UM10531

TEA1721DT 5 W GreenChip SP small-size demo board

Rev. 1 — 8 June 2012 User manual

Document information

Info	Content
Keywords	TEA1721DT, 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. This demo board is based on the GreenChip SP TEA1721DT. GreenChip SP TEA1721DT enables low no-load power dissipation <25 mW. The TEA1721DT design ensures a low external component count for cost-effective applications. In addition, the TEA1721DT provides advanced control modes for optimal performance. The TEA1721DT integrates the 700 V power MOSFET switch and SMPS controller.

Revision history

Rev	Date	Description
v.1	20120608	first issue

Contact information

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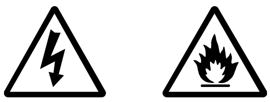
1. Introduction

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. This demo board is based on the TEA1721DT GreenChip SP.

The TEA1721DT GreenChip SP provides ultra-low <25 mW, no-load power dissipation without using additional external components. Designs are cost-effective using the TEA1721DT GreenChip SP because only a few external components are needed in a typical application. In addition, the TEA1721DT provides advanced control modes for optimal performance. The TEA1721DT 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 <25 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: >77 %
- 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	23 mW	average of 115 V and 230 V
Output			
Output voltage	-	5.0 V	-
Maximum output current	-	1.0 A	-
Maximum output power	-	5.0 W	-

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a. Top view

aaa-003107

b. Bottom view

Fig 2. TEA1721DT 5 W demo board

5. performance data

5.1 No-load Input power dissipation

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

Output voltage	Conditions	Power dissipation	Unit
5.0 V	115 V; 60 Hz	21.8	mW
5.0 V	230 V; 50 Hz	24.1	mW

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

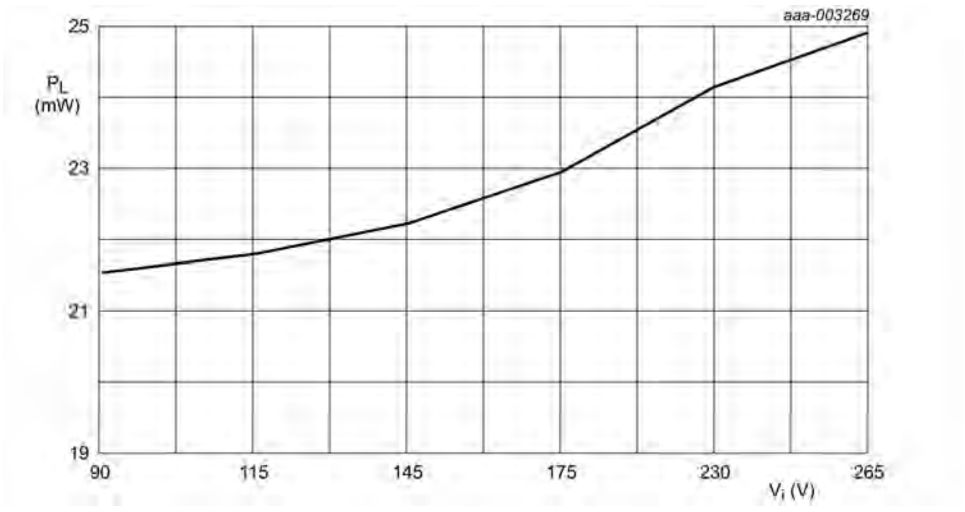


Fig 3. No-load Input power dissipation

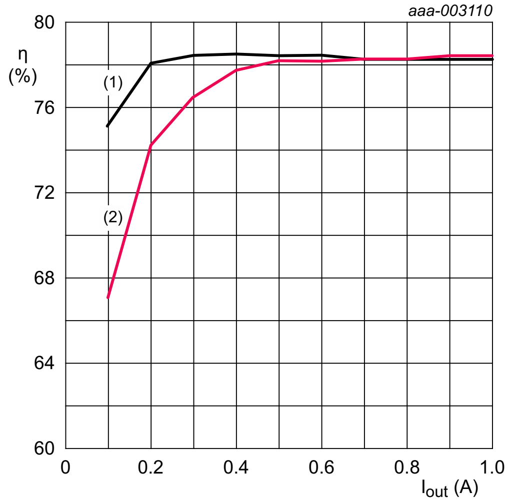
5.2 Output voltage and efficiency performance data

Table 3 and Figure 4 show the measured efficiency figures and VI characteristics of the GreenChip SP TEA1721DT demo board. The efficiency and VI characteristics have been measured after 20 minutes warm-up time.

