AN3040
Application note

STEVAL-ILB008V1 4 x 18 W/T8 ballast driven by L6585DE

Introduction

This application note describes a demonstration board able to drive a 4 x 18 W linear T8 fluorescent tubes.

The ballast is controlled by the new L6585DE IC that integrates the PFC and half-bridge control circuits, relevant drivers, and the circuitry that manages all the operating phases (preheating, ignition and run mode) of the lamp. Protections against failures such as lamp disconnection, anti-capacitive mode and PFC overvoltage are guaranteed and obtained with a minimum number of external components. In addition to the description of the circuit and design criteria, this document provides a short overview of the ballast performances.

Fluorescent lamps are driven more and more by electronic ballasts rather than by electromagnetic ballasts, primarily because fluorescent lamps can produce around 20% more light for the same input power when driven above 20 kHz instead of 50/60 Hz. Operation at this frequency also eliminates both light flickering (the response time of the discharge is too slow for the lamp to have a chance to extinguish during each cycle) and audible noise. Electronic ballasts consume less power and therefore dissipate less heat than electromagnetic ballasts. The energy saved can be estimated in the range of 20-25% for a given lamp power. Finally, the electronic solution allows better control of the filament current and lamp voltage during preheating with the unquestionable benefit of increasing the average lamp life.

Figure 1. 4 x 18 W T8 ballast demonstration board

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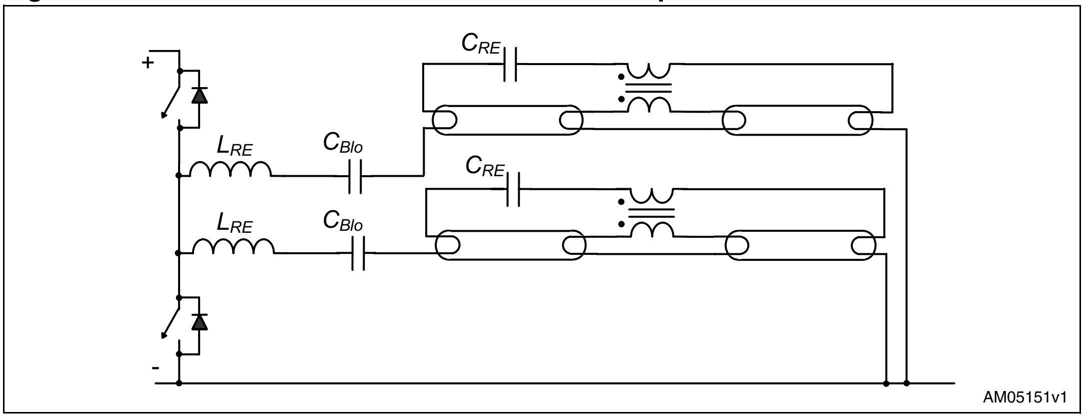
1 Basis of half-bridge inverter topology

The half-bridge inverter operates in zero voltage switching (ZVS) resonant mode to reduce the switching losses and the electromagnetic interference generated by the output wiring and the lamp. Voltage-fed, series-resonant, half-bridge inverters are currently used for compact fluorescent lamp (CFL) ballasts and for many european tube lamp (TL) ballasts.

For this circuit, we have chosen a lamp-to-ground configuration with current preheating and have implemented two parallel resonant circuits that each supply two lamps in series, as shown in *Figure 2*.

