UM10460

Low-cost 4 W mains LED driver for the Japanese market using the TEA1523

Rev. 1 — 16 June 2011 **User manual**

Document information

Info	Content
Keywords	TEA1523, SSL, low-cost, LED driver, AC/DC conversion, buck converter, driver, mains supply, user manual
Abstract	This is the user manual for the TEA1523 4 W LED driver demo board

Revision history

Rev	Date	Description
v.1	20110616	first issue

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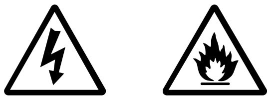
1. Introduction

WARNING

Lethal voltage and fire ignition hazard



The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

The 4 W TEA1523 buck converter board is a low-cost solution with an excellent price performance ratio. Only a minimum number of commercial off-the-shelf components are needed to build a fully functional LED driver that can be powered directly from the AC mains supply.

The board can achieve an efficiency greater than 90 %.

1.1 Safety warning

The board needs to be connected to 100 V mains voltage and it has no galvanic isolation between the mains and the LEDs. Touching the demo board during operation must be avoided at all times. An isolated housing for the board and the LEDs is mandatory when used in uncontrolled, non-laboratory environments. Therefore the board must be connected to the mains supply via a galvanic isolated (variable) transformer. These devices can be recognized by the symbols shown in Figure 1.

a. Isolated

b. Not isolated

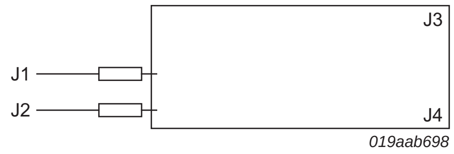
Fig 1. Variac isolation symbols

Remark: This board is for 100 V only, do not connect it to 230 V mains.

2. Connecting the board

The board is optimized for a 100 V (AC) mains supply but it is also possible to operate it from a 120 V supply. The target load is a string of 24 LEDs with a total voltage of 68 V and an output current of 60 mA. The TEA1523 is supplied from the mains input voltage using a dVdt supply, removing the need for an auxiliary power supply.

The board footprint is as small as possible requiring the fuse and the inrush resistor to be mounted outside the board. The LED string can be directly connected to the board.



(1) J1 and J2: 100 V (AC).

(2) J3: LED+.

(3) J4: LED–.

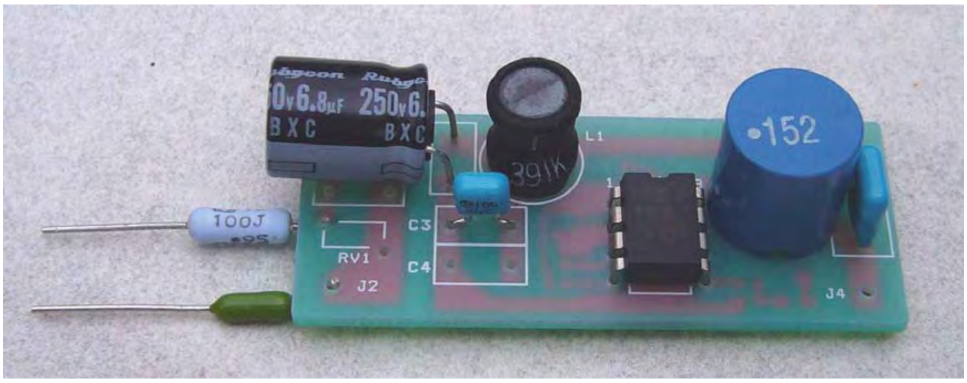
Fig 2. Board connection diagram

3. Power supply specification

Table 1. Output specification

Description	Value	Comment
AC line input voltage	100 V, ±10 %	-
output current (LED current)	60 mA	see Figure 8
output LED voltage	68 V	-
LED current ripple	38 mA (42 %)	see Figure 9. This ripple current has a 100 Hz component and a ±100 kHz component.
Maximum switching frequency	110 kHz	-
efficiency	> 90 %	see Figure 10