Table 3. Efficiency and VI characteristics[1]

V_{CC}	Parameter	Values													
115 V	output current (A)	0.00	0.02	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	output voltage (V)	5.10	5.08	5.05	5.04	5.00	4.99	4.99	5.00	5.01	5.02	5.03	5.05	5.06	5.07
	input power (W)	0.0136	0.17	0.23	0.35	0.65	1.27	1.90	2.53	3.18	3.83	4.50	5.15	5.80	6.48
	efficiency (%)	-	-	-	-	75.2	78.1	78.4	78.5	78.4	78.4	78.3	78.3	78.3	78.3
230 V	output current (A)	0.00	0.02	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	output voltage (V)	5.09	5.09	5.08	5.05	5.01	4.99	4.99	4.99	5.01	5.02	5.03	5.04	5.05	5.06
	input power (W)	0.0163	0.18	0.29	0.43	0.73	1.34	1.95	2.55	3.20	3.84	4.48	5.15	5.78	6.44
	efficiency (%)	-	-	-	-	67.0	74.2	76.5	77.8	78.2	78.2	78.3	78.3	78.4	78.4

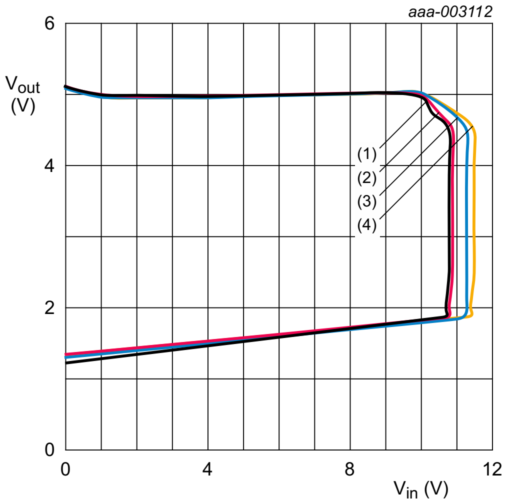
[1] The no-load input power has been measured after 20 minutes warm-up time.



(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

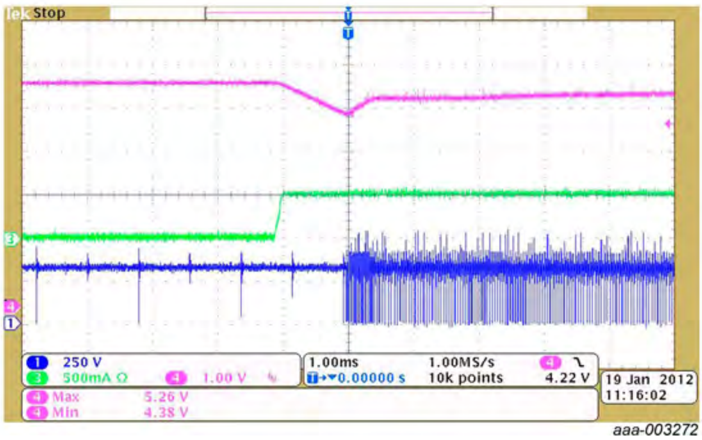
(3) 230 V

(4) 265 V

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

5.3 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 TEA1721DT detects the load step only after the next switching cycle. The load step is measured at V_{mains} = 230 V. The output capacitor (C6) is 680 µF/6.3 V (see Table 4). The burst frequency is 1270 Hz.



CH1 = V_{DRAIN}

CH3 = I_o

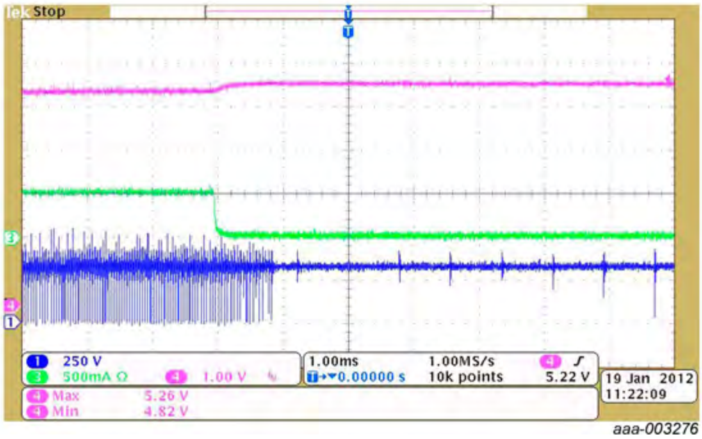
CH4 = V_o

Fig 6. Load step 0 A to 0.5 A

In the worst case (see Figure 6), the output voltage drops to 4.38 V which fulfills the USB charger specification 1.1.

