UM10780

TEA1721ADB1102 GreenChip 5 W QBIC demo board

Rev. 1 — 7 May 2014 **User manual**

Document information

Info	Content
Keywords	TEA1721AT, ultra-low standby power, constant output voltage, constant output current, primary sensing, integrated high-voltage switch, integrated high-voltage start-up, USB charger, 5 V/1 A supply
Abstract	This user manual describes a 5 W Constant Voltage (CV) or Constant Current (CC) universal input power supply for mobile phone adapters and chargers. The TEA1721ADB1102 demo board is based on the GreenChip SP TEA1721AT. GreenChip SP TEA1721AT enables low no-load power consumption <10 mW. The TEA1721AT design ensures a low external component count for cost-effective applications. In addition, the TEA1721AT provides advanced control modes for optimal performance. The TEA1721AT integrates the 700 V power MOSFET switch and SMPS controller.

Revision history

Rev	Date	Description
v.1	20140507	first issue

Contact information

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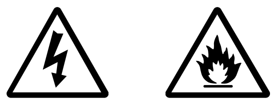
1. Introduction

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.

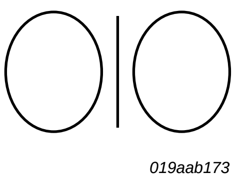
This User Manual describes a 5 W Constant Voltage (CV) or Constant Current (CC) universal input power supply for mobile phone adapters and chargers. The TEA1721ADB1102 demo board is based on the TEA1721AT GreenChip SP.

The TEA1721AT GreenChip SP provides ultra-low < 10 mW, no-load power consumption without using additional external components. Designs are cost-effective using the TEA1721AT GreenChip SP because only a few external components are needed in a typical application. In addition, the TEA1721AT provides advanced control modes for optimal performance. The TEA1721AT integrates the 700 V power MOSFET switch and SMPS controller.

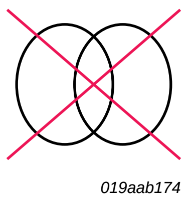
Remark: All voltages are in V (AC) unless otherwise stated

2. Safety warning

The complete demo board application is AC mains voltage powered. Avoid touching the board when power is applied. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Always provide galvanic isolation of the mains phase using a variable transformer. The following symbols identify isolated and non-isolated devices.



a. Isolated.



b. Non-isolated

Fig 1. Isolated and non-isolated symbols

3. Features

- Enables low no-load power dissipation <10 mW
- Low component count for a cost-effective design
- Advanced control modes for optimal performance
- SMPS controller with integrated power MOSFET switch
- 700 V high-voltage power switch for global mains operation
- Primary sensing at end-of-conduction for accurate output voltage control
- Avoids audible noise in all operation modes
- Compensation of cable impedance included
- Jitter function for reduced EMI
- USB battery charging and Energy Star compliant
- Universal mains input
- Isolated output
- Highly efficient: > 76 %
- OverTemperature Protection (OTP)

4. Technical specification

Table 1. Input and output specification

Parameter	Condition	Value	Remark
Input			
input voltage	-	90 V to 265 V	universal AC mains
input frequency	-	47 Hz to 63 Hz	
average power dissipation	no-load	< 10 mW	
Output			
output voltage	-	5.0 V	-
maximum output current	-	1.0 A	-
maximum output power	-	5.0 W	-

5. Board photograph

aaa-012476

Fig 2. TEA1721ADB1102 5 W QBIC demo board

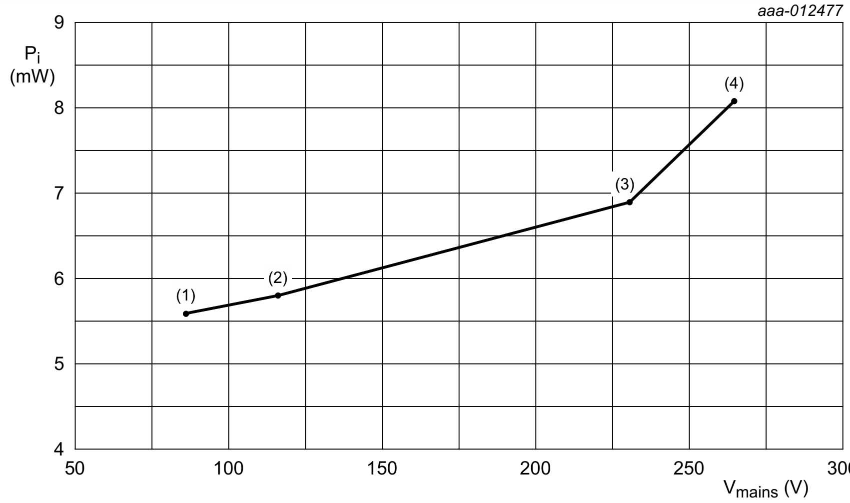
6. Performance

6.1 No-load input power dissipation

Table 2. No-load Input power dissipation[1]

Output voltage	Conditions	Power dissipation	Unit
5.16 V	115 V; 60 Hz	5.8	mW
5.14 V	230 V; 50 Hz	6.9	mW

[1] The no-load input power has been measured after 20 minutes temperature stabilization time.



