UM10700

SSL21083ADB1104 7 W 230 V non-dimmable buck GU10 demo board

Rev. 1 — 29 March 2013 **User manual**

Document information

Info	Content
Keywords	SSL21083ADB1104 reference board, SSL21083A, buck converter, LED driver, LED retrofit lamp, low power
Abstract	This document describes the performance, technical data and the connection of the SSL21083A demo board. The SSL2108 series is an NXP Semiconductors driver IC providing a low-cost, small form factor LED driver. This board operates at 230 V (AC), using an output voltage ≤ 25 V.

Revision history

Rev	Date	Description
v. 1	20130329	first issue

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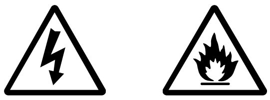
1. Introduction

WARNING

Lethal voltage and fire ignition hazard



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The SSL21083A is a highly integrated switch mode LED driver enabling constant current driving from the mains input. It is a solution for small LED retrofit lamp application. The SSL21083A is a buck converter controller suitable for non-isolated, non-dimmable LED retrofit lamps.

2. Safety warnings

The board has to be connected to the mains voltage. Touching the board during operation must be avoided at all times. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Even though the secondary circuit with LED connection has galvanic isolation, this isolation is not according to any norm. Thus a galvanic isolation of the mains phase using a variable transformer is always recommended. The symbols shown in Figure 1 indicate these devices.

a. Isolated

b. Not isolated

Fig 1. Variable transformer (Variac) isolation symbols

3. Specification

Table 1. Specifications

Parameter	Value(s)	Comment(s)
AC line input voltage	175 V to 265 V (AC) at 50 Hz and 60 Hz	
output voltage (LED voltage)	15 V to 25 V (DC)	
output voltage protection	30 V (DC)	
output current (LED current)	290 mA (typical)	
input voltage/load current dependency	±1 % at an input voltage range of 175 V (AC) to 265 V (AC)	see Figure 7

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Table 1. Specifications *...continued*

Parameter	Value(s)	Comment(s)
output voltage/load current dependency	±2 % at an output voltage range of 15 V to 25 V (DC)	see Figure 8
current ripple	±20 %	
maximum output power (LED power)	7 W	
Efficiency	83 % at a 230 V (AC) input voltage and a 21 V (DC) output voltage	T_{amb} = 30 °C
power factor	> 0.7 at an input voltage range of 175 V to 265 V (AC)	
switching frequency	55 kHz to 88 kHz at an output voltage range of 15 V to 25 V (DC)	input voltage = 230 V (AC)
board dimensions	28 mm × 15 mm × 15 mm	
operating temperature	−20 °C to +85 °C	ambient temperature
EMC compliance	EN55015 CE	see Figure 9 and Figure 10

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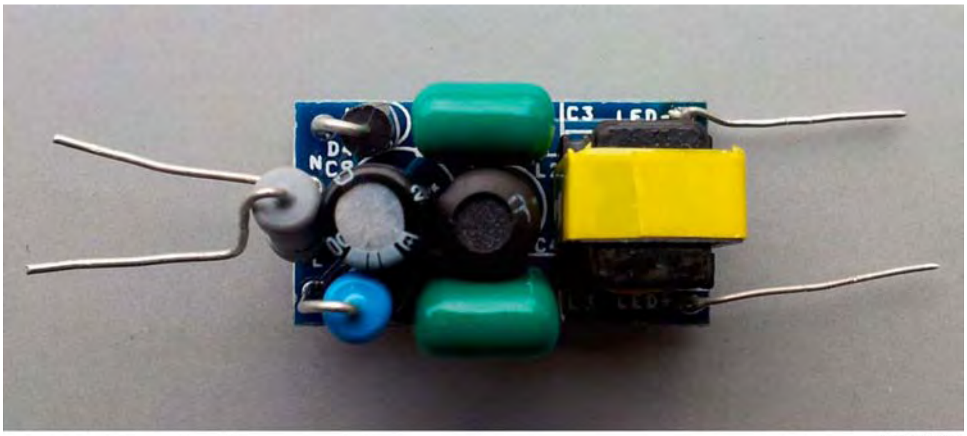
4. Board photographs



aaa-006946

Fig 2. Demo board (top)