5.4 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 TEA1721DT detects the load step only after the next switching cycle. The load step is measured at V_{mains} = 230 V. The output capacitor (C6) is 680 µF/6.3 V (see Table 4).



CH1 = V_{DRAIN}

CH3 = I_o

CH4 = V_o

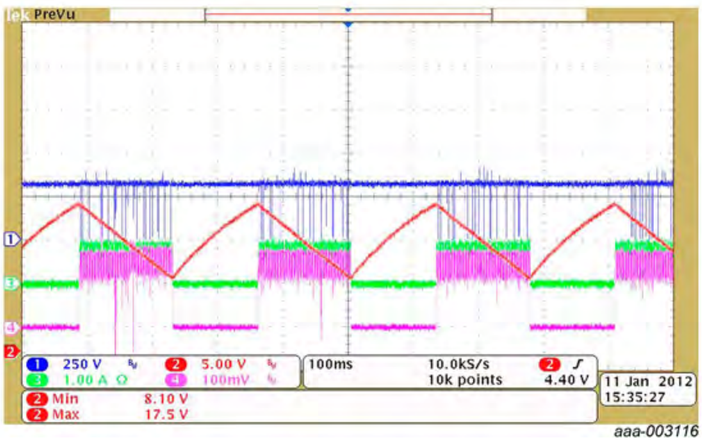
Fig 7. Load step 0.5 A to 0 A

After the load step from 0.5 A to 0 A, the output voltage rises from 5.0 V to 5.26 V. Due to the large electrolytic output capacitor (680 µF), the transition takes about 2 ms and the controller switches from CV to CVB.

5.5 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. The average output current during switching of the converter is 0.5 A.



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CH1 = V_{DRAIN}

CH2 = V_{CC}

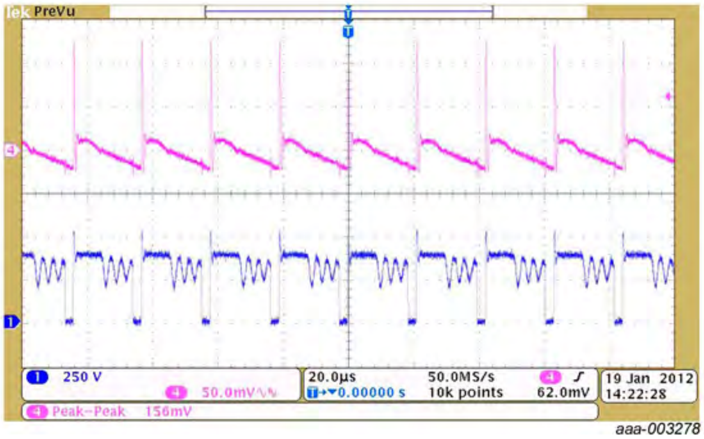
CH3 = I_o

CH4 = V_o

Fig 8. Short circuit of the output

5.6 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 230 V.



CH1 = V_{DRAIN}

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

Fig 9. Output voltage ripple

Figure 9 shows the output voltage ripple at a 1 A load at 230 V. The output ripple voltage is 156 mV using output capacitor C6 (680 µF/6.3V Nichicon RL80J681MDN1KX).

5.7 Conducted EMI measurements results

The conducted EMI is measured with the secondary GND connected to the protected mains earth GND. No y-cap between primary side and secondary side is used. EMI is measured on the neutral phase and on the line phase at V_{mains} = 230 V and at full load. The frequency range is 150 kHz to 30 MHz.