(1) P_i = 5.6 mW

(2) P_i = 5.8 mW

(3) P_i = 6.9 mW

(4) P_i = 8.1 mW

Fig 3. No-load Input power dissipation

6.2 Output voltage and efficiency performance data

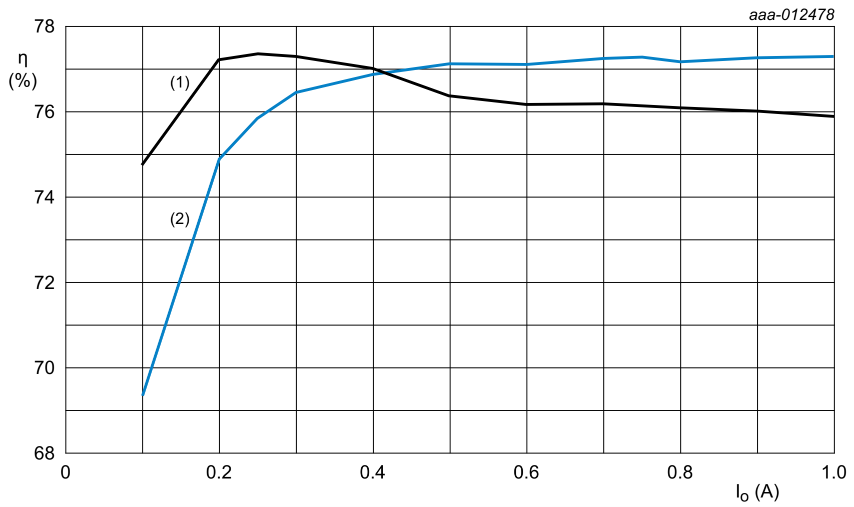
Table 3 and Figure 4 show the measured efficiency figures and VI characteristics of the GreenChip SP TEA1721AT demo board. The efficiency and VI characteristics have been measured after 20 minutes temperature stabilization time.

Table 3. Efficiency and VI characteristics

V_{CC}	Parameter	Values									
115 V/60 Hz	output current (A)	0.000	0.010	0.020	0.030	0.050	0.100	0.250	0.500	0.750	1.000
	output voltage (V)	5.16	5.14	5.12	5.09	5.06	5.00	4.98	4.97	5.01	5.03
	output power (W)	0.000	0.052	0.102	0.152	0.253	0.500	1.245	2.483	3.754	5.030
	input power (W)	0.0058	0.097	0.182	0.244	0.366	0.669	1.609	3.252	4.929	6.625
	efficiency (%)	-	-	-	-	-	74.8	77.4	77.4	76.2	75.9

Table 3. Efficiency and VI characteristics *...continued*

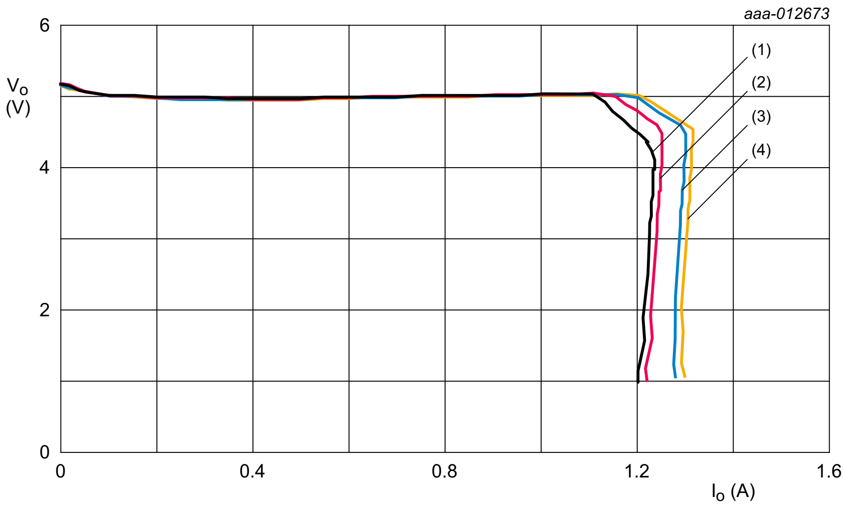
V_{CC}	Parameter	Values									
230 V/50 Hz	output current (A)	0.000	0.010	0.020	0.030	0.050	0.100	0.250	0.500	0.750	1.000
	output voltage (V)	5.14	5.11	5.10	5.09	5.06	5.00	4.97	4.95	5.00	5.02
	output power	0	0.051	0.101	0.152	0.253	0.500	1.242	2.473	3.746	5.020
	input power (W)	0.0067	0.111	0.210	0.299	0.423	0.721	1.635	3.205	4.848	6.494
	efficiency (%)	-	-	-	-	-	69.3	75.9	77.2	77.3	77.3



(1) efficiency at 115 V

(2) efficiency at 230 V

Fig 4. Efficiency at 115 V and 230 V



(1) 85 V

(2) 115 V

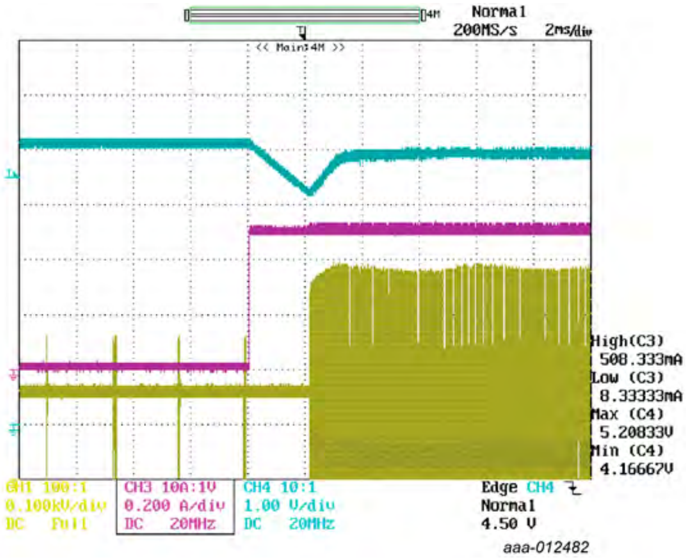
(3) 230 V

(4) 265 V

Fig 5. VI characteristics at 85 V, 115 V, 230 V and 265 V

6.3 Dynamic loading from 0 A to 0.5 A

The dynamic loading was tested according to the USB-charger specification 1.1. At a load step of 0 A to 0.5 A, the output voltage must stay above 4.1 V. Due to primary sensing, the TEA1721AT detects the load step only after the next switching cycle. The load step is measured at V_{mains} = 115 V.