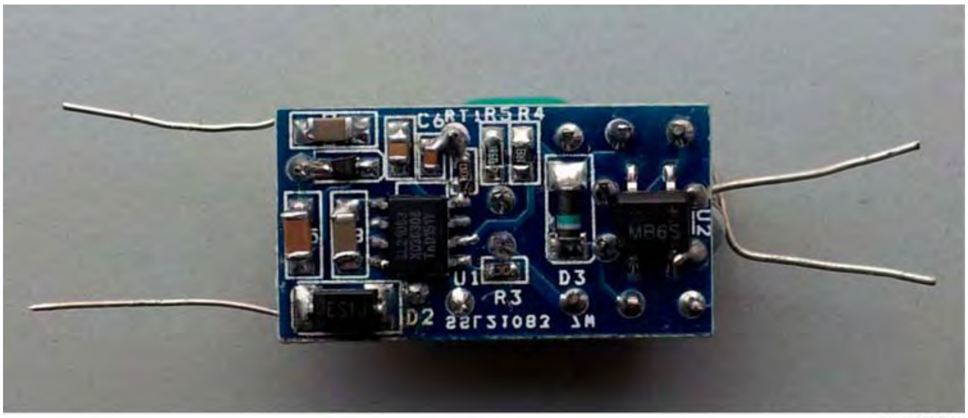


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Fig 3. Demo board (bottom)

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5. Connecting the board

The board is optimized for a 175 V to 265 V (AC; at 50 Hz) mains source. It has been designed to work with multiple high power LEDs with a total working voltage between 15 V and 25 V. The output current is set to 290 mA. The output voltage is limited to 30 V.

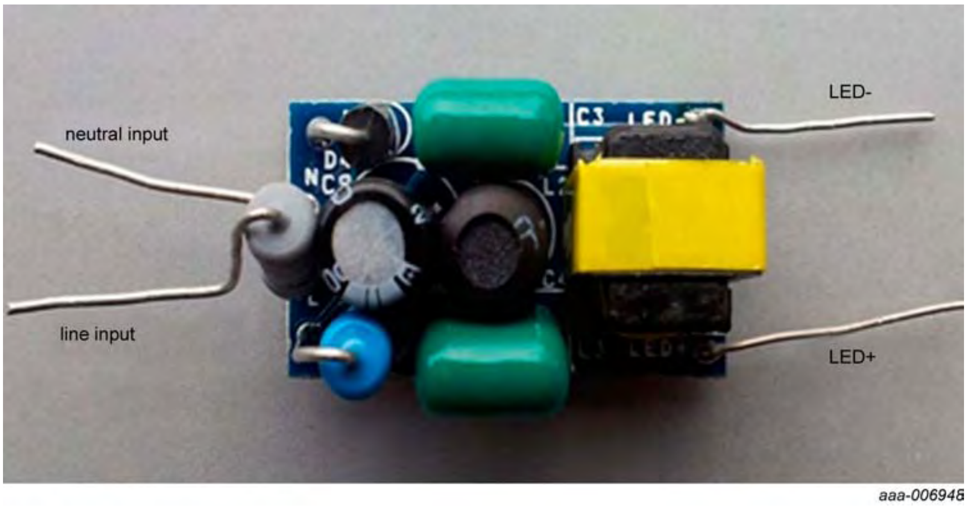

Fig 4. Board connection (front)

For demonstration purposes it is recommended to mount the board in a shielded or isolated box. If a galvanic isolated transformer is used, placed it between the AC source and the evaluation board. Board output: Connect a string of LED lamps (5 to 8).

6. System optimization

The following modifications can be made to meet customer application specifications.

6.1 Changing the output current

The SSL21083A monitors the charging current in the inductor using sense resistors R4 and R5. The device controls a MOSFET to retain a constant peak current. In addition, the IC supports valley switching.

These features enable a driver to operate in Boundary Conduction Mode (BCM) with valley switching where the average current in the inductor is the output current.

