UM10532

TEA1723AT GreenChip SP low standby power SMPS demo board

Rev. 1 — 21 May 2012 **User manual**

Document information

Info	Content
Keywords	TEA1723AT, ultra-low standby power, constant output voltage, constant output current, primary sensing, integrated high-voltage switch, integrated high-voltage start-up, tablet charger, 5 V/2.1 A supply
Abstract	This user manual describes an 11 W Constant Voltage/Constant Current (CV/CC) universal input power supply for tablet adapters/chargers. This demo board is based on the GreenChip SP TEA1723AT. GreenChip SP TEA1723AT enables low no-load power consumption <20 mW. The TEA1723AT design ensures a low external component count for cost-effective applications. In addition, the TEA1723AT provides advanced control modes for optimal performance. The TEA1723AT integrates the 700 V power MOSFET switch and SMPS controller.

Revision history

Rev	Date	Description
v.1	20120521	first issue

Contact information

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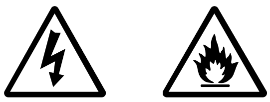
1. Introduction

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 an 11 W Constant Voltage or Constant Current (CV/CC) universal input power supply for tablet adapters and chargers. This demo board is based on the TEA1723AT GreenChip SP integrated circuit.

The TEA1723AT GreenChip SP provides ultra-low no-load power consumption without using additional external components. Designs are cost-effective using the TEA1723AT GreenChip SP because only a few external components are needed in a typical application. In addition, the TEA1723AT provides advanced control modes for optimal performance. The TEA1723AT 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. TEA1723AT features

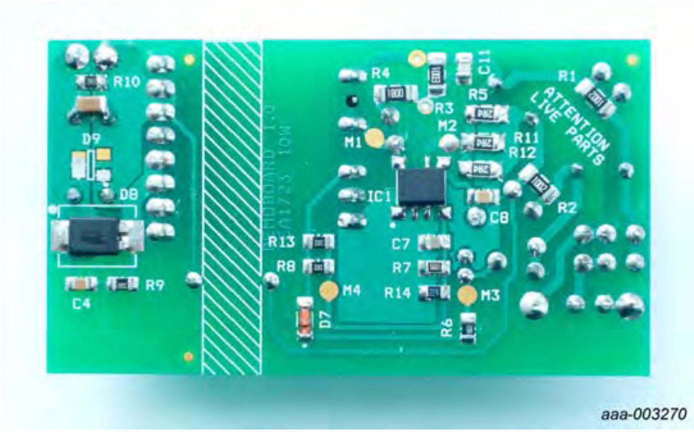
- Enables low no-load power consumption <20 mW
- Low component count for a cost-effective design
- Advanced control modes for optimal performance
- SMPS controller with integrated power MOSFET switch
- 700 V high-voltage power switch for global mains operation
- Primary sensing at end-of-conduction for accurate output voltage control
- Avoids audible noise in all operation modes
- Jitter function for reduced EMI
- Energy Star 2.0 compliant
- Universal mains input
- Isolated output
- Highly efficient >78 %
- 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 consumption	no-load	13 mW	average of 115 V and 230 V
Output			
Output voltage	-	5 V	-
Maximum output current	-	2.1 A	-
Maximum output power	-	11 W	-

a. Top view.



b. Bottom view.

Fig 2. TEA1723AT 11 W demo board

5. Performance data

5.1 No-load input power consumption

Test condition: The no-load input power is measured after a 20 minute warm-up time.

Table 2. No-load input power consumption

Condition	Output voltage	Power consumption
115 V at 60 Hz	5 V	11 mW
230 V at 50 Hz	5 V	14.7 mW

