Технически Университет Варна
катедра „Електронна техника и микроелектроника“

„Промишлени средства за измерване и контрол“

Управление и контрол на осветление с луминисцентни лампи

ас. д-р Георги Николов

2015

Съдържание

- Видове луминисцентни лампи
- Управление
  - Запалване
    - Чрез дросел
    - Чрез електронен стартер
  - Регулиране силата на светене

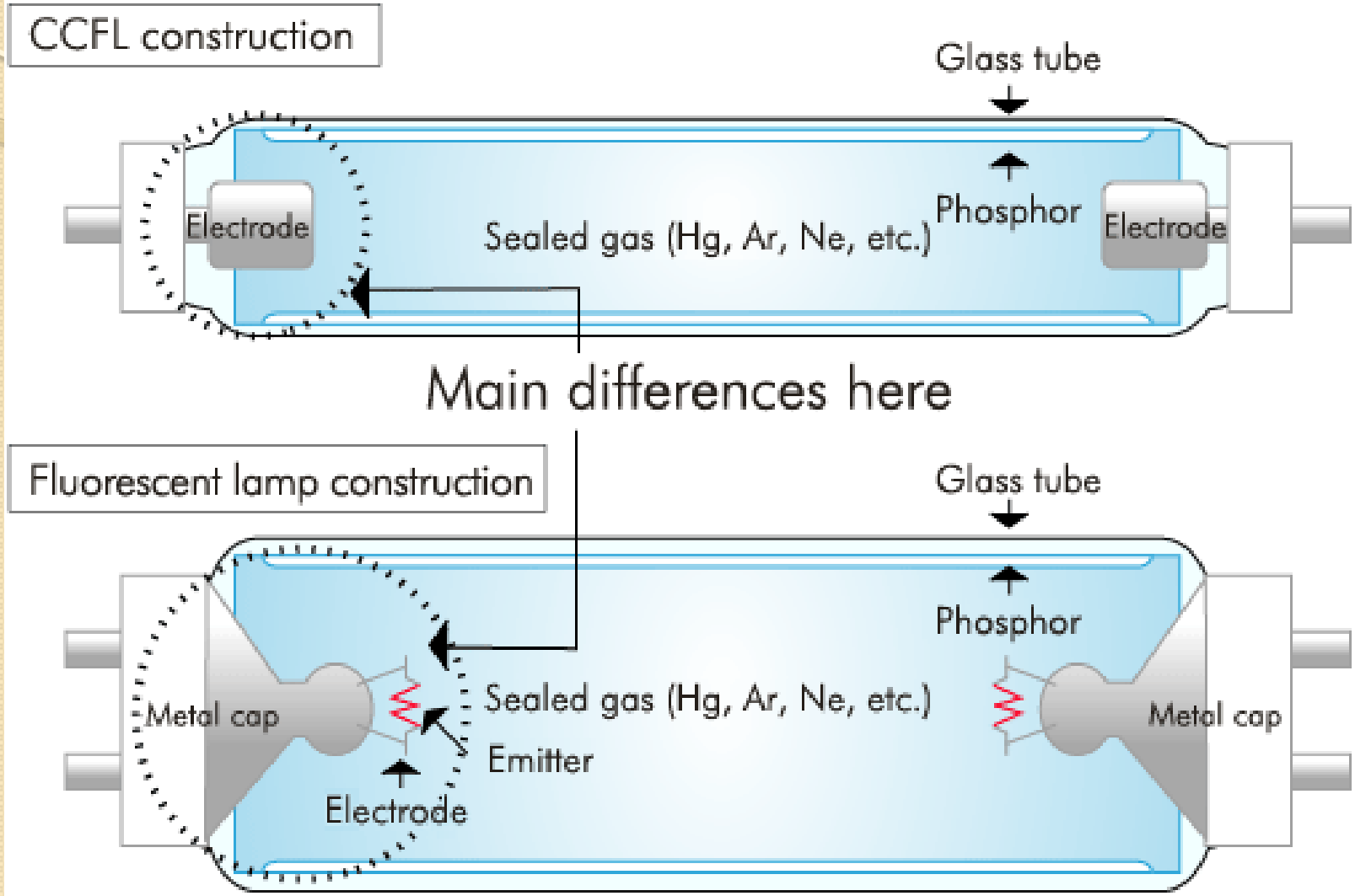
Fluorescent lamps

Fluorescent lamps are a type of gas discharge tube. A pair of electrodes, one at each end - are sealed along with a drop of mercury and some inert gases (usually argon) at very low pressure inside a glass tube. The inside of the tube is coated with a phosphor which produces visible light when excited with ultra-violet (UV) radiation.

Fluorescent Light Bulb Types

- T-16: This tube has a 2-inch diameter. It is a preheat lamp, so it requires a starter. The tubes are usually 60 inches long.
- T-12: A T-12 has a diameter of 1½ inches. This is the most common diameter of tube-shaped light bulbs. It is usually bi-pin and it does not require a starter. It is available in a variety of lengths including a 15-inch (14-watt), an 18-inch (15-watt), a 24-inch (20-watt bulb), as well as a 36-inch and a 48-inch bulb.
- T-8: The T-8 tube is in the process of replacing the T-12. It has a 1-inch diameter, it is more energy-efficient and it gives off more light than the T-12. It is available in a variety of lengths including a 12-inch (13-watt), a 15-inch (14-watt), and an 18-inch (15-watt).
- T-5: One of the benefits of the T-5 tubes is that it is more efficient than the T-8 and is currently used in some commercial locations and throughout Europe.
- U-tube: A U-tube is a tube bent in half to form a "U" shape. A 48-inch bulb bent into a 24-inch U-tube bulb is brighter than a 24-inch tube bulb.
- Circle tube: Circle tubes are generally either 8 inches or 12 inches in

Cold cathode fluorescent lamp (CCFL)



Main differences between cold and hot cathode fluorescent lamps

	Cold cathode fluorescent lamps	Hot cathode fluorescent lamps
Lamp diameter	1.8 to 5.0 mm	15 to 32 mm
Starting voltage	High	Low
Tube current	Low	High
Luminous flux	Low	High
Luminous efficacy	Low	High
Lifetime	up to 60,000 hours	3,000 to 15,000 hours
Strong points	Tube can be made thinner	Highly efficient
	Longer lifetime	Greater volume of light

Light sources for scanners and backlights for LCD televisions, LCD monitors, and the like, signs, lighting fixtures, etc.

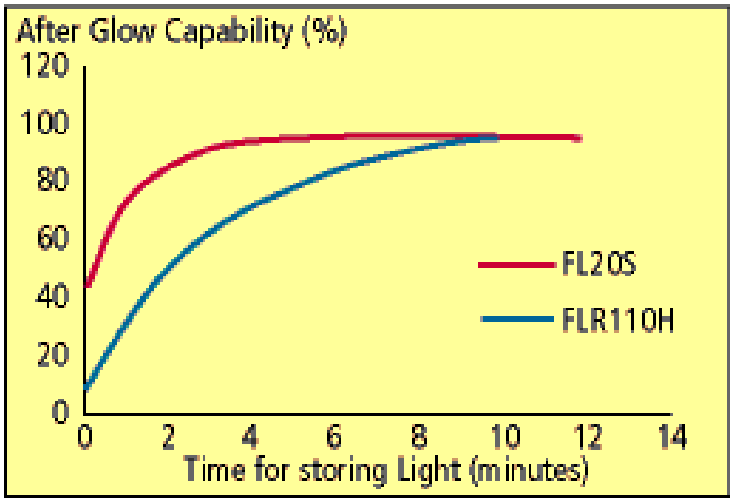
After Glow Lamps

- These lamps emit a faint glow even after the power supply has been switched off. So, rooms will not be left in complete darkness immediately after lights are turned off or in the event of a power interruption

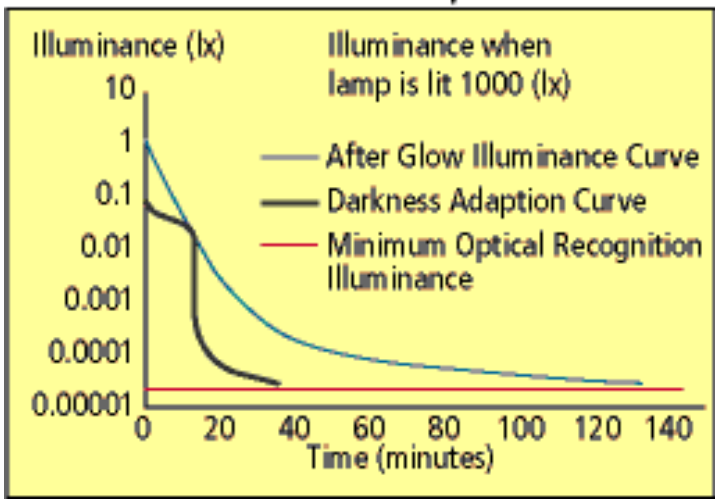
FL40SSEX-D/37-SHG:6,700K

- After glow effect is available after lamp has been in operation for approximately 10 minutes.
- An after glow is maintained for approximately 60 minutes that allow you to recognize objects in dark places

Storing Time and After Glow Capability

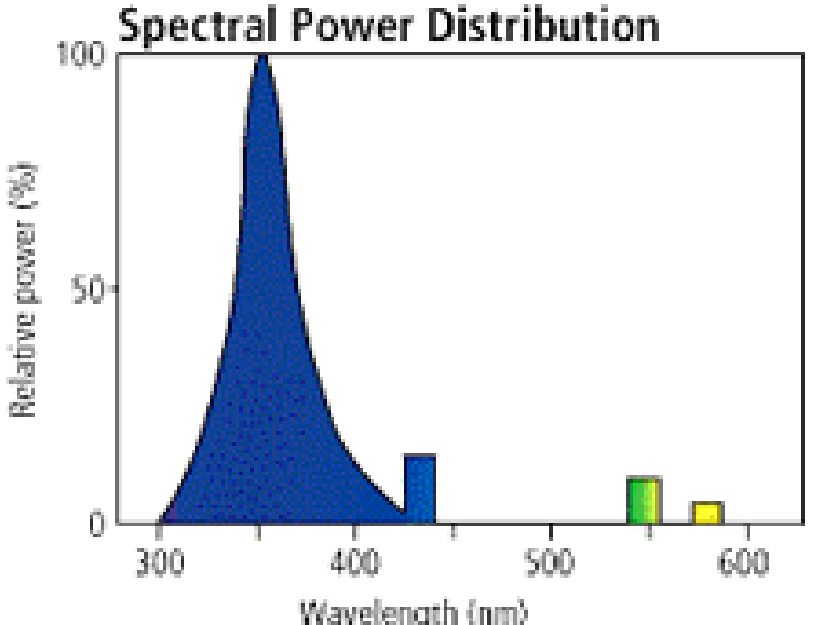


After Glow Illuminance Decaying Characteristics and Darkness Adaption Curve



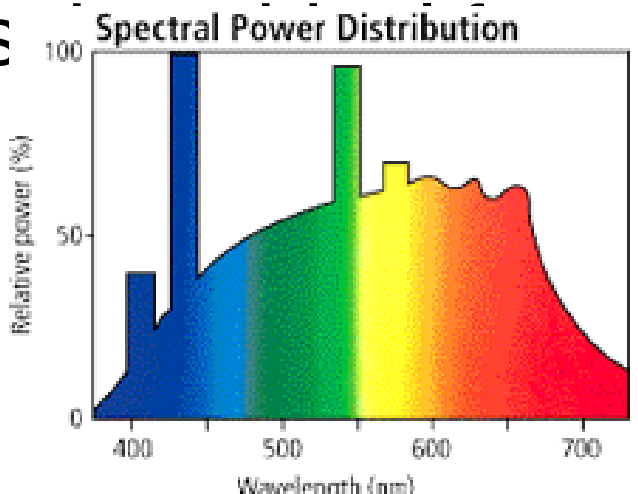
Special uses of FL

- Black light and black light blue fluorescent lamps use phosphor that emits mainly near ultraviolet (300 to 400 nm) light. This allows users to take advantage of the photochemical and fluorescent action unique to ultraviolet rays. The BL is also used in electrical insect control units to attract insects.



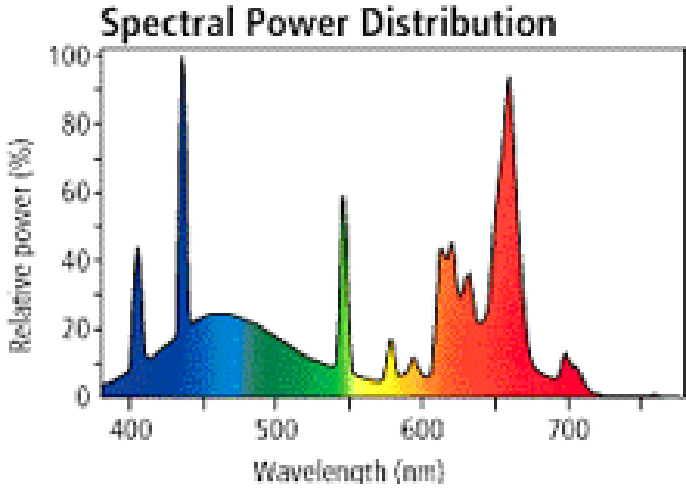
Special uses of FL

- With high-color rendering fluorescent lamps, the emphasis is placed on color rendering rather than brightness. N-SDL lamps are rated at a color of temperature 5,000K and have an average color rendering index value (Ra) of 92. This makes
wcases



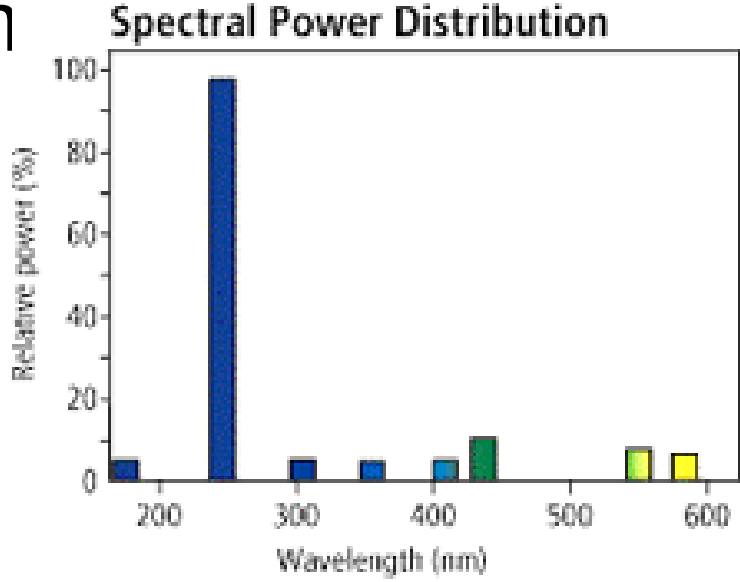
Special uses of FL **food**

- “LX” for Delicatessen and Pastry **more yellowish**
- “Vi” (Viande) for Meat **more reddish**
- “R” for Red Sea Food and Meat **even more reddish** for high priced seafood



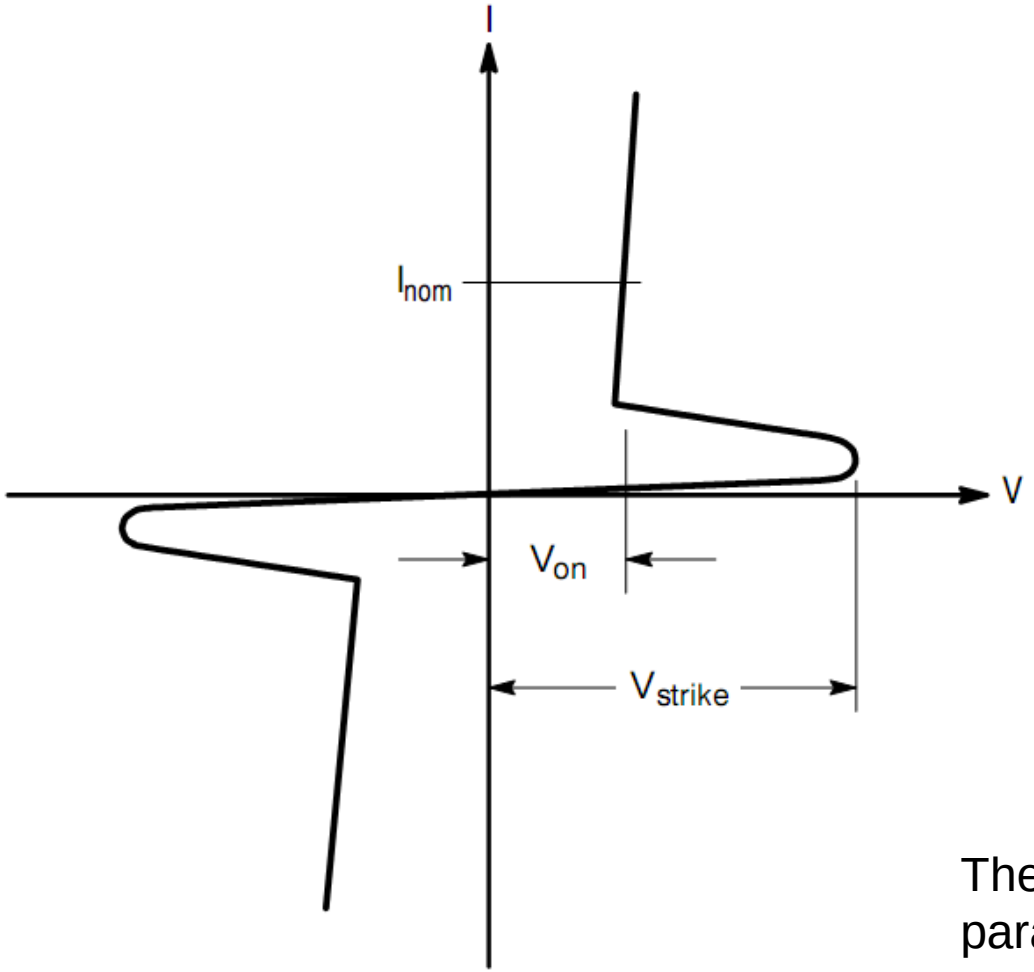
Special uses of FL

- NEC sterilization lamps are made of special glass that allows ultraviolet rays to pass through, and are designed to emit large amounts of 253.7 nm ultraviolet rays that are close to the maximun
sterilization point



УПРАВЛЕНИЕ

Fluorescent lamps



Typical Low Pressure Fluorescent Tube I/V Characteristic

The value of V_{strike} is a function of several parameters:

- gas filling mixture
- gas pressure and temperature
- tube length
- tube diameter
- kind of electrodes: cold or hot

Electromechanical ballast

The fluorescent tube turns off when the current is zero: this is the source of the 50 Hz flickering.