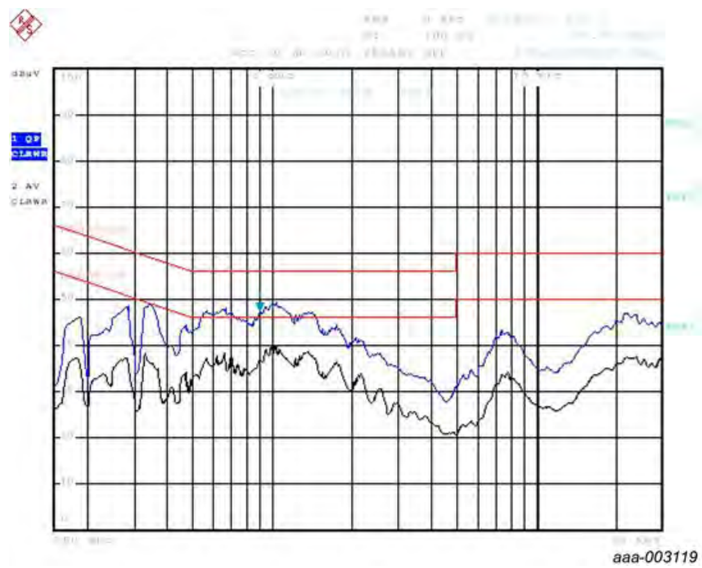


Fig 10. Neutral 230 V

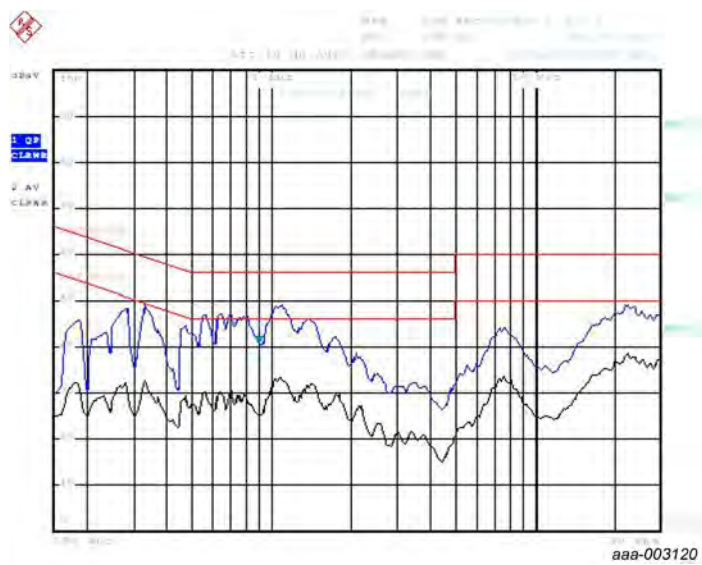


Fig 11. Line 230 V

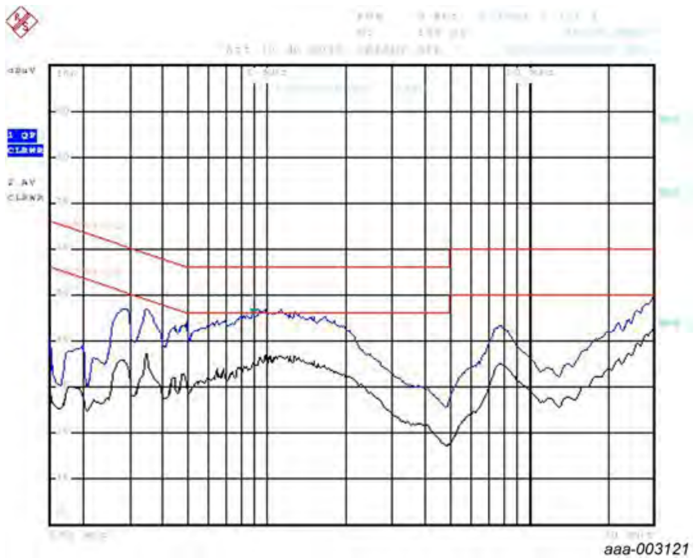


Fig 12. Neutral 115 V

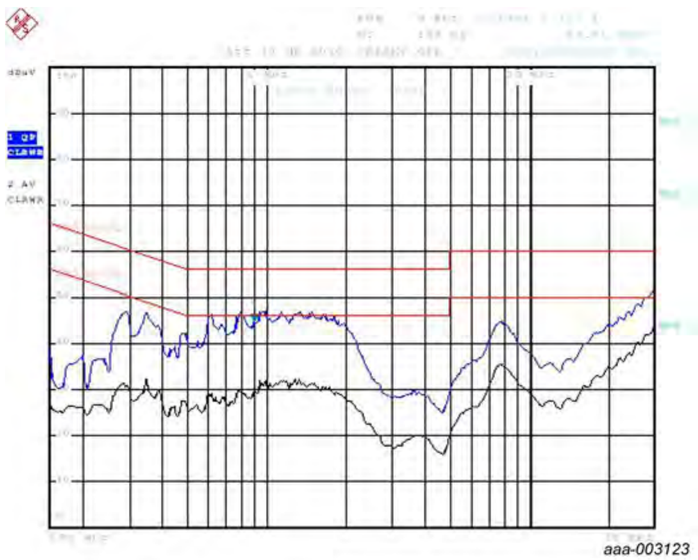


Fig 13. Line 115 V

6. Schematic and Bill Of Material (BOM)

6.1 Small-size 5 W TEA1721DT demo board schematic

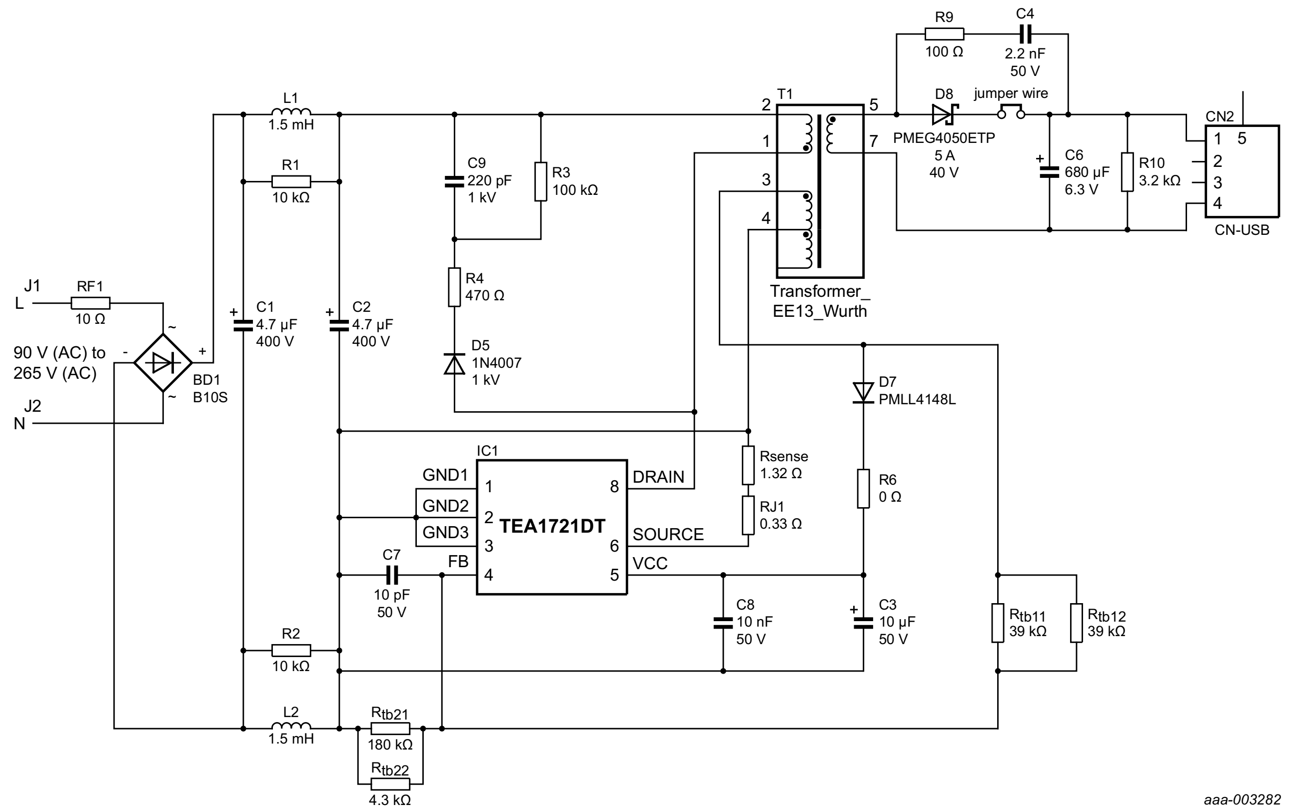


Fig 14. 5 W TEA1721DT small-size demo board schematic

6.2 Bill of materials

Table 4. Bill of materials

Part	Description	Part number	Manufacturer
BD1	B10S; 1 kV; Mini SMD; 0.8 A	B10S-G	Comchip Tech.
C1	4.7 μF; 400 V; 8 × 9 mm	AX-series	Rubycon
C2	4.7 μF; 400 V; 8 × 9 mm	AX-series	Rubycon
C3	10 μF; 50 V; 5 × 11 mm	EKY500ELL100ME11D	United Chemi-Con
C4	2.2 nF; 50 V; 0805	-	-
C6	680 μF; 6.3 V;	RL80J681MDN1KX	Nichicon
C7	10 pF; 0603	-	-
C8	10 nF; 0603	-	-
C9	220 pF; 1 kV; film-ceramic	-	-
CN2	USB-port; USB A type flat 4-pin DIP	KS-001PDH-ANB1-L	Kuon Yi
D5	1N4007; 1 kV; DO-41; 1 A	1N4007	Vishay
D7	1N4148; SOD80C glass	PMLL4148L	NXP Semiconductors
D8	PMEG4050ETP; 40 V; DO-214AA(SMB); 5 A	-	NXP Semiconductors
IC1	TEA1721DT; S07	TEA1721DT	NXP Semiconductors
J1	L (line)	pin	-
J2	N (neutral)	pin	-
L1	1.5 mH; DIP	-	-
L2	1.5 mH; DIP	-	-