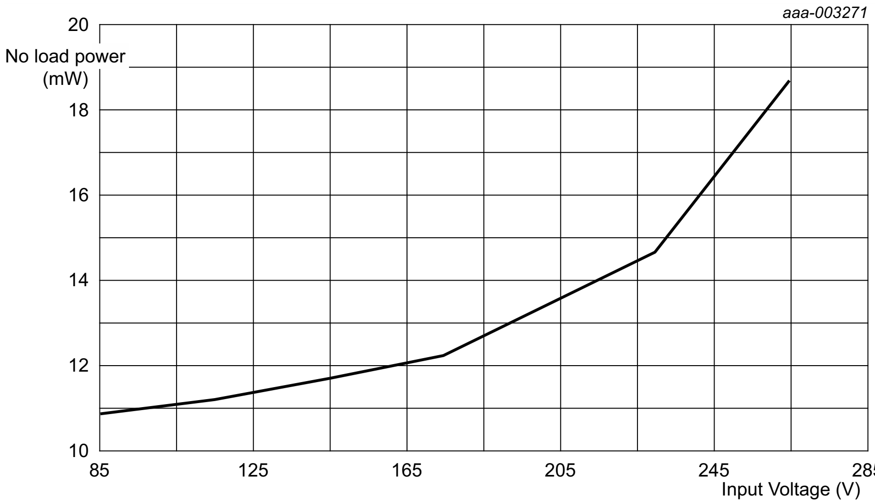


Fig 3. No-load input power consumption

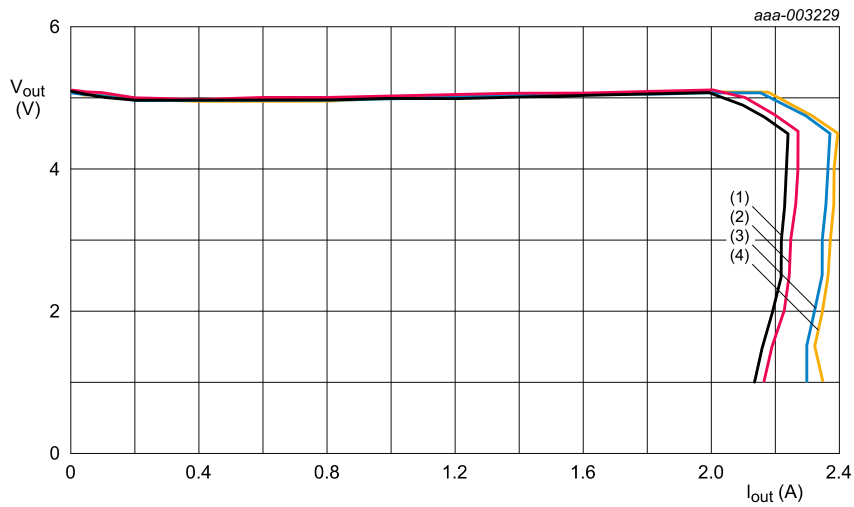
5.2 Output voltage and efficiency

Test condition: The efficiency and VI power characteristics are measured after a 20 minute warm-up time.

Table 3, Figure 4 and Figure 5 show the efficiency figures and VI characteristics measured of the GreenChip SP TEA1723AT demo board.

Table 3. Efficiency and VI characteristics at 115 V and 230 V

V_{CC}	Parameter	Values													
115 V	I_{out} (A)	0	0.04	0.1	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.1
	V_{out} (V)	5.09	5.06	5.03	4.98	4.96	4.97	4.97	4.99	5.01	5.03	5.04	5.06	5.08	4.97
	P (W)	0.023	0.37	0.74	1.35	2.54	3.83	5.09	6.42	7.72	9.04	10.4	11.7	13.1	13.5
	η (%)		54.7	68	73.8	78.1	77.9	78.1	77.7	77.9	77.9	77.7	77.6	77.6	77.4
230 V	I_{out} (A)	0	0.04	0.1	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.1
	V_{out} (V)	5.06	5.04	5.03	4.97	4.96	4.96	4.96	4.99	5.01	5.02	5.04	5.05	5.07	5.08
	P (W)	0.0256	0.41	0.84	1.43	2.63	3.82	5.04	6.33	7.6	8.86	10.1	11.4	12.7	13.4
	η (%)		49.2	59.9	69.5	75.4	77.9	78.7	78.8	79.1	79.3	79.6	79.6	79.7	79.8



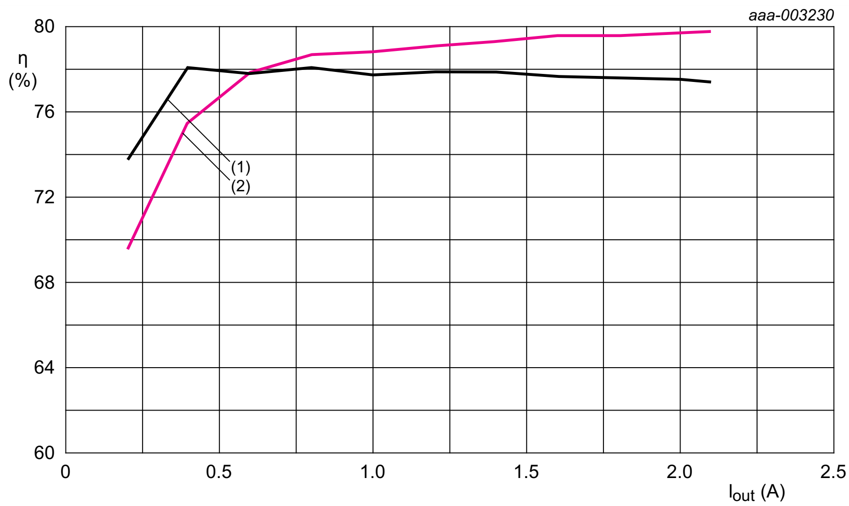
(1) 90 V.