Figure 2. Electrical architecture used for four-lamp electronic ballasts



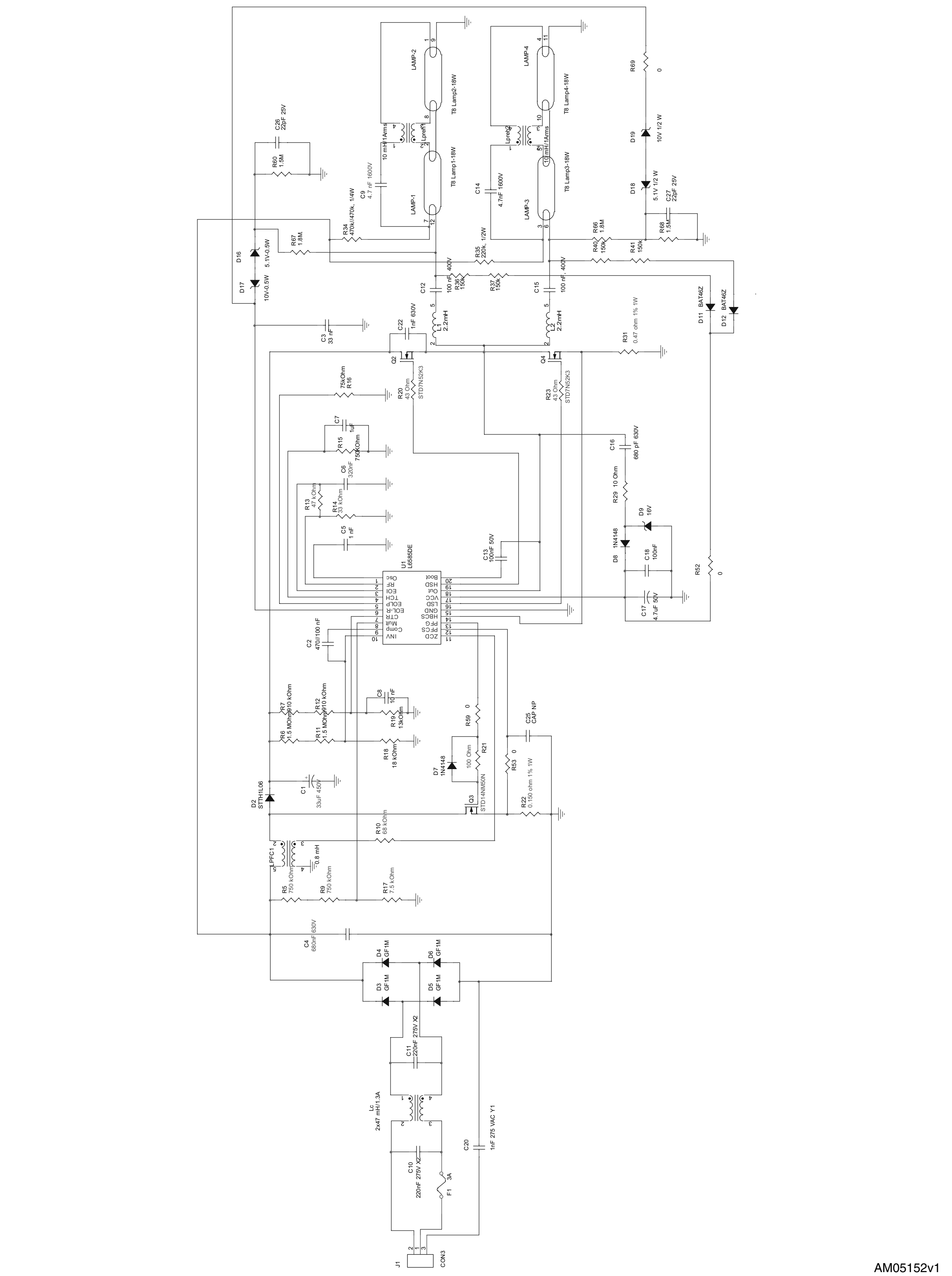
2 Main characteristic

The electrical specifications of the lamp ballast are shown in *Table 1*.

Table 1. Input and output parameter

Input parameters		
V_{IN}	Input voltage range	85 to 265 V_{RMS}
f_{line}	Line frequency	50/60 Hz
Tube lamp		
Number	4	
Type	T8	
Power	18 W	
Expected output parameters		
PF	Power factor	≥0.9
THD%	Total harmonic distortion	≤10
η %	Efficiency	≈90

Figure 3. Electrical schematic 4 x 18 W T8 - main wide range



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3 Ballast design

This sections describes the main components of the circuit.

3.1 L6585DE pin-by-pin biasing circuitry

Designed in high-voltage BCD offline technology, the L6585DE embeds a PFC controller, a half-bridge controller, the relevant drivers and the logic necessary to build an electronic ballast.

- Pin1 OSC is one of the two oscillator inputs. The value of the capacitor connected to ground defines the half-bridge switching frequency in each operating state. C_5 is set to 1 nF.
- Pin2 RF: the choice of component and oscillator capacitance defines the half-bridge switching frequency in each operating state. A resistor R_{14} connected to ground sets the run frequency, while during the preheating phase the switching frequency is set by the parallel of the above resistance with the R_{13} resistor connected between the RF and EOI pins (the EOI pin is pulled to ground during preheating).
With the following frequencies and ignition time:

$$f_{run} = 40\text{kHz} \quad f_{pre} = 67\text{kHz} \quad t_{ign} = 45\text{ ms}$$

R_{14} can be calculated with the following formula.

Equation 1

$$e = 1 - \frac{1.33}{(C_5)^{0.581}} \quad k = \frac{499.6 \cdot 10^3}{(C_5)^{0.872}} \quad R_{14} = \left(\frac{k}{f_{run}}\right)^{1/e} = 33\text{ k}\Omega$$

The value of R_{13} is therefore given by:

Equation 2

$$R_{13} // R_{14} = \left(\frac{k}{f_{pre}}\right)^{1/e} \Rightarrow R_{13} = 47\text{ k}\Omega$$

- Pin3 EOI is a multi-function pin. During preheating, the pin is internally shorted to ground by the logic, so the resistor (Rpre//Rrun) connected between the RF pin and ground sets the preheating switching frequency. During ignition it goes into a high impedance state: the ignition time is the time necessary for the pin voltage to - exponentially - rise from zero to 1.9 V. The growth is steered by the C_6*R_{13} time constant; since the value of R_{13} has already been calculated and t_{ign} at the start is fixed, C_6 is calculated with the following formula.

Equation 3

$$C_6 = \frac{t_{ign}}{3 \cdot R_{13}} = 319\text{ nF}$$

For this circuit, C_6 has been set to 320 nF.

- Pin4 TCH is the time counter and is activated during the preheating phase as well as after a protection is triggered (HBCS crossing during ignition run mode, window comparator at EOL). To achieve this, an $R_{15}C_7$ parallel network is connected between this pin and ground. With a protection time $t_{Tch,reduced}$ fixed at 0.27 seconds (needed for the startup sequence with old or damaged lamps), C_7 can then be calculated.

Equation 4

$$t_{Tch,reduced} \cong C_7 \cdot 0.26974 \cdot 10^6 \Rightarrow C_7 = 1\,\mu F$$

With t_{pre} set to 1 second and considering the internal current generator I_{CH} = 31 μA, R_{15} can be calculated.

Equation 5

$$R_{15} = \frac{t_{pre} - \frac{C_7}{I_{CH}} \cdot 4.63}{C_7 \cdot \ln\frac{4.63}{1.5}} = 755\,k\Omega \Rightarrow 750\,k\Omega$$

- Pin5 EOLP is a 2 V reference and allows programming the window comparator of Pin6 (EOL) according to the values defined in *Table 4* in the L6585DE datasheet. Working in a lamp-to-ground configuration, a fixed reference mode has been selected, and for a window voltage amplitude of ± 240 mV, R_{16} has been set to 75 kΩ.
- Pin6 EOL is the input of the window comparator. Concerning this comparator, the fixed reference configuration requires two Zener diodes to shift the mean value of the lamp voltage to 2.5 V. The values of the two Zener diodes relate to the symmetry of the protection intervention, and the best symmetry is obtained by choosing two values whose difference is equal to twice the reference voltage.

