桥逆变器的振荡启动电路。一旦电路启动，晶体管像开关一样，轮流导通，将DC高压（约300 V）转换成25～45 kHz的交流高频信号，为CFL供电。

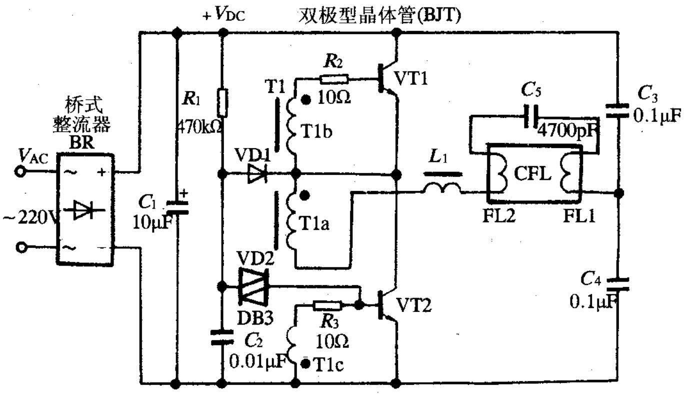

图1 由分立元器件组成的基本CFL镇流器电路

图1所示的CFL电子镇流器电路优点是电路简简，成本较低，但需要一个带三个绕组（T1a、T1b和T1c）的铁氧体磁环变压器，开关频率不能准确设定，也不带灯丝预热和保护功能。

到20世纪90年代中期，CFL镇流器专用控制功率集成电路（IC）大量出现，这些IC用来驱动半桥中的两个功率MOSFET开关（VT1和VT2），如图2所示。

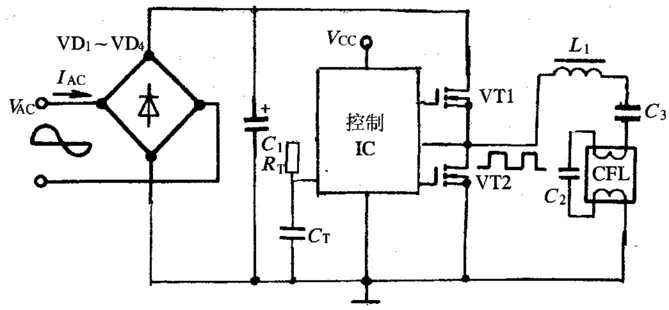

图2 采用控制IC的CFL镇流器电路

采用控制IC的CFL镇流器电路，不再需要磁环脉冲变压器（如图1中的T1）。开关频率可由阻容元件（如图2中的R_T和C_T）设定，而且还可以带灯阴极预热和保护功能。对灯丝预热，通常是输出较高的一个频率来实现的。一旦灯点亮，对工作在45 kHz左右的一个较低频率上。

CFL镇流器控制器之所以选择驱动半桥中的两个作为开关使用的功率MOSFET，是由于MOSFET有着优良的耐高温特性和较大的安全工作区，不存在BJT固有的二次击穿现象，十分坚固耐用。MOSFET是金属—氧化物—半导体场效应晶体管的简称，它有三个电极，即栅极（G）、漏极（D）和源极（S），相应于普通BJT的基极（B）、集电极（C）和发射极（E）。BJT是一种电流驱动器件，而MOSFET是一种电压驱动器件。

进入21世纪以来，将CFL镇流器控制器和两个半桥功率MOSFET集成在一起的功率IC不断推出，由飞利浦半导体创建的某公司不久前推出的UBA2025功率集成电路IC，就是最新代表性器件之一。

1 功率集成电路（UBA2025）结构与特点

1.1 封装与引脚功能

UBA2025采用16引脚塑料小外形（Small Outline，

SO）封装，引脚排列如图3所示。

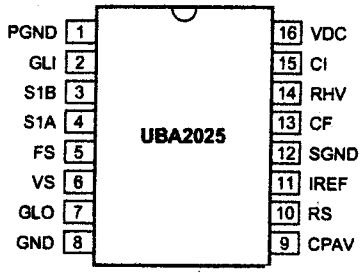

图3 UBA2025引脚排列

UBA2025的各个引脚功能见表1。

表1 UBA2025引脚功能

引脚号	引脚符合	功能描述
1	PGND	功率地，低端(LS)MOSFET源极
2	GLI	低端MOSFET(T2)栅极，必须连接到GLO
3	S1B	半桥中间点，低端MOSFET(T2)漏极
4	S1A	半桥中间点，必须连接到引脚S1B
5	FS	浮置电源端，自举电路经该端为高端驱动器加电
6	VS	IC电源施加端
7	GLO	低端驱动器输出，必须连接到引脚GLI
8	GND	芯片焊盘地
9	CPAV	连接预热电容器
10	RS	电流检测输入
11	IREF	连接参考电阻
12	SGND	信号地
13	CF	连接振荡器电容
14	RHV	启动和前馈输入
15	CI	连接积分电容
16	VDC	高压电源输入

1.2 芯片电路结构及其主要特点

UBA2025集成了电源电路(含2.5 V的参考电压)、电流控制振荡器、控制电路（其中包括电流监控、计时、非重迭时间产生器和电平移位器）、半桥高端驱动器和低端驱动器以及两个半桥功率MOSFET（T1和T2），其芯片电路结构如图4所示。

