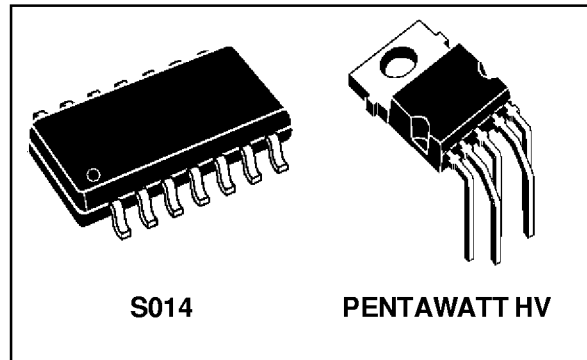


DESCRIPTION

The EFS Kit is a 2 chips set used with 4 additional passive components as direct replacement of the Glow switch Starter.

The ASD™ (Application Specific Discretes) includes a bi-directional Power Switch and a Power Supply for the driver.

The driver provides a program to ensure a fully optimised fluorescent lamp ignition.



FEATURES

- **VERY WIDE POWER RANGE:**
linear lamp ignition from **18 to 125W**
- **VERY WIDE TEMPERATURE RANGE:**
tube ignition from - **40 to 85 °C**
- **8 STRIKING PULSE CAPABILITY:**
for very cold environment or aging lamp
- **SELECTABLE PRE-HEAT TIME:**
1.5 s or 2.5 s
- **IGNITION at 350mA, 1350V**
- **STARTER SHUTDOWN WITH FAILED LAMP**

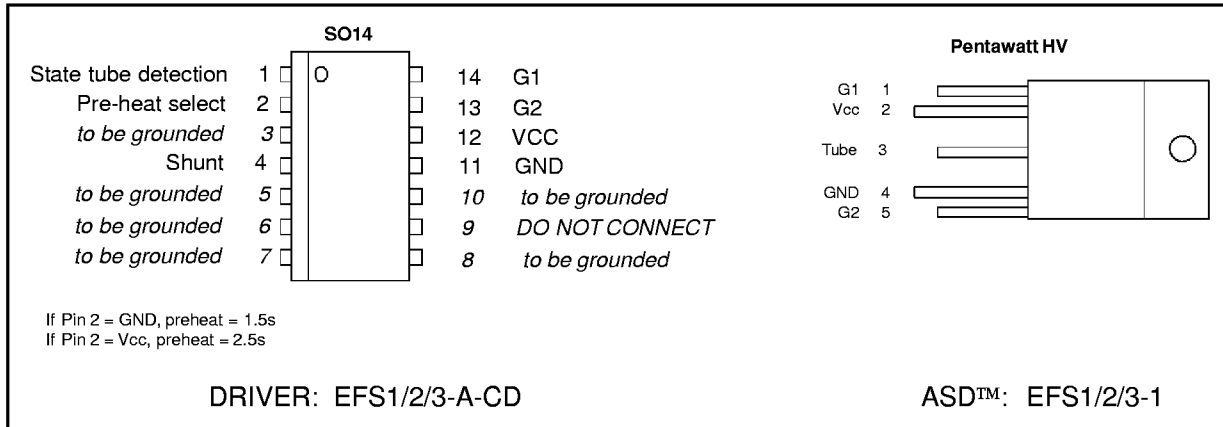
BENEFITS

- **Very low component count:** 2 chips + 4 passive components
- **Universal Core** for any multi power multi temperature range starter application
- **Serial tube lamp connection capability (note 1)**
- **Compatible with EMI Capacitor** to meet EMI standards
- **Extended life time of the fluorescent lamp** due to smooth and single shot ignition
- Very Cold and Lower power application coverage with **selectable and accurate pre heat time**
- Unaffected by Mains Power micro-interruptions
- **Reduced maintenance** thanks to failed lamp automatic safety shut down
- **Extended life time of the starter** that survives to the tube lamp failure
- **Inherent high reliability** of the electronic power elements

note1: see section on tubes in series in attached application note

EFS

PIN CONNECTION (top view)



EFS STARLIGHT-KIT PARTS SELECTION:

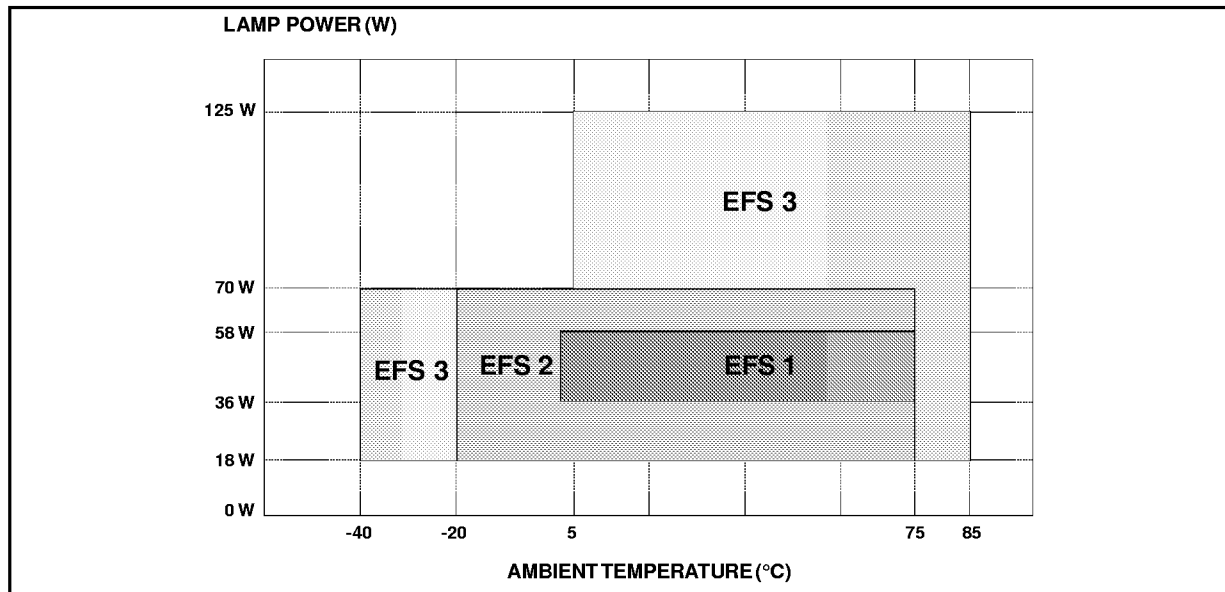
The EFS STARLIGHT-KIT family offers an effective answer to linear fluorescent lamp ignition needs

AC MAINS = 230/240V			
CONDITIONS FOR USE	EFS STARLIGHT-KIT FAMILY		
	EFS1	EFS2	EFS3
LAMP POWER RANGE	36 to 58W	18 to 70W	18 to 125W (note 2)
AMBIENT TEMPERATURE RANGE	5 to 75°C	-20 to 75°C	-40 to 85°C (note 3)
TWIN TUBE SERIAL CONNECTION (2 X 18W - 115V)	YES	YES	YES
DRIVER	EFS1A	EFS2A	EFS3A
ASD™	EFS11	EFS21	EFS31

Note 2: above 70W, the operating temperature is higher than 5°C

Note 3: below -20°C, the lamp power range is less than 70W

UNIVERSAL CORE FOR WIDE RANGE APPLICATIONS



ABSOLUTE MAXIMUM RATINGS

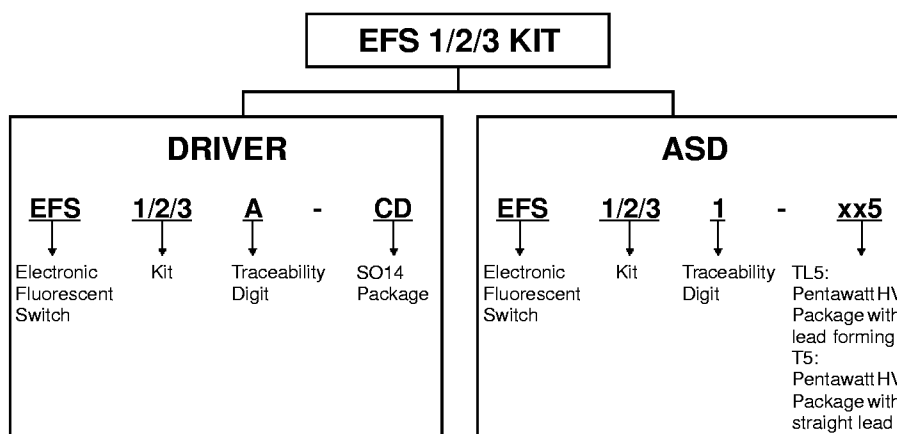
DRIVER: EFS1/2/3-A			
Symbol	Parameter	Value	Unit
V _{CC}	Supply Voltage	14	V
T _{oper}	Operating Ambient Temperature range (refer to EFS selection table)	-40 to +85	°C
P _{tot}	Power Dissipation	500	mW
ESD	Electrostatic Discharge between any pins	1	kV
ASD™: EFS1/2/3-1			
Symbol	Parameter	Value	Unit
I _{TRMS}	RMS On-State Current @ T _{case} = 90°C	1	A
I _{TSM}	Non repetitive Surge peak On-State Current T _j initial = 25°C, T _p = 10ms	15	A
V _{DRM/RRM}	Repetitive peak off-State voltage	600	V
T _{oper}	Operating Ambient Temperature range (refer to EFS selection table)	-40 to +85	°C
T _{case}	I _{RMS} = 1A T _{OFF} = 0.16s T _{ON} = 0.75s	+ 120	°C
T _j	Maximum Operating Junction Temperature	+125	°C