  Referring to the first series lamp (*Figure 3*):

Equation 6

$$V_{K\max} = 2.5 + V_{zD16} + V_{fD17} + W/2$$

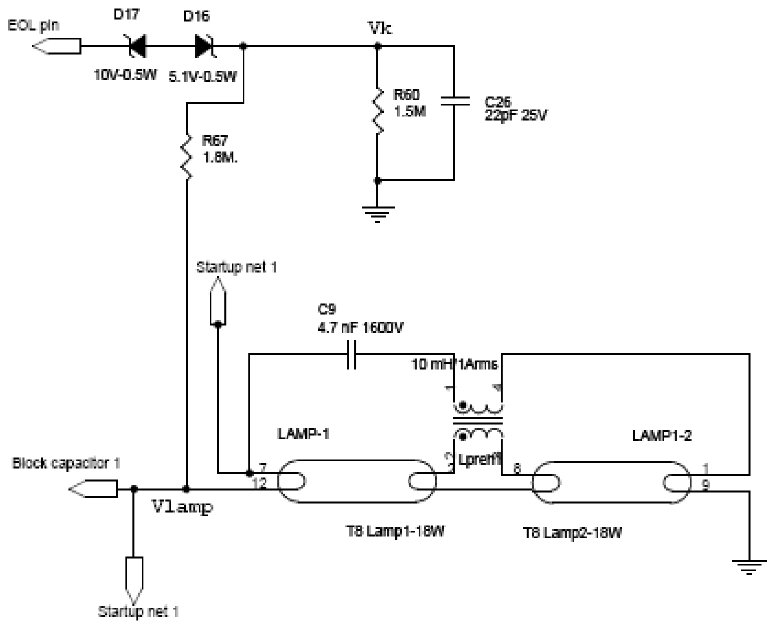
$$V_{K\min} = 2.5 - (V_{zD17} + V_{fD16}) - W/2$$

$$V_{K\max} = -V_{K\min} \Rightarrow 2 \cdot 2.5 = V_{zD17} - V_{zD16} \Rightarrow V_{zD17} = 5.1\,V, V_{zD16} = 10\,V$$

If we consider that V_{fD17} = V_{fD16} = 0.7 V and take into account that W/2 = 0.240 V, the maximum/minimum voltage on the low resistance of the voltage divider of the lamp is $|V_K| = 8.2V$.

With R_{67} equaling 1.8 MΩ, considering the current capability of EOL and fixing the maximum deviation voltage lamp $|V_{lamp}| = 18V$, the value of R_{60} can be calculated as 1.5 MΩ.

Figure 4. EOL circuit for first-series lamp



The same design procedure can be used for the EOL circuit of the second series lamp.

- Pin7 CTR is a multi-function pin (PFC overvoltage, feedback disconnection, reference for EOL in case of tracking reads), connected through a resistive divider to the PFC output bus. By establishing a maximum PFC overvoltage (PFC output overshoot, for example, at startup) $V_{OVPBUSpfc}$ of 480 V and considering that the corresponding threshold on the CTR pin (V_{thrCTR}) must be 3.4 V, R_7+R_{12} can be calculated as 1.82 MΩ and R_{19} as 13 kΩ.
- Pin8 MULT: first, the maximum peak value for V_{MULT}, $V_{MULTmax}$ is selected. This value, which is reached at the maximum mains voltage, should be 3 V (linearity limit) or nearly so in wide-range mains and less in case of single mains. The PFC sense resistor selected is $R_S = R_{22} = 0.150\ \Omega$ and is described in the section on Pin12. Considering that the maximum slope of the multiplier (maxslope) is 0.75, it is possible to calculate the maximum peak value occurring at the maximum mains voltage and the multiplier divider ε.

Equation 7

$$V_{MULT\,max} = \frac{I_{Lpk} \cdot R_{22}}{\max slope} \cdot \frac{V_{AC\,max}}{V_{AC\,min}} = \frac{2 \cdot \sqrt{2} \cdot \dfrac{P_{out}}{\eta \cdot V_{in\,min} \cdot PF} \cdot R_{22}}{\max slope} \cdot \frac{V_{AC\,max}}{V_{AC\,min}} = 1.83$$

$$\varepsilon = \frac{R_{17}}{R_{17} + (R_5 + R_9)} = \frac{V_{MULT\,max}}{\sqrt{2} \cdot V_{AC\,max}} = \frac{1.83}{\sqrt{2} \cdot 265} = 4.89 \cdot 10^{-3}$$

Supposing there is a 240 µA current flowing into the divider, the value of the lower resistor R_{17} can be calculated, and then the value of the upper resistance R_5+R_9.

Equation 8

$$R_{17} = \frac{V_{MULT\,max}}{240\mu A} = 7.79k\Omega \Rightarrow R_{17} = 7.5k\Omega$$

$$R_5 + R_9 = \frac{1-\varepsilon}{\varepsilon} \cdot R_{17} = 1.52M\Omega \Rightarrow R_5 + R_9 = 1.5M\Omega$$

The voltage on the multiplier pin with the selected component values is recalculated at a minimum line voltage of 0.59 V and at maximum line voltage of 1.85 V. As a result, the multiplier operates correctly within its linear region.

- Pin9 COMP is the output of the E/A and also one of the two inputs of the multiplier. The feedback compensation network, placed between this pin and INV (10), is a capacitor C_2 calculated as follows (considering that R_6+R_{11} is the upper resistance of voltage divider between the PFC bus and the COMP pin).

Equation 9

$$C_2 = \frac{10}{2 \cdot \pi \cdot (R_6 + R_{11})} = 530\,nF$$

C_2 has been set to a commercial value of 470//100 nF.

- Pin10 INV: to implement the voltage control loop, a resistive divider (*Figure 4*) must be connected between the regulated output voltage (V_{BUSpfc} = 420 V) of the boost and the pin. The internal reference on the non-inverting input of the E/A is 2.5 V so R_6 and R_{11} (*Figure 4*) can then be selected fixing R_{18} to 18 kΩ.

Equation 10

$$\frac{R_6 + R_{11}}{R_{18}} = \frac{V_{BUSpfc}}{2.5} - 1$$

$$R_6 + R_{11} = 3\ M\Omega$$

- Pin11 ZCD is the input to the zero current detector circuit. The ZCD pin is connected to the auxiliary winding of the boost inductor through a limiting resistor R_{10}. The ZCD circuit is negative-going, edge-triggered: when the voltage on the pin falls below 0.7 V, the PWM latch is set and the MOSFET is turned on. However, the circuit must first be armed: prior to falling below 0.7 V, the voltage on pin 11 must experience a positive-going, edge-exceeding 1.4 V (due to the MOSFET switching off). The maximum main-to-auxiliary winding turn ratio (m) has to ensure that the voltage delivered to the pin during the MOSFET's OFF time is sufficient to arm the ZCD circuit.