4. Board photographs



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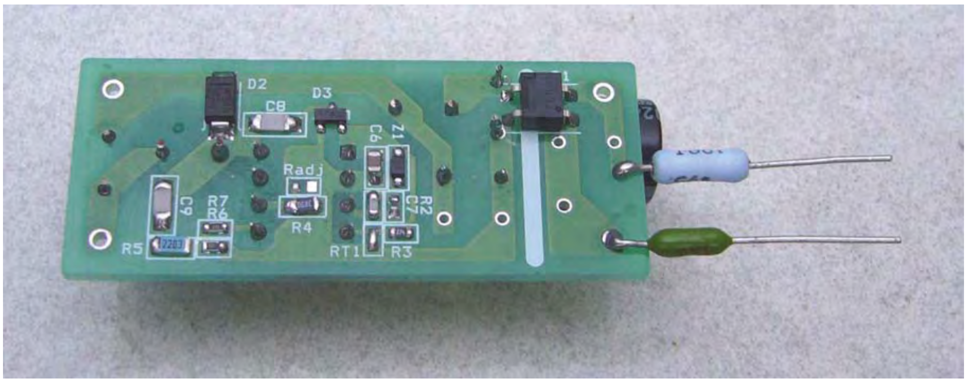
a. Top view



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b. Bottom view

Fig 3. Demo board views

5. Functional description

Although the TEA1523 is often promoted as a flyback controller, it is possible to use it as a non-isolated down converter (Ref. 1).

Figure 4 shows the fundamental circuit of the buck converter. The buck converter that is described in this user manual is in the nominal operating range of 90 V to 110 V working in boundary conduction mode (BCM).

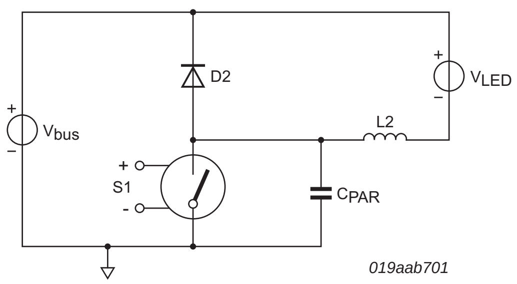


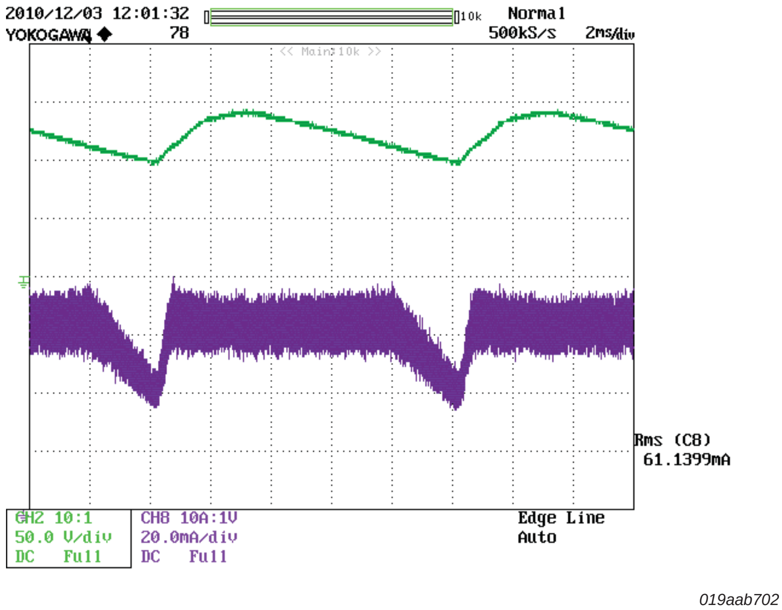
Fig 4. Fundamental circuit

The maximum value of the peak current is fixed in the design and the value of the LED current is calculated using Equation 1:

$$I_{LED(AV)} = \frac{\hat{I}}{2} \quad (1)$$

At higher bus voltages (> 113 V), the peak current is fixed by the design at $V_{SOURCE(max)}$ / R_{SOURCE} = 0.5 V / 3 = 167 mA.