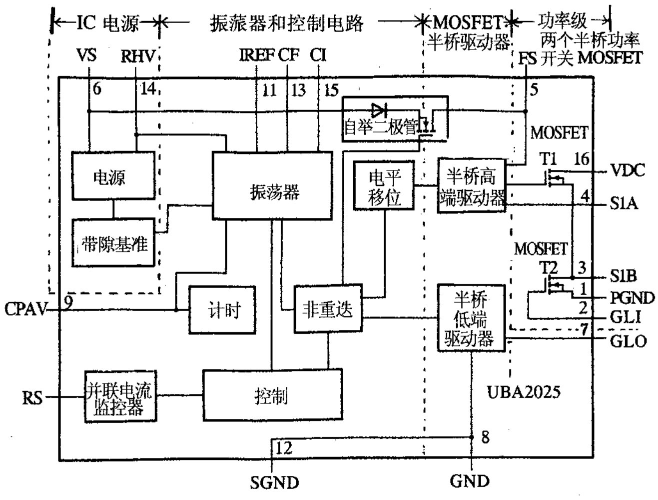

图4 UBA2025芯片电路

UBA2025中的两个N沟道MOSFET的耐压达600 V，导通态电阻$R_{DS(on)} \leqslant 3\,\Omega$（典型值是2.7 Ω）。在稳态时半桥电流达280 mA，在灯触发（亦称引燃或点灯）时半桥电流达1.5 A，可用来驱动5～25 W的节能灯。UBA2025的预热频率、预热时间、灯引燃时间和正常点燃频率均可由外部阻容元件来设定，并对灯温应力、电容性模式和MOSFET驱动电压过低等提供保护。

2 采用UBA2025的23 W CFL镇流器

由UBA2025组成的23 W CFL电子镇流器电路如图5所示。这种镇流器的AC输入电压是220 V，所驱动的灯管为E27 CFL/23 W。

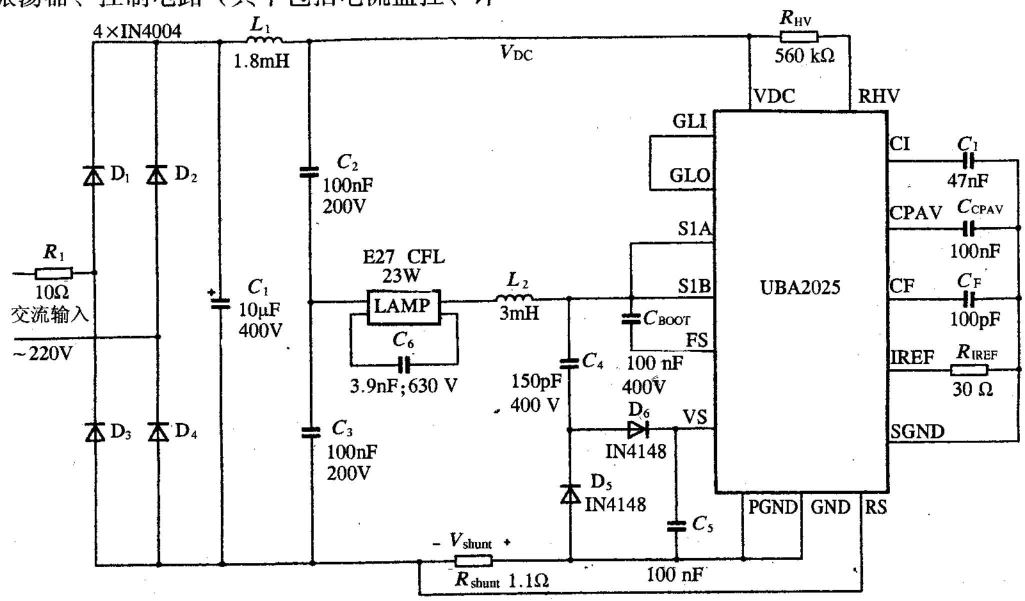

图5 基于UBA2025的CFL镇流器电路

2.1 电路工作原理

2.1.1 IC电源与启动

接通220 V的A C电源，经D_1～D_4桥式整流和电感L_1、电容C_1滤波，产生约330 V（$220\sqrt{2}$V）的DC高压V_{DC}。输入端上连接的R_1，是浪涌限制电阻（也可以为保险电阻）。通过启动电阻R_{HV}的电流以IC引脚RHV流入，经内部一个二极管（在图4中未给出）后，从IC引脚VS流出，对电容C_5充电。只要引脚VS上的电压达到启动门限电平（12 V），电路就会开始振荡。一旦IC启动，引脚VS则由电容C_4和二极管D_5、D_6组成的电荷泵供电。电荷泵的工作原理可以这样理解：IC在引脚S1A/S1B输出的占空比为50%的高频方波，经电容C_4耦合和二极管高速整流及电容C_5滤波，产生约12 V的DC电压为IC供电。这样就可以使启动电阻R_{HV}上的功率损耗大大减小，从而允许使用0.25 Ω的电阻，并有助于提升系统效率。

IC中的高端驱动器由自举电容C_{BOOT}供电。在IC中低端驱动器驱动低端MOSFET（图4中的T2）导通时，V_{VS}电压经IC内的自举二极管及开关（MOSFET）对IC引脚FS与S1A/S1B之间的外部电容C_{BOOT}充电。一旦C_{BOOT}上的充电电压达到高端驱动器启动门限，高端驱动器就驱动上部的MOSFET（T1）导通。在T1导通期间，C_{BOOT}放电，直到高端驱动器因电压太低关断。在T1关断时，T2则又开始导通。T1和T2轮流导通，产生占空比为50%的高频方波输出。