EFS

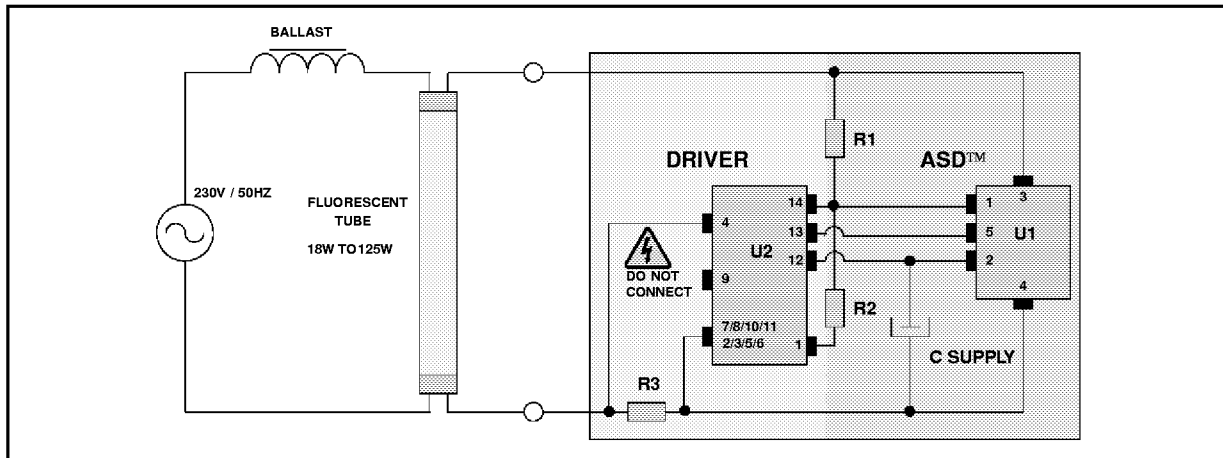
ELECTRICAL CHARACTERISTICS ($T_j = 25^\circ\text{C}$, unless otherwise specified)

EFS STARLIGHT KIT		EFS1			EFS2			EFS3			
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Unit
ASD™											
VT +	Positive On-State voltage $I_T = 1.5\text{A}$ $t_p = 500\mu\text{s}$		2.5			2.5			2.5		V
VT -	Negative On-State voltage $I_T = 1.5\text{A}$ $t_p = 500\mu\text{s}$		1			1			1		V
V _{BR}	Breakdown Forward voltage $I_{DRM} = 5\text{mA}$ $t_p = 10\text{ms}$	1100	1200		1150	1350		1200	1350		V
I _{DRM/RRM}	Forward and reverse leakage current, V _{DRM/RRM} rated			20			20			20	μA
I _H	Holding current $dI/dt = 9\text{A/s}$ Pin1 = Pin2 = Pin4 = Pin5		130			150			200		mA
DRIVER											
I _{SO}	Ignition Switch-Off current with: R _{sense} = 0.4Ω, T _j = T _{jMIN} , L = 0.7H	Not applicable			275	350		275	350		mA

ORDERING INFORMATION

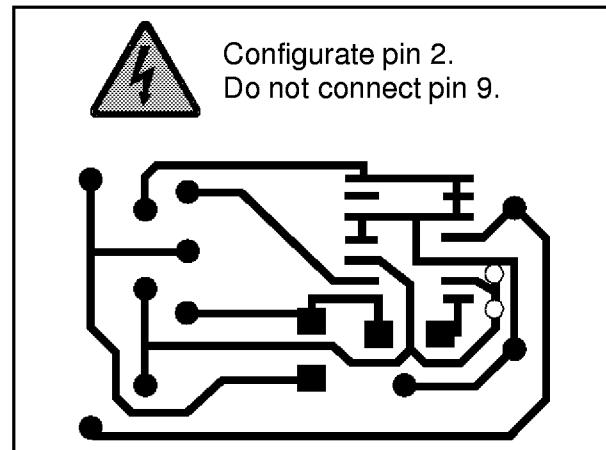
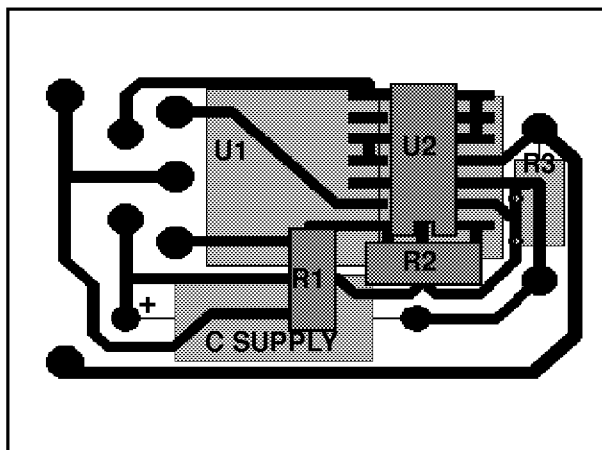