R1	10 kΩ; 0805	-	-
R2	10 kΩ; 0805	-	-
R3	100 kΩ; 0805	-	-
R4	470 Ω; 0805	-	-
R_{sense}	1.32 Ω; DIP; 1 W	-	-
R6	0 Ω; 0805	-	-
R9	100 Ω; 0805	-	-
R10	3.2 kΩ; 0603	-	-
R_{tb11}	39 kΩ; 0603	-	-
R_{tb12}	39 kΩ; 0603	-	-
R_{tb21}	4.3 kΩ; 0603	-	-
R_{tb22}	180 kΩ; 0603	-	-
RF1	10 Ω; 2 W; fusible	-	-
RJ1	0.33 Ω; 1206, 1 %	-	-
T1	2 mH; 124 : 8 : 20 EE13/12/6 horizontal;	-	Würth Elektronik
W1	jumper wire; DIP	-	-

7. Circuit description

The GreenChip SP TEA1721DT demo board consists of a single-phase full-wave rectifier circuit, a filtering section, a switching section, an output section and a feedback section. The circuit diagram is shown in Figure 14 and the component list is shown Table 4 on page 15.

7.1 Rectification section

The bridge diodes BD1 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 1 and 2 connect the input to the electricity utility network. Swapping these two wires has no effect on the operation of the converter.

7.2 Filtering section

Inductors L1 and L2, with capacitors C1 and C2, form 2 filters to attenuate conducted differential mode EMI noise.

7.3 GreenChip SP section