(2) 115 V.

(3) 230 V.

(4) 265 V.

Fig 4. VI characteristics at 90 V, 115 V, 230 V and 265 V



(1) Efficiency at 115 V.

(2) Efficiency at 230 V.

Fig 5. Efficiency at 115 V and 230 V

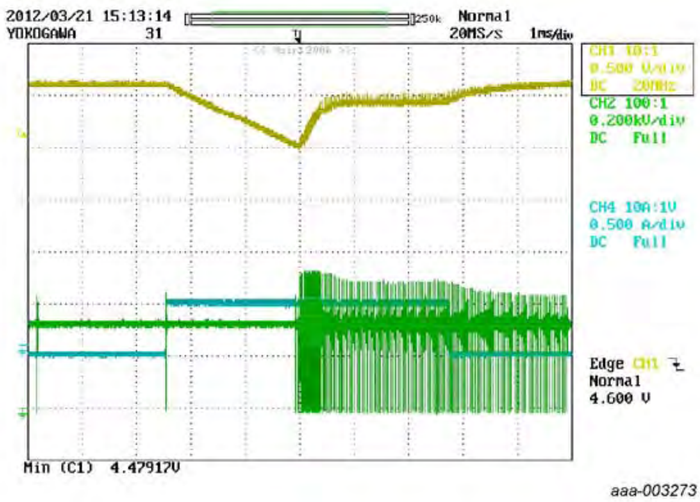
5.3 Dynamic loading from 0 A to 0.5 A

Test condition: The dynamic loading is tested at a load step of 0 A to 0.5 A. The TEA1723AT detects the load step only after the next switching cycle because of the primary sensing feature.

The load step is measured at V_{mains} = 230 V and the output capacitors are

- C5/C6: 1000 μF/6.3 V
- C12: 22 μF

The output ripple voltage is 113 mV and the burst frequency is 885 Hz.



(1) CH1 = V_{DRAIN}.

(2) CH2 = I_O.

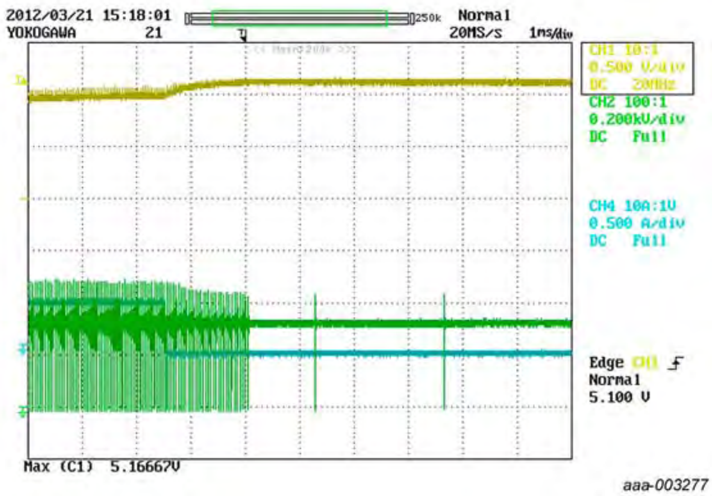
(3) CH3 = V_O.

Fig 6. Load step from 0 A to 0.5 A

5.4 Dynamic loading from 0.5 A to 0 A

Test condition: The dynamic loading is tested at a load step of 0 A to 0.5 A. The TEA1723AT detects the load step only after the next switching cycle because of the primary sensing feature.

The load step is measured at V_{mains} = 230 V and the output capacitors C5/C6 are 2 × 1000 μF.



(1) CH1 = V_{DRAIN}.

(2) CH2 = I_O.

(3) CH3 = V_O.