CH1 = V_{DRAIN}

CH3 = I_o

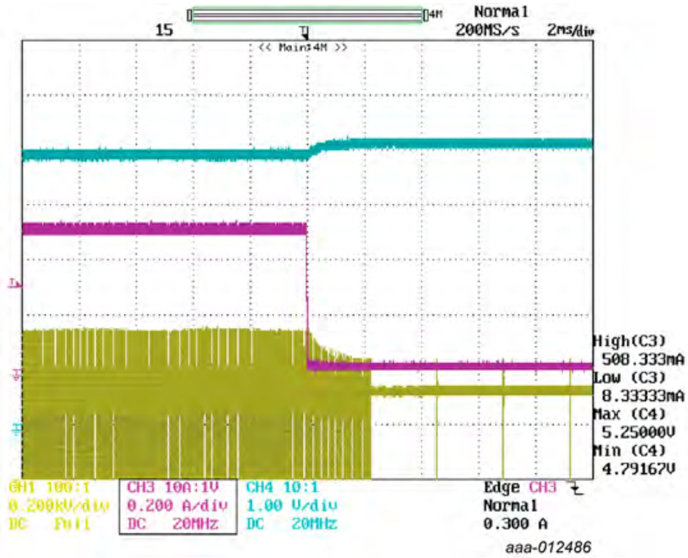
CH4 = V_o

Fig 6. Load step 0 A to 0.5 A; V_{mains} = 115 V

In the worst case (see Figure 6), the output voltage drops to 4.17 V which fulfills the USB-charger specification 1.1.

6.4 Dynamic loading from 0.5 A to 0 A

The dynamic loading was tested according to the USB-charger specification 1.1. At a load step of 0.5 A to 0 A, the output voltage must stay below 6.0 V. Due to primary sensing, the TEA1721AT detects the load step only after the next switching cycle. The load step is measured at V_{mains} = 230 V.



CH1 = V_{DRAIN}

CH3 = I_o

CH4 = V_o

Fig 7. Load step 0.5 A to 0 A; V_{mains} = 230 V

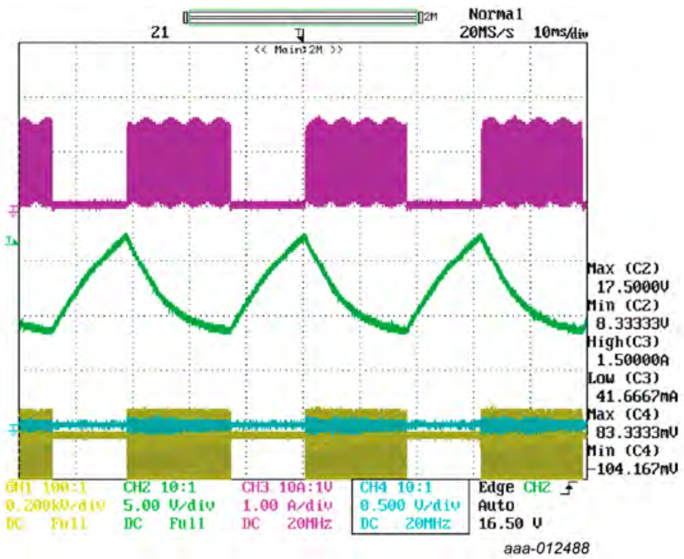
After the load step from 0.5 A to 0 A, the output voltage rises from 4.8 V to 5.25 V.

6.5 Short-circuit of the output

The output of the demo board can be short-circuited without damaging of any component.

Figure 8 shows the behavior of the converter when the output is short-circuited. During short-circuit of the output, the V_{CC} voltage (CH3) switches between $V_{CC(startup)}$ (17 V) and $V_{CC(stop)}$ (8 V) level.

At 115 V the average output current during short circuit is 470 mA. The input power is 0.32 W.



CH1 = V_{DRAIN}

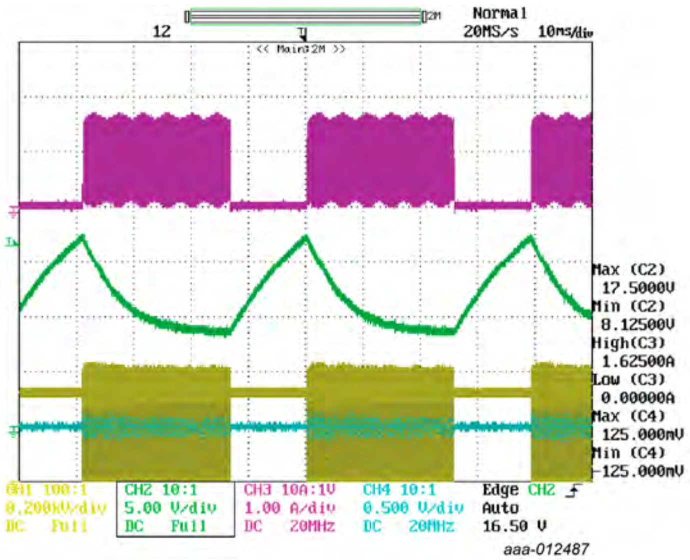
CH2 = V_{CC}

CH3 = I_o

CH4 = V_o

Fig 8. Short circuit of the output; V_{mains} = 115 V

At 230 V, the average output current during a short circuit is 610 mA. The input power is 0.44 W.