At lower bus voltages, this peak current is not reached in time, making the LED current dependent on the bus voltage. This is shown in Figure 6 and Figure 7.



(1) CH2: V_{bus}.

(2) CH8: I_{LED}.

(3) V_{mains} = 100 V RMS.

Fig 5. V_{bus} and I_{LED} at 100 V RMS

At higher bus voltages (> 150 V), the converter starts to work in Discontinuous Conduction Mode (DCM) and the LED current starts to drop.

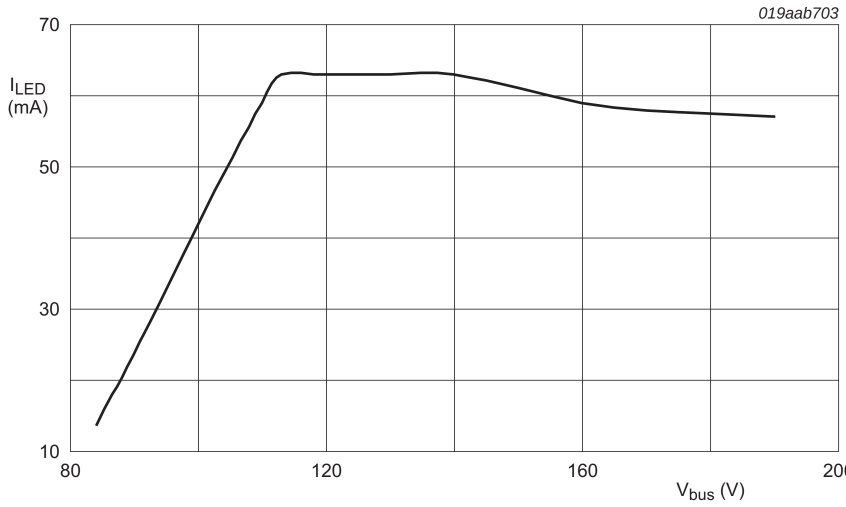


Fig 6. Average LED current as a function of bus voltage

Figure 6 shows the average LED current as a function of the bus voltage. The bus voltage was supplied from a DC source for this measurement, so there is no 100 Hz ripple.

Figure 7 shows the circuit diagram based on the fundamental circuit shown in Figure 4. The input voltage is rectified and buffered in electrolytic capacitor C2. The larger the value of this capacitor, the larger the higher mains harmonics are. The combination of L1 and C2 prevents drawing high frequency currents from the mains. The TEA1523 is supplied by a dVdt supply that consists of C8 and (double) diode D3.

The drain voltage is sensed via C9, R5 and R6 and supplied to the AUX input. This detects when the flux in inductor L2 reaches 0.

The maximum switching frequency is set with C7 and R2. The peak current is set with R4 and R_{adj}.

The optional R3 and RT1 circuitry enables the implementation of an overtemperature protection. In this case, the REG pin is supplied with a fixed voltage that drops when the temperature of the circuit rises. An Negative Temperature Coefficient (NTC) resistor should be mounted at position RT1.