The SSL21083A turns off the MOSFET when the voltage on the SOURCE pin reaches 500 mV. If the value of resistor R4 in parallel with resistor R5 is 0.847 Ω, the peak current is limited to 590 mA (see Equation 1):

$$I_{peak} = \frac{0.5 \times (R4 + R5)}{R4 \times R5} \quad (1)$$

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When the MOSFET is turned off, inductor L3 is discharged and the current flowing through the inductor decreases. When the current in the inductor reaches 0 mA, the voltage on the DRAIN pin starts to oscillate because of the stray capacitance (ringing). The SSL21083A waits for a valley of this oscillation.

The charge time of the inductor is calculated using Equation 2:

$$t_{ch} = L3 \times \frac{2 \times I_{LED}}{V_i - V_{LED}} \quad (2)$$

The discharge time of the inductor is calculated using Equation 3:

$$t_{dch} = L3 \times \frac{2 \times I_{LED}}{V_{LED}} \quad (3)$$

A current flow through the inductor when it is charging/discharging. However, there is also an effective current when ringing. Consider the oscillation frequency when adjusting the output current. It is calculated using Equation 4:

$$f_{ring} = \frac{1}{2 \times \pi \times \sqrt{L3 \times (C_{FET} \pm C8)}} \quad (4)$$

The time from the start of oscillation to the first valley is calculated with Equation 5:

$$t_{ring} = \frac{1}{2 \times f_{ring}} \quad (5)$$

The output current is calculated using Equation 6:

$$I_{LED} = \frac{1}{2} \times I_{peak} \times \frac{t_{ch} + t_{dch}}{t_{ch} + t_{dch} + t_{ring}} \quad (6)$$

Conclusion: By changing I_{peak} I_{LED} can be changed.

6.2 External OverTemperature Protection (OTP)

The SSL21083A supports external OTP by adding an external Negative Temperature Coefficient (NTC) resistor. This feature is delivered by detecting a voltage on pin NTC. Pin NTC has an integrated current source. The resistance of the NTC resistor decreases as the temperature rises.

When the NTC temperature rises and the voltage on pin NTC falls below 0.5 V, the SSL21083A lowers the threshold level for detecting peak current in the inductor.

Decreasing the peak current in the inductor causes the power current to decrease. The output current is regulated so a balance between temperature and output current can be retained (the so-called thermal management).

If the temperature on NTC increases continuously and the voltage on the pin drops below 0.3 V, the SSL21083A starts the NTC time-out timer. If the voltage on pin NTC pin does not drop below 0.2 V within the time-out, the SSL21083A detects an abnormal condition and stops switching. If the voltage reaches 0.2 V within the time-out period, a Pulse Width Modulaton (PWM) signal is assumed.

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An NTC resistor can be connected directly to the NTC pin. It is also possible to tune the protection temperature by adding a resistor in parallel or in series with the NTC. One NTC is installed on the reference board. The values of these components can be changed depending on protection temperature requirements and component availability.

6.3 Adapting the circuit to $P_{in} \leq 5$ W/PF < 0.7

Design example:

The driver specification is 5 LEDs of 0.28 A at 230 V (AC).

Solution:

Remove capacitor C3 and diode D3, short circuit resistor R2. Keep capacitor C9 (1 μF e-cap).

The board test data at a 230 V (AC) input voltage are:

- PF = 0.64
- P_{in} = 5 W
- V_o = 14.6 V
- I_o = 0.281 A
- η = 0.82 %

6.4 Improving the driver efficiency

- Select a slightly lower PF by decreasing the value of resistor R2. The power consumption of the resistor decreases as well, causing the driver efficiency to increase.
- Use a larger inductor type (L3) or a larger wire diameter of the inductor.
- Choose a lower operating frequency.
- Reduce the value of the DV/dt capacitor, making sure that $V_{CC} > V_{CC(stop)}$ (9 V typical).