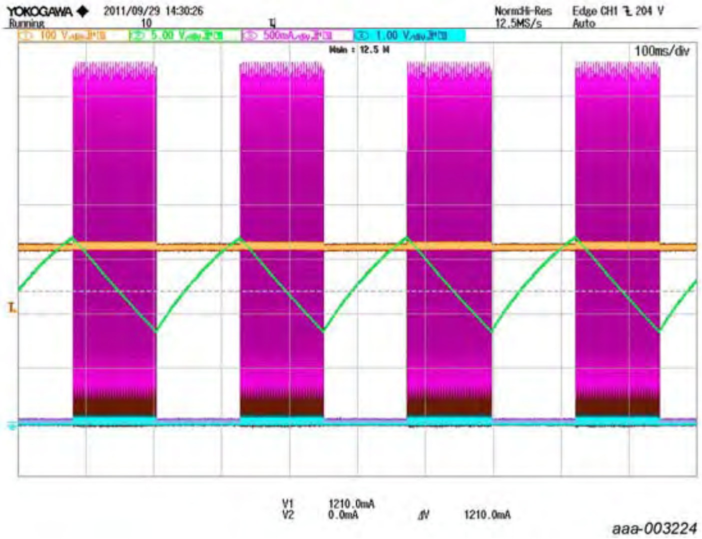
Fig 7. Load step from 0.5 A to 0 A

After the load step 0.5 A to 0 A, the output voltage rises to 5.1 V. The transition takes about 1 ms when the controller switches from CV to CVB because of the large electrolytic output capacitors C5/C6.

5.5 Short-circuit of the output

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

Test condition: Figure 7 shows the converter behavior when the output is short-circuited. During a short-circuit of the output, the VCC voltage (CH3) switches between $V_{CC(startup)}$ = 17 V and $V_{CC(stop)}$ = 8.5 V levels. The average output current during converter switching is 1.2 A.



(1) CH1 = V_{DRAIN}.

(2) CH2 = V_{CC}.

(3) CH3 = I_O.

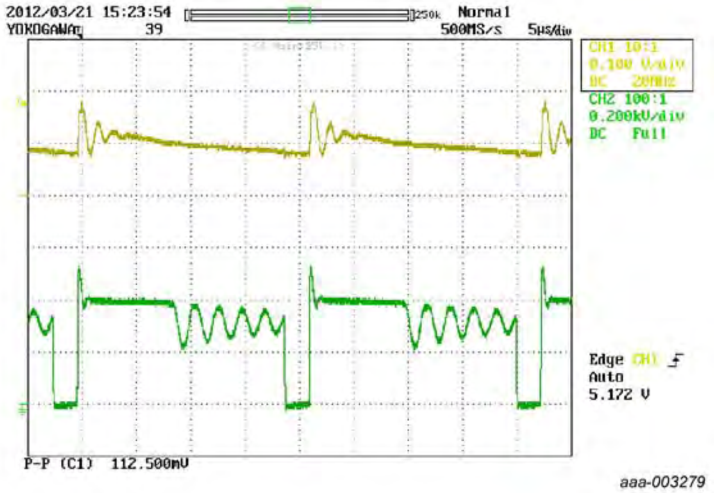
(4) CH4 = V_O.

Fig 8. Short-circuit of the output

5.6 Output voltage ripple performance

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

Figure 8 shows the output voltage ripple at 2.1 A load at 230 V. When output capacitors C5/C6 are 1000 μF/6.3 V, the output ripple voltage is 113 mV.



(1) CH1 = V_{DRAIN}.

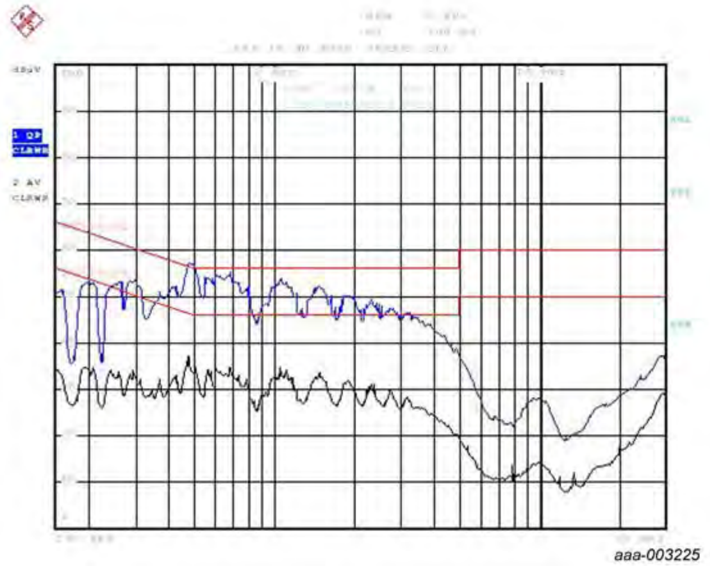
(2) CH4 = V_O on board. Scale = 100 mV/division.