The TEA1721DT 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 winding on transformer T1 generates the supply voltage and primary sensing information for the TEA1721DT. Diode D7 and capacitor C3 half-wave rectify the voltage. C3 charged via the current limiter resistor R6. The voltage on C3 is the supply voltage for the VCC pin.

The RCD-R clamp consisting of R4, C9, D5 and R3 limits drain voltage spikes caused by leakage inductance of the transformer.

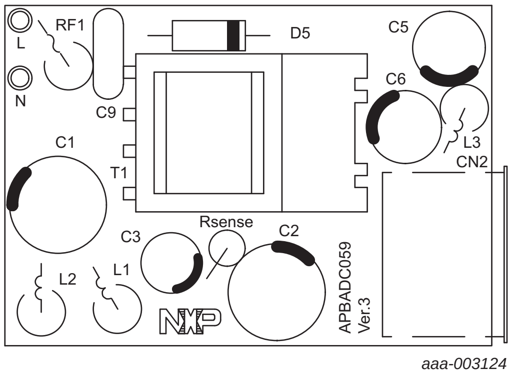
7.4 Output section

Diode D7 is a Schottky barrier type diode and capacitors C5/C6 rectify the voltage from secondary winding of transformer T1. Using a Schottky barrier type diode results in a higher efficiency of the demo board. C5 and C6 must have sufficient low ESR characteristics to meet the output voltage ripple requirement without adding an LC post filter. Resistor R9 and capacitor C4 dampen high frequency ringing and reduce the voltage stress on diode D8. Resistor R10 provides a minimum load to maintain output control in no-load condition.

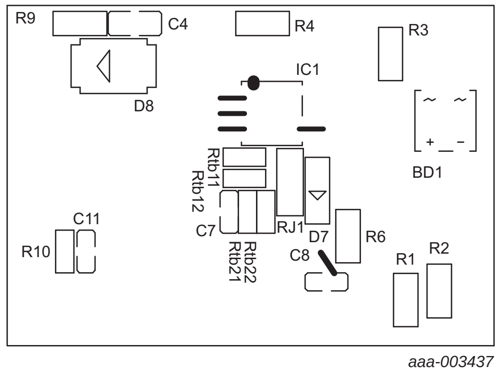
7.5 Feedback section

The TEA1721DT controls the output by current and frequency control for CV and CC regulation. The auxiliary winding on Transformer T1 senses the output voltage. The FB pin senses the reflected output voltage using feedback resistors R_{tb1} and R_{tb2}.