Two bulbs in single fixture from two different phases (real or virtual).

Computing the value of L is straightforward:

Computing the value of L is straightforward. Assuming a European line (230 V/50 Hz) and a 55 W tube (Von = 100 V, Vtrig = 800 V), then:

$$I_{RMS} = \frac{P_{tube}}{V_{on}}$$

$$I_{RMS} = 55/100 = 0.55\ A$$

$$Z = (Vline - Von)Irms$$

$$Z = (230 - 100)/0.55 = 238\ \Omega$$

$$L = \frac{Z}{2 * \pi * F}$$

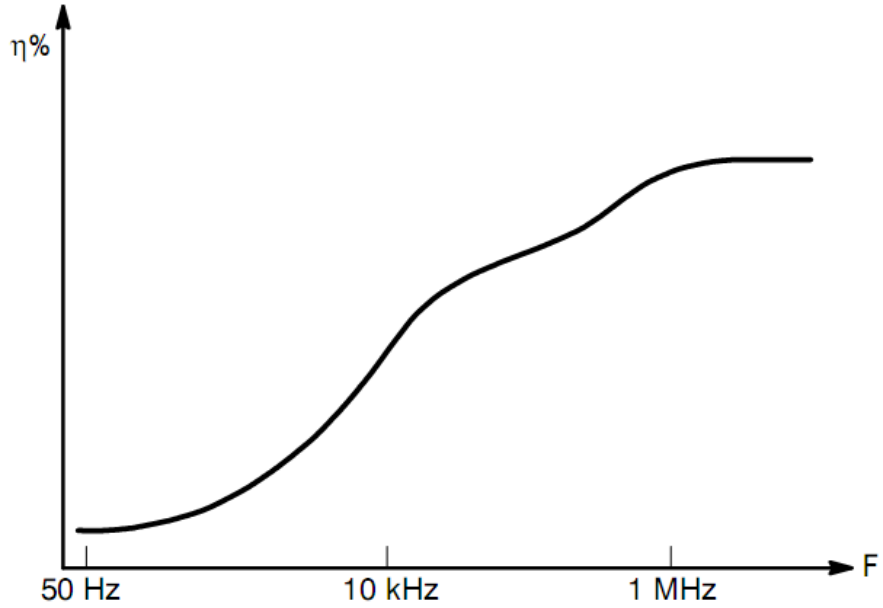
$$L = 238/(2 * \pi * 50) = 0.75\ H$$

The electromechanical ballast has two main drawbacks:

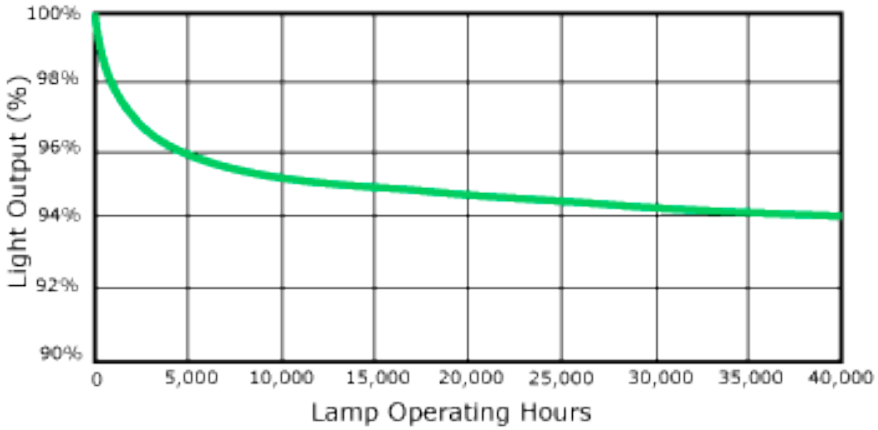
- Ignition of the lamp is not controlled.
- Light out of the lamp flickers at the same frequency as the AC line voltage.

Advantage

- very low cost solution



Typical Fluorescent Lamp Efficiency as a Function of the Operating Frequency



Decline in brightness for a high quality T8 lamp

CFL Ballasts

Today, 90 percent of CFLs are electronic ballasted lamps and they come in two basic varieties: (1) High power factors (somewhere between 0.9 and very close to 1) and (2) Low power factor (usually less than 0.6).

The high power factor lamps require more components (or from the corporations point of view, cost) so there are more low power factor lamps on the market than high power factor.

Main features

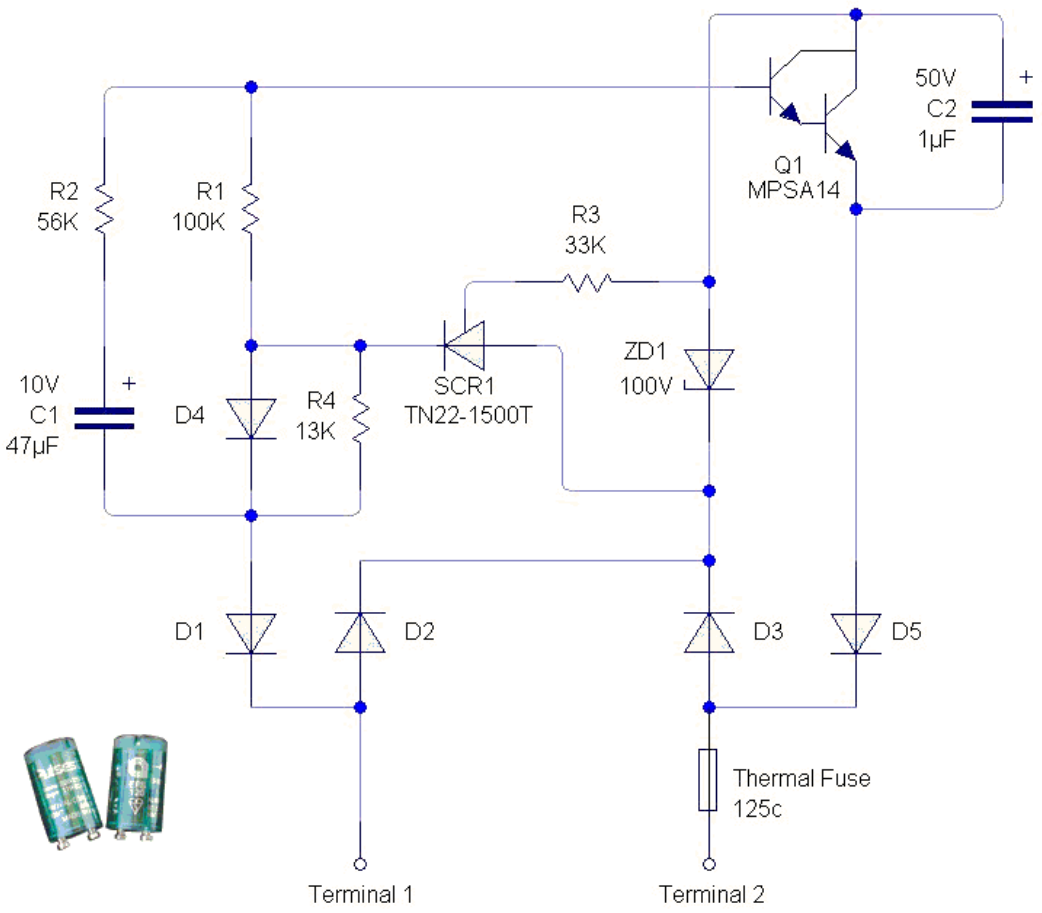
- Provide a start−up voltage across the end electrodes of the lamp.
- Maintain a constant current when the lamp is operating in the steady state.
- Assure that the circuit will remain stable, even under fault conditions.
- Comply with the applicable domestic and international regulations (PFC, THD, RFI, and safety).

Additional features

- dimming capability
- lamp wear out monitoring
- remote control

Pulse starters

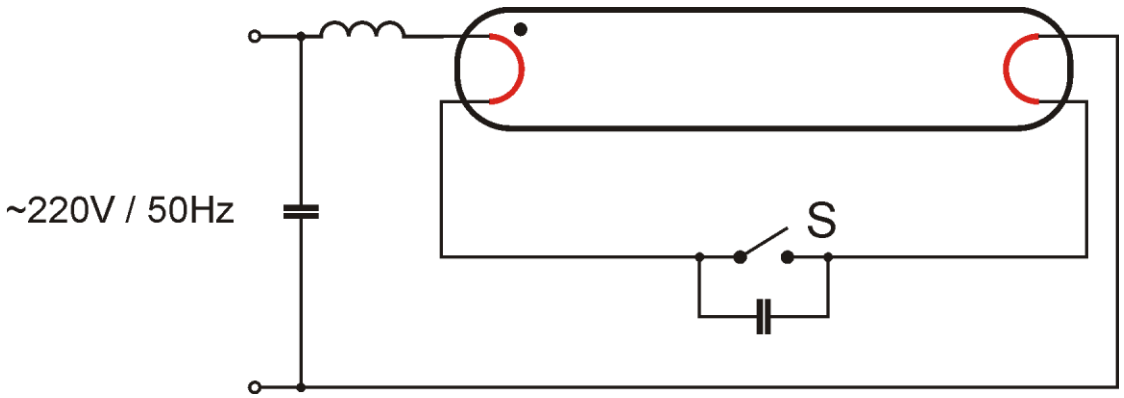
These devices are pin compatible devices and contain a bit of electronics that detect the appropriate time to interrupt the filament circuit to generate the optimal inductive kick from the ballast. So, starting should be more reliable with few/no blink cycles even with hard-to-start lamps. They will also leave used-up tubes off, without letting them blink annoyingly.



Arlen EFS-120 "Pulsestarter"

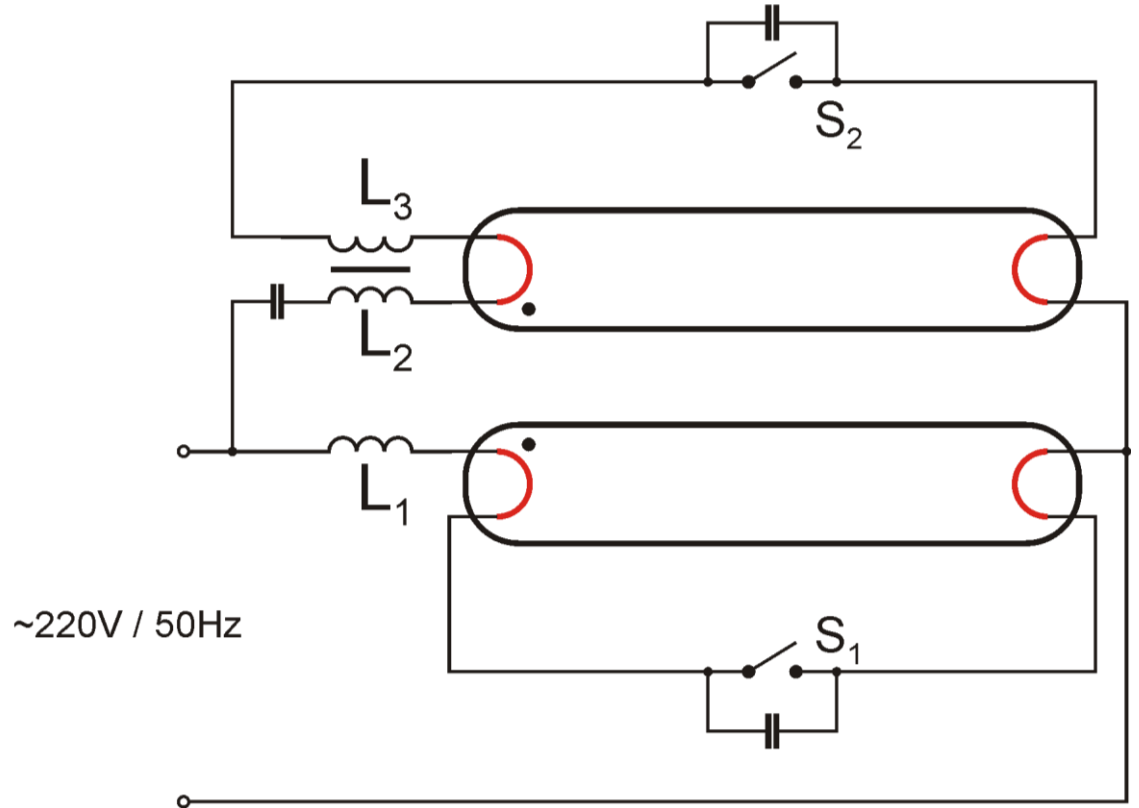
Вкл. / Изкл.

