AN2961
Application note

STEVAL-ILL026V1 non-isolated 3 W offline LED driver based on the VIPER22A-E

Introduction

This application note describes the functioning of the STEVAL-ILL026V1 non-isolated 3 W offline LED driver power supply designed using the VIPER22A-E low power offline SMPS primary switcher from STMicroelectronics. The circuit regulates the load current to 350 mA and generates about 10 V. The load is composed of three high-brightness (HB) LEDs, connected in series.

The project does not provide safety isolation between the input and output.

This document provides the power supply specification, circuit diagrams, the complete bill of materials, and reports the results of circuit testing.

Figure 1. STEVAL-ILL026V1 board photographs



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1 Specification

The electronic lamp ballast electrical specifications are given in the table below.

Table 1. Specification

Input parameters		
V_{IN}	Input voltage range	90 to 265 V_{RMS}
f_{line}	Line frequency	50/60 Hz
HB LEDs		
Number	3	
Power / current	3 W / 350 mA	

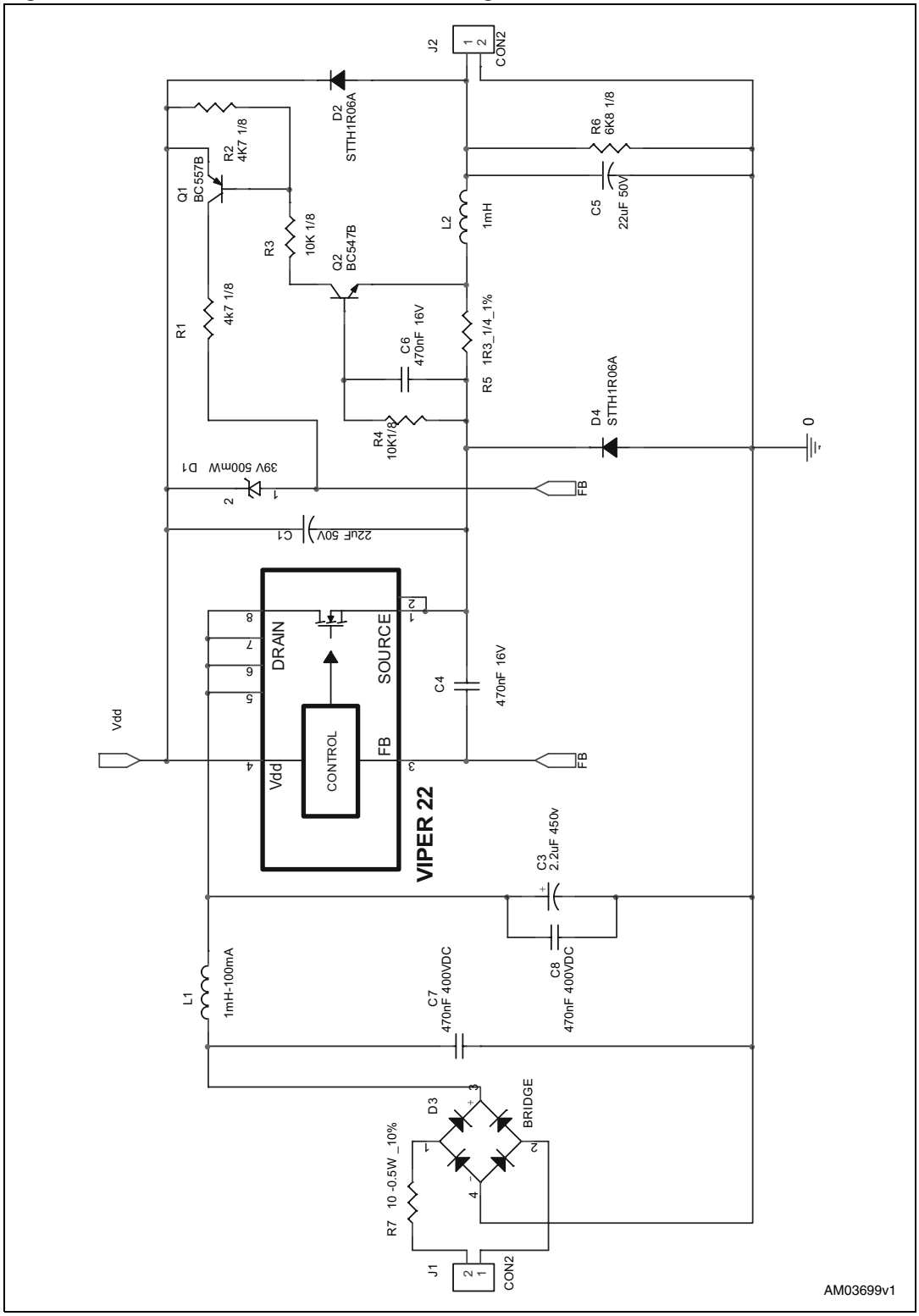
2 Bill of material

Table 2. STEVAL-ILL026V1 bill of material

Type	Name	Value	Rated	Description
C	C1	22 µF	50 V	Electrolytic
C	C3	2.2 µF	450 V	Electrolytic
C	C4	470 nF	50 V	Ceramic
C	C5	22 µF	50 V	Electrolytic
C	C6	470 nF	50 V	Ceramic
C	C7	470 nF	400 VDC	Polyester EPCOS B32561J6474K
C	C8	Do not fit	Do not fit	Do not fit
D	D1	39 V		Zener diode
D	D2	STTH1R06A	600 V	STMicroelectronics
D	D3	Bridge	600 V 500 mA	Rectifier bridge
D	D4	STTH1R06A	600 V	STMicroelectronics
L	L1	1 mH		EPCOS B7818S1105J000
L	L2	1 mH		Coilcraft MSS1260-105KLB
Q	Q1	BC557B		PNP transistor