CH1 = V_{DRAIN}

CH2 = V_{CC}

CH3 = I_o

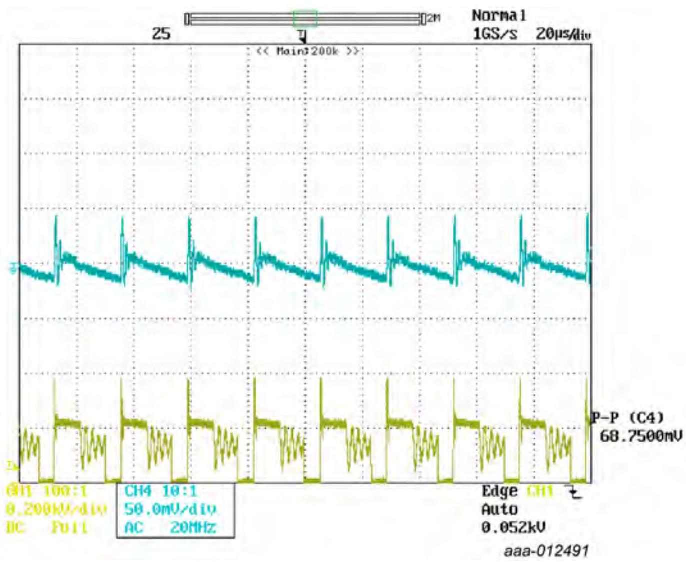
CH4 = V_o

Fig 9. Short circuit of the output; V_{mains} = 230 V

6.6 Output voltage ripple performance

The output voltage ripple was measured with an oscilloscope probe connected to the output of the demo board. A probe tip was used with a very small GND connection. A 100 nF capacitor between output voltage and GND was used to reduce high frequency noise. The output voltage ripple was measured at full load and at V_{mains} of 115 V and 230 V.

Figure 10 shows the output voltage ripple at V_{mains} = 115 V. The output ripple voltage is 72 mV using output capacitors C6, C8 and C10 as specified in the Bill Of Materials (BOM).

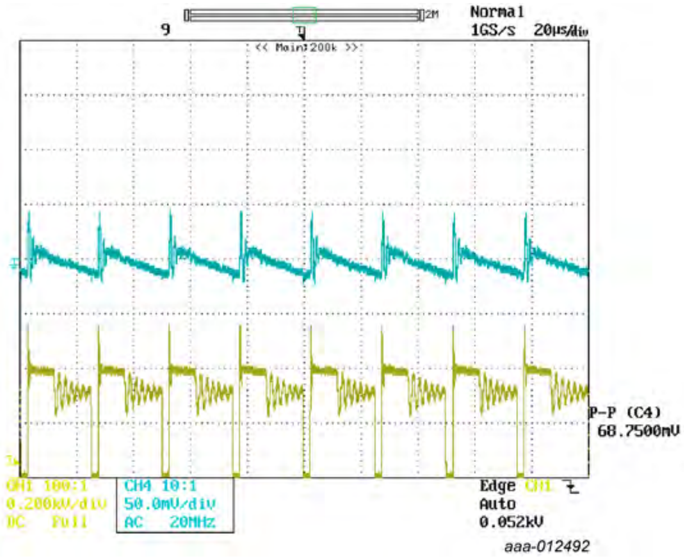


CH1 = V_{DRAIN}

CH4 = V_o on board (scale 50 mV/division).

Fig 10. Output voltage ripple; V_{mains} = 115 V

Figure 11 shows the output voltage ripple at a 1 A load at 230 V. The output ripple voltage is 69 mV using output capacitors C6, C8 and C10 as specified in the Bill Of Materials (BOM).



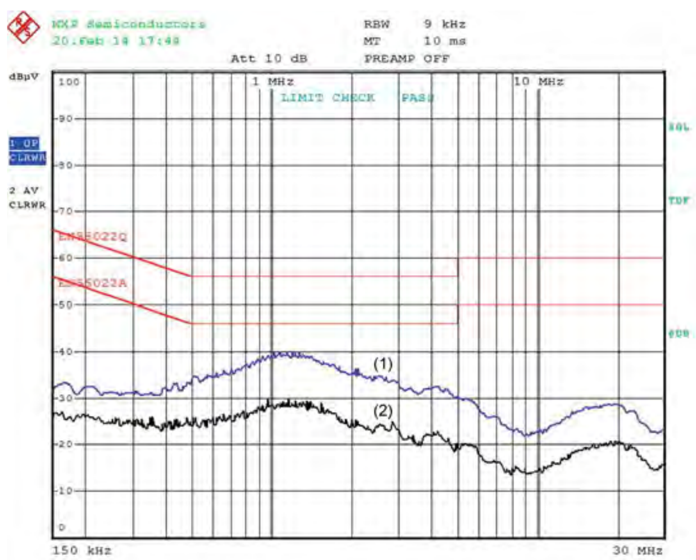
CH1 = V_{DRAIN}

CH4 = V_o on board (scale 50 mV/division).

Fig 11. Output voltage ripple at 1 A load; V_{mains} = 230 V

6.7 Conducted EMI measurement results

The conducted EMI is measured according to CISPR22, with a 5 Ω load at the end of a 1m USB cable. EMI is measured on neutral and on line at V_{mains} = 230 V. The frequency range is 150 kHz to 30 MHz.



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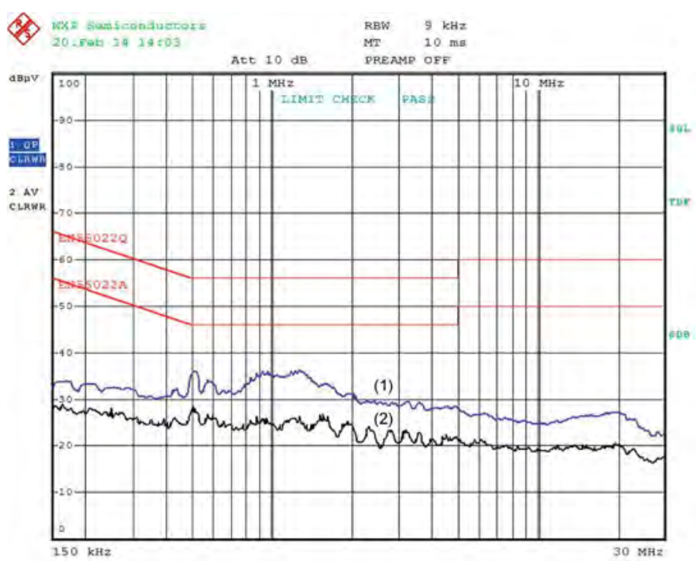
(1) Quasi-peak