2.1.2 工作时序

IC启动后，振荡器在起始（最高）频率上f_{start}开始振荡，进入预热阶段。电流控制振荡器产生锯齿波V_{CF}（见图6），锯齿波频率由IC引脚CF外部电容C_F确定。IC中驱动器驱动T1和T2交替导通，非交迭（即死区）时间电路在T1和T2不导通时产生一个非重叠时间t_{no}，其值由IC引脚IREF外部的参考电阻R_{IREF}设定，计算公式是：

$$t_{no}=1.4\ \mu s\times\frac{R_{IRFF}}{30k\Omega} \quad (1)$$

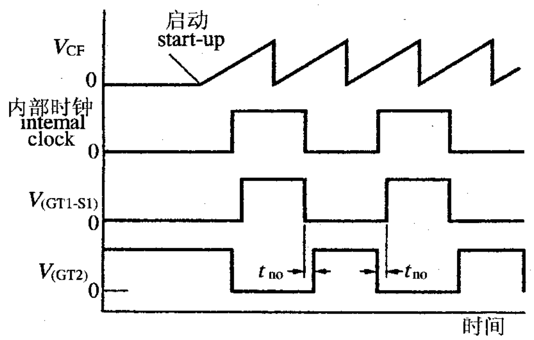

图6 振荡器相关电压波形

振荡器在f_{start}频率上开始振荡，尔后频率迅速降至预热频率f_{ph}，如图7所示。频率下降斜率由IC引脚CI外部电容C_1设定。起始振荡频率f_{start}可按照（2）式来进行计算：

$$f_{start}=2.5\times\frac{1}{2\times[(C_F+4.7pF)\times(3.68\times R_{IREF}-3k\Omega)+0.4\mu s} \quad (2)$$

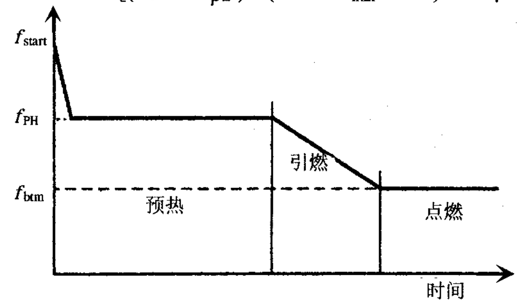

图7 预热、引燃和点燃时的频率

在预热期间，有一个高频电流通过CFL灯丝，对其加热。灯丝预热的目的是延长灯管寿命，并降低灯管启动（即引燃）电压。预热时间t_{ph}由IC引脚CPAV外部电容C_{CPAV}和参考电阻R_{IREF}设定：

$$t_{ph}=\frac{C_{CPAV}}{150\,nF}\times\frac{R_{IRFF}}{30\,k\Omega}\ (s) \quad (3)$$

在预热期间，利用R_{SHUNT}来检测负载电流。如果IC引脚RS上的电压V_{RS}大于电阻R_{SHUNT}上的电压降V_{shunt}，频率则减小；如果$V_{RS}<V_{shunt}$，频率就会升高。

一旦预热结束，即进入灯引燃阶段，频率从f_{ph}向底部点燃频率f_{btm}向下偏移。当频率通过由L_2和C_6等决定的负载谐振频率时，则发生串联谐振，在电容C_6上产生一个600～1200 V的高电压将灯管击穿而点亮。灯引燃时间t_{ign}的计算公式是：

$$t_{ign}=\frac{15}{16}\times t_{ph}\ (s) \quad (4)$$

灯被点亮后，在最低频率f_{btm}上工作，f_{btm}为f_{start}的40%，即

$$f_{btm}=0.4\ f_{start} \quad (5)$$

2.1.3 保护

在常态下，电路在零电压开关（ZVS）操作，从而使MOSFET（T1和T2）有最小的开关损耗。如果功率级电路脱离ZVS并进入或太接近电容性模式，流过MOSFET的电流将增大，结温也会升高，易使器件损坏。UBA2025能够检测电容性模式，使频率降至前馈（feed forward）频率，对电容性模式进行保护。

在AC线路电压较高时，UBA2025对灯温应力也提供保护。此外，IC还对内部MOSFET（T1/T2）的驱动电压过低提供保护。

UBA2025在引脚VDC上的电压高达556 V，IC结温和环境温度范围达-40℃～+150℃。

2.1.4 主要参数计算

在图5中，R_{IREF}=30 kΩ，C_F=100 pF，C_{CPAV}=100 nF，

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据此可以计算频率和时间参数。根据 (2) 式可以计算振荡器初始频率 f_{start}：

$$f_{start}=2.5\times\frac{1}{2\times[(100\ \text{pF}+4.7\ \text{pF})\times(3.68\times30\ \text{k}\Omega-3\ \text{k}\Omega)+0.4\ \mu\text{s}]}\approx108\ \text{kHz} \qquad (6)$$

正常点燃频率 f_{btm} 利用（5）式计算：

$$f_{btm}=0.4\ f_{start}=0.4\times108\ \text{kHz}\approx43\ \text{kHz} \qquad (7)$$

预热频率 f_{ph} 约为 f_{btm} 的 2.09 倍，即

$$f_{ph}=2.09\times f_{btm}=2.09\times43\ \text{kHz}\approx90\ \text{kHz} \qquad (8)$$

灯丝预热时间 t_{ph} 利用（3）式计算：

$$t_{ph}=\frac{100\ \text{nF}}{150\ \text{nF}}\times\frac{30\ \text{k}\Omega}{30\ \text{k}\Omega}\approx0.67\ \text{s} \qquad (9)$$

灯管点灯时间利用（4）式计算：

$$t_{ign}=\frac{15}{16}\times t_{ph}=\frac{15}{16}\times0.67\ \text{s}=0.63\ \text{s} \qquad (10)$$

3 结束语

对节能CFL电子镇流器的基本要求是使用寿命不低于灯管寿命、电路简单、成本低、可靠性高、并具有灯预热启动。基于 UBA2025 的 CFL 镇流器，符合上述这些基本要求。

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UBA2025

CFL power IC

Rev. 01 — 16 October 2009 Product data sheet

1. General description

The UBA2025 is a high voltage power IC intended to drive and control a Compact Fluorescent Lamp (CFL). It contains a half bridge power circuit, an oscillator, and a control circuit for starting up, preheating, ignition, lamp burning, and protection.