6. Schematic TEA1523 demo board

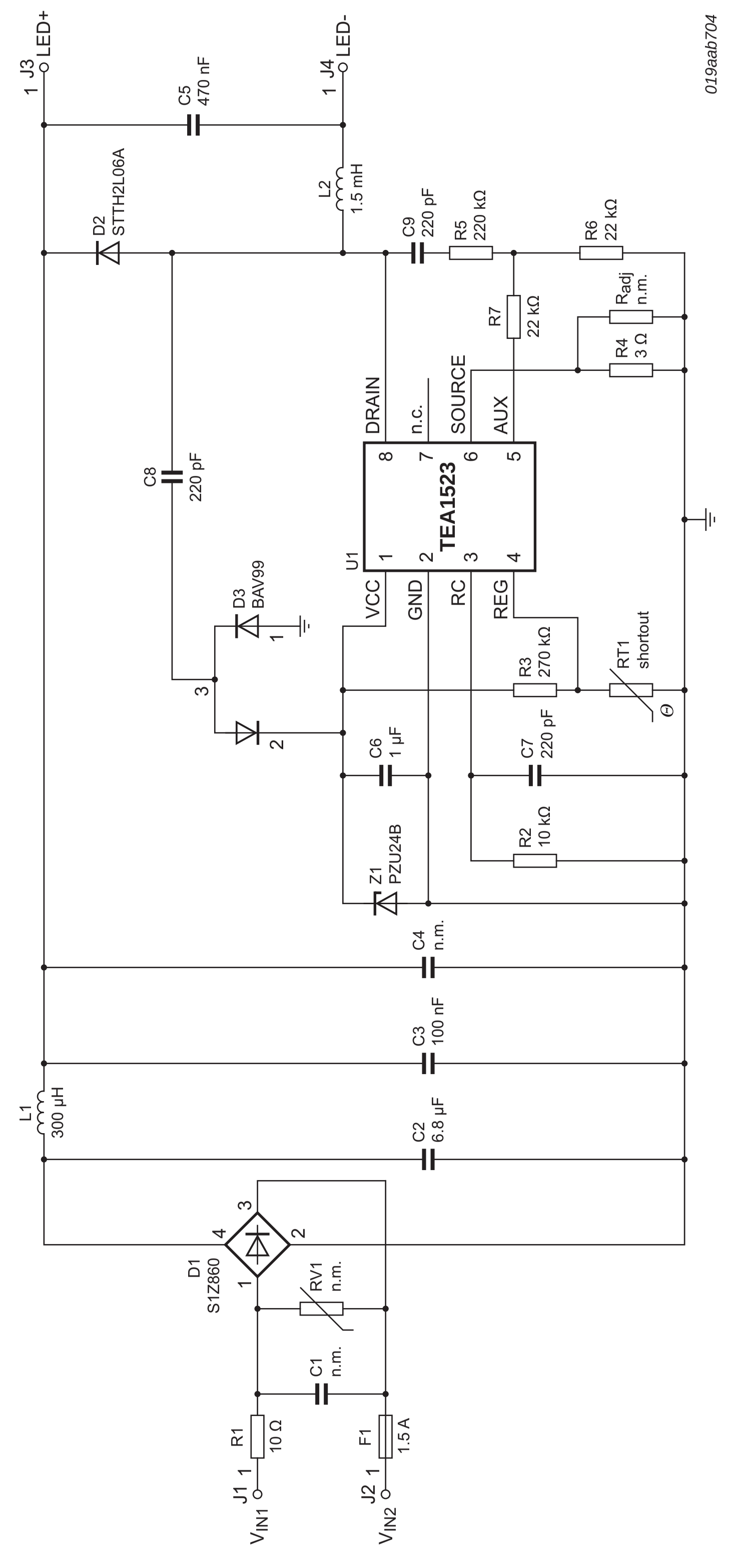


Fig 7. Schematic TEA1523 demo board

7. Bill of materials

Table 2. Bill of materials

Reference	Description	Value	Manufacturer and Type	Farnell number
F1	fuse	1 A; 125 V	Littelfuse; 0251001.MAT1L	9921974
R1	power resistor; thin film chip	10 Ω	Panasonic; ERG1SJ100A	-
RV1	not mounted	-	-	-
R2	SMD 0603; resistor	10 kΩ	Yageo; RC0603FR-0710KL	9238603
R3	SMD 0603; resistor	270 kΩ	Yageo; RC0603FR-07270KL	9238778
RT1	SMD 0603; resistor	0 Ω	Yageo; RC0603JR-070RL	9233130
R4	SMD 0805; resistor	3 Ω	KOA; SR732ATTD3R00F	1399723
R_{adj}	SMD 0603; resistor	-	-	-
R5	SMD 0805; resistor	270 kΩ	Yageo; RC0805FR-07220KL	9237917
R6	SMD 0603; resistor	220 kΩ	Yageo; RC0603FR-0722KL	9238646
R7	SMD 0603; resistor	220 kΩ	Yageo; RC0603FR-0722KL	9238646
C1	not mounted	-	-	-
C2	electrolytic capacitor	6.8 μF	Rubycon; BXC	-