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7. Schematic

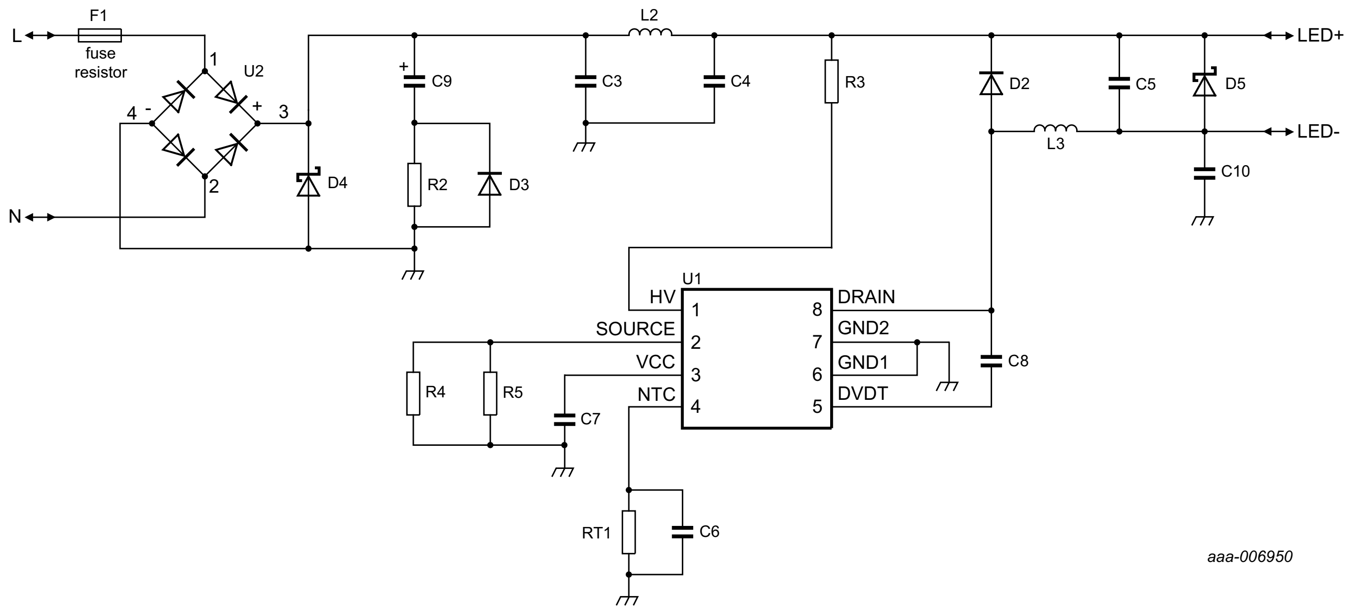

Fig 5. SSL21083A schematic

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8. Bill Of Material (BOM)

Table 2. Bill of material

Reference	Description and values	Part number	Manufacturer
C3; C4	film capacitor; 100 nF; 450 V; pitch = 10 mm; axial	-	Fara
C5	capacitor; 10 μF; 50 V; X5R; 1206	GRM31CR61H106KA12	Murata
C6	capacitor; 100 nF; 50 V; X5R; 0603	-	Murata
C7	capacitor; 1 μF; 50 V; X5R; 0603	-	Murata
C8	capacitor; 56 pF; 630 V; COG; 1206	GRM31A5C2J560JW01D	Murata
C9	electrolytic capacitor; 1 μF; 400 V; 6.3 mm × 11 mm	-	Yonming
C10	capacitor; 220 pF; 630 V; COG; 1206	GRM31A5C2J221JW01D	Murata
D2	diode; 2 A; 600 V; SMB; ES2J	ES2J	Taiwan Semiconductor
D3	diode; 0.5 A; 600 V; SOD80; GL34J	GL34J	Diotec
D4	diode; 400 A; 400 V; TVS; axial	P6KE400A	Vishay
D5	Zener diode; BZX384-C30	BZX384-C30	NXP Semiconductors
F1	fusible resistor; 10 Ω; 250 V (AC)		Xiang Zeng
L2	inductor; 2.0 mH; axial; 0608	-	Chuang Xin
L3	inductor; axial; SO8; 4 + 4 pins	-	Kang Ci
R2	resistor; 510 Ω; ±5 %; 1 W	-	Yageo
R3	resistor; 10 kΩ; ±5 %; 0603	-	Yageo
R4	resistor; 1.6 Ω; ±1 %; 0805	-	Yageo
R5	resistor; 1.8 Ω; ±1 %; 0805	-	Yageo
RT1	NTC; 100 kΩ; 0603	-	Thinking
U1	controller IC; SO8; SSL21083A	SSL21083A	NXP Semiconductors
U2	rectifier bridge; 0.5 A; 600 V; MBS; MB6S	MB6S	Vishay

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9. Transformer specification

Figure 6 shows the transformer schematic.