2. Features

- Two internal 600 V, 3 Ω max NMOST half bridge powers
- For steady state half bridge currents up to 280 mA
- For ignition half bridge currents up to 1.5 A
- Adjustable preheat and ignition time
- Adjustable preheat current
- Adjustable lamp power
- Lamp temperature stress protection at higher mains voltages
- Capacitive mode protection
- Protection against too low a drive voltage for the power MOSFETs.

3. Applications

- 5 W to 25 W CFLs provided that the maximum junction temperature is not exceeded.

4. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
UBA2025T	SO16L	plastic small outline package; 16 leads; body width 7.5 mm	SOT162-1

5. Block diagram

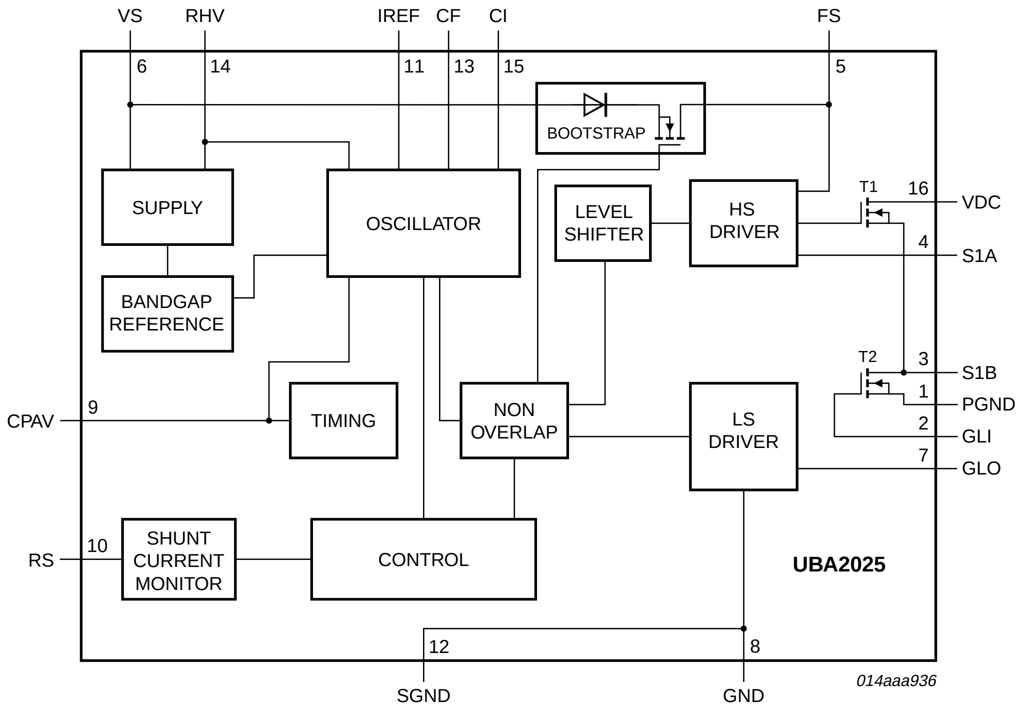


Fig 1. Block diagram

6. Pinning information

6.1 Pinning

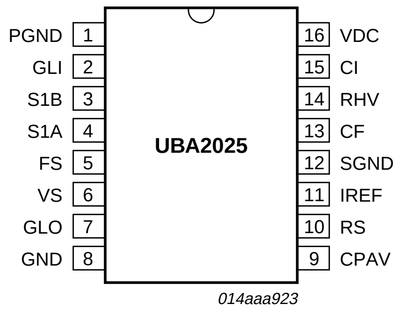


Fig 2. Pin assignment

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
PGND	1	power ground
GLI	2	LS gate power MOSFET, must be connected to GLO
S1B	3	half bridge point, must be connected to S1A
S1A	4	half bridge point, must be connected to S1B
FS	5	floating supply
VS	6	IC supply
GLO	7	LS driver output, must be connected to GLI
GND	8	diepad ground
CPAV	9	preheat and averaging capacitor
RS	10	current monitoring input
IREF	11	reference resistor
SGND	12	signal ground
CF	13	oscillator capacitor
RHV	14	start-up/feed forward input
CI	15	integrating capacitor
VDC	16	high voltage power input

7. Functional description

7.1 Introduction

The IC is an integrated circuit for electronically ballasted compact fluorescent lamps and its derivatives, up to a nominal mains voltage of 230 V (RMS). It provides all the necessary functions for proper preheat, ignition and on-state operation of the lamp. Besides the control function, the IC provides the level shift and drive for the two internal power MOSFETs.

7.2 Initial start-up

Initial start-up is achieved by charging CS9 (see Figure 6) with the current applied to pin RHV. The start-up of the circuit is such that (see Figure 1) T2 shall be conductive and T1 shall be non-conductive, in order to make sure that C_{BOOT} gets charged. This start-up state is reached for a supply voltage V_{rst}, 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 $V_{startup}$.

7.3 Oscillation

If the low voltage supply (V_{VS}) has reached the value of $V_{startup}$ 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 CF and the current out of pin CF (mainly set by R_{IREF}). The sawtooth frequency is twice the frequency of the signal across the load. The IC brings alternately the power MOSFETs T1 and T2 into conduction with a duty cycle of approximately 50%. Figure 3 represents the timing of the IC. The circuit block 'non-overlap' generates a non-overlap time t_{no} when T1 and T2 are not conducting. This is dependent on the reference current.