Q	Q2	BC547B		NPN transistor
R	R1	4.7 kΩ		SMD resistor 0805
R	R2	4.7 kΩ		SMD resistor 0805
R	R3	10 kΩ		SMD resistor 0805
R	R4	10 kΩ		SMD resistor 0805
R	R5	1.3 Ω		SMD resistor 1206
R	R6	6.8 kΩ		SMD resistor 0805
R	R7	10 Ω	1/2 W	Through hole resistor
U	IC1	VIPER22A-E		STMicroelectronics

3 Electrical schematic

Figure 2. STEVAL-ILL026V1 schematic diagram



4 Circuit description

The demonstration board is based on a non-isolated buck converter designed and implemented with STMicroelectronics' VIPER22A-E low power offline SMPS primary switcher.

AC input section

The input section for AC voltage is composed of a fuse resistor R7, a bridge rectifier D3 and, in order to reduce the conduced EMI, an input filter consisting of C7, L1 and C3.

Buck converter

The buck converter is based on the VIPER22A-E, which integrates a power MOSFET with the logic parts, and is composed of the VIPER22A-E device, freewheeling diode D4, main inductor L2, and a circuit to supply the VIPER22A-E composed of a D2 diode and C1 capacitor.

The buck converter works in continuous conduction mode with a frequency of 60 kHz.

Constant current circuit

Current feedback is provided by sensing the voltage drop across R5. This voltage is filtered by R4 and C6. When the voltage drop exceeds the VBE of the NPN transistor, both Q2 and Q1 turn on, adding additional current on the FB pin of the VIPER22A-E, and causing the device to switch off.

In this way the average inductor current is controlled simply and accurately. Capacitor C5 is the filter for the output current.

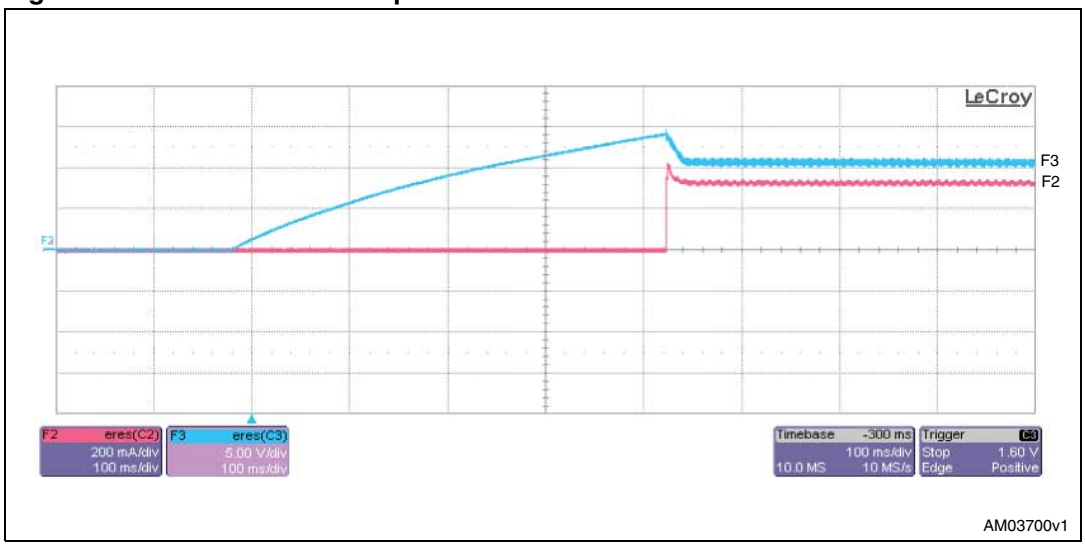
Resistor R6 provides a minimum load to ensure correct operation at zero load.