Fig 9. Output voltage ripple

5.7 Conducted EMI measurement results

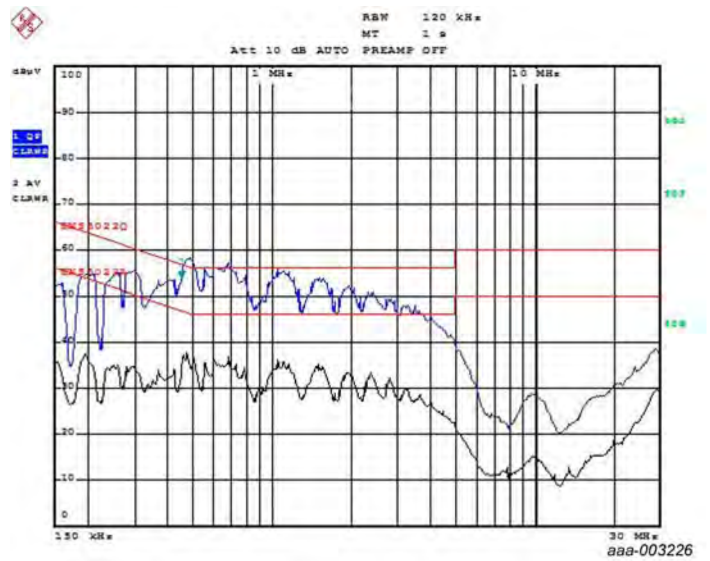
The EMI is measured with the secondary GND connected to the protected mains earth GND. Y-capacitor (C10 = 2.2 nF; 2 kV) is added and only one input coil L1 = 1.5 mH is used. EMI is measured on the neutral phase and on the line phase at V_{mains} = 230 V and at full load. The frequency range is 150 kHz to 30 MHz.

Remark: Improved transformer design will enhance TEA1723AT EMI performance significantly.



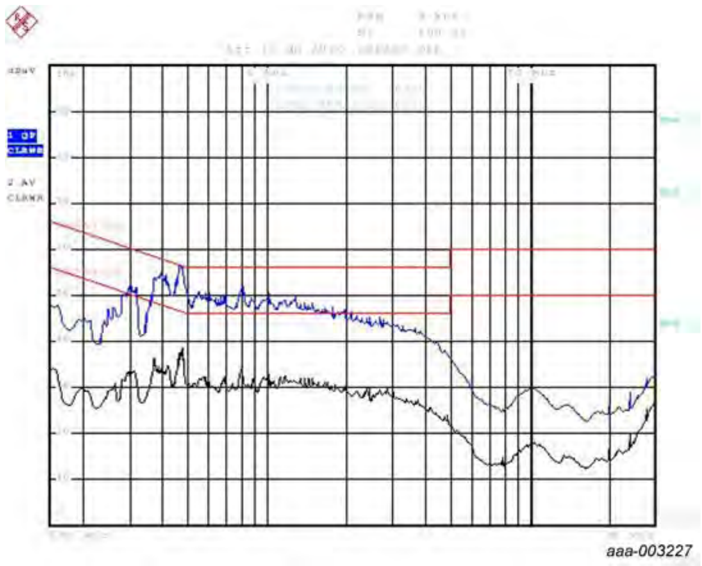
Remark: Improved transformer design will enhance TEA1723AT EMI performance significantly.

Fig 10. Line 230 V, full load and negative output connected to protected earth



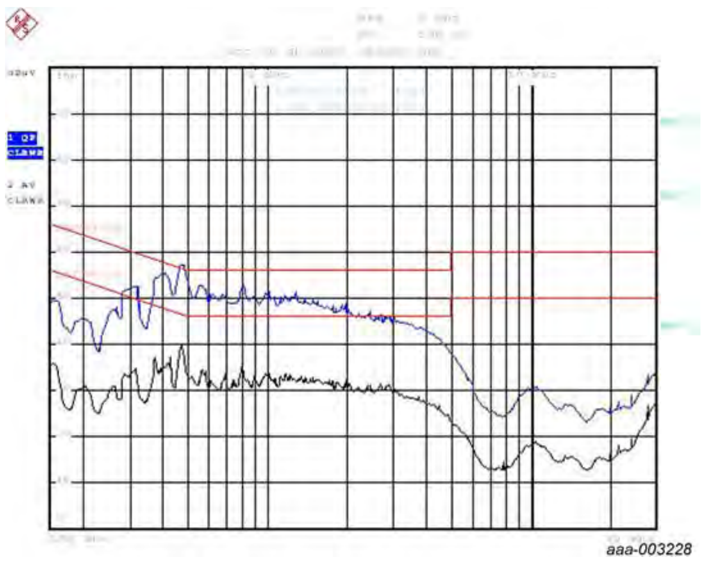
Remark: Improved transformer design will enhance TEA1723AT EMI performance significantly.