- С дросел

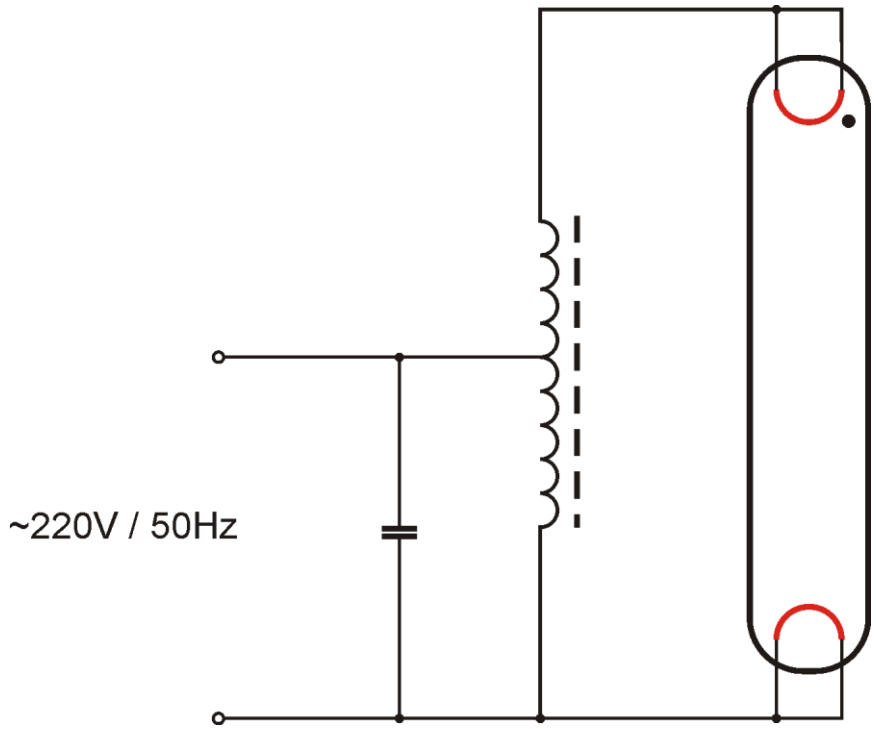


Промишлени приложения

- Две пури в едно тяло
- Трифазни схеми

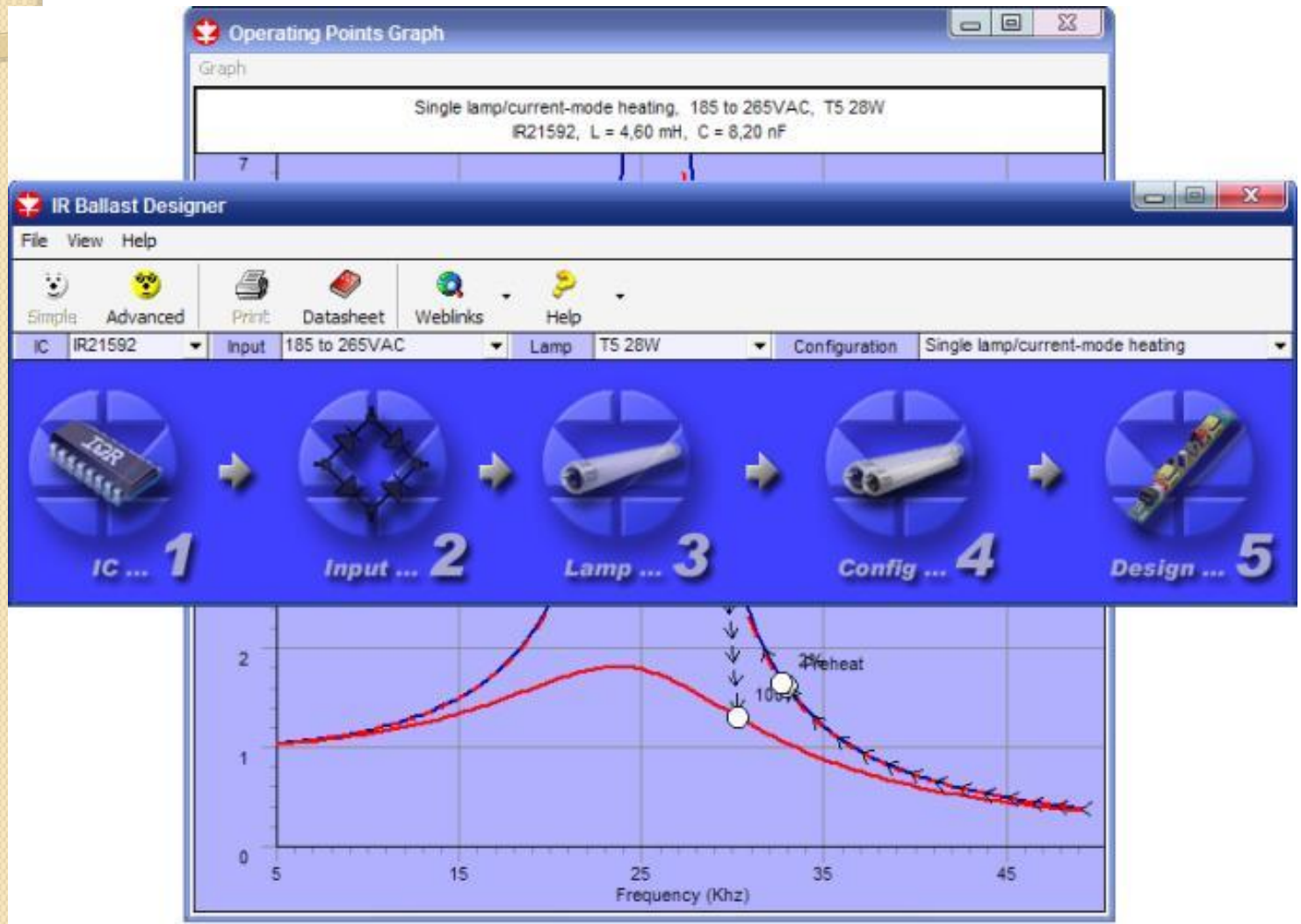


Без стартер



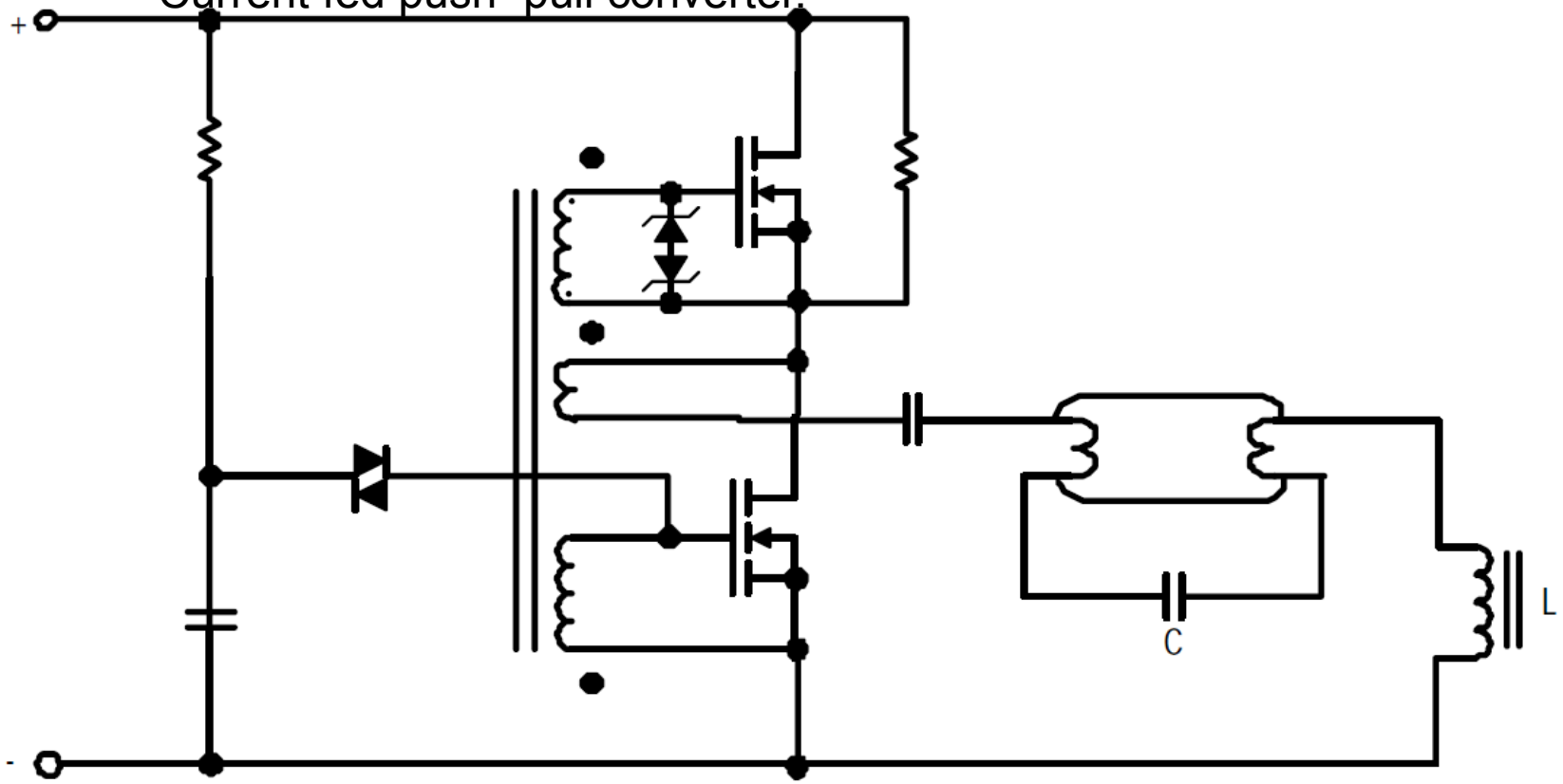
Dimming Control Method

Ballast design assistant (BDA) Software



Електронни баласти

- Single switch topology, with unipolar AC current, (unless the circuit operates in the parallel resonant mode).
  - flyback
- Dual switch circuit, with a bipolar AC output current
  - Half bridge, series resonant.
  - Current fed push−pull converter.



Push Pull Topology

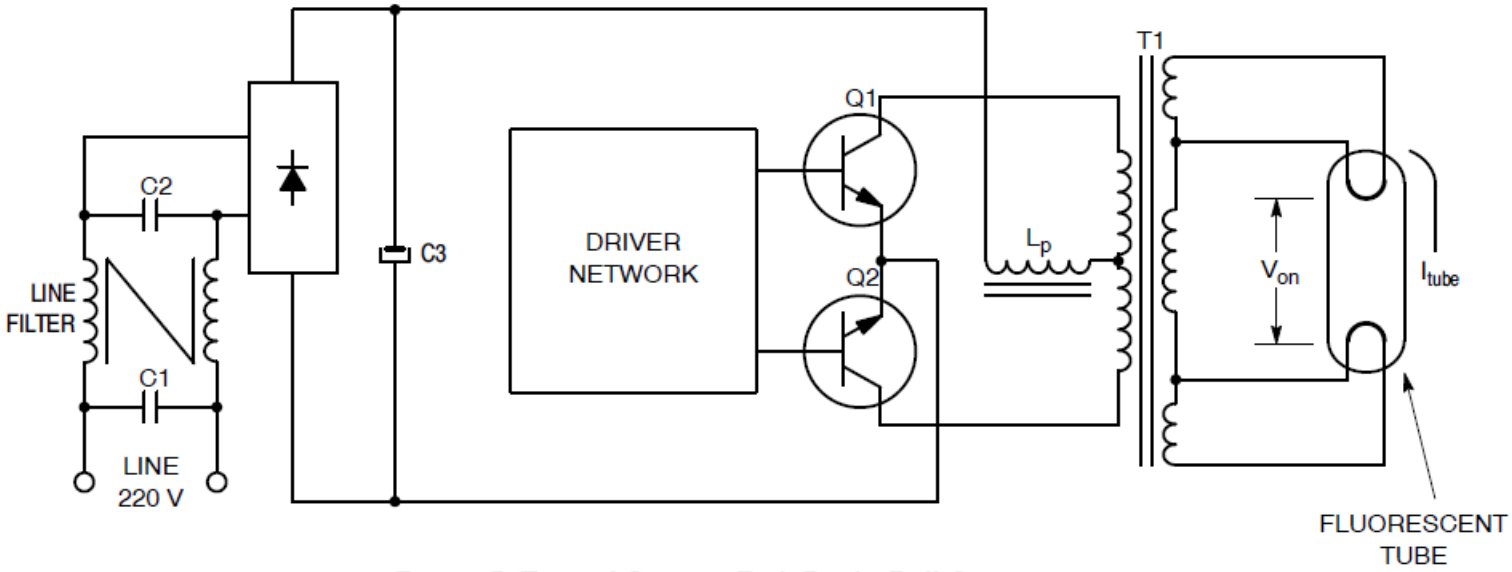


Figure 5. Typical Current Fed, Push−Pull Converter

Half Bridge Topology

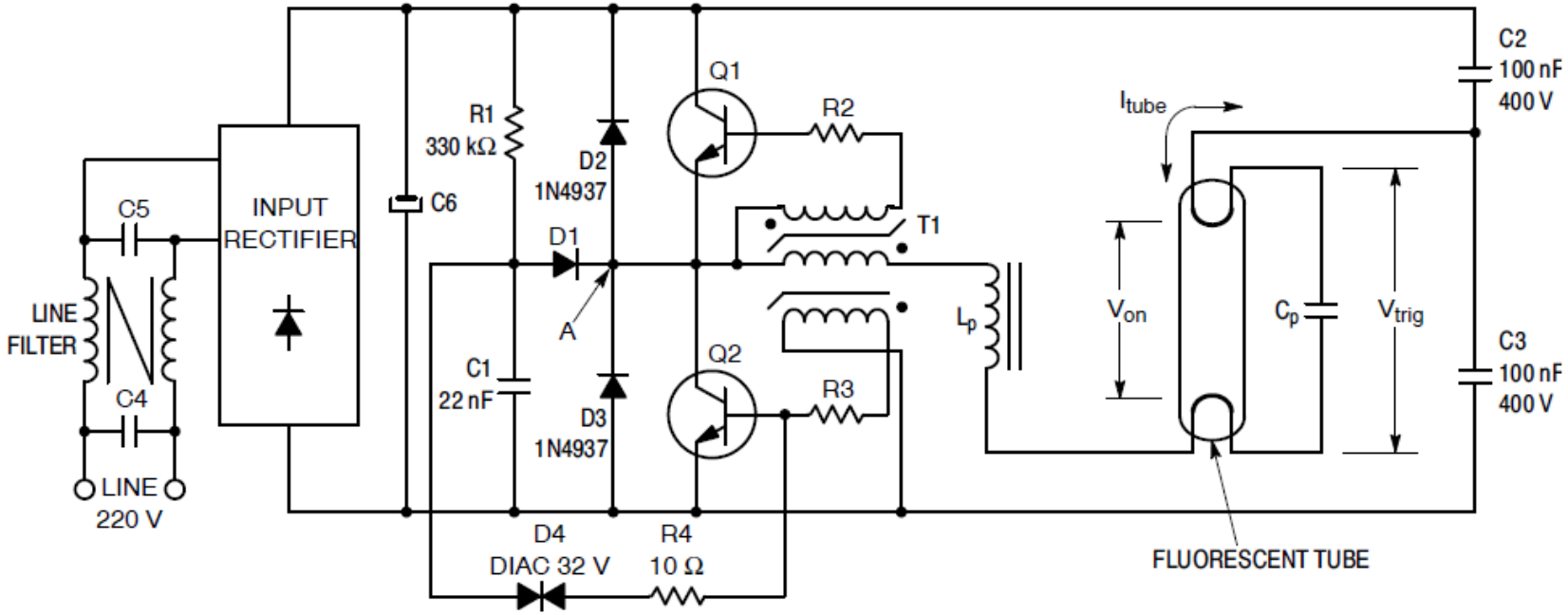


Figure 11. Typical Half Bridge Topology

Half Bridge		Push–Pull
• 700 V	$V_{(BR)CER}$	• 1100 V to 1600 V
• 3 to 4 times Inom	Inrush Current	• 2 to 3 times Inom
• High & Low side	Drive	• Low side only
• не	Intrinsic Galvanic Isolation	• да