5 Test results

VIPER22A-E startup

As shown in *Figure 3* below, the internal current generator of the device charges the capacitor connected at the pin. When the voltage across this capacitor reaches the VIPER22A-E turn-on threshold, the system starts.

Figure 3. VIPER22A-E startup

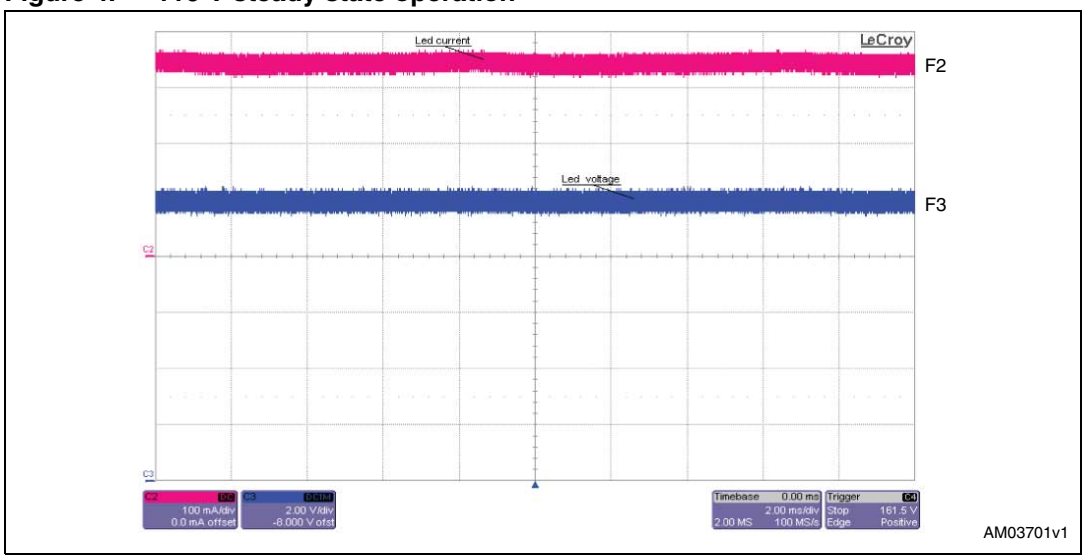


F2 - LED current (magenta waveform), F3 - VIPER22A-E voltage (cyan waveform).

Steady state

In *Figure 4*, the LED current and voltage are shown.

Figure 4. 110 V steady state operation

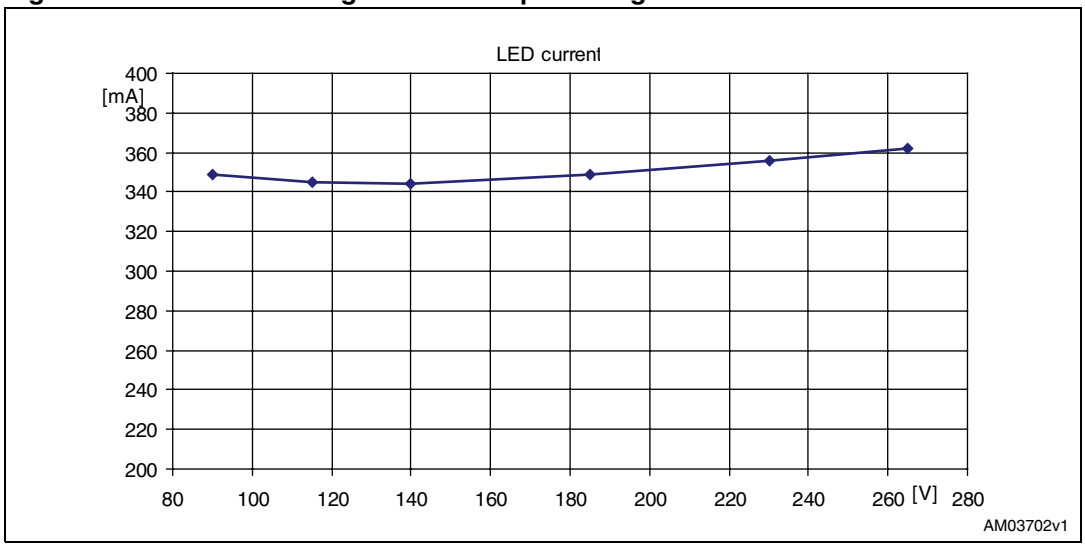


F2 LED current (magenta waveform), F3 LED voltage (blue waveform).