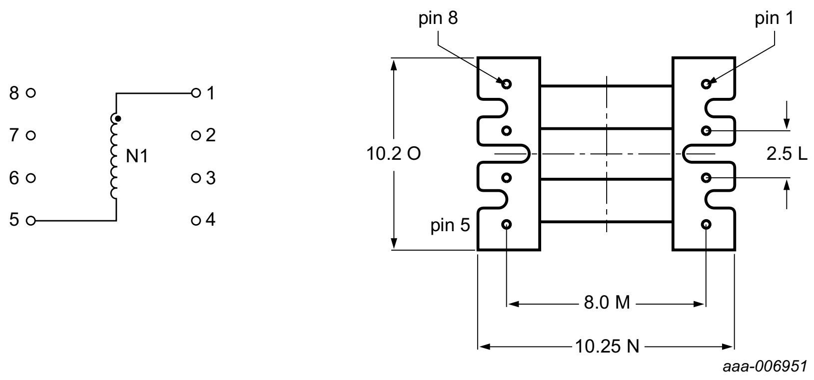

Fig 6. Transformer schematic

9.1 Winding specification

Table 3. Winding specification

Number	Section	Wire	Layers	Turns	Begin pin	End pin
1	N1	∅0.28 mm	5	78	1	5

9.2 Electric characteristics

Table 4. Electric characteristics

Section	Inductance
N1	0.4 mH; ±10 %; at 50 kHz; at 1 V

9.3 Core and bobbin

- Core: FEE-10 NC-2H Nicera or equivalent material
- Bobbin: EE10 TF-10 Taiwan Shulin

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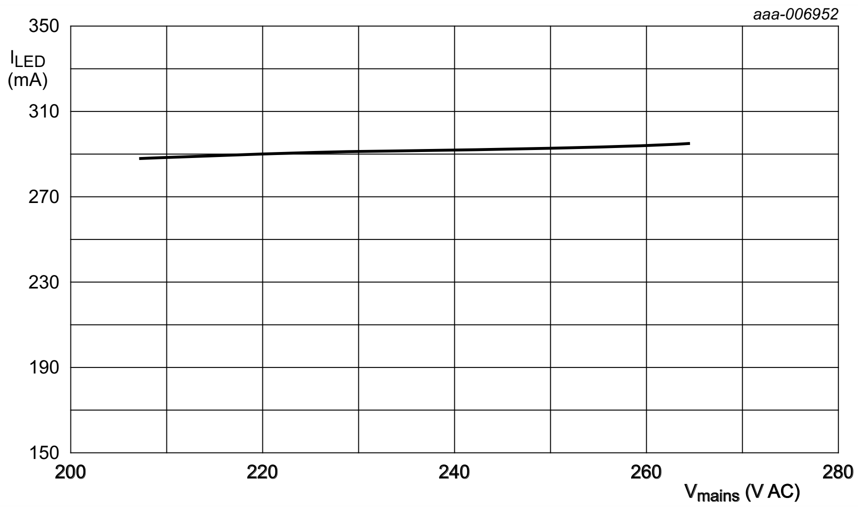
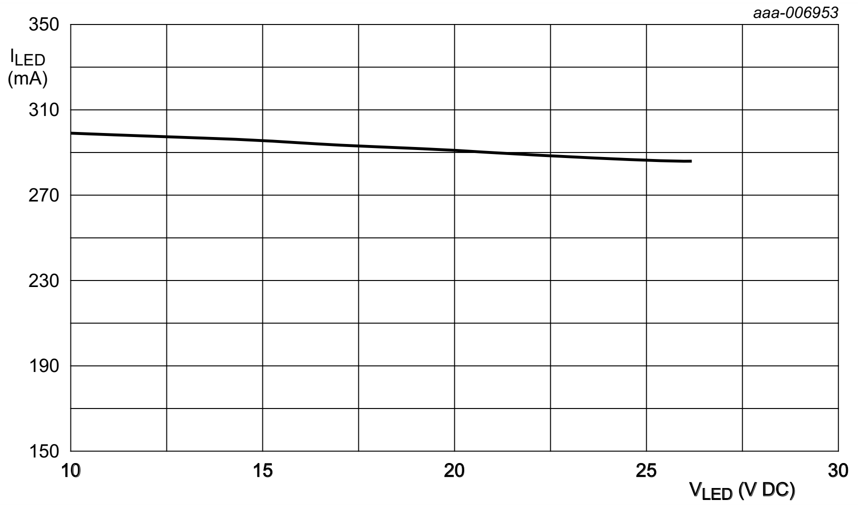
10. Performance test results