Сравнение на двата вида топологии

Typical PFC Circuit

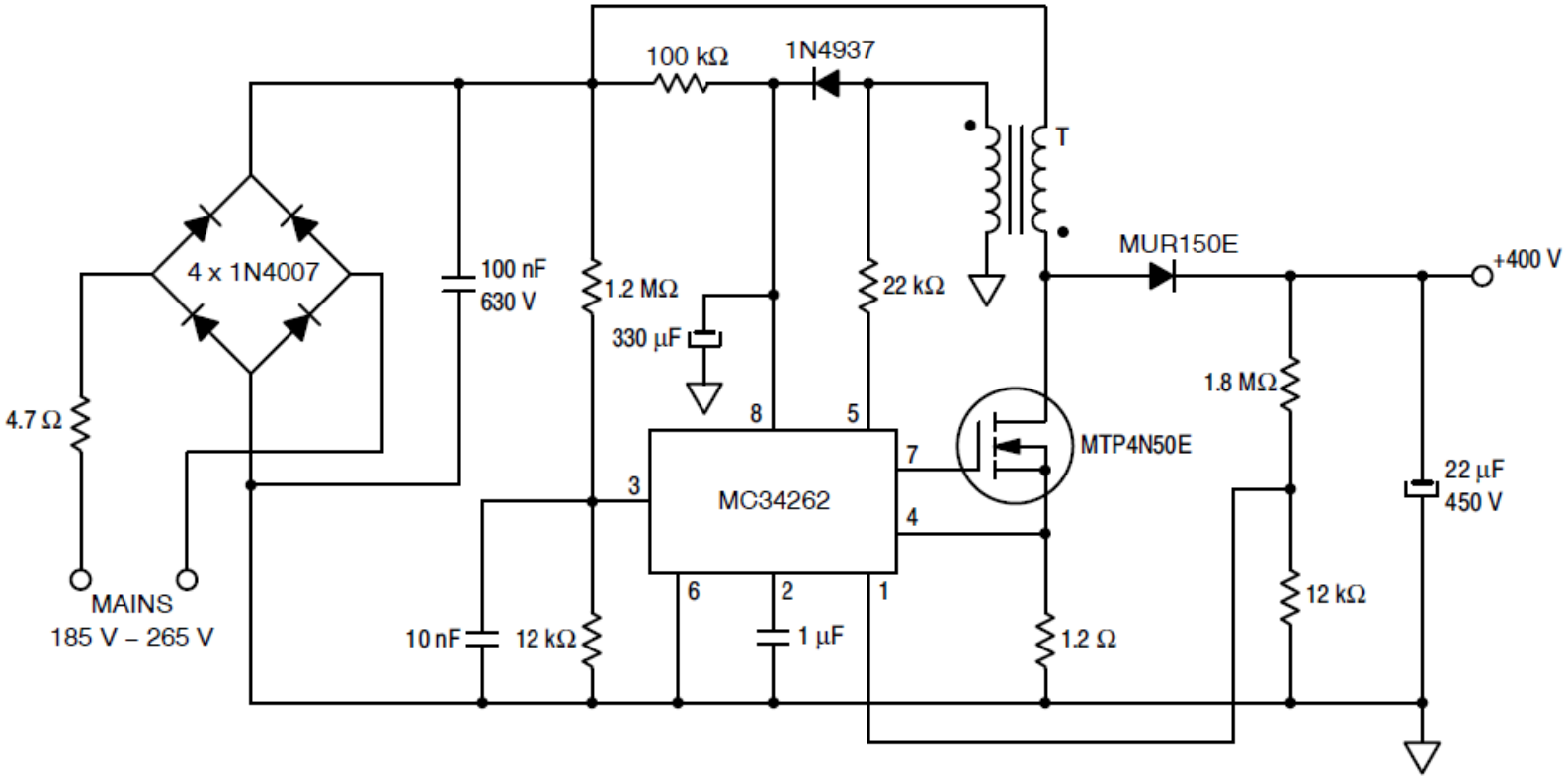
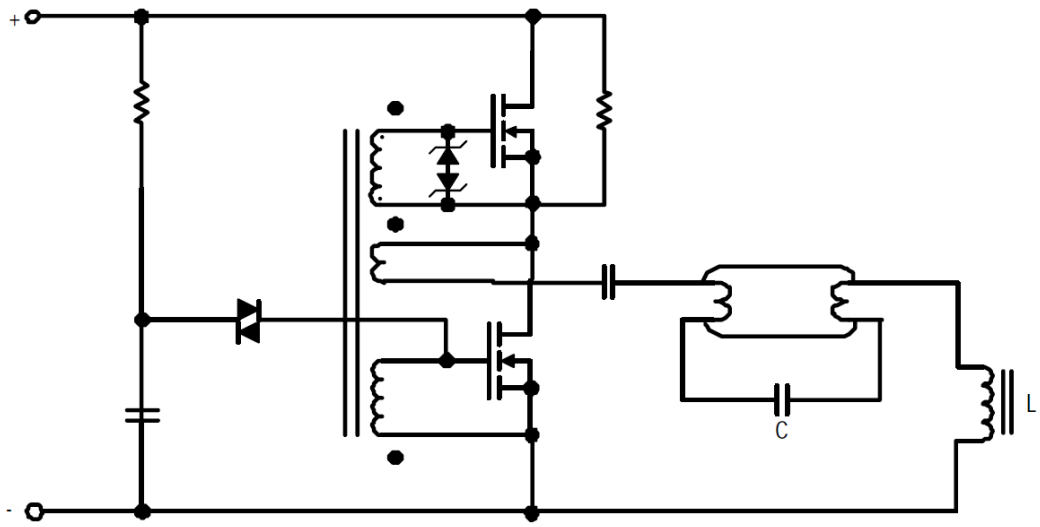


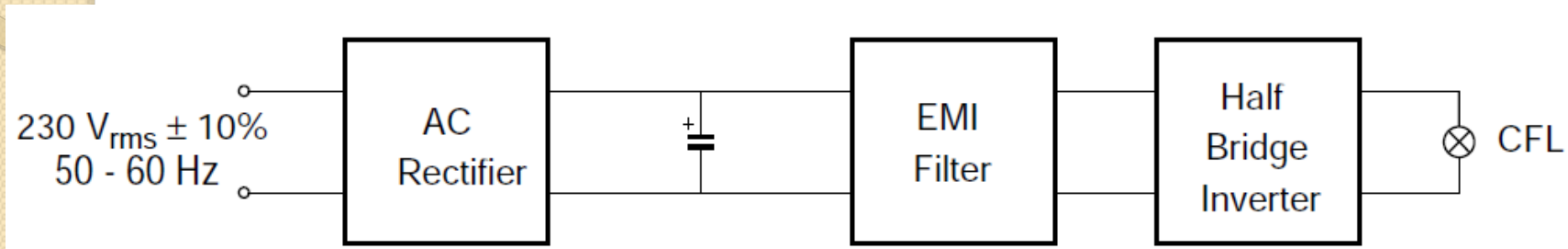
Figure 23. Typical PFC Circuit

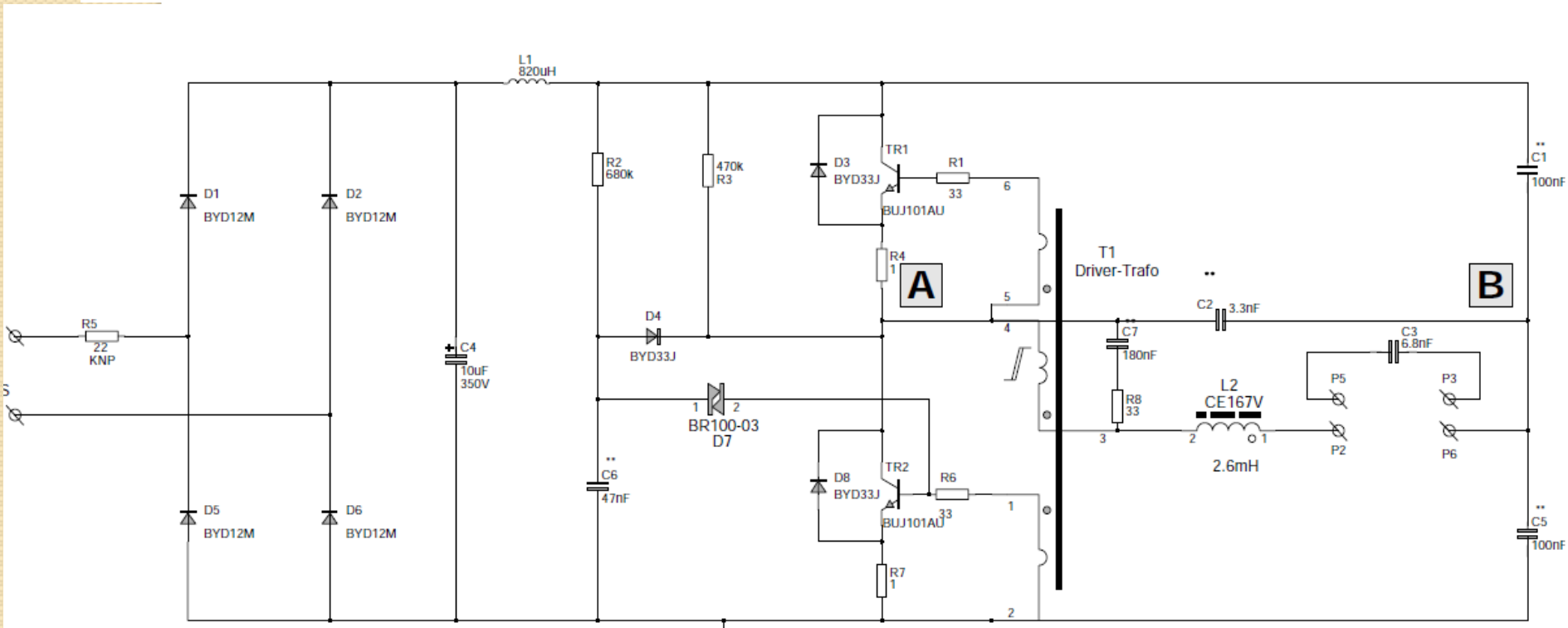
Електронни баласти

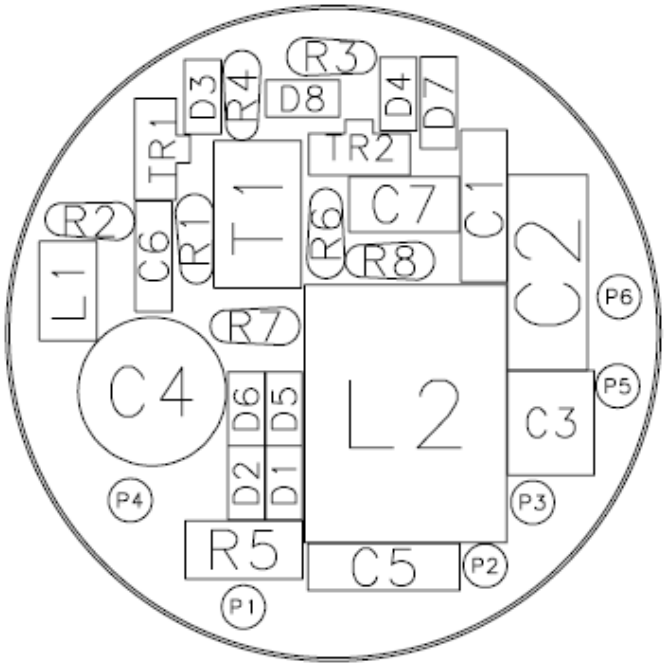
- 1) трудно стартира
- 2) труден за навиване тородидален трансформатор
- 3) трудно регулиране на силата на светене
- 4) скъпо производство в големи количества