Equation 11

$$m \le \frac{V_{BUSpfc} - \sqrt{2} \cdot V_{inRMS(max)}}{1.4} = 33.10$$

m has been set to 10.

Considering the upper and lower clamp voltages of the ZCD pin and its minimum sink current capability according to the maximum and minimum voltages of the PFC bus, R_{10} has been calculated and set to 68 kΩ.

- Pin12 PFCS is the inverting input of the current sense comparator. As the voltage across the sense resistor (proportional to the instantaneous inductor current) crosses the threshold set by the multiplier output, the power MOSFET is turned off. *Equation 12* determines the PFC sense resistor.

Equation 12

$$I_{L\max} = \frac{2 \cdot \sqrt{2} \cdot \frac{P_{outTOT}}{\eta}}{V_{in\min} \cdot PF} = 2.68\ A$$

$$R_{22} < \frac{V_{CSmin}}{I_{Lmax}} = \frac{1}{2.68} = 0.37\Omega \Rightarrow R_{22} = 150m\Omega$$

R_{22} has been set to 150 mΩ with a power rating of 1 W.

- Pin13 PFG: to drive the external MOSFET correctly, R_{21} has been set to 100 Ω.
- Pin 14 HBCS: assuming that during each lamp's ignition phase there is a maximum current I_{IGNmax} of 1.9 A and an HBCS threshold during the ignition phase $V_{HBCS\text{-}ign}$ of 1.6 V, we can calculate that $R_{senseHB} = R_{31}$.

Equation 13

$$R_{31} = \frac{V_{HBCS-ign}}{I_{IGN\max TOT}} = 0.42\Omega$$

R_{31} has been set to 0.47 Ω with a power rating of 1 W.

- Pin 15 GND: device ground.
- Pin 16 LSD: to drive the external half-bridge low-side MOSFET correctly, the resistor R_{23} has been set to 43 Ω.
- Pin 17 Vcc: this pin is externally connected to the startup circuit (by means of R_{34}, R_{35}, R_{36}, R_{37}, R_{40} and R_{41}) and to the self-supply circuit made of a charge pump composed by the net C_{16}, C_{17}, C_{18}, D_8, D_9 and R_{29}.
- Pin 18 out: floating reference of the high-side driver. This pin is connected close to the source of the high-side power MOSFET.
- Pin 19 HSD: to drive the external half-bridge low-side MOSFET correctly, the resistor R_{20} has been set to 43 Ω.
- Pin 20 boot: for the high-side section C_{13} has been set to 100 nF.

3.2 PFC power section design

3.2.1 Input capacitor

The input high-frequency filter capacitor has to attenuate the switching noise due to the high frequency inductor current ripple. The worst conditions will occur on the peak of the minimum rated input voltage (V_{inmin} = 85 V). The following values have been established.

- The coefficient of the maximum high-frequency voltage ripple r = 0.05.
- Total system efficiency is possible. Taking into account a minimum half-bridge switching frequency (f_{swmin}) of 39 kHz and a total output power (P_{outTOT}) equal to 4*18 = 72 W, the input capacitor C_4 can be determined by the following equation.

Equation 14

$$C_4 = \frac{\frac{P_{outTOT}}{\eta \cdot V_{in\,min}}}{2 \cdot \pi \cdot f_{sw\,min} \cdot V_{in\,min} \cdot r} = 904\text{nF}$$

To obtain a good margin from f_{swmin}, C_4 has been set to 680 nF.

3.2.2 Output capacitor

The selection of the output bulk capacitor C_1 depends on the DC output voltage, the admitted overvoltage, the output power and the desired voltage ripple. With the following values:

- PFC output voltage V_{busPFC} = 420 V.
- the coefficient of the low frequency (twice the mains frequency (f_{main}) = 50 Hz) voltage ripple r_1 = 0.05.

the bulk capacitor can be calculated as:

Equation 15

$$C_1 = \frac{\frac{P_{outTOT}}{V_{busPFC}}}{2\pi \cdot 2f_{main} \cdot V_{busPFC} \cdot r_1} = 13\mu\text{F}$$

To obtain the smallest possible ripple and good reliability, a commercial capacitor C_1 of 33 µF, 450 V has been used.

3.2.3 Boost inductor

The inductance L_{pfc} is usually determined so that the minimum switching frequency ($f_{min\ pfc}$) is greater than the maximum frequency of the internal starter to ensure correct TM operation. Considering the minimum suggested value for the PFC section ($f_{min\ pfc}$) is 20 kHz and that this last can occur at either the maximum $V_{inrmsMax}$ = 265 V or the minimum $V_{inrmsMin}$ = 85 V mains voltage, the inductor value is defined by:

Equation 16

$$L_{pfc} = \frac{V_{inrms}^2 \cdot \left(V_{busPFC} - \sqrt{2} \cdot V_{inrms}\right)}{2 \cdot f_{minpfc} \cdot \frac{P_{out}}{\eta} \cdot V_{busPFC}}$$

To margin from $f_{min\ pfc}$ we have set f_{pfc} to 38 kHz. In this condition, the lower value for the inductor is determined by $V_{inrms} = V_{inrmsMin}$ and the result $L_{pfc} = 0.8$ mH with (as stated in the PFCS pin description) a minimum I_{Lmax} of 3 A and a maximum I_{Lmax} of 5 A (using the inductor 1646-0004 manufactured by MAGNETICA).

3.2.4 Power MOSFET

The choice of MOSFET relates mainly to its $R_{DS(on)}$, which depends on the output power and its breakdown voltage, the latter being fixed by the output voltage V_{buspfc}=420 V only, plus the overvoltage V_{OVPpfc} = 60 V allowed, and a safety margin.

The MOSFET's power dissipation depends on the conduction and switching losses. Assuming maximum total power losses $P_{lossesAdm}$ = 1%, P_{outTOT} = 0.7 W, it easy to verify that with the second-generation MDmesh™ V Power MOSFET STB12NM50N, the estimated total MOSFET power losses $P_{lossesEst}$ are about = 0.5 W (worst case) and that this was the correct choice.