(2) Average

a. Neutral



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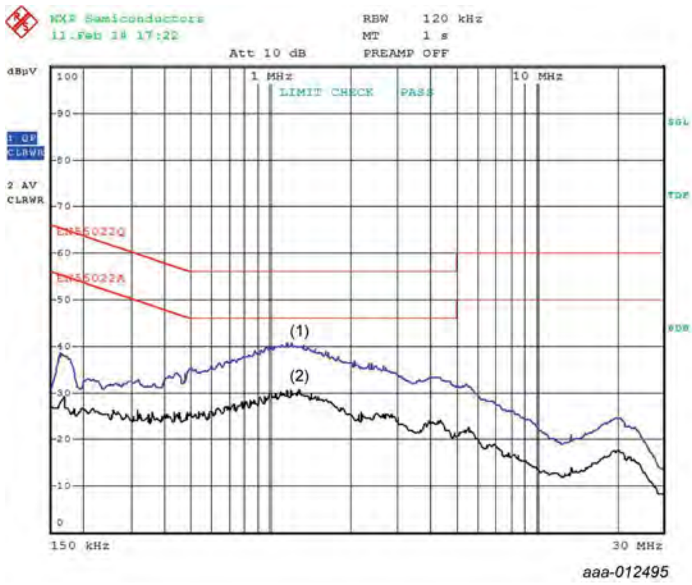
(1) Quasi-peak

(2) Average

b. Line

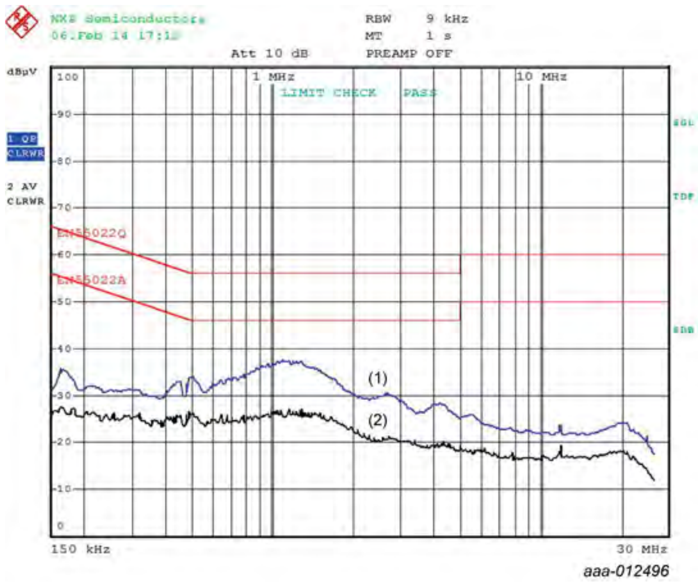
Fig 12. Electromagnetic Interference; V_{mains} = 230 V