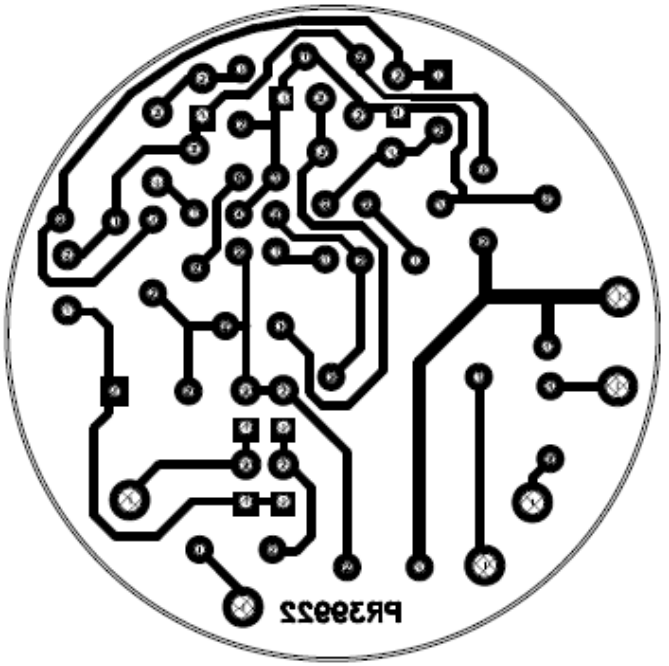


Self Oscillating 25W CFL Lamp Circuit Osram Dulux T/E GX24q-3



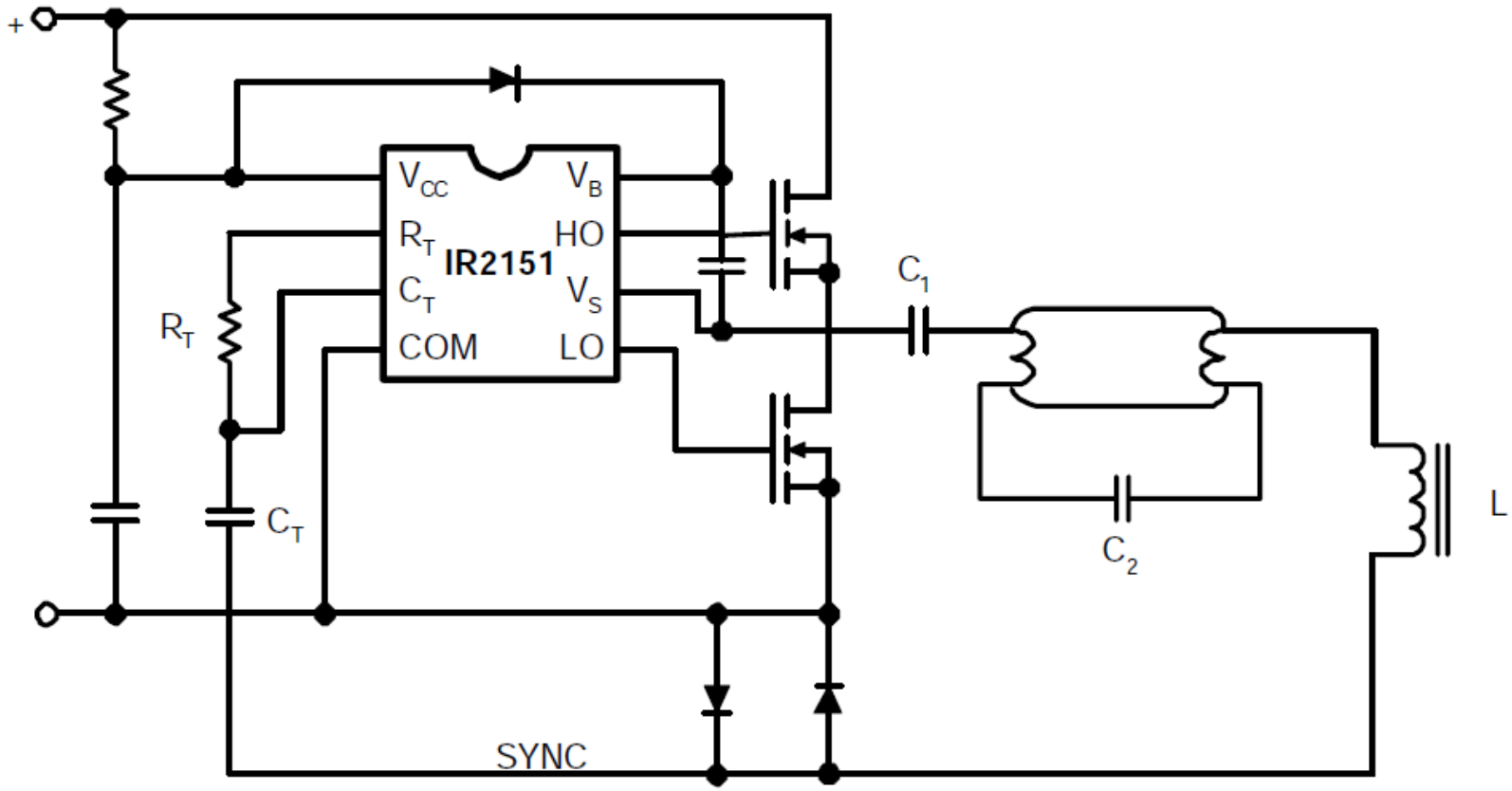




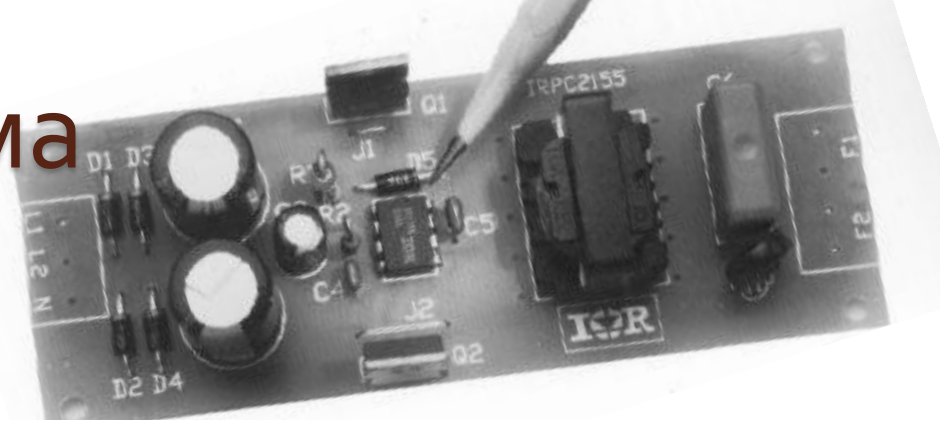


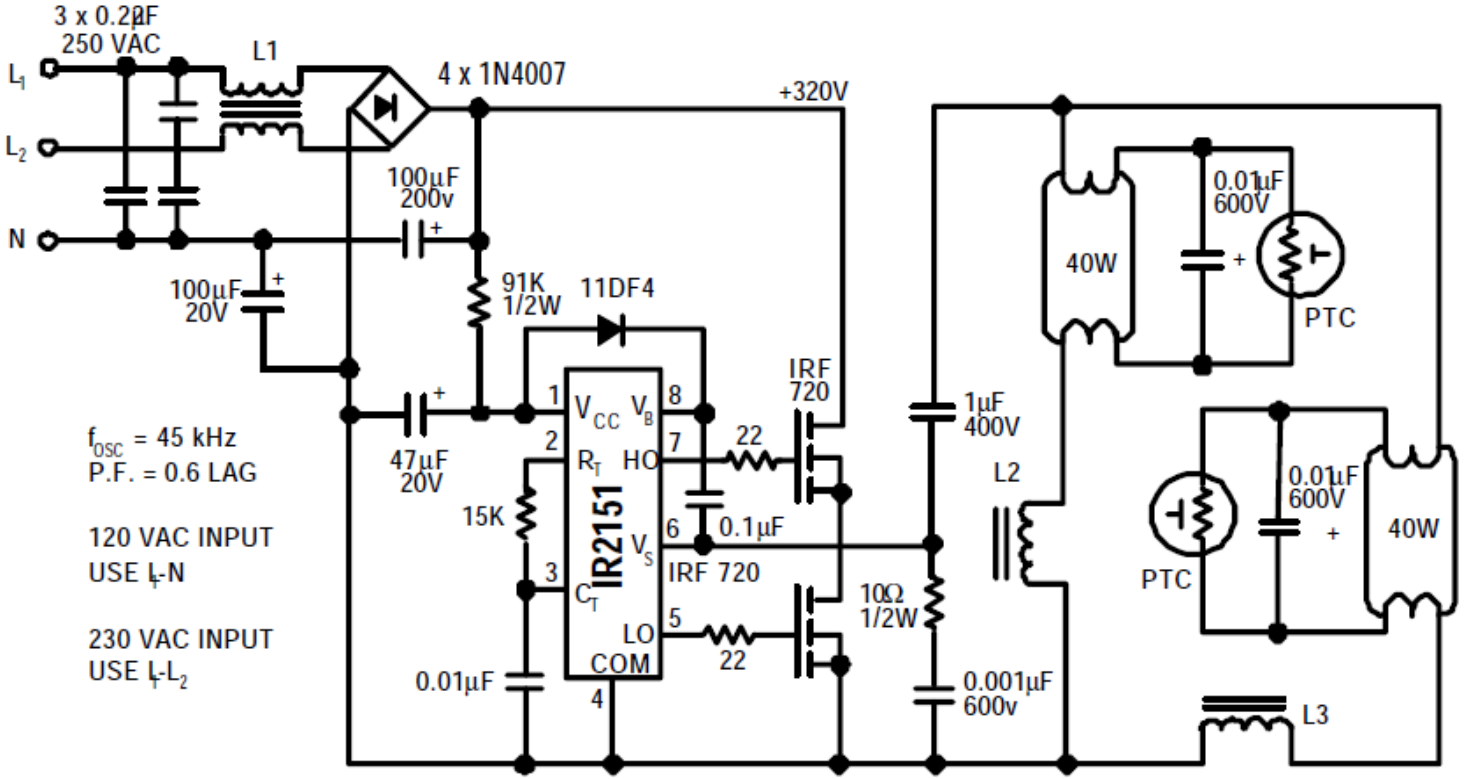
APPLICATION NOTE AN00048 Self Oscillating 25W CFL Lamp Circuit TP97036.2/F5.5 Philips Semiconductors

Следващо поколение драйвери



Примерна схема





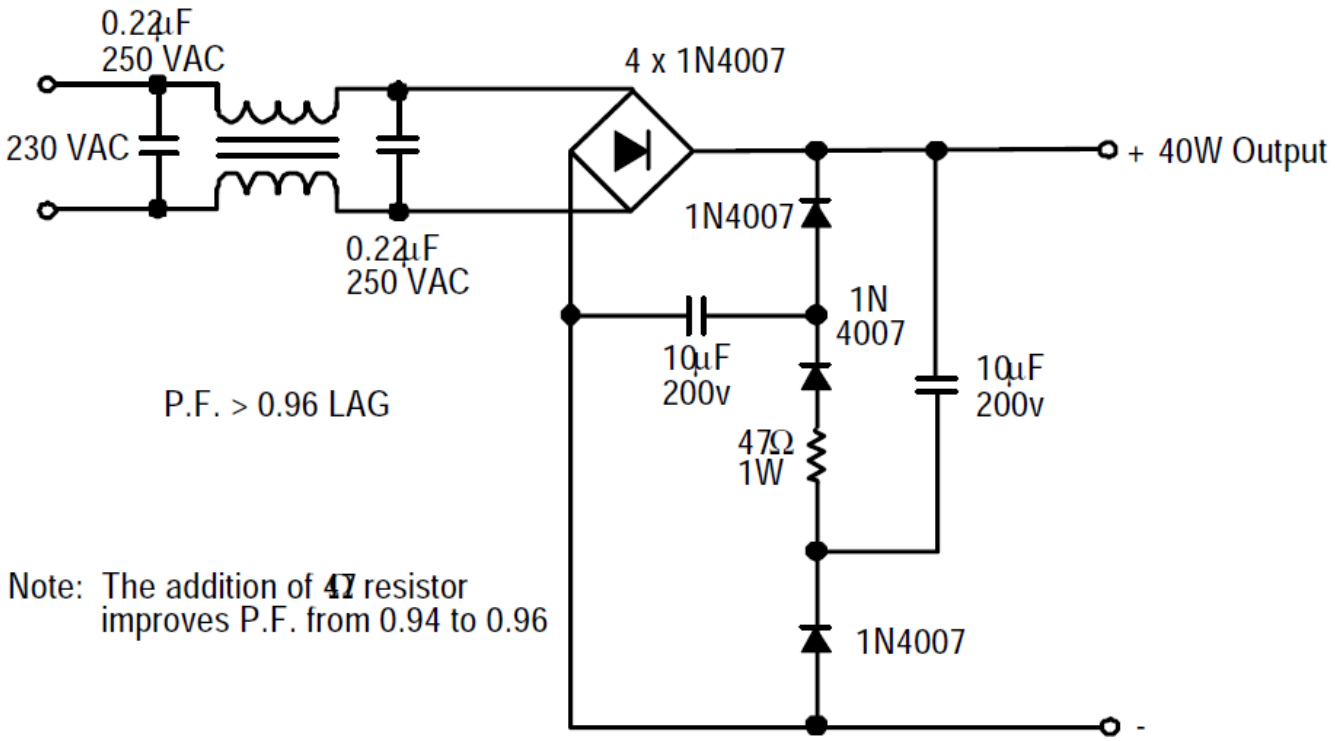
*Polyproplylene Capacitor

L1 Core: Micrometals T106-26 18T Bifilar #18 HAPT Inductance 2 x 30µH

L2-L3 Core: TDK PC30EE302 Bobbin: TDK BE30-1110CP 64T #22 HATP Inductance 1.35 mH: Gap spacer 0.01 inch or XFMRS Inc. part #XFO213EE30

P.T.C. CERA MITE #307C1260BHEAB

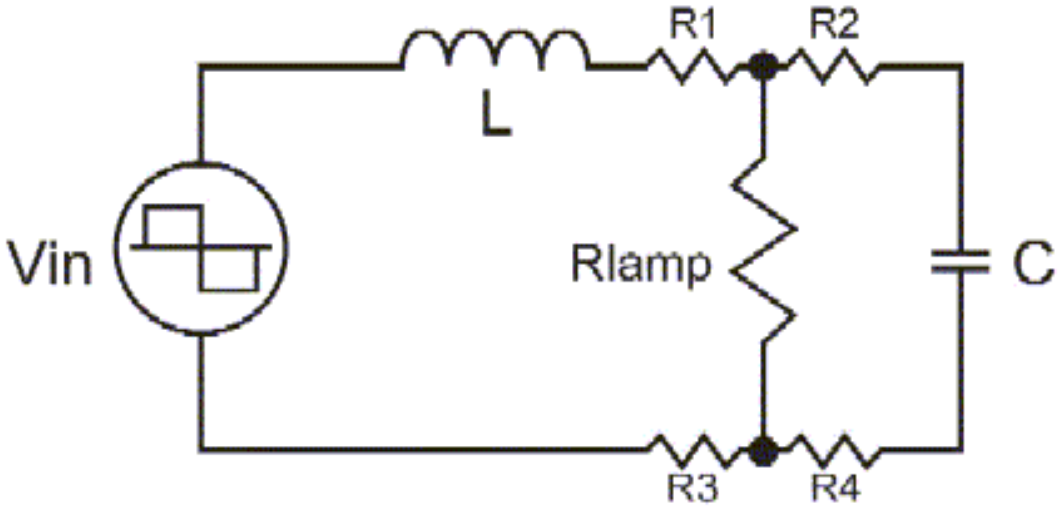
High Power Factor

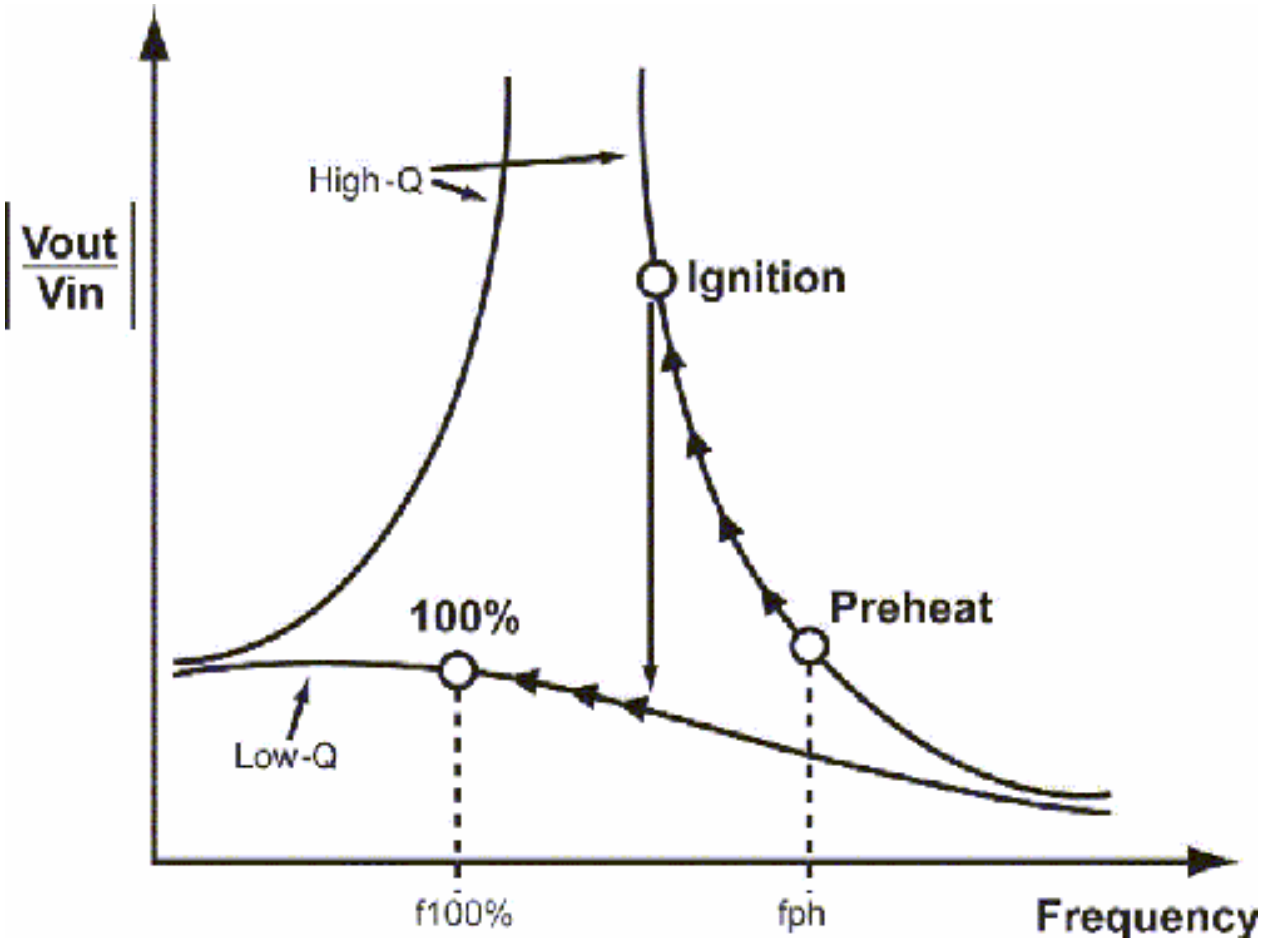


Регулиране на силата на светене

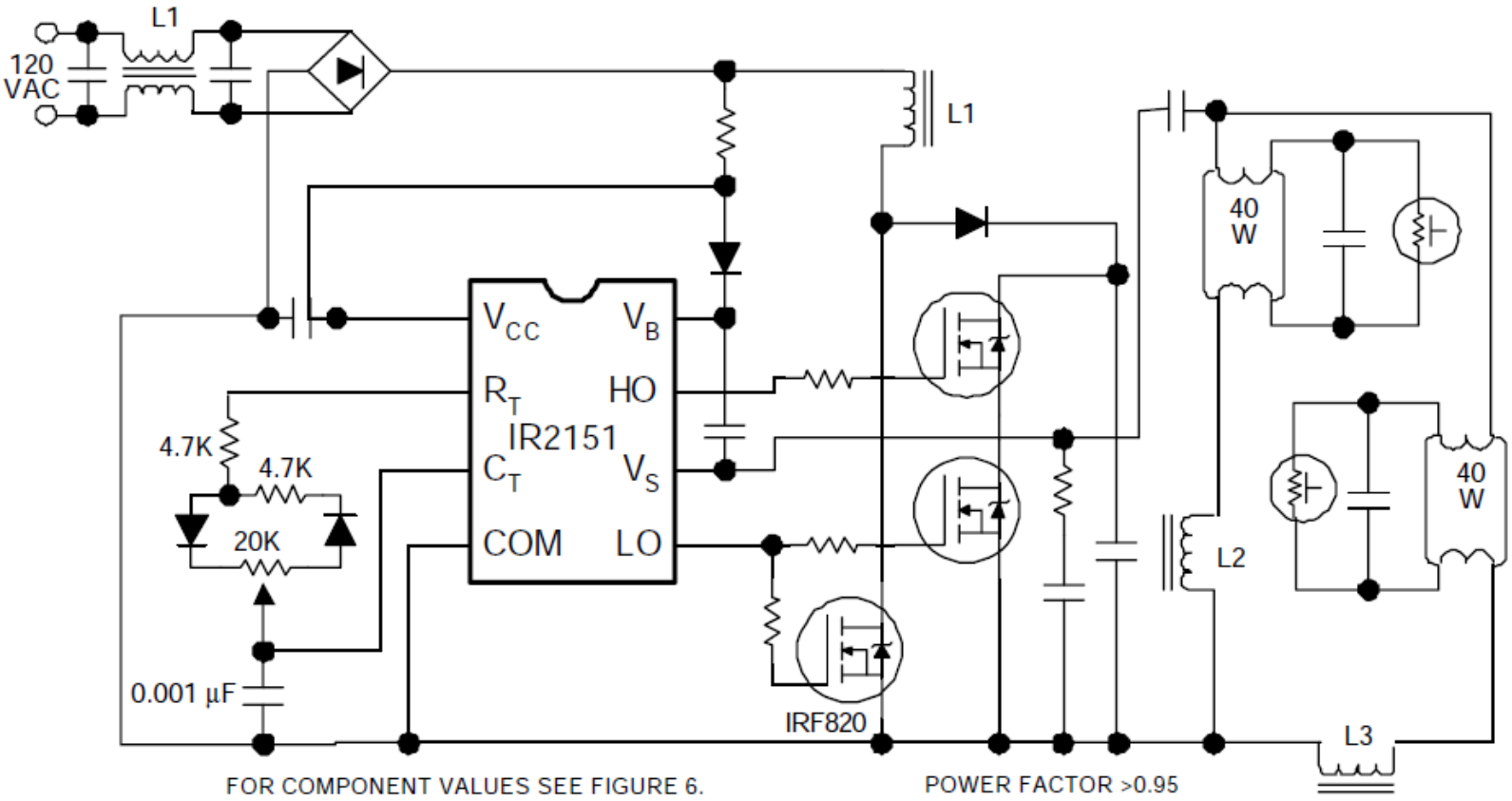
- During dimming, the **current** flowing through the lamp resistance determines the lamp **power and brightness**
- At low brightness levels (typically below 20%), the lamp requires additional heating current through the filament resistors for maintaining the arc

- A resonant RCL output stage is used to control the fluorescent. The resonant behavior of the circuit is used to preheat, ignite and dim the lamp.