BASIC APPLICATION DIAGRAM



PCB WITH PENTAWATT HV and SO14

COMPONENT SIDE LAYOUT



Pin 2 is the preheat time select pin. To select a 1.5s preheat time, drill and cut the Vcc to pin 2 wiring at the metallization hole. To select a 2.5s preheat time, drill and cut the GND to pin 2 wiring. The layout must be configured for either choice to avoid **supply short circuit**.

RECOMMENDED COMPONENTS ACCORDING TO APPLICATION CONDITIONS

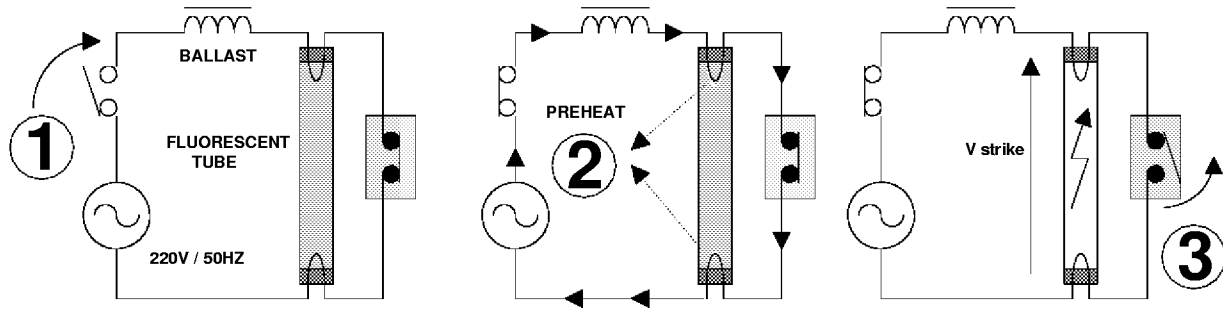
Application Conditions		
AC mains	Single 230V - 50Hz	Twin series 230V / 50Hz or single 115V / 50Hz
Lamp Power Range	18 to 125W	18 to 36W
Ambient Temperature Range	-40 to +85°C	-40 to +85°C
Recommended Components		
Starter Kit	EFS1/2/3 (see note 4)	EFS1/2/3 (see note 4)
R1	150kΩ - 0.5W - 5%	150kΩ - 0.5W - 5%
R2	1kΩ - 0.25W - 5%	2kΩ - 0.25W - 5%
R3	0.39Ω - 0.25W - 5%	0.39Ω - 0.25W - 5%
Csupply	22μF - 16V - 10%	22μF - 16V - 10%

Note 4: refer to EFS selection table on page 2

1/ THE AC POWER SWITCH: FUNCTIONAL DESCRIPTION

The Starter is a bi-directional switch which performs two functions:

- the preheat of the tube,
- the ignition of the tube.



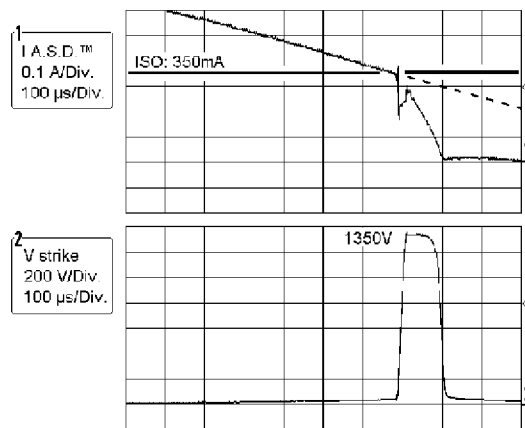
The mains voltage is applied

Preheating of the tube

Striking of the tube

During the preheat period, the ASD™ is fully conducting. The tube lamp is short circuited by the starter, and the current flows through its filaments. In these conditions, the tube can not light up, but the temperature of the tube electrodes increases.