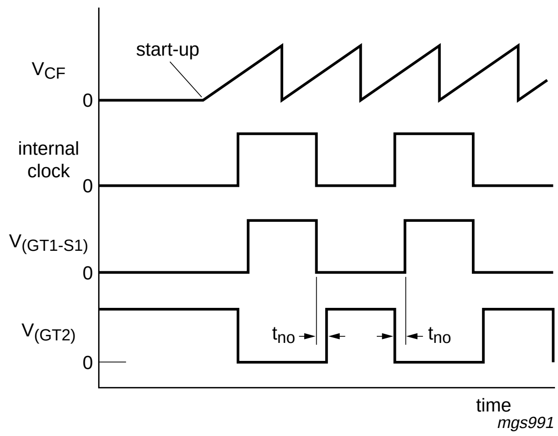


Fig 3. Oscillator timing

7.4 Operation in preheat mode

The circuit starts oscillating at a frequency of approximately $2.5f_{btm}$ (108 kHz). The frequency will gradually decrease until a defined value of the current through R_{SHUNT} is reached (see Figure 4). The slope of the decrease in frequency is determined by the capacitor connected to pin CI. The frequency during preheating will be 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 (see Figure 6). The preheat time is determined by the capacitor connected to pin CPAV. The circuit can be locked in the preheat state by connecting pin CPAV 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_{shunt}. The frequency is decreased as long as $V_{RS} > V_{shunt}$. The frequency is increased for $V_{RS} < V_{shunt}$.

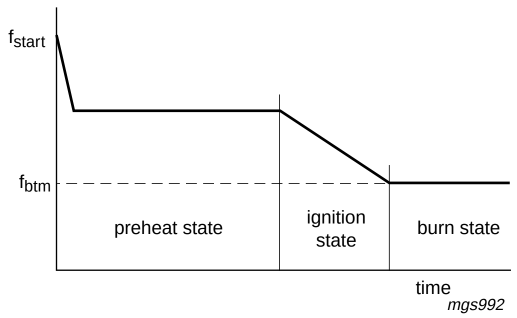


Fig 4. Operation in preheat mode

7.5 Ignition state

The RS current monitoring function changes from V_{shunt} 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_{btm} (approximately 43 kHz). The frequency change per ms is lowered with respect to the frequency change in the preheat mode. During the downward frequency sweep the circuit sweeps through the resonant frequency of the load. A high voltage will then appear across the lamp. This voltage will normally ignite the lamp.

7.6 Failure to ignite

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

7.7 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:

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

The bottom frequency is determined by resistor R_{IREF} and capacitor CF.

7.8 Feed forward frequency

Above a defined voltage level at pin VDC the oscillation frequency also depends on the supply voltage of the half bridge (see Figure 5). The current for the current controlled oscillator is in this feed forward range and is derived from the current through R_{HV} (this is similar to pin RHV current). The feed forward frequency is proportional to the average value of the current (within its operating range) through R_{HV}. The feed forward frequency is clamped for currents beyond the operating range (i.e. between 1.0 mA and 1.6 mA). In order to prevent feed forward of the ripple on the input voltage on pin VDC, the ripple is filtered out. The capacitor connected to pin CPAV 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}).

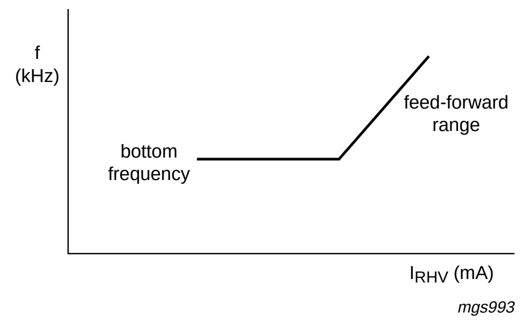


Fig 5. Feed forward frequency

7.9 Capacitive mode

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 the voltage across R_{SHUNT}. If the voltage at pin RS is below $V_{th(capm)}$ the capacitive mode threshold voltage at the time of turn-on of T2, then capacitive mode operation is assumed. Consequently, the frequency will be increased 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.

7.10 IC supply

Initially, the IC is supplied from the bus voltage VDC by the current through R_{HV}. This current charges the supply capacitor CS9 via an internal diode. As soon as VS exceeds $V_{startup}$, the circuit starts oscillating. After the preheat phase is finished, pin RHV is connected to an internal resistor (R_{RHV}); prior to this the pin is internally connected to pin VS. The voltage level at pin RHV thus drops from (VS + V_d) to a voltage equal to the RHV pin current × R_{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 the clamp voltage (V_{clamp}) on pin VS.

7.11 Minimum gate source voltage of T1 and T2

The high side driver is supplied via capacitor C_{BOOT}. C_{BOOT} is charged via the bootstrap switch during the on-periods of T2. The IC stops oscillating at a voltage level V_{stop}. Given a maximum charge consumption on the gate of T1 (G1) of 1 nC/V, this safeguards the minimum drive voltages $V_{(G1-S1)}$ for the high side driver; see Table 3.

Table 3. Minimum gate voltages

Frequency	Voltage
< 75 kHz	8 V (min.)
75 kHz to 80 kHz	7 V (min.)
> 85 kHz	6 V (min.)

The drive voltage at gate of T2 (G2) will exceed the drive voltage of the high side driver.

7.12 Frequency and change in frequency

At any point in time during oscillation, the circuit will operate between f_{btm} 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 a 100 nF connected to pin CI):

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

7.13 Ground pins

Pin PGND and pin GND are the ground references of the IC with respect to the application. Pin SGND provides a local ground reference for the components connected to pins CPAV, CI, IREF and CF. Other external connections to pin SGND are not preferred. The sum of currents flowing out of the pins CPAV, CI, IREF, CF and SGND must remain zero at any time. Pin GND is internally connected to SGND.