Vout
Vin
High-Q
Ignition
100%
Preheat
Low-Q
f100%
fph
Frequency

Регулиране силата на светене



Princip of function we explain on a LUXAR 11W lamp. Circuit contains supply section, which includes interference suppressor L2, fuse F1, bridge rectifier from 1N4007 diodes and filtering capacitor C4. Starting section includes D1, C2, R6 and diac. D2, D3, R1, R3 have protect function. Other parts have normal operation function. **Lamp start**

R6, C2 and DIAC mades first pulse to base of transistor Q2 and cause his opening. After start is this section blocked by diode D1. After every opening of Q2 is discharged C2. There is not possible to collect enough energy for reopening of diac. Next are transistors excitated over very small transformer TR1. It consists of ferrite ring with three windings (5 to 10 coils). Now are filaments powered over capacitor C3 from voltage rises from resonant circuit from L1, TR1, C3 and C6. Than the tube lights up is resonation frequency specified by capacity of C3, because he has much lower capacity than C6. In this moment is voltage on a C3 over 600V in a relation to used tube. During start is peak collector current about 3 to 5 times bigger than during normal operation. When the tube is damaged, there are hazard of transistor destroying.

Normal operation

When the gas is ionisated in a pipe, C3 will be practically shorted and thanks to this frequency goes down and changer is now drived only by C6 and changer generates much lower voltage but enough to keep the light on. In a normal situation, when transistor opens, that current to TR1 increasing until his core is saturated and next his feedback to base drop away and transistor closes. Now opens second transistor which is excitated by reversly connected windind of TR1 and all process repeats.

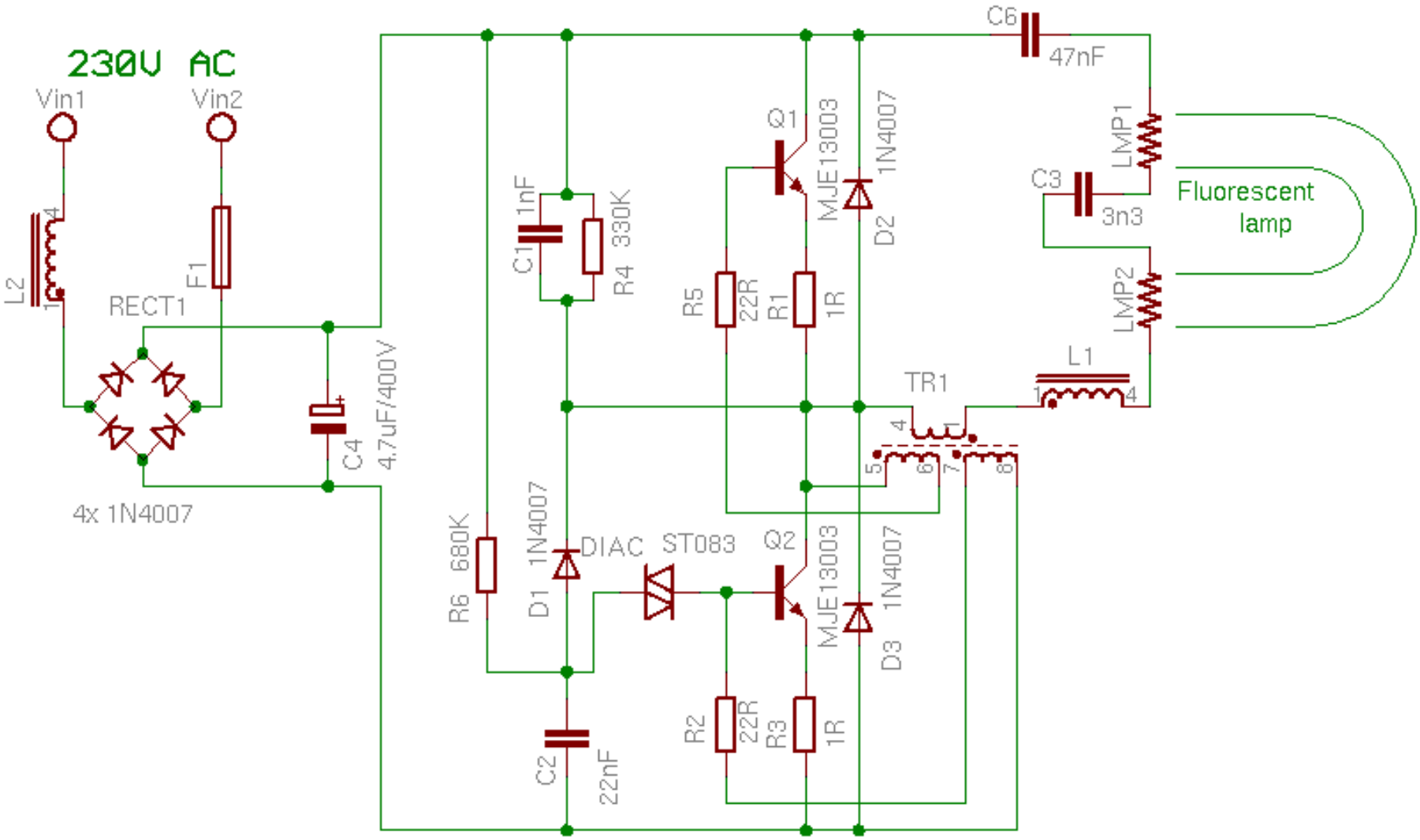
Failures

Common failure is broken capacitor C3. it is possible mainly at cheap lamps, where are used cheaper components for lower voltage. Whet the pipe doesn't lights up on time, there are risk of destroying transistors Q1 and Q2 and next resistors R1, R2, R3 and R5. When lamp starts, changer is very overloaded and transistors usually doesn't survive longer temperature overloading. When the pipe serve out, electronics is usually destroyed too. When the pipe is old, there can be overburned one of filaments and lamp doesn't lights up anymore. Electronics usually survives. Sometimes can be pipe broken due to internal tension and temperature difference. Most frequently lamp fails, when power on.

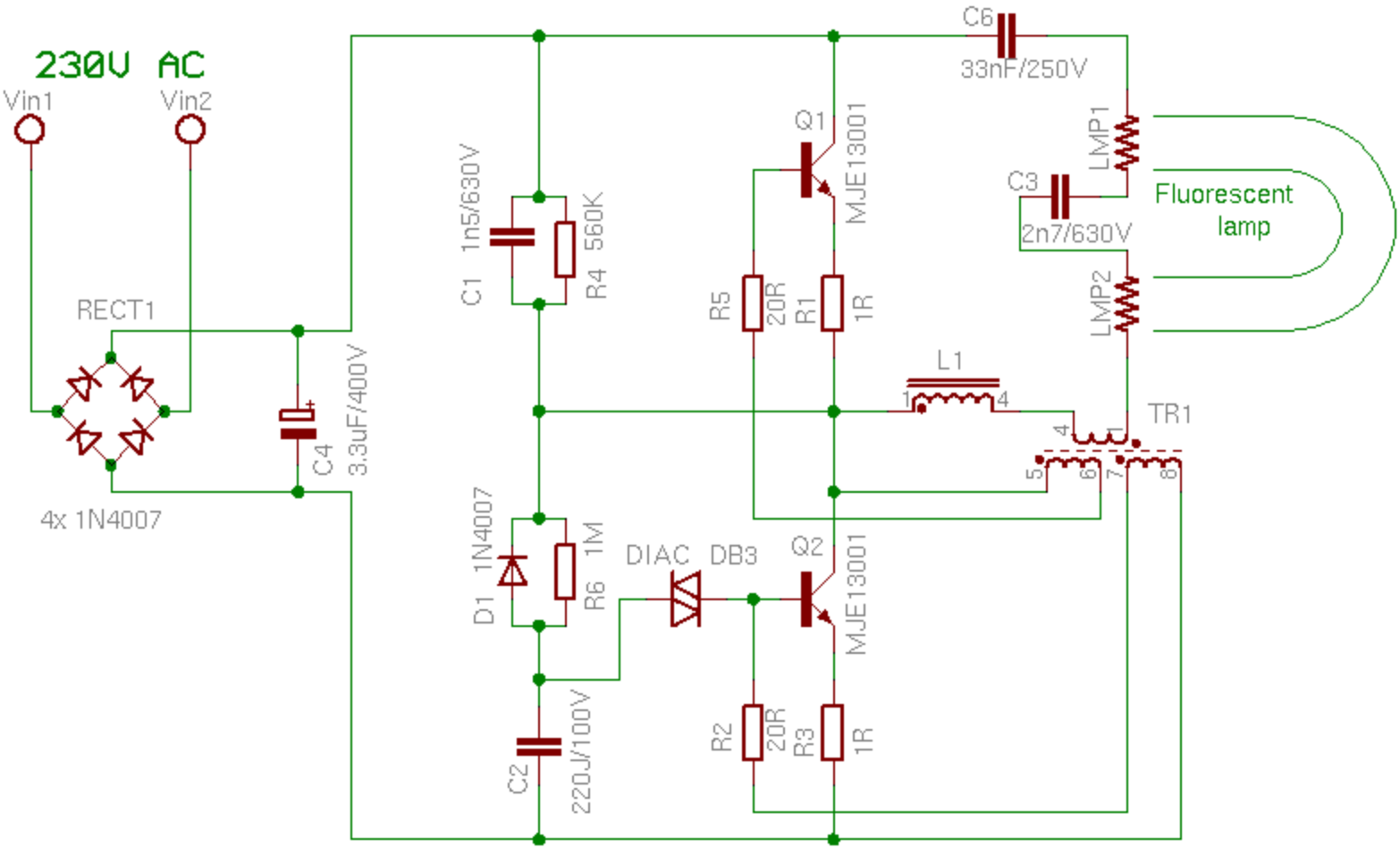
Repair of electronics

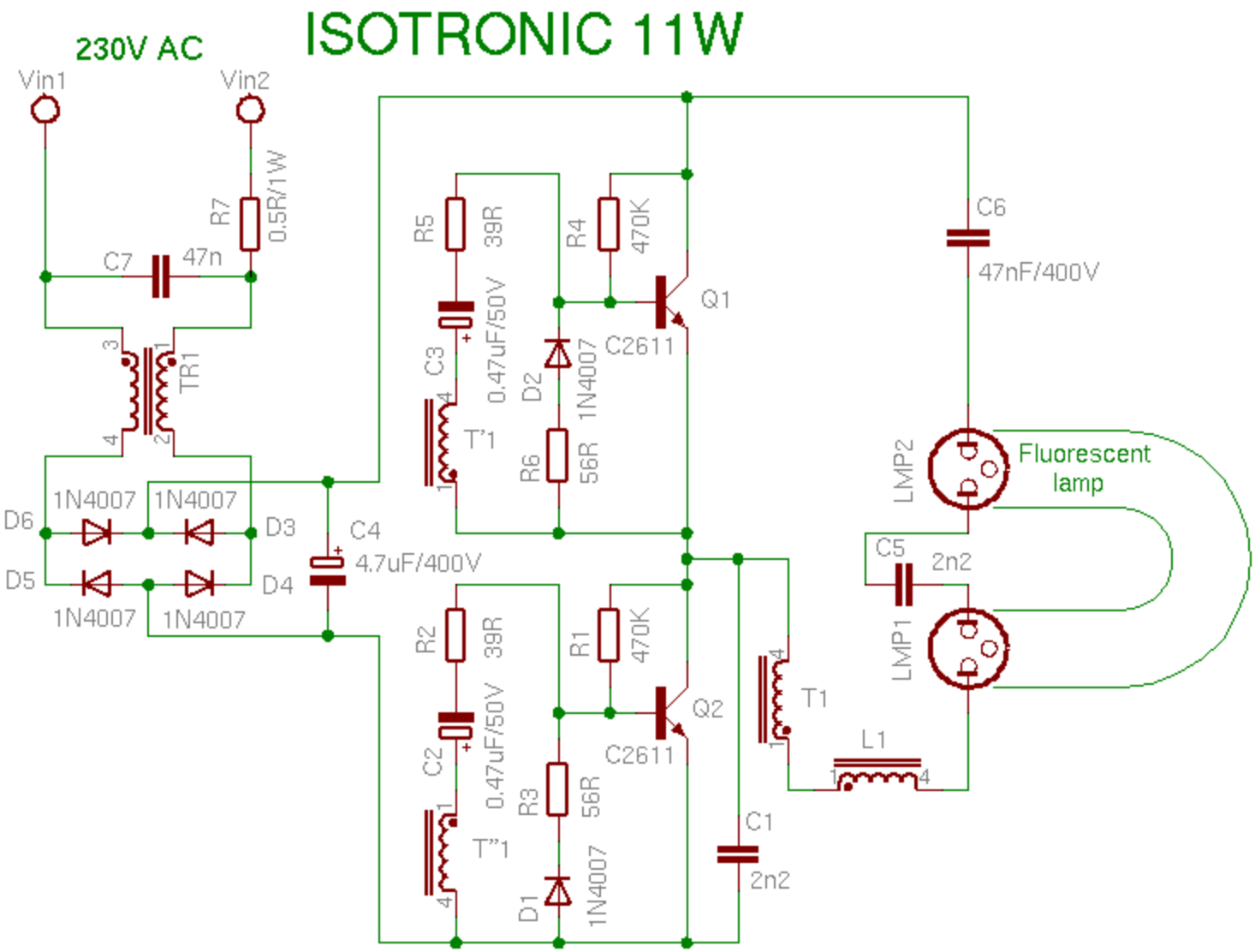
Repair of electronics usually means change of capacitor C3 if he is brobek. When burns fuse, probably will be damaged transistors Q1, Q2 and resistors R1, R2, R3, R5. You can replace fuse with resistor 0R5. Failures can be multiplied. For example, when is shorted capacitor there can be thermally overloaded transistors and will be destroyed. Best transistors for replacing of original types are MJE13003, but it is not easy to find them. I replaced them with BD129, but they are not available now. There exists other variants like a 2SC2611, 2SC2482, BD128, BD127, but I am not sure if they will be long-life. Original transistors are not available on our market. If doesn't matter size of case TO220, it's possible to use transistors MJE13007.