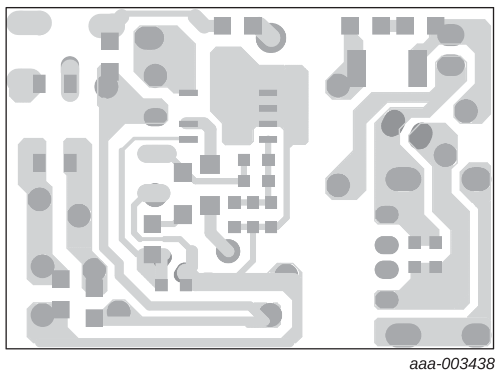
8. PCB layout



a. Top silk



b. Bottom silk



c. Bottom layer

Fig 15. Board layout

9. Transformer specifications

9.1 Transformer schematic design and winding construction

The transformer used in the small-size demo board has size EE13 with bobbin EE13/12/6 horizontal 7 pins. A few measures have been taken for a low EMI emission. Copper foil shields are used between core and primary windings and between primary windings and secondary windings. The winding start point of the primary winding is connected to the third layer (N3) after second layer N2 is connected to pin 1. The primary windings are using a barrier tape of 1 mm on both sides. The secondary winding is winded with 2 wires in parallel to improve efficiency.

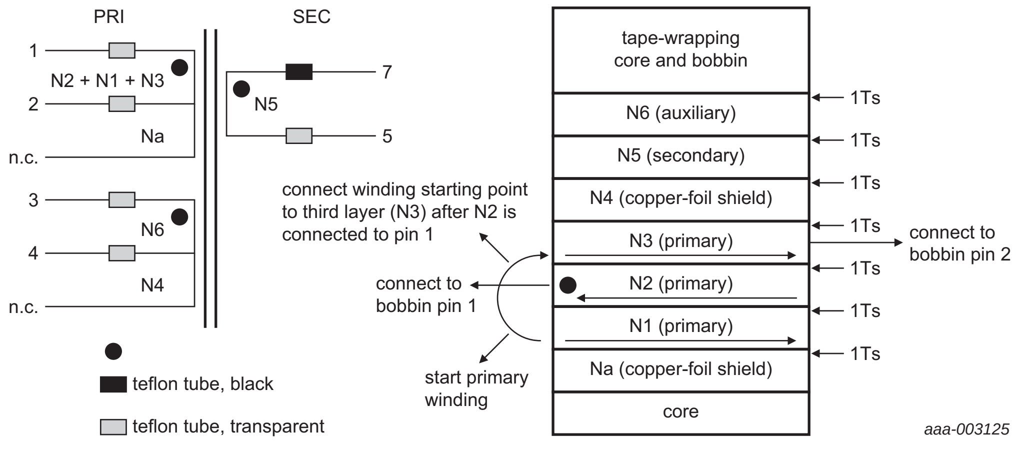


Fig 16. Transformer schematic design and winding construction

9.2 Winding specification

Table 5. Electrical specification

Winding layer	Wire diameter (φ)		Turns (T)	Winding method	Number of winding layers	Remark
Na	2	copper foil 0.05 mm × 7.5 mm	1		1	solder to pin 2
N2 + N1 + N3	1 to 2	2UEW-B 0.12 mm × 1P	143	tight	3	solder to pins 1 and 2
N4	4	copper foil 0.05 mm × 7.5 mm	1		1	solder to pin 4
N5	7 to 5	triple wire 0.5 mm × 2P	9	tight	2	solder to pins 7 and 5
N6	3 to 4	2UEW-B 0.2 mm × 1P	23	loose	1	solder to pins 3 and 4

9.3 Electrical characteristics

Table 6. Electrical specification

Parameter	Pin	Value	Remark
primary inductance	1 to 2	2 mH, ±7 %	
Leakage inductance	1 to 2	100 µH	secondary side shorted

9.4 Core, air gap and bobbin

Core: EE13/12 (3C90)

Size of the air gap depends on the A_L value of the ungapped core. After gapping, the A_L of the core will be 98 nH/T^2 $\pm$ 10 %.