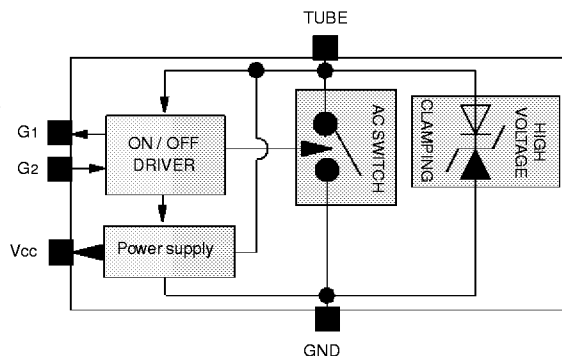
At the end of the preheat period, the lamp filaments are warm enough to emit electrons in the gas and to permit the lamp ignition in good conditions. The ASD switches off the preheating current. At this moment, the ballast is equivalent to a current generator ($I=I_{SO}$, I_{SO} = Switched Off current). As the ASD switches off, the starter voltage increases. The amplitude of this high voltage spike is clamped by the ASD ($V_{BR}=1350$ V). As the starter and the tube are in parallel, the striking pulse is directly applied to the tube. The electromagnetic energy of the ballast is then discharged through the tube and the ASD.



Striking pulse

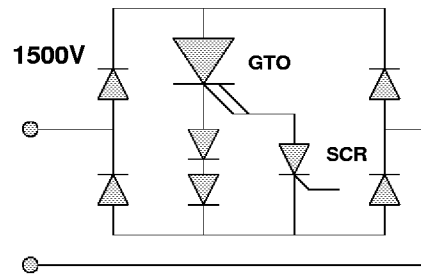
2/ WHAT'S NEW IN THIS SWITCH?

The AC SWITCH merges an auxiliary power supply for the driver, a power clamping device (1350V) and a bi-directional switch with his execution pilot block.



NEW EFS ASD™

Present solutions work with a unidirectional switch, like MOS transistors or GTO (Gate Turn Off thyristor). As a starter is a bi-directional switch, it is necessary to use a rectifier bridge (4 diodes of 1500V or 8 diodes with a lower breakdown voltage). More, 2 or 3 diodes in series with the GTO are required to get the necessary switch off effect, and the whole switch is controlled with an analog timer built around a small SCR.



Conventional discrete circuit
(Minimal version)

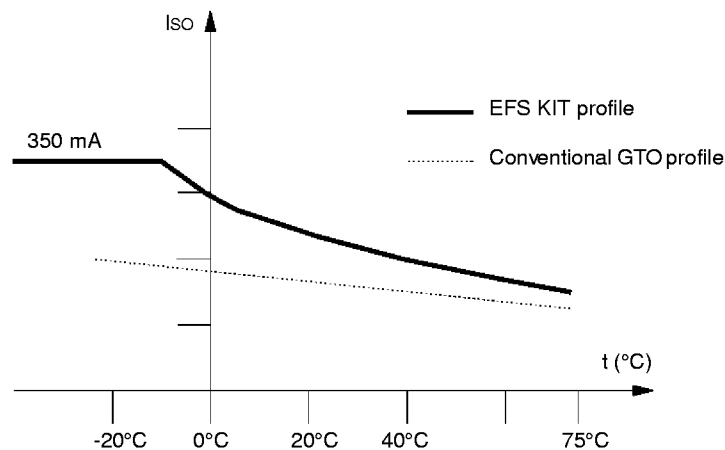
The interest of a bi-directional switch arises itself: a drastic reduction of the number of components, and of course, a reduction of power losses (only 1 forward voltage instead of 5 or 8 depending on the version).

The ignition feature is another interesting point. A lamp requires a minimum energy level to be ignited, but this energy depends especially on the temperature of the tube. The lower the temperature is, the more energetic the lamp strike is.

This energy stored in the ballast is directly proportional to the I_{SO} ($E = \frac{1}{2} LI^2$ with $I = I_{SO}$).

In other words, the required energy and of course the I_{SO} , are maximum for the minimum temperature. Results based on experiments show that it is necessary to switch off a current of 350mA to strike a 58W tube at -20°C (with a voltage amplitude clamped at 1300V).

Therefore, the best way to strike a tube independently of the temperature is to keep the maximum I_{SO} level for all the temperature range. Unfortunately, the solution is not so simple to implement because the energy level at ambient or warm temperature would be much important: the lamp would be ignited, but the lamp life time would be shortened. This is why one of the innovations of the ASD is to modulate the striking energy versus temperature (see feature hereafter).



For negative temperatures, the I_{SO} level is maintained at 350 mA, and for positive temperature, the I_{SO} level decreases slowly, a little bit above the conventional GTO profile.