C3	ceramic capacitor	100 nF	MuRata; RDER72E104K3B1C11B	-
C4	not mounted	-	-	-
C5	ceramic capacitor	470 nF	MuRata; RDER72E474K5B1C13B	-
C6	SMD 0805; ceramic capacitor	1 μF; 25 V	Yageo; CC0805KKX7R8BB105	1458903
C7	SMD 0603; ceramic capacitor	220 pF; 50 V	Yageo; CC0603JRNPO9BN221	430948
C8	SMD 1206; ceramic capacitor	220 pF; 200 V	Yageo; CC0603JRNPO9BN221	1284139
C9	SMD 1206; ceramic capacitor	220 pF; 200 V	Yageo; CC0603JRNPO9BN221	1284139
L1	inductor	390 μH; 0.46 A; 0.86 Ω	Panasonic; ELC09D391F	8094926
L2	inductor with coil	1.5 mH; 0.43 A; 2.4 Ω	TDK; TSL1112S-152JR38-PF	-
D1	bridge rectifier; 1Z	0.6 A; 600 V	Shindengen; S1ZB60	-
D2	SMT diode	2 A; 600 V	ST; STTH2L06A	-
D3	dual diode	-	NXP Semiconductors; BAV99	1081211
ZD2	Zener diode; SMT SOD323F	24 V	NXP Semiconductors; PZU24B	-

8. Measurements

8.1 Transformer schematic diagram

Figure 8 to Figure 11 show measurements that were performed on the board.