(1) Quasi-peak

(2) Average

a. Neutral



(1) Quasi-peak

(2) Average

b. Line

Fig 13. Electromagnetic Interference; V_{mains} = 115 V

7. Schematic

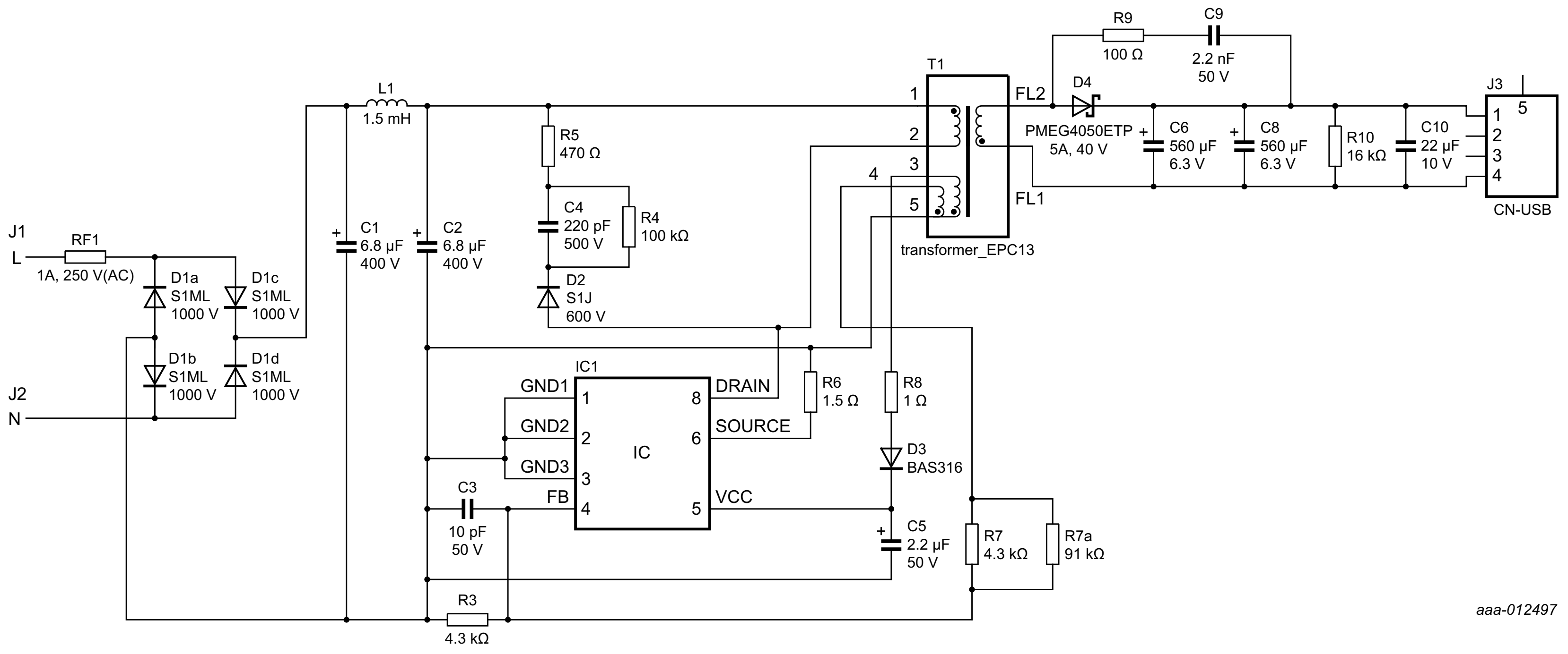


Fig 14. TEA1721AT 5 W schematic

8. Bill of Materials (BOM)

Table 4. TEA1721ADB1102 bill of material

Reference	Description and values	Part number	Manufacturer
C1; C2	capacitor; 6.8 μF; 400 V; 8 × 10.8 mm	AX series	Rubycon
C3	capacitor; 10 pF; 50 V; X7R; C0603	-	-
C4	capacitor; 220 pF; 500 V; C0805	CC0805JRNPOBBN221	Yageo
C5	2.2 μF; 50 V; C0805	C2012X7R1H225K	TDK
C6; C8	560 μF; 6.3 V; 6.3 × 8 mm	RS80J561MDN1JT	Nichicon
C7	capacitor; not mounted	-	-
C9	capacitor; 2.2 nF; 50 V; X7R; C0603	-	-
C10	capacitor; 22 μF; 10 V; 1206	GRM31CR71A226KE15L	Murata
D1a; D1b; D1c; D1d	diode; S1ML; 1000 V; sub-SMA	S1ML	Taiwan Semiconductor
D2	diode; S1JL; 600 V; sub-SMA	S1JL	Taiwan Semiconductor
D3	diode; BAS316; 100 V; SOD323	BAS316	NXP Semiconductors
D4	diode; PMEG4050ETP; 40 V; SOD128	PMEG4050ETP	NXP Semiconductors
IC1	TEA1721AT; 700 V; SO7	TEA1721AT/N1	NXP Semiconductors
J1; J2	connector; input pin	SN/040/LT SILVER	Oxley Group
J3	connector	USB AF DIP -094-H	Gold Conn
L1	inductor; 1.5 mH	ZAL-0512-152K	Zenith-Tek
R3; R7	resistor; 4.3 kΩ; 1 %; 0603	-	-
R4	resistor; 100 kΩ; 0805	-	-
R5	resistor; 470 Ω; 250 mW; 1206	-	-
R6	resistor; 1.5 Ω; 1 %; 1206	-	-
R7a	resistor; 91 kΩ; 1 %; 0603	-	-
R8	resistor; 1 Ω; 0603	-	-
R9	resistor; 100 Ω; 0603	-	-
R10	resistor; 16 kΩ; 0603	-	-
RF1	Fusistor; 1 A; 250 V (AC); 3.18 × 7.6 mm	MCPMP 1A 250V	Multicomp
T1	transformer; EPC13	750313567	Würth Elektronik

9. Circuit description

The GreenChip SP TEA1721AT demo board consists of a single-phase full-wave rectifier circuit, a filtering section, a switching section, an output section and a feedback section. Figure 14 shows the circuit diagram. Table 4 shows the component list.

9.1 Rectification section

The bridge diodes D1a to D1d form the single-phase full-wave rectifier. Capacitors C1 and C2 are reservoir capacitors for the rectified input voltage. Resistor RF1 limits inrush current and acts as a fuse. Terminals J1 and J2 connect the input to the electricity utility network. Swapping these two wires has no effect on the operation of the converter.

9.2 Filtering section

Inductor L1, with capacitors C1 and C2, form a filter to attenuate conducted differential mode EMI noise.

9.3 GreenChip SP section

The TEA1721AT device (IC1) contains the power MOS switch, oscillator, CV/CC, start-up control and protection functions all in one IC. Its integrated 700 V MOSFET allows sufficient voltage margins in universal input AC applications, including line surges. The auxiliary windings on transformer T1 generate the supply voltage and primary sensing information for the TEA1721AT. Diode D3 and capacitor C5 half-wave rectify the voltage. Capacitor C5 is charged via the current limiter resistor R8. The voltage on capacitor C5 is the supply voltage for the VCC pin.

The RCD-R clamp consisting of R4, C4, D2 and R5 limits drain voltage spikes caused by leakage inductance of the transformer.

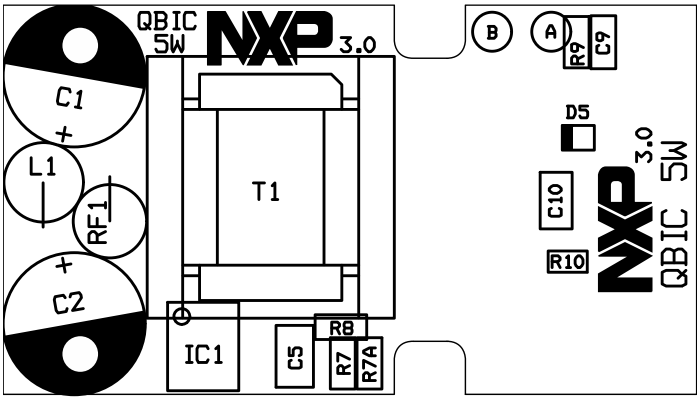
9.4 Output section

Diode D4 is a Schottky barrier type diode and capacitors C6/C8 rectify the voltage from secondary winding of transformer T1. Using a Schottky barrier type diode results in a high efficiency of the demo board. Capacitors C6, C8, and C10 must have sufficient low ESR characteristics to meet the output voltage ripple requirement without adding an LC post filter. Resistor R9 and capacitor C9 dampen high frequency ringing and reduce the voltage stress on diode D4. Resistor R10 provides a minimum load to maintain output control in no-load condition.