7.14 Charge coupling

Due to parasitic capacitive coupling to the high voltage circuitry, all pins are exposed to a repetitive charge injection. Given the typical application in figure 6, the pins IREF and CF are sensitive to this charge injection. For the rating Q_{coup} a safe functional operation of the IC is guaranteed, independent of the current level. Charge coupling at current levels below 50 µA will not interfere with the accuracy of the $V_{th(capm)}$ and V_{shunt} levels. Charge coupling at current levels below 20 µA will not interfere with the accuracy of any parameter.

8. Limiting values

Table 4. Limiting values

Symbol	Parameter	Conditions		Min	Max	Unit
$V_{i(VDC)}$	input voltage on pin VDC	operating		-	556	V
		during 0.5 s		-	600	V
V_{FS}	voltage on pin FS	operating, with respect to S1A and S1B		-	14	V
		during 0.5 s, with respect to S1A and S1B		-	17	V
I_{clamp}	clamp current	during 0.5 s		-	35	mA
I_D	drain current	on T1; pulsed; t_p limited by $T_{j(max)}$; $T < T_{j(max)}$		-	1.5	A
		on T2; pulsed; t_p limited by $T_{j(max)}$; $T < T_{j(max)}$		-	1.5	A
V_I	input voltage	on pin RS; transient of 50 ns		–2.5	+2.5	V
		on pin RS; operating normaly		–1.5	+2.5	V
SR	slew rate	pins S1A and S1B with respect to GND		–4	+4	V/ns
T_{amb}	ambient temperature			–40	+150	°C
T_j	junction temperature			–40	+150	°C
T_{stg}	storage temperature			–55	+150	°C
Q_{coup}	coupling charge	at pins IREF and CF; normal operation		–8	+8	pC
V_{ESD}	electrostatic discharge voltage	human body model	[1]			
		pins 1, 8, 9, 10, 11, 12, 13, 14, 15		-	3000	V
		pin 4, 5, 6		-	1500	V
		pin 7		-	1000	V
		pin 2, 3, 16		-	< 500	V
		machine model	[2]			
		pins 1, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16		-	250	V
		pin 2		-	200	V
		pin 7		-	<125	V

[1] Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

[2] Equivalent to discharging a 200 pF capacitor through a 0.75 µH coil and a 10 Ω resistor.

9. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air; SO16L package	80	K/W

10. Characteristics

Table 6. Characteristics

T_{amb} = 25 °C; voltage on pin VS = 11 V; V_{FS} – S1A and S1B voltage= 11 V, GLI and GLO voltage measured with respect to PGND; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
High voltage supply							
I_{leak}	leakage current	high voltage pins		-	-	10	µA
Start-up state							
V_{rst}	reset voltage			4.0	5.5	6.5	V
$V_{startup}$	start-up voltage			11.35	11.95	12.55	V
V_{stop}	stop voltage			9.55	10.15	10.75	V
V_{hys}	hysteresis voltage			1.5	1.8	2.0	V
I_{stb}	standby current	on pin VS	[1]	150	200	250	µA
$V_{(RHV-VS)}$	voltage difference pin RHV and pin VS	RHV pin current = 1.0 mA		0.7	0.8	1.0	V
$\Delta V_{clamp(startup)}$	start-up clamp voltage difference		[2]	0.2	0.3	0.4	V
I_{clamp}	clamp current	VS pin voltage < 17 V		-	14	35	mA
Preheat mode							
f_{start}	start frequency	CI pin voltage = 0 V		98	108	118	kHz
t_g	conduction time	T1; T2; f_{start} = 108 kHz		-	3.2	-	µs
I_{ch}	charge current	on pin CI; pin CI voltage = 0 V; pin RS voltage = –0.3 V		38	44	50	µA
		on pin CPAV; pin CPAV voltage = 1 V		-	6.0	-	µA
I_{dch}	discharge current	on pin CI; pin CI voltage = 0 V; pin RS voltage = –0.9 V		79	93	107	µA
		on pin CPAV; pin CPAV voltage= 1 V		-	5.95	-	µA
t_{ph}	preheat time			599	666	733	µs
$\Delta V_{M(CPAV)}$	peak voltage difference on pin CPAV	measured during preheat timing		-	2.5	-	V
V_{ctrl}	control voltage	at pin RS	[3]	–636	–600	–564	mV
Frequency sweep to ignition							
I_{ch}	charge current	on pin CI; CI pin voltage = 1.5 V; f = 85 kHz		0.8	1	1.2	µA
f_{btm}	bottom frequency	pin CI voltage at clamp level		-	42.9	-	kHz
t_{ign}	ignition time			-	625	-	ms
Normal operation							
f_{btm}	bottom frequency	V_{ctrl} < 1 V		42.21	42.90	44.59	kHz
t_g	conduction time	for T1 and T2; f_{btm} = 43 kHz		-	10.2	-	µs
t_{no}	non-overlap time			1.05	1.4	1.75	µs
I_{tot}	total current	for supply; f = 43 kHz		-	-	1.6	mA
V_{ctrl}	control voltage	for capacitive mode control	[4]	0	20	40	mV
V_{ref}	reference voltage		[5]	2.425	2.5	2.575	V
R_{on}	on-state resistance	half bridge power		-	-	3	Ω