LUXAR 11W

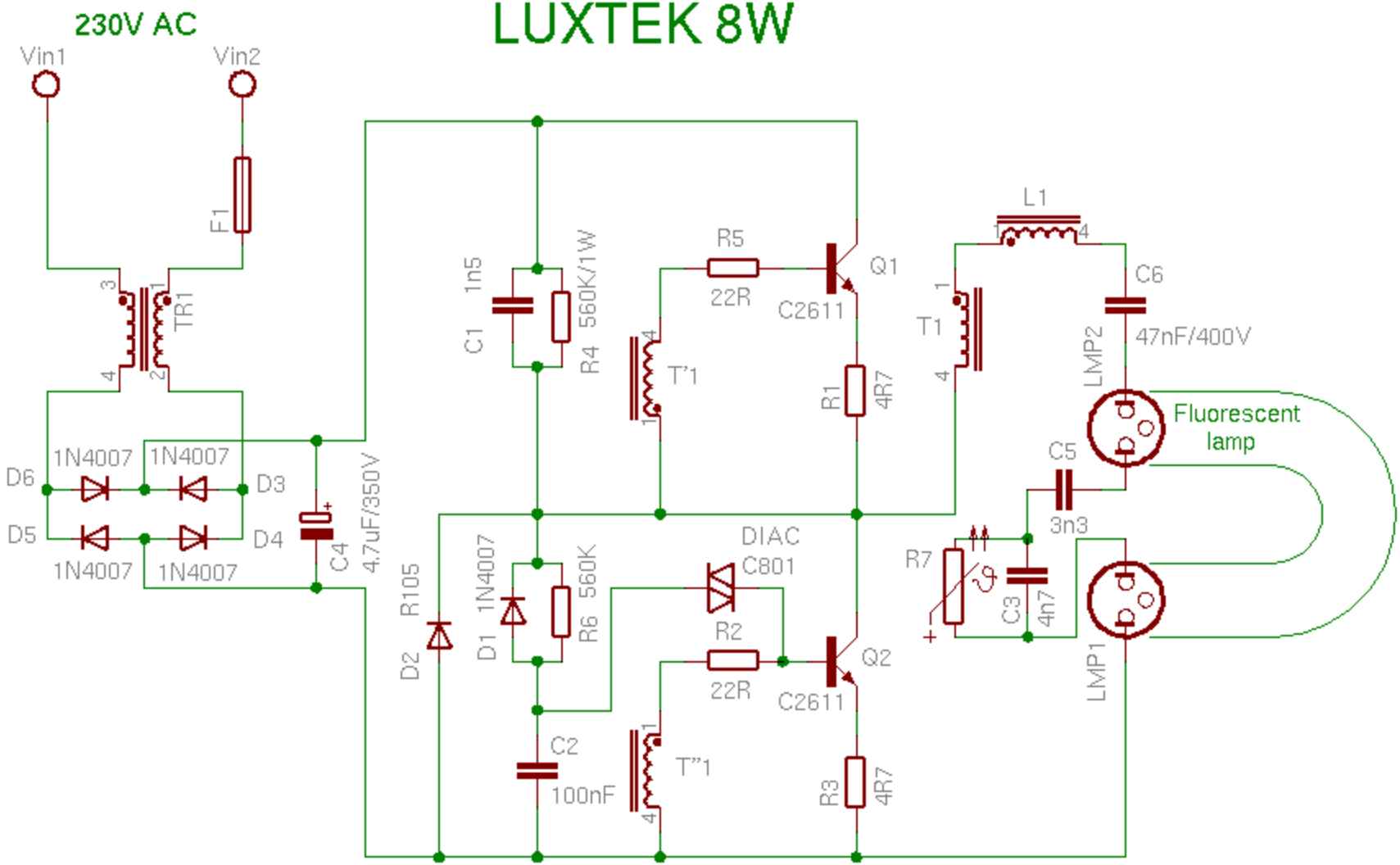

230V AC
Vin1
Vin2
L2
F1
RECT1
4x 1N4007
C4
4.7uF/400V
C1
1nF
R4
330K
R5
22R
R1
1R
Q1
MJE13003
D2
1N4007
C6
47nF
LMP1
C3
3n3
LMP2
Fluorescent lamp
L1
TR1
R6
680K
D1
1N4007
DIAC
ST083
Q2
MJE13003
D3
1N4007
R2
22R
R3
1R
C2
22nF

BIGLUZ 20W

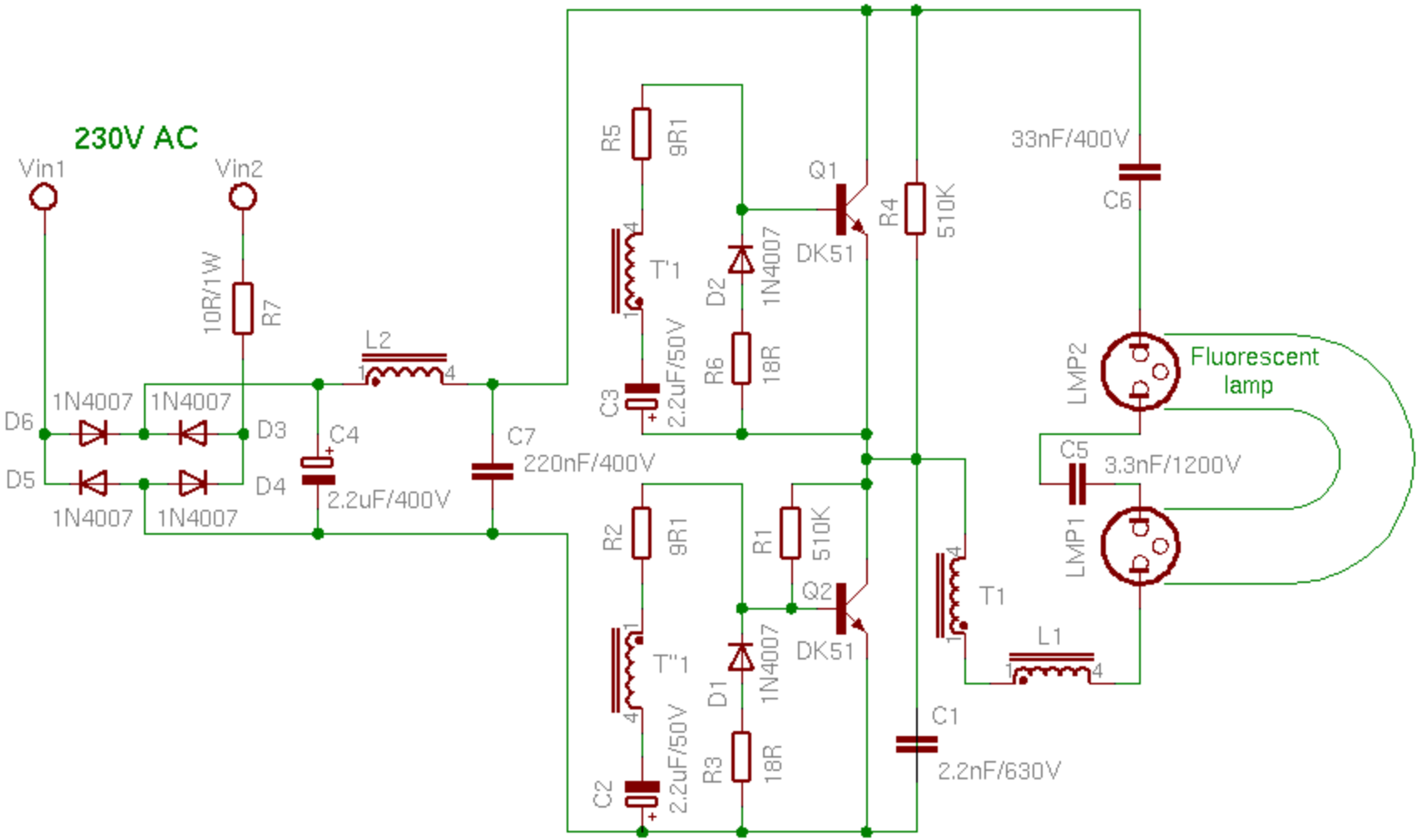

230V AC
Vin1
Vin2
RECT1
4x 1N4007
C4 3.3uF/400V
C1 1n5/630V
R4 560K
D1 1N4007
R6 1M
C2 220J/100V
DIAC DB3
Q1 MJE13001
Q2 MJE13001
R5 20R
R1 1R
R2 20R
R3 1R
C6 33nF/250V
C3 2n7/630V
LMP1
LMP2
Fluorescent lamp
L1
TR1

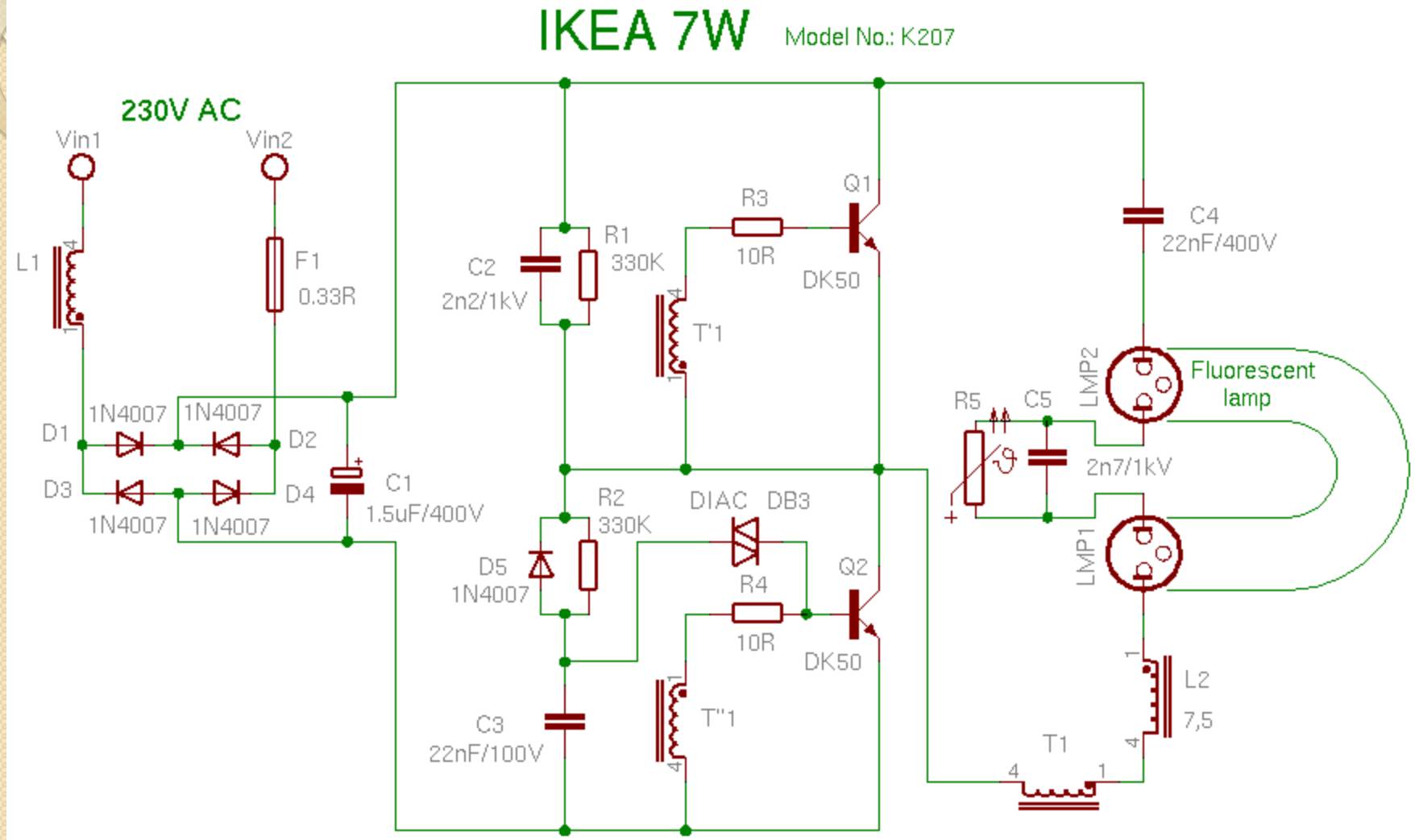

ISOTRONIC 11W
230V AC
Vin1
Vin2
R7
0.5R/1W
C7
47n
TR1
1N4007
1N4007
D6
D3
D5
D4
1N4007
1N4007
C4
4.7uF/400V
R5
39R
C3
0.47uF/50V
T'1
R4
470K
D2
1N4007
R6
56R
Q1
C2611
C6
47nF/400V
LMP2
Fluorescent
lamp
C5
2n2
LMP1
R2
39R
C2
0.47uF/50V
T"1
R1
470K
R3
56R
D1
1N4007
Q2
C2611
T1
L1
C1
2n2