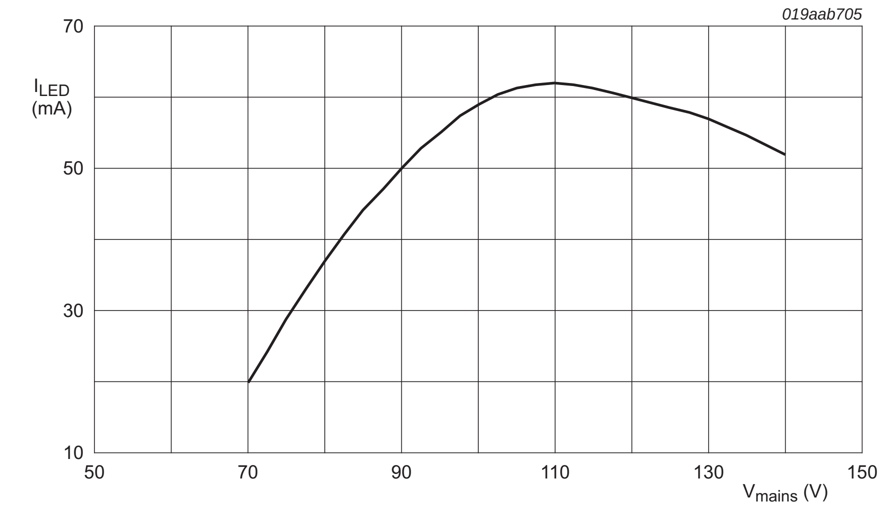


Fig 8. LED current as a function of the 50 Hz mains voltage

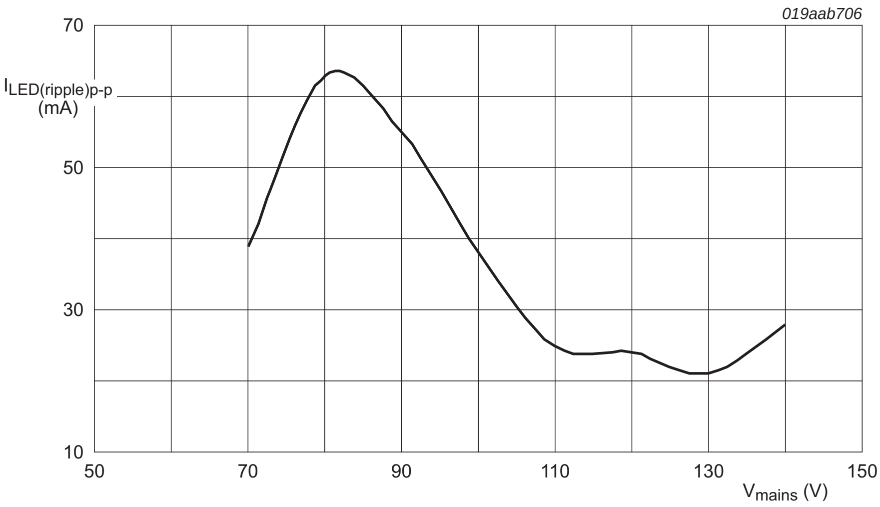


Fig 9. Peak-to-peak ripple LED current as a function of the 50 Hz mains voltage

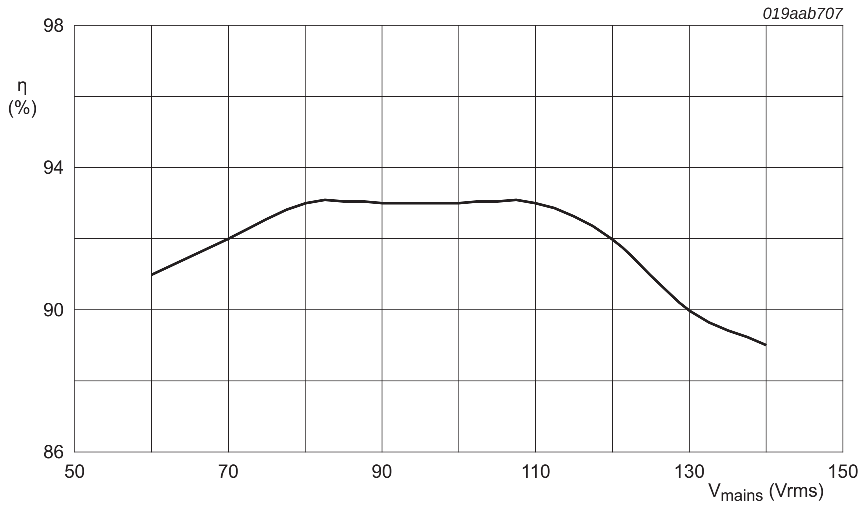


Fig 10. Efficiency of the converter as a function of the 50 Hz mains voltage

Table 3. Mains conducted harmonic values

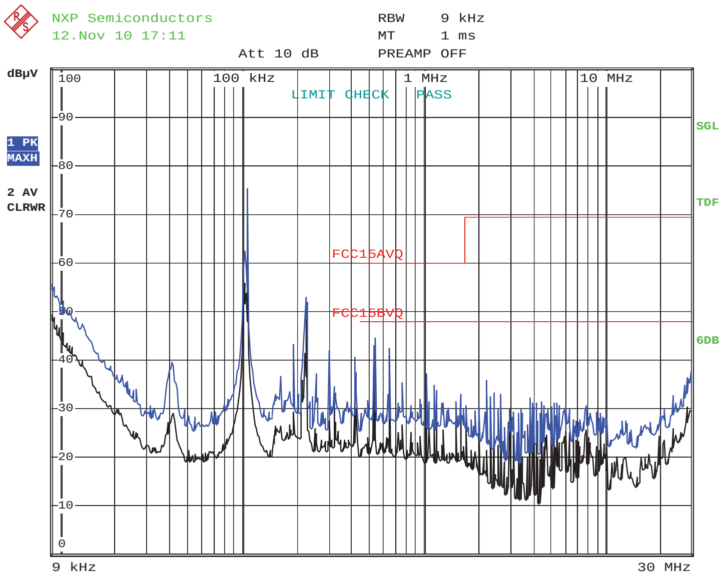
Harmonic	120 V (AC); 50 Hz	Harmonic	120 V (AC); 50Hz
1	100 %	11	29 %
2	-	12	-
3	83 %	13	21 %
4	-	14	-
5	58 %	15	9 %
6	57 %	16	-
7	41 %	17	-
8	-	18	-
9	34 %	19	3 %
10	-	20	-

The Total Harmonic Distortion (THD) is 0.133 %.

The value of the parasitic capacitance between drain and ground is calculated using Equation 2:

$$C_{PAR} = \hat{I} \frac{\Delta t}{\Delta V} \quad (2)$$

The voltage across the internal MOSFET rises to 133 V during 240 ns. The maximum value of the peak current is 0.163 A. This results in a parasitic capacitance of 294 pF.



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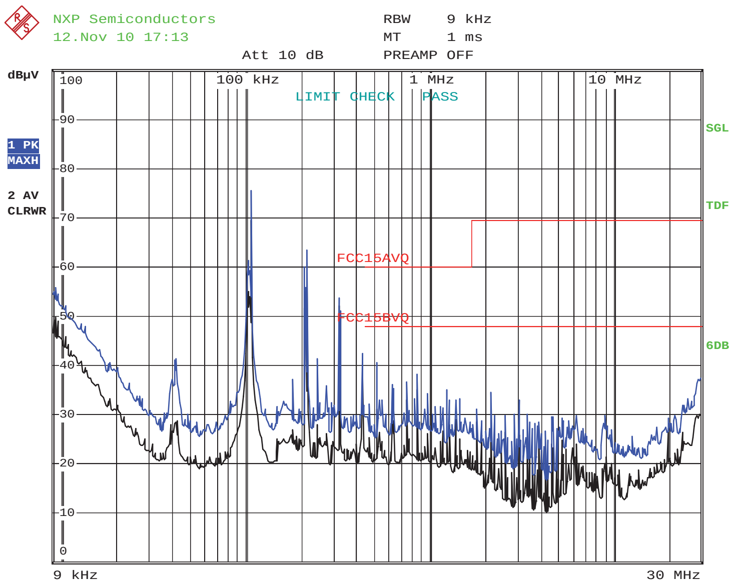
a. Phase line.



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b. Neutral line.

Fig 11. Emission measurements

9. Optimization TEA1523 demo board

When operated at 100 V mains, a 100 Hz (or 120 Hz in case of 60 Hz mains) ripple on the LED current can be seen because at lower bus voltages, the maximum value of the peak current (I_{peak}) is not reached. This can be solved by making the ripple voltage on the bus voltage smaller by increasing the value of the bus electrolytic capacitor. The penalty for this is that THD performance decreases.

Another solution is to increase the value of R2 from 10 kΩ to 12 kΩ for example. This shifts the maximum operating frequency to a lower value and the maximum peak current is reached at a lower bus voltage. The bus voltage level at which the converter switches from BCM to DCM also shifts to a lower value.

The LED voltage range is limited: the converter works efficiently when the LED voltage is about half the bus voltage.

10. References

[1] **AN00055 —** STARplug Efficient Low Power supply with the TEA152x

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12. Contents

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