LED current regulation

In *Figure 5*, the LED current regulation versus AC input voltage is shown. As illustrated, the system is capable of regulating the current between a 90 VAC and 265 VAC input mains with little variation.

Figure 5. LED current regulation vs. input voltage



Open load operation

Open load operation is an abnormal condition, and the system is capable of protecting itself. When this condition occurs, the circuit regulates the output voltage at a typical value of 39 V. In this situation the constant current circuit does not operate, but the D1 Zener diode does. When diode D1 conducts, the output voltage is regulated at 39 V.

Short-circuit condition

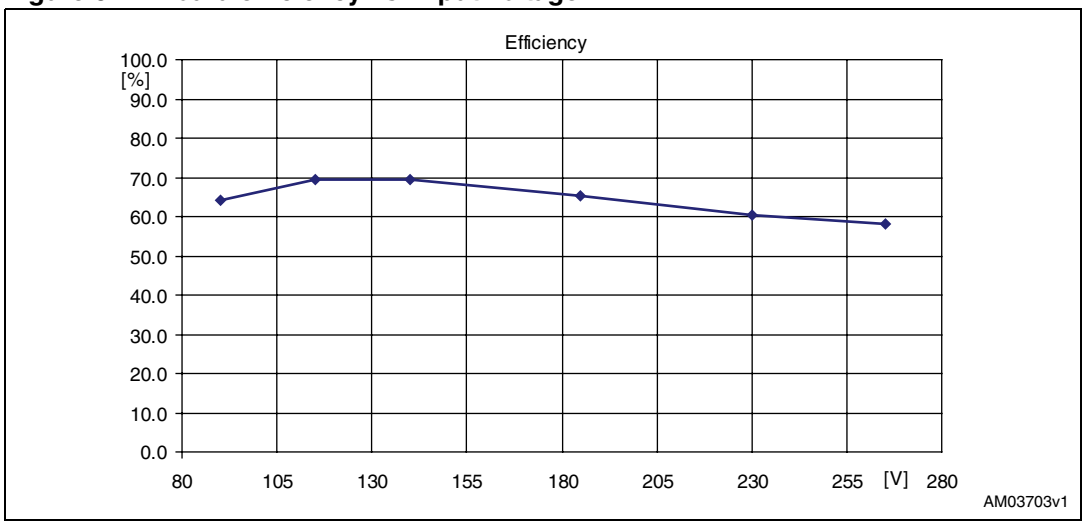
When a short-circuit occurs the device works at the minimum admissible duty cycle until the voltage on the pin of the VIPER22A-E falls below the shutdown threshold. This is due to the supply circuit, composed of D2 and C1. When the load is connected at the output, the C1 capacitor is charged to the same voltage as the output voltage.

In a short-circuit condition the C1 capacitor is not charged and after each startup, the voltage decrease causes the VIPER22A-E to switch off. After this, the VIPER22A-E repeats the startup sequence. The board is also capable of protecting itself under these conditions.

Board efficiency

The figure below reports the result of the board efficiency measurement.

Figure 6. Board efficiency vs. input voltage



As shown, the typical efficiency of the system is between 58% and 70%.

Thermal measurements

These measurements have been conduced at an ambient temperature of 25 °C, using an infrared thermal camera. The measures refer to the top of the case of the VIPER22A-E.

Table 3. Thermal measurements

Vin [V]	T_{amb} [°C]	T VIPer [°C]
115	25	78
230	25	100

Power factor

The power factor value at 115 V and 230 VAC input voltage is reported below.

Table 4. Power factor

Voltage	PF
115	0.62
230	0.55

EN6100-3-2 standard

The board satisfies EN 6100-3-2 standards. The system is defined as a lighting unit, so the equipment is required to satisfy class C limits with active input power < 25 W.

6 Conducted emission tests

Conducted emissions have been measured in neutral and line wires, using a peak detector and considering average and quasi peak limits based on EN 55015 standards. The measurements have been performed in worst-case conditions at 230 VAC input. The results show that the emission levels are below the limits.