3.2.5 Boost diode

The boost freewheeling diode is a fast recovery one. The breakdown voltage is fixed with the same criterion as the MOSFET. The value of its DC and RMS current, needed to choose the current rating of the diode, are reported.

Equation 17

$$I_{D2dc} = \frac{P_{outTOT}}{V_{BUSpfc}} = 0.171A$$

$$I_{D2rms} = 2\sqrt{2} \cdot I_{inrmsMax} \cdot \sqrt{\frac{4\sqrt{2}}{9\pi} \cdot \frac{V_{inrmsMin}}{V_{BUSpfc}}} = 0.53A$$

Since the PFC works in transition mode, we have used the Turbo 2 ultrafast high-voltage rectifier STTH1L06.

3.3 Design of the half-bridge inverter and choice of preheating inductor

According to the criteria described in AN993 chapter 5 (design tips) with regard to the design of the resonant circuit, the following values have been selected.

- $L_{res} = L_1 = L_2 = 2.2$ mH
- $C_{res} = C_9 = C_{14} = 4.7$nF, 1600 V
- $C_{block} = C_{12} = C_{15} = 100$ nF, 400 V

We have used the inductor 1646-0005 manufactured by MAGNETICA.

A SuperMESH3 power MOSFET STD7N52K3 has been inserted in the half-bridge section to reduce the power losses.

For the preheating inductor, we have selected a common mode choke-type inductor with the following features: $L_{preh1} = L_{preh2}$ = 10 mH/250 V/1.4 A.

4 Experimental results

The schematic of the tested board is shown in *Figure 3*. The board has been tested for efficiency, power factor, total harmonic distortion and thermal behavior for the input voltage range. *Table 2* and *Table 3* show the results obtained for a 45-minute test.

Table 2. 4 x 18 W T8 board performance

V_{IN}(V)	P_{IN}(W)	$P_{OUTlamp1-2}$(W)	η	I_{IN}(A)	PF	THD(%)
85	82.3	34.4	83.6%	0.9	0.99	6
110	80	34.4	86%	0.997	0.99	4.4
140	78.5	34.4	87.6%	0.555	0.99	5.5
185	78.4	34.4	87.7%	0.424	0.98	6.5
230	77.7	34.4	88.5%	0.344	0.97	8.5
265	77.2	34.4	89.1%	0.301	0.95	10

All the results are very good. Efficiency is approximately 85%, the power factor corrector is constantly 0.9 and THD is lower than 10%.

Table 3. 4 x 18 W T8 thermal results of critic system components

V_{IN}(V)	Ambient temp (°C)	Temp $MOS_{LowSide}$(°C)	Temp $MOS_{HighSide}$(°C)	Temp MOS_{PFC}(°C)	Temp L6585DE(°C)
85	25	54	55	120	44
110	25	53	54	108	43
140	25	53	54	102	43
185	25	53	54	94	43
230	25	53	54	84	43
265	25	53	54	74.5	43

With regard to the thermal behavior, it is easy to deduct from *Table 3* that there is a good safety margin from the maximum junction temperature of the MOSFET.

4.1 Start sequence

As shown in *Figure 5*, it is during the start sequence that, as the IC supply voltage V_{CC} reaches V_{CCon}, the half-bridge starts oscillating and the charge capacitor connected to TCH begins charging. When the voltage at the TCH pin reaches VCHP (4.63 V), the same capacitor is discharged following an exponential decrease steered by the time constant; this defines the preheating time.

During this time, the EOI pin is forced to ground and the switching frequency is set by the oscillator to the preheating value. When the voltage at the TCH pin drops down to 1.53 V, the EOI pin is exponentially charged according to a time constant that defines the ignition time.

At the same time the TCH pin goes down to ground. During this phase, the oscillator generates a reduction of the switching frequency; when the voltage at the EOI pin exceeds 1.9 V, the chip enters run mode.

Figure 5. L6585DE startup sequence

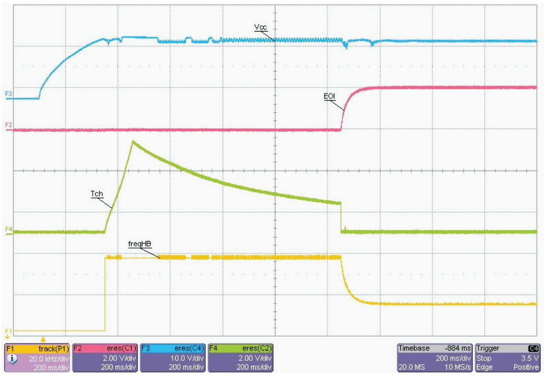


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Figure 6 shows the lamp ignition phase, across and through which the voltage and current increase linearly.

Figure 6. One lamp ignition phase

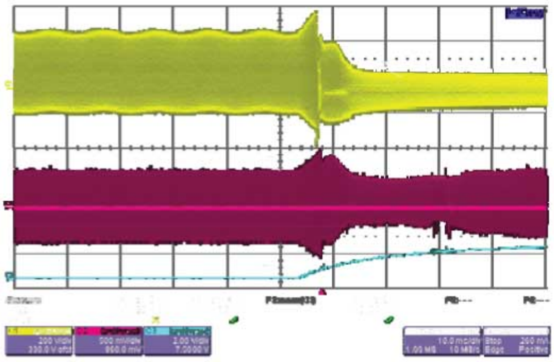

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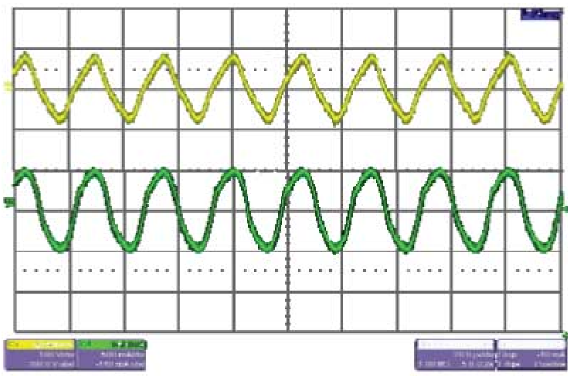
Figure 7. Lamp voltage and current in run mode condition



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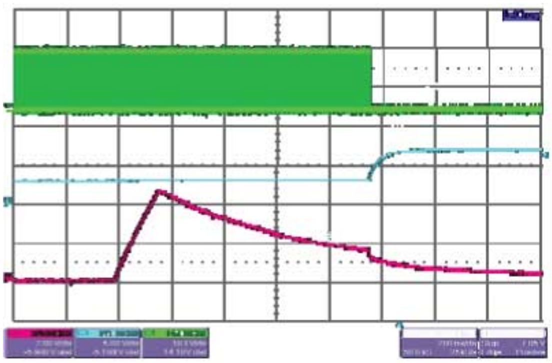
4.2 Protections

With old lamps, abnormal behavior may occur during run mode as a result of the rectifying effect.