Output voltage = 20 V (DC)

Fig 7. Line regulation



Input voltage = 230 V (AC)

Fig 8. Load regulation

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11. EMC test results

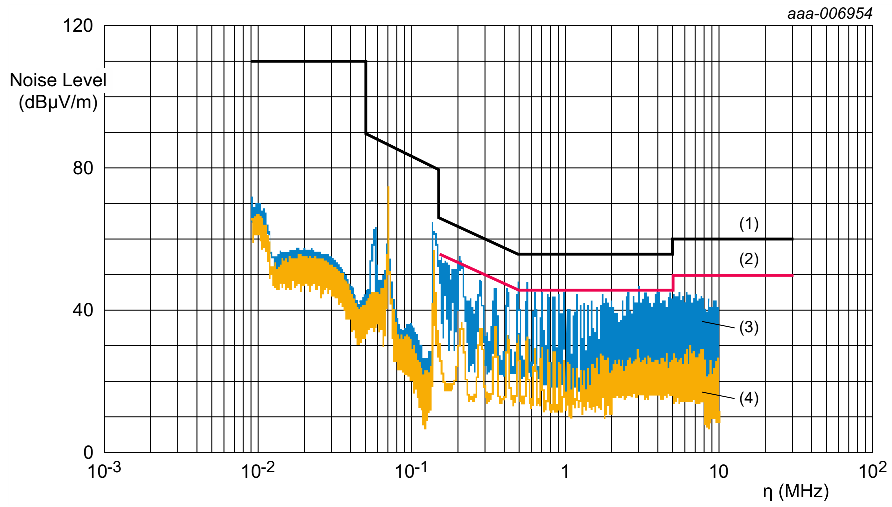

Fig 9. Conducted emission line

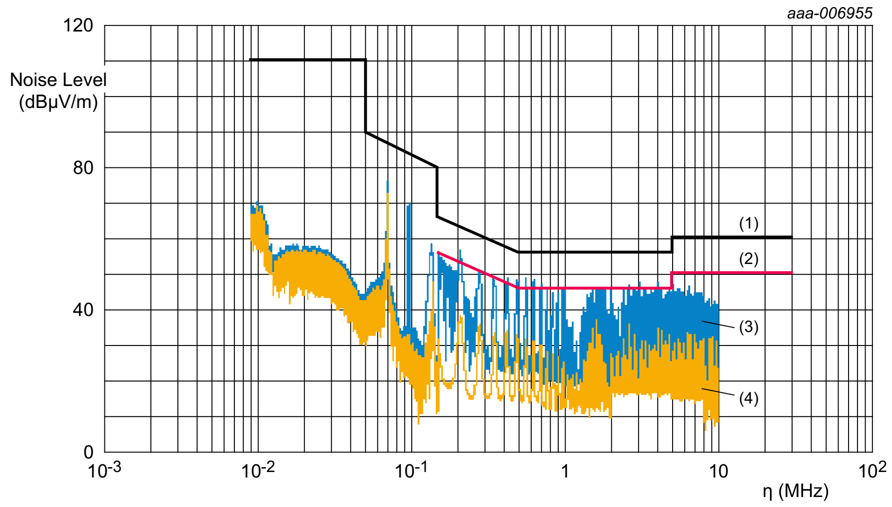

Fig 10. Conducted emission neutral

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