Bobbin: EE13/12/6 horizontal, 7 pins

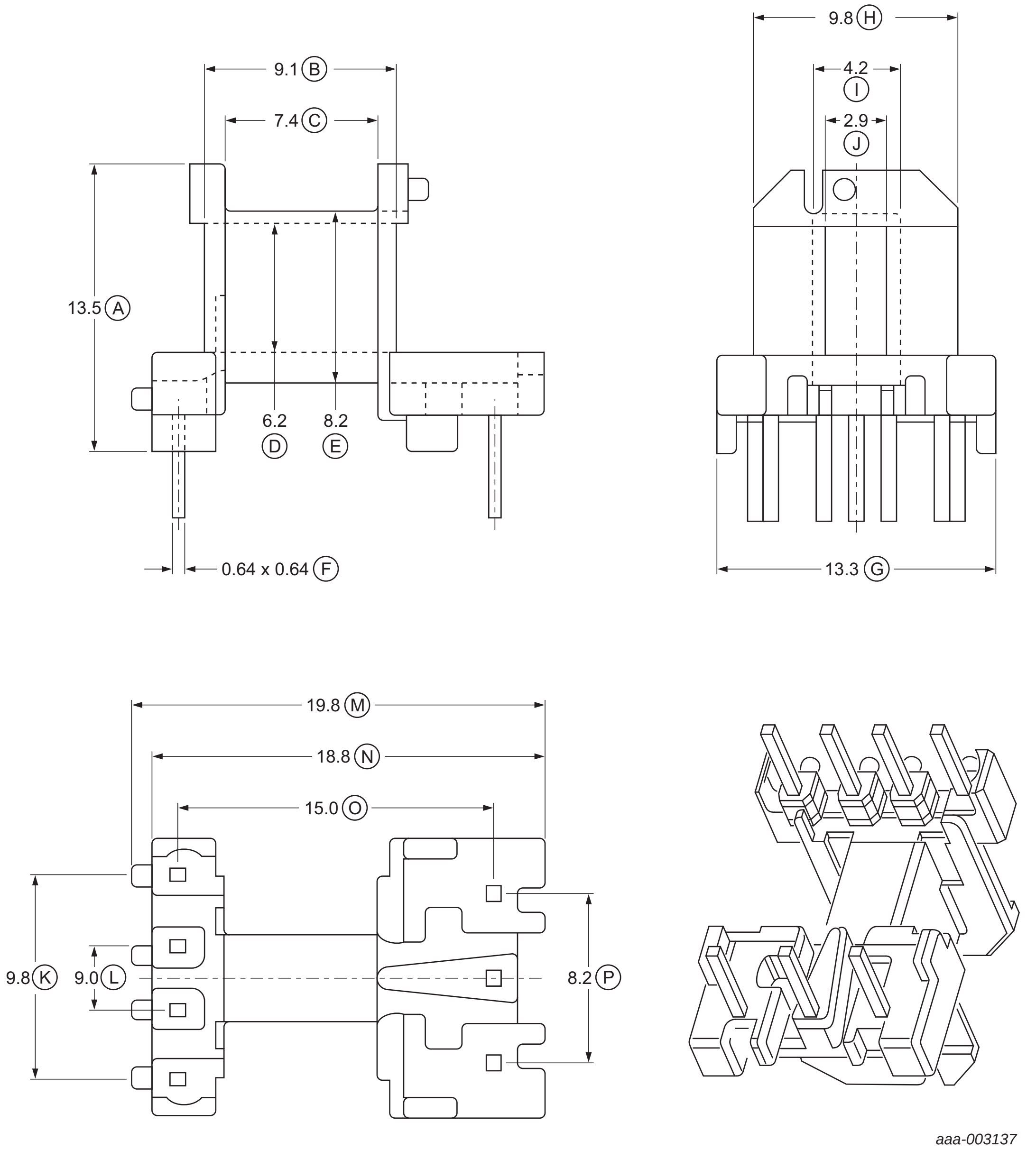


Fig 17. EE13/12/6

9.5 Marking

Wurth/Midcom 750341253

10. Attention points

When testing the CC mode of the TEA1721DT, 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 TEA1721DT controller behavior is not incorrect. Only test it in the correct way.

11. References

[1] **TEA1721AT/BT/DT/FT —** data sheets: ultra-low standby SMPS controller with integrated power switch

[2] **TEA1723AT/BT/DT/FT —** data sheets: ultra-low standby SMPS controller with integrated power switch data sheet

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

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

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

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

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

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

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