This effect relates to a differential increase of the ohmic resistance of the two cathodes. The lamp equivalent resistance is therefore higher when the lamp current flows in one direction than in the other. The current waveform is distorted and the mean value of the lamp current is no longer zero. *Figure 8* shows the behavior of a dual lamp ballast during a rectifying effect. In the EOL pin, as soon as the internal window comparator is triggered by a voltage variation due to the rectifying effect, the T_{ch} cycle starts, and if at its end the comparator is again triggered, the L6585DE stops.

Figure 8. Run mode, rectifying effect



When an old lamp is connected to the ballast, the strike voltage is higher than the nominal voltage and may also be higher than the safety threshold. In this case, the lamp can take longer than usual to ignite or may not ignite at all. In both cases, because of the frequency drop, the voltage at the output of the ballast can easily reach dangerous values during this ignition time.

The same problem occurs if any one of the lamp's four tubes is broken: the lamp cannot ignite and the lamp voltage must be limited. *Figure 9* and *Figure 10* show how the four-lamp ballast ignites when two lamps are broken.

When the preheating time $T_{pre} = t_{Tch}$ is finished, the L6585DE detects the lost ignition of one of the two lamps and starts reducing the preheating time $t_{Tch,reduced}$. At the end of this time, if one of the four lamps is not ignited, the IC is latched.

Figure 9. Ignition phase with broken lamps: case 1 (lamp 1 works, lamp 2 is broken, lamp 3 is broken, lamp 4 works)

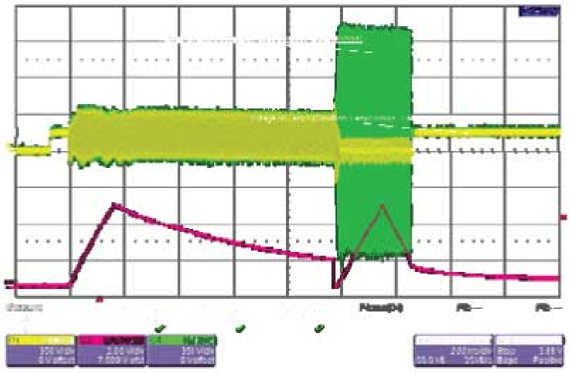


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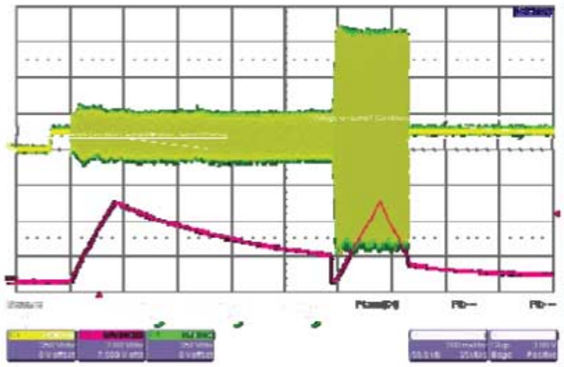
Figure 10. Ignition phase with broken lamps: case 2 (lamp 1 is broken, lamp 2 works, lamp 3 is broken, lamp 4 works)



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The HB choke saturation protection has also been tested. Because of the intense current, a very high V_{HBCS} is present; the 2.75 threshold triggers this event and immediately stops the IC.

4.3 Conducted emissions test

Conducted emissions have been measured in neutral and line wires, using a peak detector and considering the limits for lighting applications specified in EN55015. The measurements have been performed at 110 and 230 Vac lines. The results are shown in *Figure 11*, *12*, *13*, *14* and *15*.

Since the emission level is below both the quasi-peak and average limits with acceptable margin, the power supply passes the pre-compliance test.

Figure 11. Conducted emissions at 110 Vac 50 Hz - line 1 peak detector

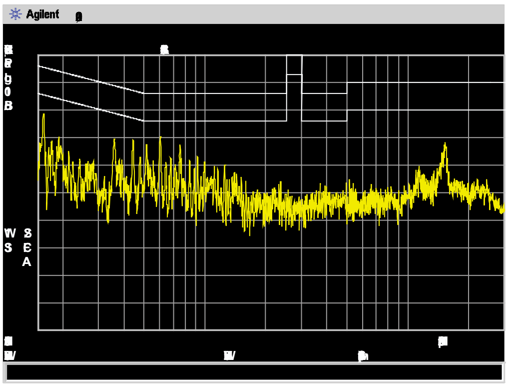

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Figure 12. Conducted emissions at 110 Vac 50 Hz - line 2 peak detector

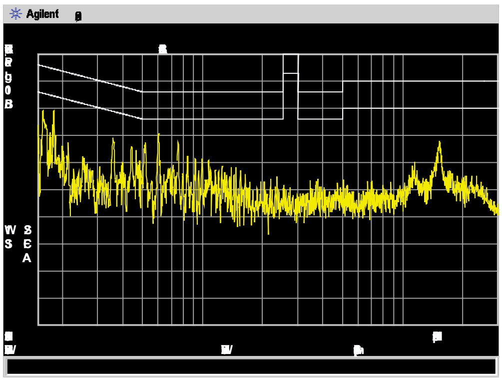

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Figure 13. Conducted emissions at 230 Vac 50 Hz - line 1 peak detector