3/ AUXILIARY POWER SUPPLY:

In order to reduce the number of components, an auxiliary power supply is integrated in the ASD™. This active power supply works directly on the mains and requires only a low voltage capacitor 16V - 22μF. This output capacitor is charged at the beginning and the end of each positive mains half cycle.

During the preheat period, a part of the current flowing through the ASD is used to charge the output capacitor, so there is no line current distortion.

When the tube is ignited, the power supply capacitor is periodically recharged by the ASD in order to allow proper tube supervision by the whole starter kit.

4/ THE DRIVER: FUNCTIONAL DESCRIPTION ALGORITHM

1. At switch on:

At switch on, an integrated Under Voltage Lock-Out function (UVLO) resets the driver as long as the supply voltage stays below a security level.

2. Pre-heat:

The ignition sequence begins with the preheat. Two different durations can be selected with PIN 2 (Pre-heat select).

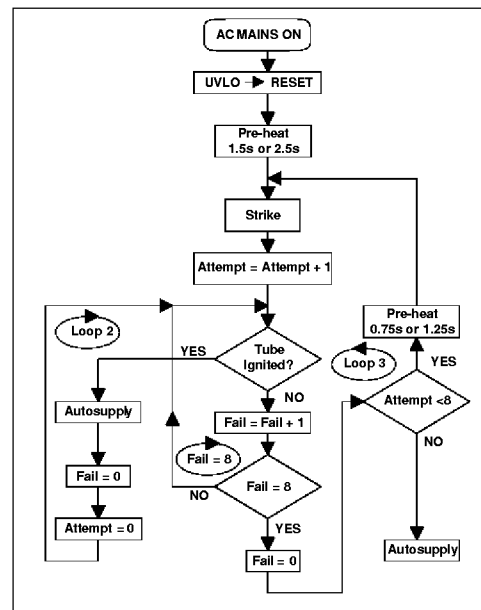
PIN 2 connected to GND

If Pin 2 = GND, preheat = 1.5s.

PIN 2 connected to VCC

If Pin 2 = Vcc, preheat = 2.5s.

During the preheat, the driver maintains the ASD in a full ON-state, thus making the starter equivalent to a conducting switch.



3. Ignition of the fluorescent tube:

At the end of the pre-heat period, the starter strikes the fluorescent tube.

For that, the driver reads continuously the current through the starter. When the current reaches the Switch Off level ($I_{SO}=350\text{mA}$), the driver turns off the ASD. This induces a high voltage pulse across the tube. This pulse is limited by the ASD breakdown voltage ($\approx 1350\text{V}$).

4. If the tube fails to strike:

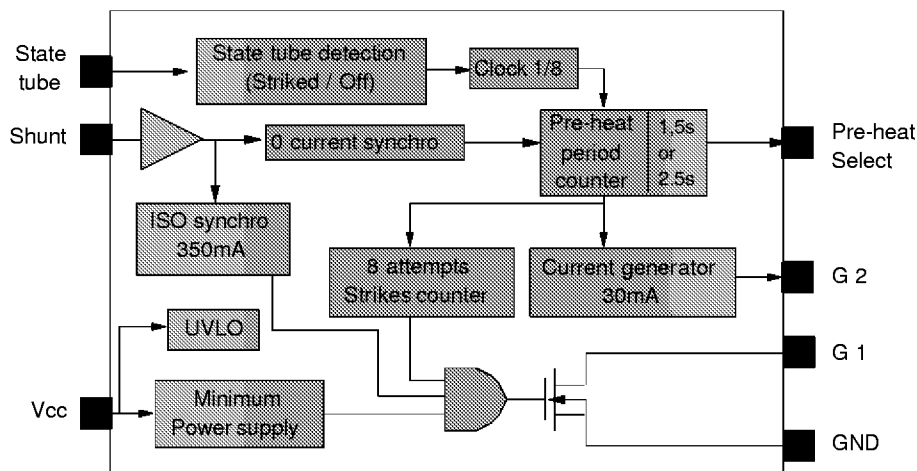
The driver detects the state of the tube (on or off). If it stays off during 8 mains cycles (loop 1), a new pre-heat period, shorter than the first one, starts again (loop 3), followed by a new ignition attempt. The driver will try to fire the tube 8 times. If none of the 8 attempts succeeds in striking the tube, the driver turns in stand-by mode, and the whole starter is fully stopped until the next mains removal and power supply reset.

5. If the tube is ignited:

If the tube is ignited, the driver stays in stand-by mode while monitoring the state of the tube (loop 2). The ASD applies a short high voltage pulse ($\approx 1\text{mJ}$) at the beginning of each positive half cycle. If some spurious cut off occurs on the mains (micro sags), the lamp turns off momentarily. This short pulse is enough to sustain the arc in the lamp, avoiding a new complete ignition sequence.