9.5 Feedback section

The TEA1721AT controls the output by current and frequency control for CV and CC regulation. The auxiliary feedback winding on Transformer T1 senses the output voltage. The FB pin senses the reflected output voltage using feedback resistors Rfb1 and Rfb2.

10. PCB layout



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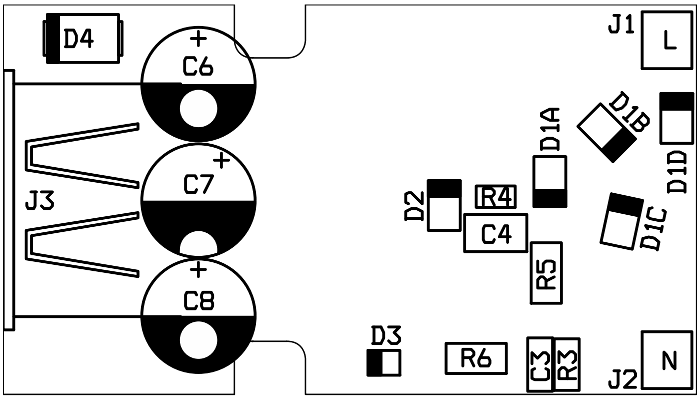
a. Top



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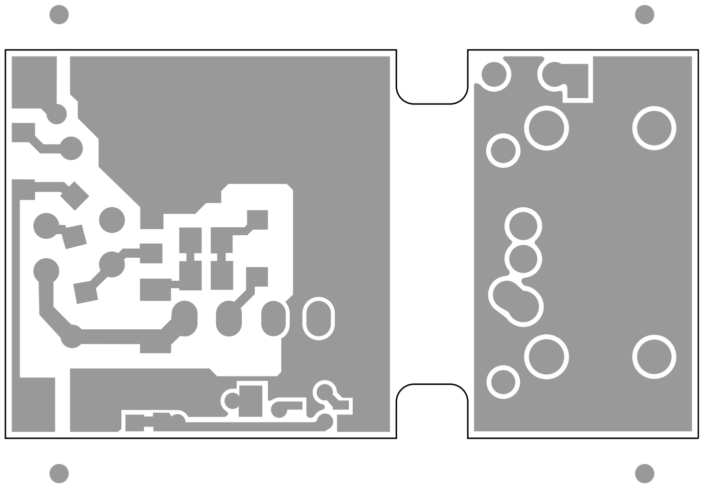
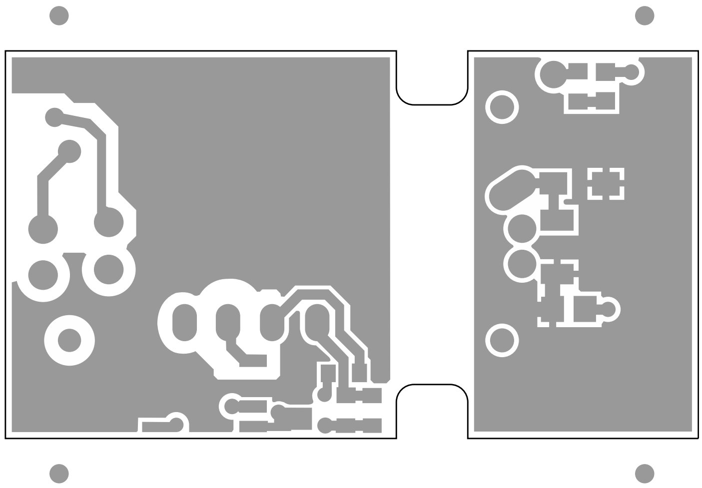
b. Bottom

Fig 15. PCB layout assembly



a. Top view



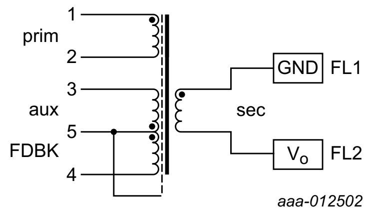
b. Bottom view

Fig 16. PCB layout copper

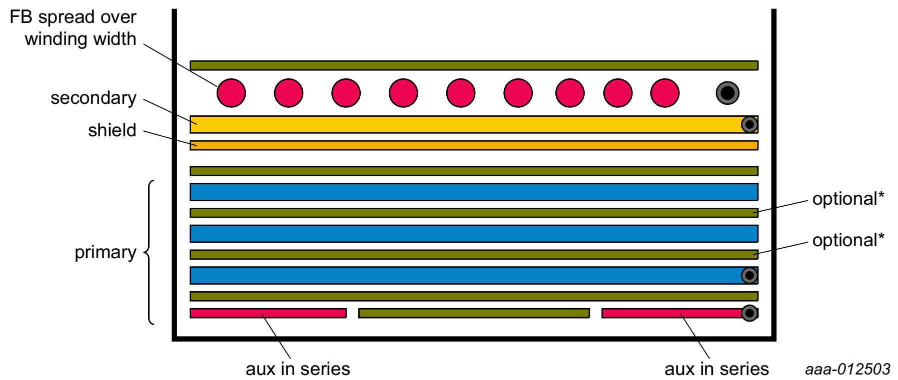
11. Transformer specifications

11.1 Transformer schematic design and winding construction

The transformer used in the small-size demo board has size EPC13 with bobbin EPC13 horizontal 10 pins. A few measures have been taken for a low EMI emission. Copper foil shields are used between primary windings and secondary windings.