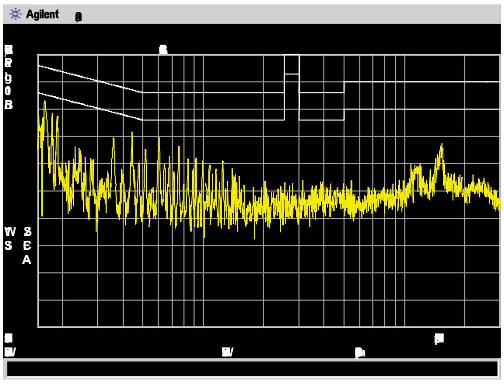

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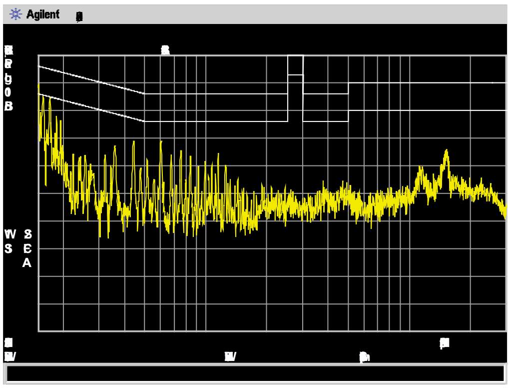
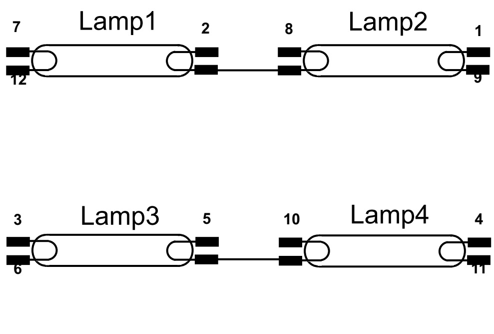
Figure 14. Conducted emissions at 230 Vac 50 Hz - line 2 peak detector



4.4 Guidelines for connecting the four lamps to the ballast

The presence of four lamps involves several wires. The following is a simple schematic that shows how to correctly connect all four lamps to the ballast.

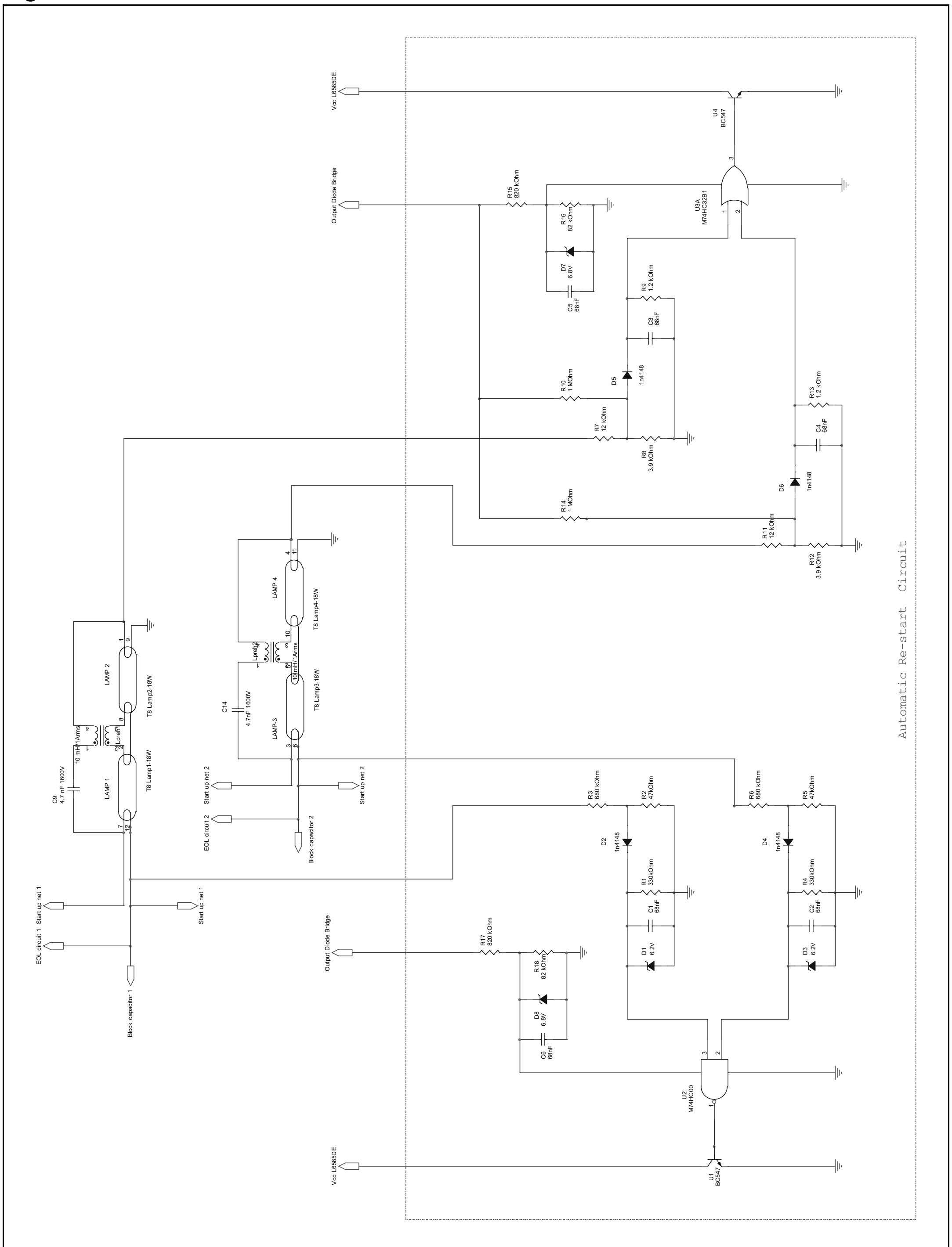
Figure 15. Connecting four lamps to the ballast



5 Automatic restart circuit for lamp replacement

The following circuit can be added to the STEVAL-ILB008V1 to implement the automatic restart feature for lamp replacement.