During normal operation of the tube, this short pulse is masked by the tube conduction. If the mains interruption is really long enough to turn off completely the lamp, a new ignition sequence starts again (loop 3) with 8 other new possible attempts.

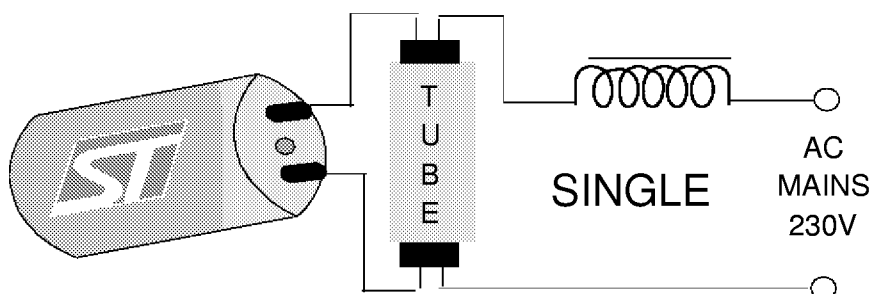
The internal block diagram of the driver



5/ EFS STARLIGHT KIT: FLUORESCENT LAMP IGNITION

5.1. OPERATION ON 230V/50Hz AC MAINS IN SINGLE LAMP CONFIGURATION

The EFS STARLIGHT KIT is ideal in the configuration described herebelow
 - Single Starter / 230V / 50Hz -.



The components to choose are the following:

Applications Conditions	
AC mains	Single 230V - 50Hz
Ballast Power Range	18 to 125W
Temperature	- 40 to 85°C

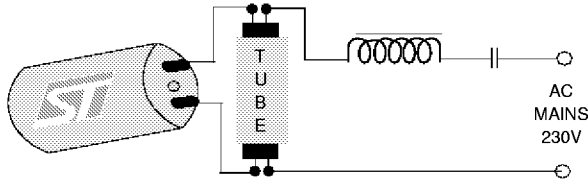
Recommended Components	
Starter Kit	EFS 1/2/3 (note 5)
R1	150kΩ - 0.25W - 5%
R2	1kΩ - 0.25W - 5%
R3	0.39Ω - 0.25W - 5%
Csupply	22μF - 16 V - 10%

Note 5: the different EFS kit versions (1, 2 or 3) should be chosen according to the table "EFS STARLIGHT KIT PARTS SELECTION" page 2.

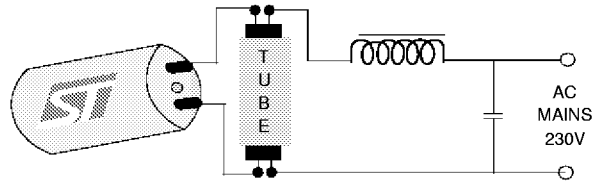
5.2. OPERATION WITH CAPACITOR FOR POWER FACTOR CORRECTION:

The EFS STARLIGHT-KIT is also suitable for magnetic ballast including front end serial capacitor (leading ballast) or parallel shunt capacitor. Nevertheless with front end serial capacitor, only one ignition attempt will be performed. After this first attempt, the serial capacitor superimposes a -300V DC voltage on the mains voltage. This offset masks the starter which detects the tube lamp as systematically alight.

LEADING MAGNETIC BALLAST WITH SERIAL CAPACITOR



MAGNETIC BALLAST WITH SHUNT PARALLEL CAPACITOR



With a front end parallel capacitor, the ignition process remains normal with 8 attempts in case of defective lamps.

Applications Conditions	
AC mains	Twin series 230V - 50Hz or single 115V - 50Hz
Ballast Power Range	18 to 36W
Temperature	- 40 to 85°C

Recommended Components	
Starter Kit	EFS 1/2/3
R1	150kΩ - 0.25W - 5%
R2	2kΩ - 0.25W - 5%
R3	0.39Ω - 0.25W - 5%
Csupply	22μF 16 V 10%

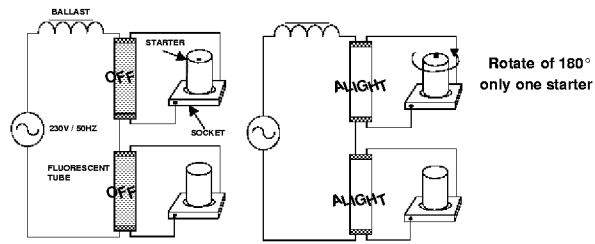
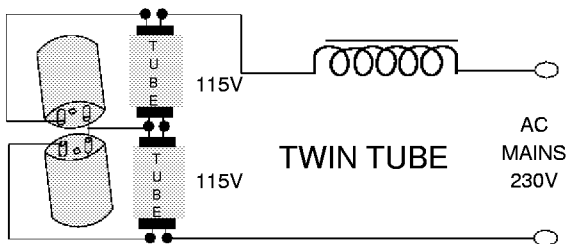
5.3. OPERATION ON 230V/50Hz AC MAINS IN TWIN TUBES CONFIGURATION OR 115V/50Hz MAINS IN SINGLE LAMP CONFIGURATION

Moreover, the EFS STARLIGHT-KIT is also suitable for the configurations - Twin tubes Starter / 230V / 50Hz, and Single Starter / 115V / 50Hz -.