Fig 11. Neutral 115 V, full load and negative output connected to protected earth



Remark: Improved transformer design will enhance TEA1723AT EMI performance significantly.

Fig 12. Line 115 V, full load and negative output connected to protected earth



Remark: Improved transformer design will enhance TEA1723AT EMI performance significantly.

Fig 13. Neutral 230 V, full load and negative output connected to protected earth

6. Schematic and Bill Of Materials (BOM)

6.1 TEA1723AT 11 W demo board schematic

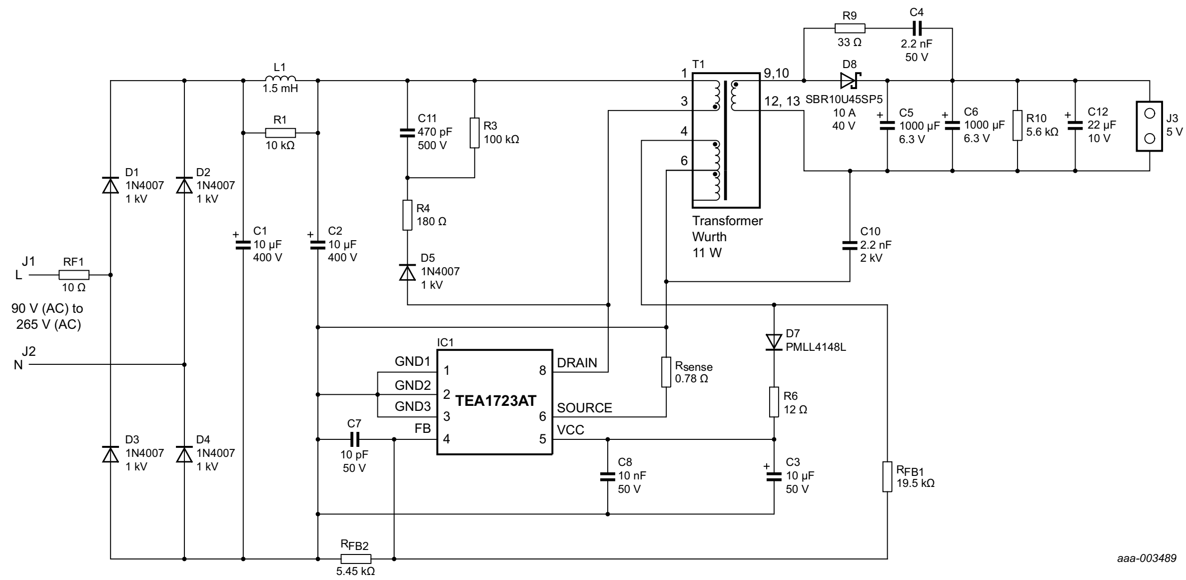


Fig 14. TEA1723AT 11 W demo board schematic

6.2 Bill of Materials

Table 4. Bill of materials

Part	Description	Part Number	Manufacturer
C1	capacitor; 10 µF; 400 V; 10 mm × 16 mm	EKMQ401ELL100MJ16S	Chemi-Con
C2	capacitor; 10 µF; 400 V; 10 mm × 16 mm	EKMQ401ELL100MJ16S	Chemi-Con
C3	capacitor; 10 µF; 50 V; 5 mm × 11 mm	ECA1HHG100	Panasonic
C4	capacitor; 2.2 nF; 50 V; 0805	C0805C222K5RACTU	KEMET
C5	capacitor; 1000 µF; 6.3 V; 8 mm × 8 mm	RL80J102MDN1KX	Nichicon
C6	capacitor; 1000 µF; 6.3 V; 8 mm × 8 mm	RL80J102MDN1KX	Nichicon
C7	capacitor; 10 pF; 0805	-	-
C8	capacitor; 10 nF; 0805	X7R	-
C9	not mounted	-	-
C10	capacitor; 2.2 nF; 2 kV	DEBB33D222KA2B	Murata
C11	capacitor; 470 pF; 500 V; 0805	CC0805JRNPOBBN471	Yageo
C12	capacitor; 22 µF; 10 V; 1206	GRM31CR71A226KE15L	Murata
D1	diode; 1N4007; 1 kV; DO-41; 1 A	1N4007	Multicomp
D2	diode; 1N4007; 1 kV; DO-41; 1 A	1N4007	Multicomp
D3	diode; 1N4007; 1 kV; DO-41; 1 A	1N4007	Multicomp
D4	diode; 1N4007; 1 kV; DO-41; 1 A	1N4007	Multicomp
D5	diode; 1N4007; 1 kV; DO-41; 1 A	1N4007	Vishay
D7	diode; PMLL4148; SOD80C glass	PMLL4148L	NXP Semiconductors