Figure 16. Automatic restart circuit



6 Bill of materials

Table 4. 4 x 18 W T8 bill of materials

Ref.	Value	Type	Package	Manufacturer	Manuf. code	RS Distrelec other code
C1	450 V, 33 µF, 20%	Electrolytic	TH radial	EPCOS	B43851F5336M000	
C2	25 V, 560 nF	Ceramic	SMD 0805			Any
C3	25 V, 33 nF	Ceramic	SMD 0805			Any
C4	630 V, 680 nF, 10%	Polyester	TH radial	EPCOS	B32524Q8684K00 0	
C5	25 V, 1 nF, 5%	COG ceramic	SMD 0805			Any
C6	25 V, 330 nF, 10%	X7R ceramic	SMD 0805			Any
C7	25 V, 1µF, 10%	Ceramic	SMD 0805			Any
C8	25 V, 10 nF, 10%	Ceramic	SMD 0805			Any
C9,C14	2000 V, 4.7 nF, 5%	Polypropylene	TH Radial	EPCOS	B32672L8472J000	
C10,C11	305 VAC x 2, 220 nF, 10%	Polypropylene	TH Radial	EPCOS	B32922C3224K000	
C12,C15	400 V, 100 nF, 10%	Polyester	TH Radial	EPCOS	B32561J6104K000	
C13	50 V, 100 nF	ceramic	SMD1206		Any	
C16	630 V, 680 pF	Polypropylene	TH Radial	WIMA	823241	Distrelec
C17	50 V, 4.7 µF	Electrolytic Lead spacing 2.5 Φ5xh11	TH Radial			
C18	50 V, 100 nF	Ceramic	SMD 0805		Any	
C20	250VAC Y1, 1 nF		TH Radial		214-5896	
C22	630 V, 1 nF	Ceramic		EVOX RIFA	240-4836	RS
C25	Not mounted		SMD 0805			Any
C26,C27	25 V, 22 pF		SMD 0805		Any	
D2	600 V, 1 A, STTH1L06	Turbo 2 ultrafast high volt rectifier	DO-41	STMicroelectronics		
D3,D4,D5,D6	1000 V, 1 A, GF1M		DO-214BA	Vishay	6291123	RS

Table 4. 4 x 18 W T8 bill of materials (continued)

Ref.	Value	Type	Package	Manufacturer	Manuf. code	RS Distrelec other code
D7, D8	75 V, 150 mA, LL4148	Switching Diode	SOD-80	DIOTEC	601496	Distrelec
D9	16 V, 500 mW	voltage regulator diode	SOD-80	General semiconductor	600819	Distrelec
D11,D12	100 V, 100 mA, TMMBAT41	Small signal Schottky diode	SOD323	STMicroelectronics		
D16, D18	5.1 V, 500 mW	voltage regulator diode	SOD80C		508-674	RS
D17, D19	10 V, 500 mW	voltage regulator diode	SOD123		545-3128	RS
F1	3 A				377-2180	RS
J1	500 V, 32 A, CON3				189-5972	RS
Lamp1,lamp2-lamp3,lamp4	T8 lamp 1, 18 W				141429	Distrelec
LPFC1	1 A, 8 mH			MAGNETICA	1646-0004	
Lpreh1,Lpreh2	250 V, 1.4 A, 10 mH		Lead spacing 10x12.5 (mm)	EPCOS	B82732R2142B030	
L1,L2	0.5 A, 2.2 mH			MAGNETICA	1646.005	
Lc	250 V, 1.3 A, 2 x 47 mH		Lead spacing 15x12.5 (mm)	EPCOS	B82734R2132B030	
Q2,Q4	STD7N52K3	N-channel 525 V, 0.84 Ω, 6.2 A SuperMESH3 power MOSFET	DPAK	STMicroelectronics	STD7N52K3	
Q3	STD14NM50N	N-channel, 500 V, 0.246 Ω, 12 A, MDmesh II power MOSFET	DPAK	STMicroelectronics	STD14NM50N	
R5	750 kΩ, 5%, 1/4 W		TH radial			Any

Table 4. 4 x 18 W T8 bill of materials (continued)

Ref.	Value	Type	Package	Manufacturer	Manuf. code	RS Distrelec other code
R9	750 kΩ, 5%, 1/4 W		SMD1206			Any
R6,R11	1.5 MΩ, 5%, 1/4 W		SMD 1206			Any
R7,R12	910 kΩ, 5%, 1/4 W		SMD 1206			Any
R10	68 kΩ, 5%, 1/4 W		TH radial			Any
R13	47 kΩ, 5%, 1/8 W		SMD 0805			Any
R14	33 kΩ, 5%, 1/8 W		SMD 0805			Any
R15	750 kΩ, 5%, 1/8 W		SMD 0805			Any
R16	75 kΩ, 5%, 1/8 W		SMD 0805			Any
R17	7.5 kΩ, 5%, 1/4 W		SMD 1206			Any
R18	18 kΩ, 5%, 1/4 W		SMD1206			Any
R19	13 kΩ, 5%, 1/4 W		SMD1206			Any
R20,R23	43 Ω, 5%, 1/8 W		SMD 0805			Any
R21	100 Ω, 5%, 1/8 W		SMD 0805			Any
R22	0.150 Ω, 1%, 1 W		TH radial			Any
R29	10 Ω, 5%, 1/4 W		SMD 1206			Any
R31	0.47 Ω, 1%, 1 W		TH radial			Any
R34	470 kΩ parallel 470 kΩ, 5%, 1/4 W		SMD 1206			Any
R35	220 kΩ, 5%, 1/2 W		TH radial			Any
R36,R40	150 kΩ, 5%, 1/4 W		TH radial			Any
R37,R41	150 kΩ, 5%, 1/4 W		SMD 1206			Any

Table 4. 4 x 18 W T8 bill of materials (continued)

Ref.	Value	Type	Package	Manufacturer	Manuf. code	RS Distrelec other code
R52,R53, R59,R69	0Ω, 5%, 1/4 W		SMD 1206			Any
R60,R68	1.5 MΩ, 5%, 1/4 W		SMD 1206			Any
R66,R67	1.8 MΩ, 5%, 1/8 W		SMD 1206			Any
U1	L6585DE	Combo IC for PFC and ballast control		STMicroelectronics	L6585DE	

7 Revision history

Table 5. Document revision history

Date	Revision	Changes
16-Apr-2010	1	Initial release.
11-Jun-2010	2	Modified: *Section 3.1*