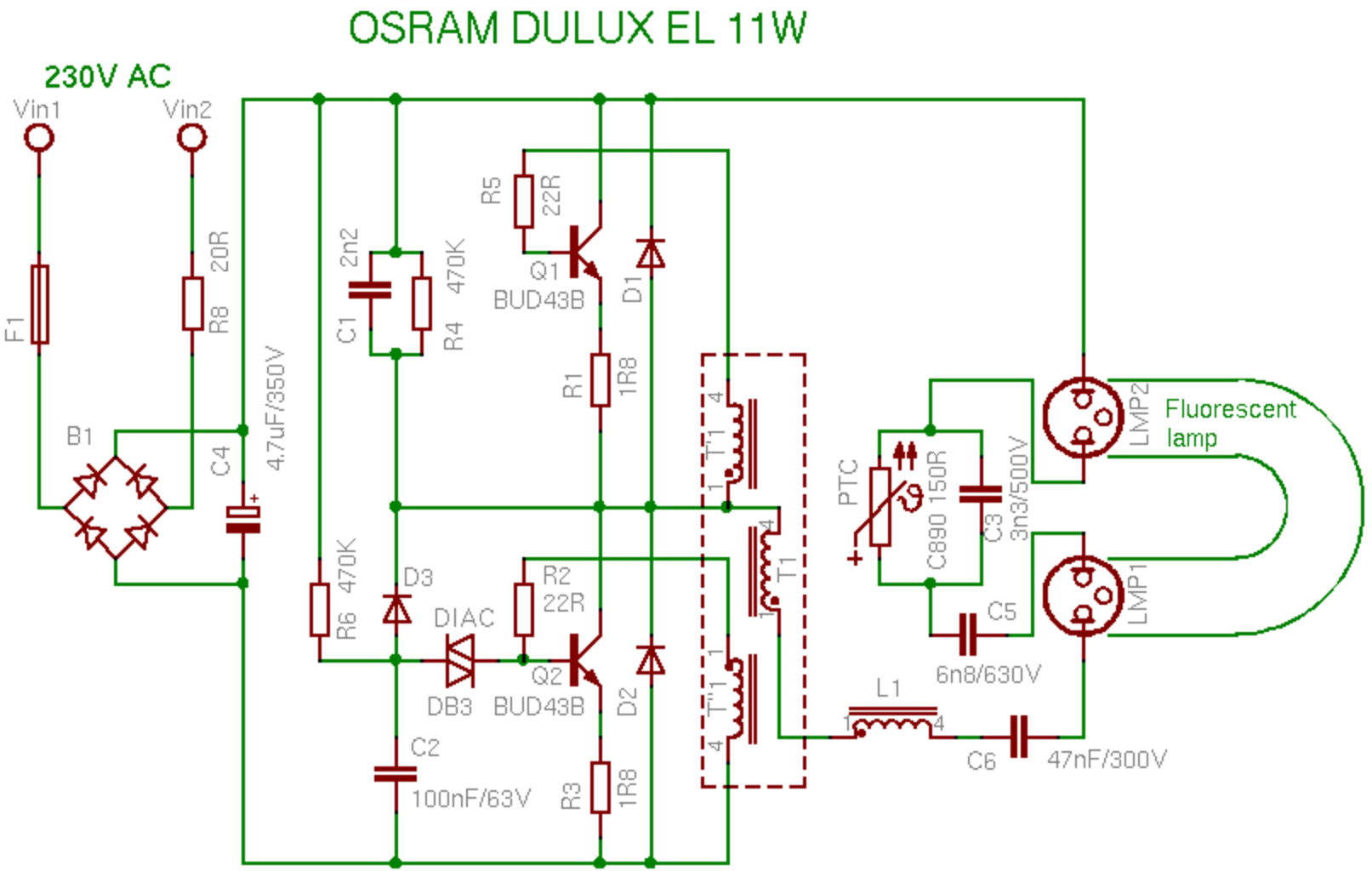
LUXTEK 8W

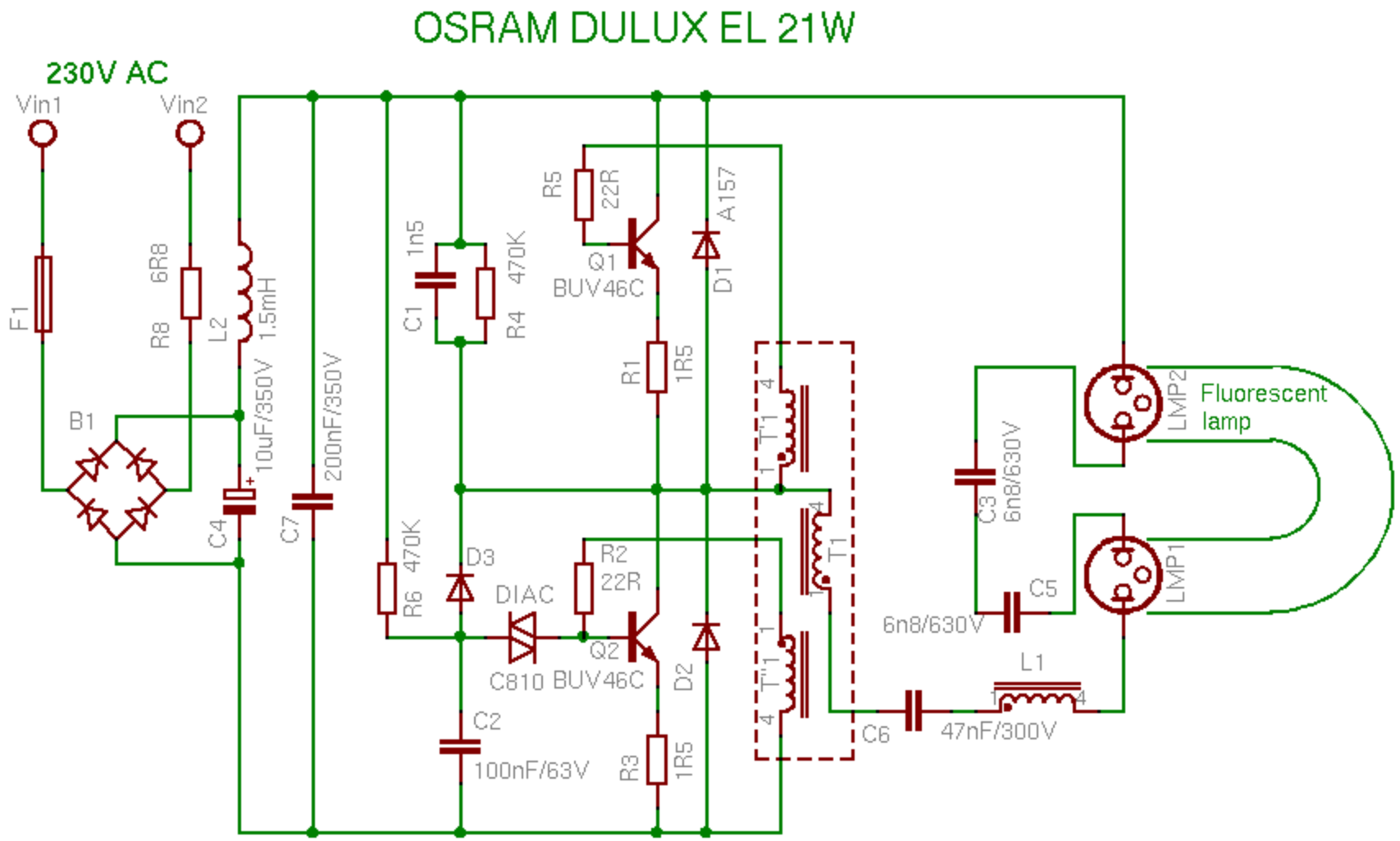

230V AC
Vin1
Vin2
F1
TR1
D6
D5
D3
D4
1N4007
1N4007
1N4007
1N4007
C4
4.7uF/350V
C1
1n5
R4
560K/1W
R5
22R
Q1
C2611
T'1
R1
4R7
L1
T1
C6
47nF/400V
LMP2
Fluorescent
lamp
C5
3n3
R7
C3
4n7
LMP1
DIAC
C801
R105
D2
D1
1N4007
R6
560K
R2
22R
Q2
C2611
C2
100nF
T"1
R3
4R7

PHILIPS ECOTONE 11W

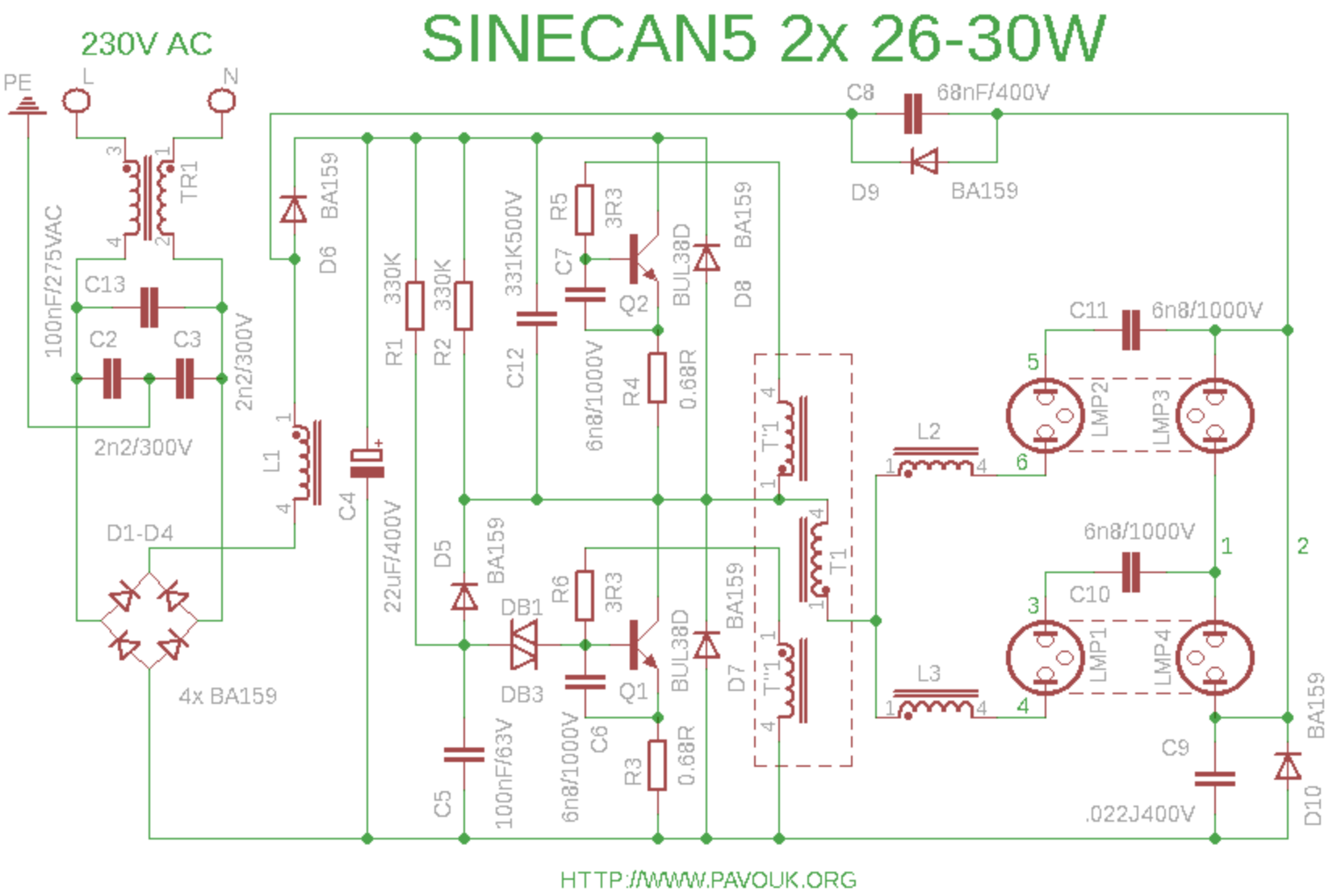



IKEA 7W
Model No.: K207
230V AC
Vin1
Vin2
L1
F1
0.33R
1N4007
1N4007
D1
D2
D3
D4
1N4007
1N4007
C1
1.5uF/400V
C2
2n2/1kV
R1
330K
R3
10R
Q1
DK50
T'1
C4
22nF/400V
LMP2
Fluorescent
lamp
R5
C5
2n7/1kV
LMP1
R2
330K
DIAC DB3
D5
1N4007
R4
10R
Q2
DK50
T''1
C3
22nF/100V
L2
7,5
T1

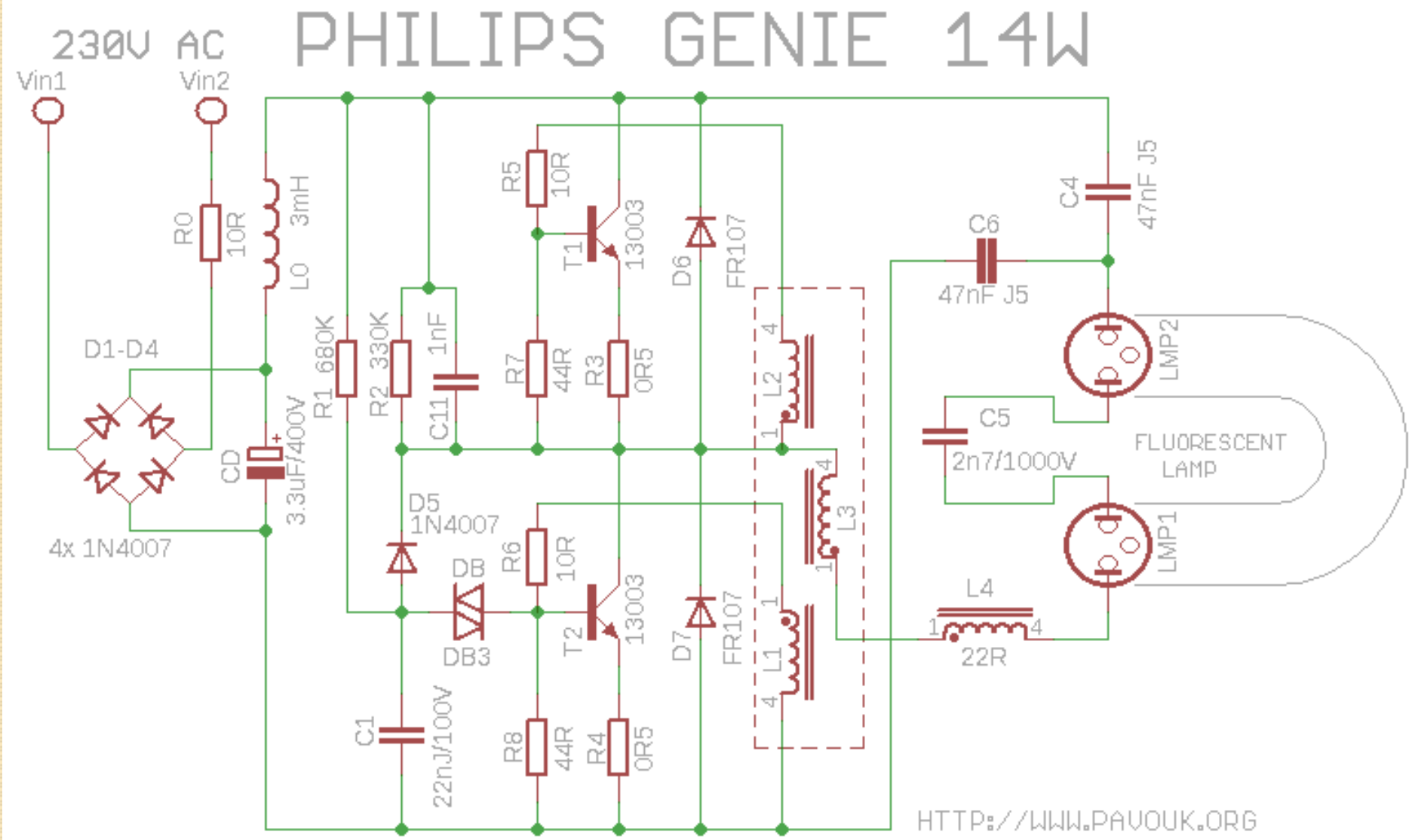

OSRAM DULUX EL 11W
230V AC
Vin1
Vin2
F1
R8 20R
B1
C4 4.7uF/350V
C1 2n2
R4 470K
R5 22R
Q1 BUD43B
D1
R1 1R8
R6 470K
D3
DIAC
DB3
R2 22R
Q2 BUD43B
D2
C2 100nF/63V
R3 1R8
T'1
T1
T"1
PTC
C890 150R
C3 3n3/500V
LMP2
Fluorescent lamp
LMP1
C5 6n8/630V
L1
C6 47nF/300V

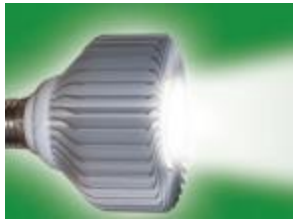


In contrast to a previous OSRAM lamp doesn't have thermistor for slow start. She has overburned one filament.

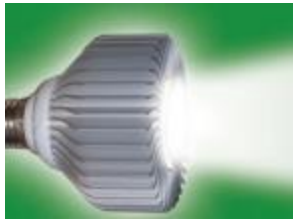


Electronic ballast SINECAN 5 for two fluorescent tubes has identical circuit like most of compact fluorescent lamps. Little differency is in powering tubes before D6 diode and wiring of start capacitors C10 a C11 about tubes. I don't understand exactly why this is wired this way. Ballast doesn't have fuse, but only thin wire. Ballasts was broken due to blowed electrolytic capacitors. It breaks transistors and resistors R3, R4, R5 and R6

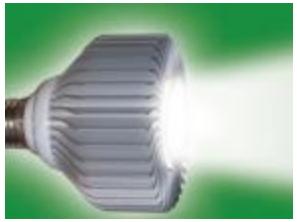

PHILIPS GENIE 14W
230V AC
Vin1
Vin2
R0
10R
L0
3mH
D1-D4
4x 1N4007
CD
3.3uF/400V
R1 680K
R2 330K
C11
1nF
R5
10R
T1
13003
R7
44R
R3
0R5
D6
FR107
D5
1N4007
DB
DB3
R6
10R
T2
13003
D7
FR107
C1
22nJ/100V
R8
44R
R4
0R5
L2
L3
L1
L4
22R
C6
47nF J5
C4
47nF J5
C5
2n7/1000V
LMP2
LMP1
FLUORESCENT
LAMP
HTTP://WWW.PAVOUK.ORG



Energy Efficiency & Energy Costs	Light Emitting Diodes (LEDs)	Incandescent Light Bulbs	Compact Fluorescents (CFLs)
Life Span (average)	**50,000 hours**	**1,200 hours**	**8,000 hours**
Watts of electricity used (equivalent to 60 watt bulb).	**6 - 8 watts**	**60 watts**	**13-15 watts**
Kilo-watts of Electricity used (30 Incandescent Bulbs per year equivalent)	**329 KWh/yr.**	**3285 KWh/yr.**	**767 KWh/yr.**



Environmental Impact	Light Emitting Diodes (LEDs)	Incandescent Light Bulbs	Compact Fluorescents (CFLs)
Contains the TOXIC Mercury	**No**	**No**	**Yes** - Mercury is very toxic to your health and the environment
RoHS Compliant	**Yes**	**Yes**	**No** - contains 1mg-5mg of Mercury and is a major risk to the environment
Carbon Dioxide Emissions (30 bulbs per year)	**451 pounds/year**	**4500 pounds/year**	**1051 pounds/year**



Light Output	Light Emitting Diodes (LEDs)	Incandescent Light Bulbs	Compact Fluorescents (CFLs)
Lumens	Watts	Watts	Watts
450	4-5	40	9-13
800	6-8	60	13-15
1,100	9-13	75	18-25
1,600	16-20	100	23-30
2,600	25-28	150	30-55

Important Facts	Light Emitting Diodes (LEDs)	Incandescent Light Bulbs	Compact Fluorescents (CFLs)
Sensitivity to low temperatures	None	Some	Yes - may not work under negative 10 degrees Fahrenheit or over 120 degrees Fahrenheit
Sensitive to humidity	No	Some	Yes
On/off Cycling	No Effect	Some	Yes - can reduce lifespan drastically
Turns on instantly	Yes	Yes	No - takes time to warm up
Durability	Very Durable - LEDs can handle jarring and bumping	Not Very Durable - glass or filament can break easily	Not Very Durable - glass can break easily
Heat Emitted	3.4 btu's/hour	85 btu's/hour	30 btu's/hour
Failure Modes	Not typical	Some	Yes - may catch on fire, smoke, or omit an odor

References

http://www.irf.com/product-info/lighting/

http://www.en-genius.net/includes/files/col_081307.pdf

http://www.pavouk.org/hw/lamp/en_index.html

http://www.designrecycleinc.com/led%20comp%20chart.html

How to design a dimming fluorescent electronic ballast,
By Tom Ribarich, Director, Lighting Design Center, International Rectifier Power Management DesignLine (01/29/2006 11:04 PM EST)