a. Schematic design



b. Winding construction

Fig 17. Transformer schematic design and winding construction

11.2 Winding specification

Table 5. Winding specification

Layer no.	Type	Wire ∅ (mm)	Turns	No. of layers	Method	Start	Finish
1	aux	0.1	12 × 2	1	split	pin 5	pin 3
2	tape	-	1	-	-	-	-
3	prim	0.1	165	3	close	pin 1	pin 2
4	tape	-	2	-	-	-	-
5	shield	0.025 · CuSn6	1	-	-	pin 5	-
6	sec	0.4 TIW	11	1	close	fly 1	fly 2
7	FDBK	0.1	10	1	spread	pin 5	pin 4
8	tape	-	-	-	-	-	-

11.3 Electrical characteristics

Table 6. Electrical specification

Parameter	Pin	Value	Remark
primary inductance	1 to 2	1.85 mH, ±10 %	
Leakage inductance	1 to 2	75 μH	all other windings short circuit

11.4 Core and bobbin

Core: EPC13. Core material: TP4/TP4A, equivalent to PC44

Bobbin: Würth Elektronik, EPC13 horizontal 10 pins, part number 070-5483

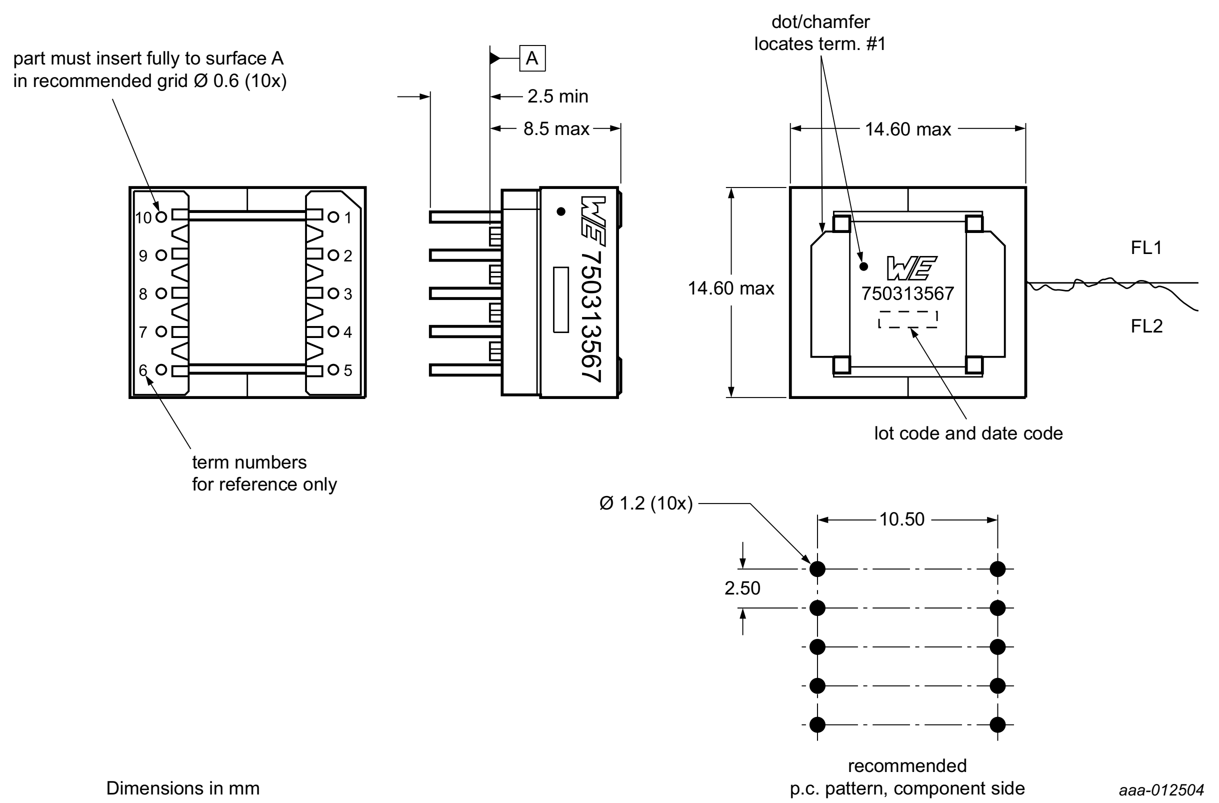


Fig 18. Bobbin: EE13/12/6

11.5 Marking

Wurth/Midcom 750313567

12. Attention points

When testing the CC mode of the TEA1721AT, use an electronic DC-load in resistive mode, not in current mode.

The current in CC mode has a small fold back characteristic (see Figure 5). When the current mode of an electronic DC-load is used, the output voltage drops immediate to zero when the maximum current is exceeded. Once the output voltage and the input voltage of the DC-load is zero, many DC-loads cannot adjust the current. Using the resistive mode of the electronic DC-load avoids this problem.

Remark: This TEA1721AT controller behavior is not incorrect. Only test it in the correct way.

13. References

[1] **TEA1721AT —** data sheet: ultra-low standby SMPS controller with integrated power switch

[2] **AN11060 —** Application note: TEA172X 5 W to 11 W power supply/usb charger

[3] **AN11029 —** Application note: Using TEA1721/TEA1723 ultra-low standby SMPS controller ICs in white goods applications

[4] **UM10520 —** TEA1721 Isolated 3-phase universal mains flyback converter demo board user manual

[5] **UM10521 —** TEA1721 isolated universal mains flyback converter demo board user manual

[6] **UM10522 —** TEA1721 non-isolated universal mains buck and buck/boost converter demo board user manual

[7] **UM10523 —** TEA1721 universal mains white goods flyback SMPS demo board user manual

[8] **UM10529 —** TEA1721AT 5 W GreenChip SP small-size demo board

[9] **UM10532 —** TEA1723AT GreenChip SP low standby power SMPS demo board

14. Legal information

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15. Contents

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Date of release: 7 May 2014

Document identifier: UM10780