Table 6. Characteristics *...continued*

T_{amb} = 25 °C; voltage on pin VS = 11 V; V_{FS} – S1A and S1B voltage= 11 V, GLI and GLO voltage measured with respect to PGND; currents are positive when flowing into the IC; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$R_{on(150)}/R_{on(25)}$	on-state resistance ratio (150 °C to 25 °C)			-	2.7	-	
$V_{Fd(bs)}$	bootstrap diode forward voltage	I_{FS} = 5 mA		0.6	1.0	1.4	V
feed forward							
$R_{i(RHV)}$	input resistance on pin RHV			1.54	2.2	2.86	kΩ
$I_{i(RHV)}$	input current on pin RHV	during normal operation	[6]	0		1	mA
f_{ff}	feed forward frequency	pin RHV current = 0.75 mA		60.4	63.6	66.15	kHz
		pin RHV current = 1 mA		80.3	84.5	88.2	kHz
$f_{ff(ratio)}$	feed forward frequency ratio	pin RHV current = 1 mA	[7]	0.9	1.0	1.1	
R_s	series resistance	CPAV switch; pin CPAV current = 100 µA		0.75	1.5	2.25	kΩ
R_{CPAV}	resistance on pin CPAV	used with C_{CPAV} for averaging; CPAV pin current = 10 µA		22.4	32	41.6	kΩ

[1] The start-up supply current is specified in a temperature (T_{vj}) range of 0 °C to 125 °C. For T_{vj} < 0 °C and T_{vj} > 125 °C the start-up supply current is < 350 µA.

[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 $V_{th(capm)}$ is performed at the end of conduction of T2.

[4] Data sampling of $V_{th(capm)}$ is performed at the start of conduction of T2.

[5] Within the allowed range of R_{IREF}, defined as 30 kΩ +10%.

[6] The input current at pin RHV may increase to 1.6 mA during voltage transient on pin VDC. Only for pin RHV currents beyond approximately 550 mA the oscillator frequency is proportional to the pin RHV current.

[7] The symmetry is best calculated using $f_{ff(ratio)}$ where $f_{ff(ratio)}$ = T1 total time divided by the T2 total time with the T1 total time the time between turn-off of G2 and turn-off of G1, and the T2 total time the time between turn-off of G1 and turn-off of G2.

11. Application information

11.1 Design equations

- Bottom frequency:

$$f_{btm} = \frac{1}{2 \times [(C_f + C_{par}) \times (X1 \times R_{IREF} - R_{int})] + t}(Hz)$$

- Feed forward frequency:

$$f_{ff} = \frac{1}{2 \times \left[(C_f + C_{par}) \times \left(\frac{X2 \times V_{ref} \times R_{HV}}{V_{i(VDC)}} - R_{int}\right)\right] + t}(Hz)$$

Where:

- X1 = 3.68
- X2 = 22.28
- t = 0.4 µs
- R_{int} = 3 kΩ
- C_{par} = 4.7 pF
- V_{ref} = 2.5 V
- $V_{i(VDC)}$ = 300 V (nominal)
- R_{HV} = 560 KΩ (see Figure 6)

- Operating frequency = $f_{btm(max)}$, $f_{ff(max)}$, and $f_{cm(max)}$

Where:

- f_{btm} = bottom frequency
- $f_{ff(max)}$ = maximum feed forward frequency
- $f_{cm(max)}$ = maximum frequency due to capacitive mode detection

- Preheat time:

$$t_{ph} = \frac{C_{CP}}{150\ nF} \times \frac{R_{ref}}{30\ k\Omega}(s)$$

- Ignition time:

$$t_{ign} = \frac{15}{16} \times t_{ph}(s)$$

- Non-overlap time:

$$t_{no} = 1.4\ \mu s \times \frac{R_{ref}}{30\ k\Omega}$$

11.2 Application diagram

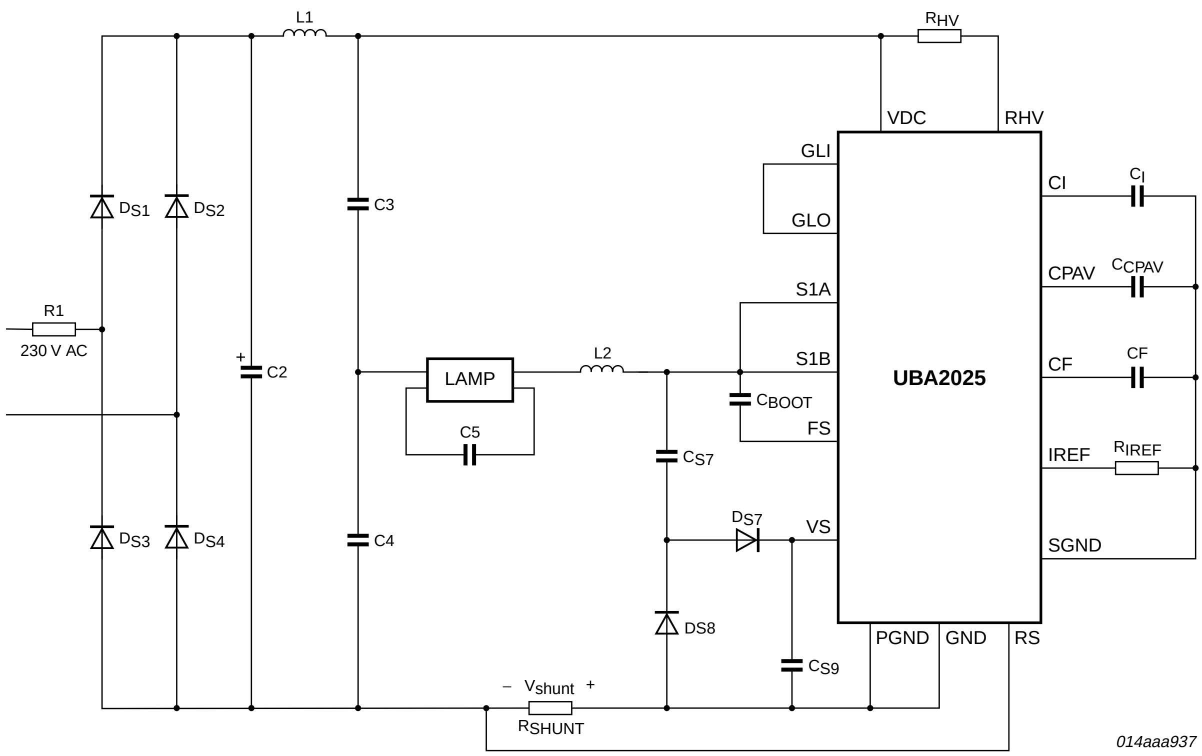


Fig 6. 23 W CFL application diagram

Table 7. 23 W CFL application component values

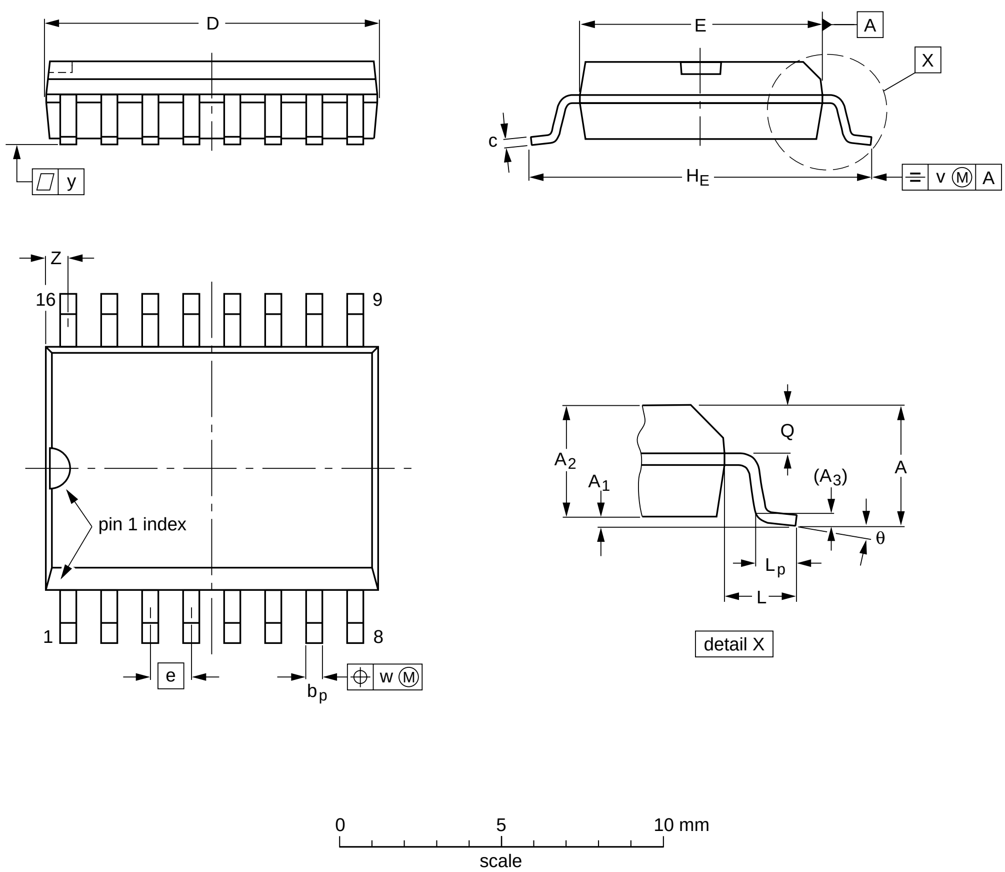
Component type	Component name	Value	Description
diodes	DS1-DS4	IN4007	bridge rectifier
	DS7, DS8	IN4148	limiting and charge pump
resistors	R1	10 Ω	inrush or fusistor
	R_{IREF}	30 kΩ	reference
	R_{HV}	560 kΩ	start-up and feed forward frequency
	R_{SHUNT}	1.1 Ω	sensing (2 W)
inductors	L1	1.8 mH	input mains filter
	L2	3 mH	resonant
capacitors	C2	5.6 μH; 400 V	mains buffer
	C3, C4	100 nF; 200 V	DC blocking
	C5	3.9 nF; 630 V	resonant
	C_I	47 nF	integrating
	C_{CPAV}	100 nF	preheat and averaging
	CF	100 pF	internal reference oscillator
	C_{BOOT}	100 nF; 400 V	bootstrap
	CS7	150 pF; 400 V	charge pump and dv/dt limiting

Table 7. 23 W CFL application component values

Component type	Component name	Value	Description
capacitor	CS9	100 nF	decoupling
CFL	E27 CFL	23 W	CFL E27 type, 23 W
IC	UBA2025T	SO16L, SOT162-1	control IC with integrated power MOSFETs

12. Package outline

SO16: plastic small outline package; 16 leads; body width 7.5 mm **SOT162-1**



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	2.65	0.3 0.1	2.45 2.25	0.25	0.49 0.36	0.32 0.23	10.5 10.1	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8^o 0^o
inches	0.1	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.41 0.40	0.30 0.29	0.05	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

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			
SOT162-1	075E03	MS-013				~~99-12-27~~ 03-02-19

Fig 7. Package outline SOT162-1 (SO16)

13. Abbreviations

Table 8. Abbreviations

Acronym	Description
CFL	Compact Fluorescent Lamp
NMOST	Negative Channel Metal-Oxide Semiconductor
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistors
LS	Low Side

14. Revision history

Table 9. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
UBA2025_1	20091016	Product 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".

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