Table 4. Bill of materials *…continued*

Part	Description	Part Number	Manufacturer
D8	diode; SBR10U45SP5; 45 V; PowerDI5; 10 A	SBR10U45SP5-13	Diodes Inc
IC1	controller; TEA1723AT; S07	TEA1723AT	NXP Semiconductors
L1	inductor; 1.5 mH; DIP	-	Murata
R1	resistor; 10 kΩ; 1206	-	-
R3	resistor; 100 kΩ; 1206	-	-
R4	resistor; 180 Ω; 1206	-	-
R5	resistor; 2.4 Ω; 1206	-	-
R6	resistor; 12 Ω; 0805	-	-
R7	resistor; 5.6 kΩ; 0805	-	-
R8	resistor; 39 kΩ; 0805	-	-
R9	resistor; 33 Ω; 0805	-	-
R10	resistor; 5.6 kΩ; 0805	-	-
R11	resistor; 2.4 Ω; 1206	-	-
R12	resistor; 2.2 Ω; 1206	-	-
R13	resistor; 39 kΩ; 0805	-	-
R14	resistor; 200 kΩ; 0805	-	-
RF1	fused resistor; 10 Ω; 3 W;	ULW310RJA1	Welwyn Components
T1	transformer; 0.9 mH; EE20/10/6 horizontal	-	Würth Elektronik
W1	jumper wire; DIP	-	-

7. Circuit description

The TEA1723AT GreenChip SP demo board consists of a single-phase full-wave rectifier circuit with sections for filtering, switching, output and feedback. The circuit diagram is shown in Figure 14 on page 14 and the component list is shown in Table 4 on page 14.

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 AC mains network. Swapping these two wires has no effect on the operation of the converter.

7.2 Filtering section

Inductors L1 and L2 in combination with capacitors C1 and C2, form Π-filters to attenuate the conducted differential mode EMI noise.

7.3 GreenChip SP section

The TEA1723AT device IC1 contains the power MOSFET switch, oscillator, CV/CC control, start-up control and protection functions. Its integrated 700 V MOSFET allows sufficient voltage margins for universal input AC applications, including line surges.

The auxiliary winding on transformer T1 generates the supply voltage and primary sensing information for the TEA1723AT. Diode D7 and capacitor C3 half-wave rectified the voltage. C3 is charged using the current limiter resistor R6. The voltage on C3 is the supply voltage for the VCC pin.

RCD-R clamp (which consists of R4, C9, D5 and R3) limits drain voltage spikes caused by any leakage inductance from 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 diode results in higher efficiency of the demo board.

C5 and C6 must have a sufficiently low ESR to meet the output voltage ripple requirement without adding an LC post filter.

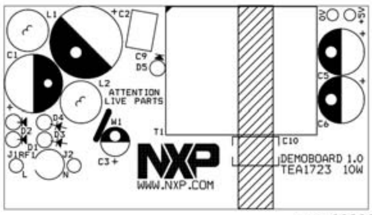
Resistor R9 and capacitor C4 dampen the high frequency ringing and reduce the voltage stress on diode D8. Resistor R10 provides a minimum load to maintain output control in the no-load condition.

7.5 Feedback section

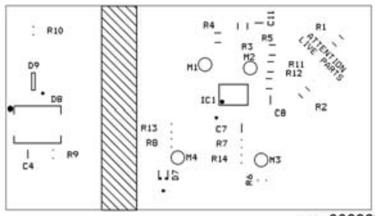
The TEA1723AT controls the output using current and frequency control for CV/CC regulation. The auxiliary winding on Transformer T1 senses the output voltage. The FB pin senses the reflected output voltage using feedback resistors R_{FB1} and R_{FB2}.

8. PCB layout

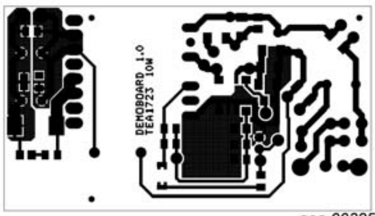
Figure 16 shows the layout of the PCB.