Figure 7. Conducted emissions at 230 VAC 50 Hz - line 1 peak detector

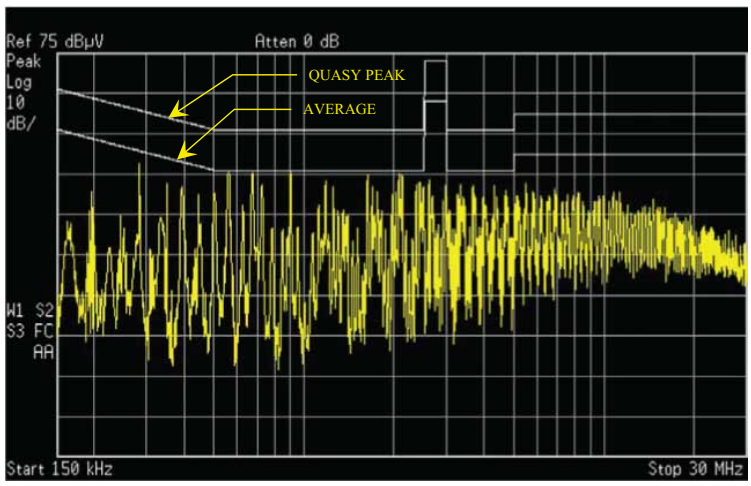
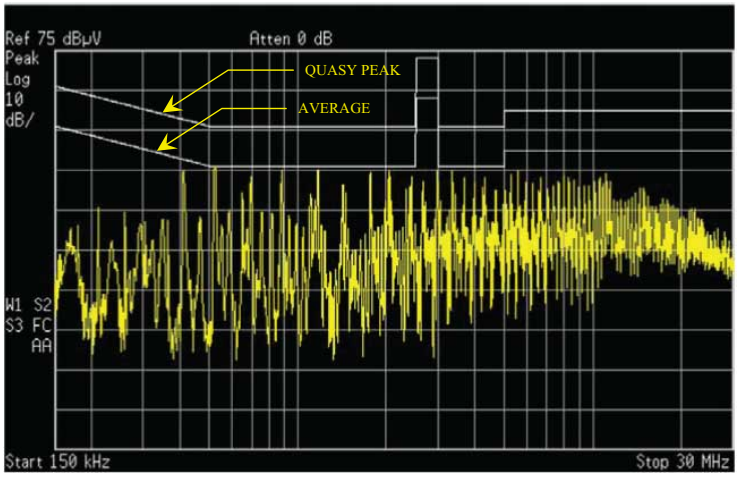


Figure 8. Conducted emissions at 230 VAC 50 Hz - line 2 peak detector



7 Adapting the board for a 230 V input mains range

The board can be adapted to operate in the 230 V input range by changing the input filter.

Table 5. Bill of material for 230 VAC input

Type	Name	Value	Rated	Description
C	C1	22 µF	50 V	Electrolytic
C	C3	Do not fit	Do not fit	Do not fit
C	C4	470 nF	50 V	Ceramic
C	C5	22 µF	50 V	Electrolytic
C	C6	470 nF	50 V	Ceramic
C	C7	470 nF	400 VDC	Polyester EPCOS B32561J6474K
C	C8	470 nF	400 VDC	Polyester EPCOS B32561J6474K
D	D1	39 V		Zener diode
D	D2	STTH1R06A	600 V	STMicroelectronics
D	D3	Bridge	600 V 500 mA	Rectifier bridge
D	D4	STTH1R06A	600 V	STMicroelectronics
L	L1	1 mH		EPCOS B7818S1105J000
L	L2	1 mH		Coilcraft MSS1260-105KLB
Q	Q1	BC557B		PNP transistor
Q	Q2	BC547B		NPN transistor
R	R1	4.7 kΩ		SMD resistor 0805
R	R2	4.7 kΩ		SMD resistor 0805
R	R3	10 kΩ		SMD resistor 0805
R	R4	10 kΩ		SMD resistor 0805
R	R5	1.3 Ω		SMD resistor 1206
R	R6	6.8 kΩ		SMD resistor 0805
R	R7	10 Ω	1/2 W	Through hole resistor
U	IC1	VIPER22ASTR-E		STMicroelectronics

The electrolytic input capacitor has been replaced by a polyester capacitor.

8 Revision history

Table 6. Document revision history

Date	Revision	Changes
13-Nov-2009	1	Initial release.

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