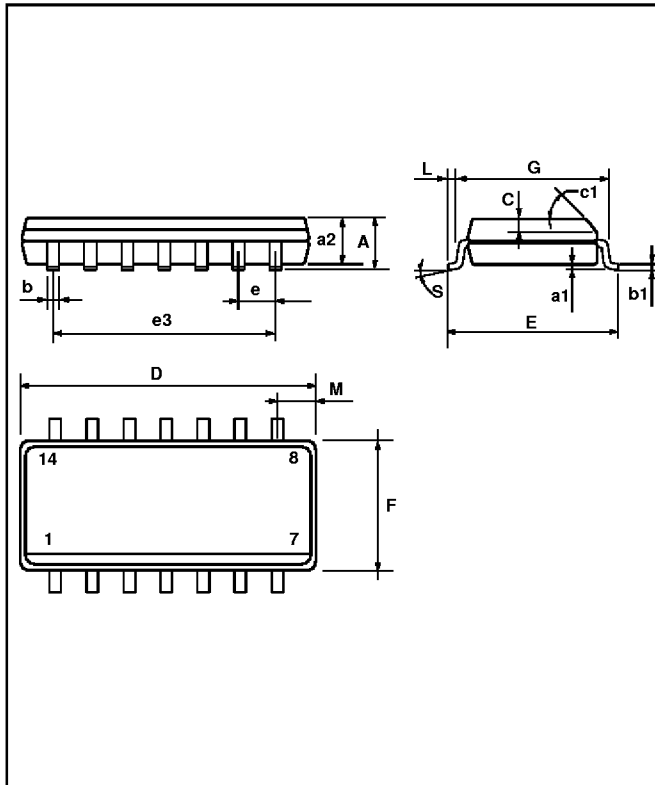
The components to choose are the following (Refer to the table "EFS STARLIGHT- KIT PARTS SELECTION" page 2.)

With the above set of components, the ignition process is exactly the same as the one described in the algorithm page 7.

The only electrical diagram difference consists of the R2 resistance which needs to be changed from 1 to 2kΩ. Without this modification, the starter will generate only one ignition attempt instead of 8 in case of defective tube lamp; the loop 3 is removed from the algorithm described in page 7.



PACKAGE MECHANICAL DATA
 SO14 (Driver)



Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

PACKAGE MECHANICAL DATA

PentawattHV with lead forming - TL5 (ASD™)

REF.	DIMENSIONS					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
B	0.6		0.8	0.024		0.031
C		2.54			0.10	
D	4.91		5.21	0.193		0.205
E		3.91			0.154	
F		7.92			0.312	
G	10.1		10.4	0.398		0.409
H	15.1		15.8	0.595		0.622
I	2.6		3	0.102		0.118
J	3.65		3.85	0.144		0.151
K	4.3		4.8	0.169		0.189
L	1.17		1.37	0.046		0.054
M	6		6.6	0.236		0.260
N		0.5			0.020	
O		3.3			0.130	
P	2.4		2.8	0.094		0.110
Q	1.49	1.59	1.69	0.059	0.063	0.067
R	2.44	2.54	2.64	0.096	0.10	0.104
S	0.35		0.55	0.014		0.021

PACKAGE MECHANICAL DATA

PentawattHV with straight lead - T5 (ASD™)

REF.	DIMENSIONS					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.30		4.80	0.169		0.188
A1	2.50		3.10	0.098		0.122
b	0.60		0.80	0.023		0.031
b1	0.75		0.90	0.029		0.035
c	0.35		0.55	0.013		0.021
c1	1.22		1.42	0.048		0.055
D	9.00		9.35	0.354		0.368
D1	15.20		15.80	0.598		0.622
e	2.44		2.64	0.096		0.103
e1	3.71		3.91	0.146		0.155
E	10.00		10.40	0.393		0.409
L	22.32		22.92	0.878		0.902
L1	25.10		25.70	0.988		1.011
P	3.65		3.95	0.143		0.155
S	2.55		3.05	0.100		0.120

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