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 TEA1723AT demo board has size EE20 with bobbin EE20/10/6 horizontal, 14-pin. The secondary side of the transformer is connected in parallel in the TEA1723AT demo board, see Figure 16.

- Würth-Midcom 760871112

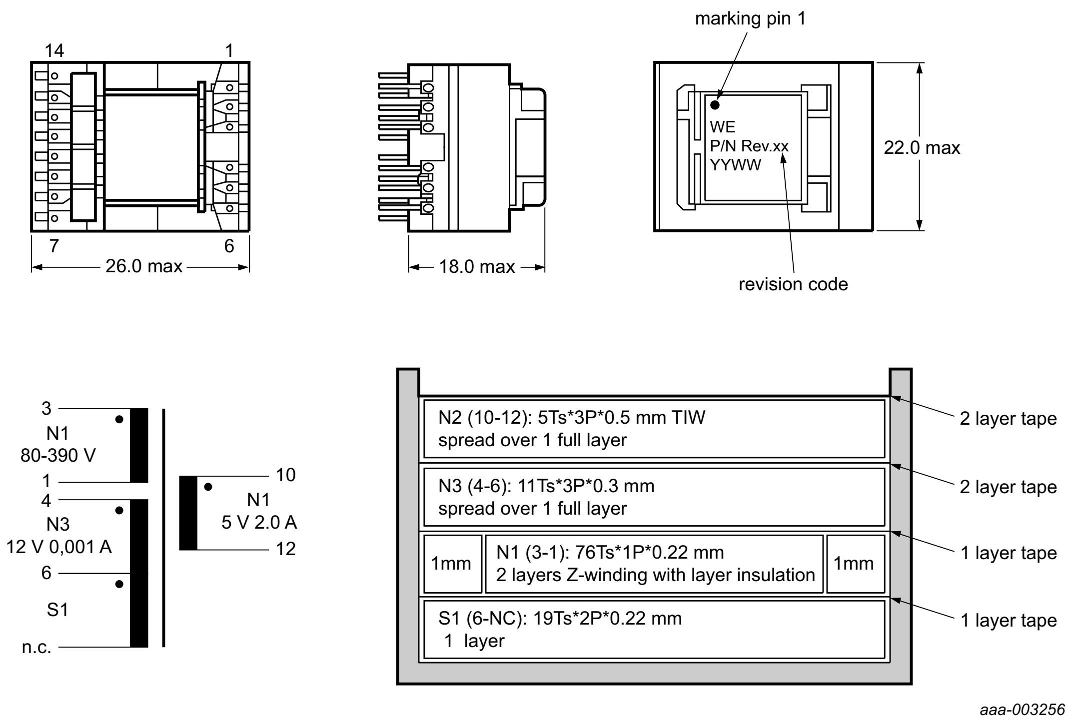


Fig 16. Transformer schematic design

9.2 Electrical characteristics

Table 5. Electrical characteristics

Description	Pin	Specifications	Comments
Primary inductance	1 to 3	0.9 mH ±10 %	-
Leakage	1 to 3	50 μH	secondary side short-circuited

9.3 Core, air gap and bobbin

- Core: EE20/10/6 (3C90)
- Size of the air gap depends on the A_L value of the ungapped core.
- Bobbin: EE20/10/6 horizontal, 14-pin

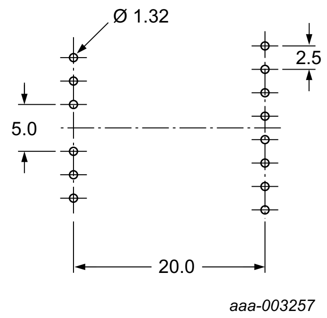


Fig 17. EE20/10/6 bobbin footprint

10. Attention points

When testing the CC mode of the TEA1723AT, 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 4). When current mode of an electronic DC-load is used, the output voltage drops immediately 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 TEA1723AT 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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Notwithstanding any damages that customer might incur for any reason whatsoever (including without limitation, all damages referenced above and all direct or general damages), the entire liability of NXP Semiconductors, its affiliates and their suppliers and customer's exclusive remedy for all of the foregoing shall be limited to actual damages incurred by customer based on reasonable reliance up to the greater of the amount actually paid by customer for the product or five dollars (US$5.00). The foregoing limitations, exclusions and disclaimers shall apply to the maximum extent permitted by applicable law, even if any remedy fails of its essential purpose.

12.3 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

GreenChip — is a trademark of NXP B.V.

13. Contents

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