UM10385

GreenChip 65 W TEA1733(L)T demo board

Rev. 02 — 2 June 2010 **User manual**

Document information

Info	Content
Keywords	Notebook adapter, TEA1733(L)T, Low standby power, High efficiency, fixed frequency flyback, jitter
Abstract	This manual provides the specification, schematics, and Printed-Circuit Board (PCB) layout of the 65 W TEA1733(L)T demo board. For details on the TEA1733(L)T IC please refer to the application note.

Revision history

Rev	Date	Description
02	20100602	Modifications • Table 2 “Output specification” $t_{startup}$ value modified. • Figure 13 “Schematic 65 W TEA1733(L)T demo board” and Table 10 “Bill of materials”, C15 value modified. • Section 8.1 “Changing the output voltage” variation range removed
01	20100413	First issue

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1. Introduction

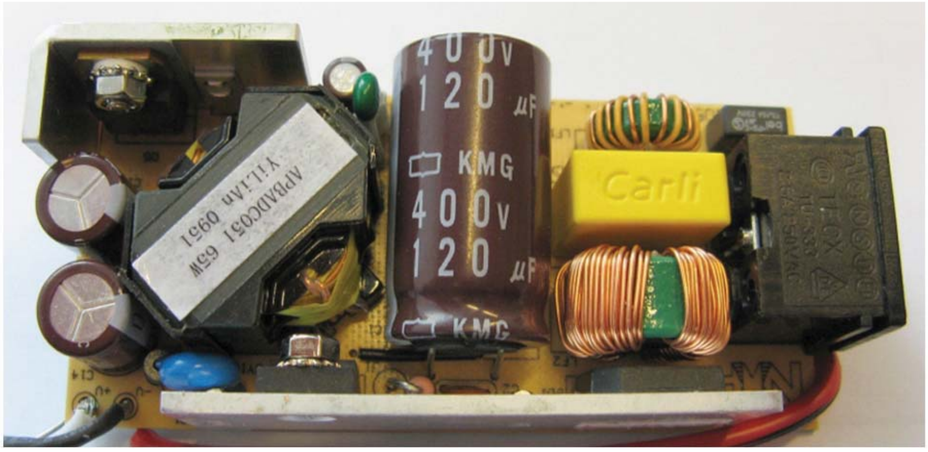

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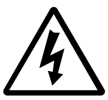
Fig 1. 65 W TEA1733(L)T demo board

This 65 W TEA1733(L)T demo board demonstrates the capabilities of the TEA1733(L)T Switched Mode Power Supply (SMPS) controller. This manual provides the specifications, schematics, and PCB layout of the 65 W TEA1733(L)T demo board. For details on the TEA1733(L)T SMPS controller please refer to the application note and data sheet for the TEA1733(L)T.

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 that is 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.

1.1 Features

- Universal mains supply operation
- OverCurrent Protection (OCP)
- OverPower Protection (OPP)
- Low ripple and noise
- Low-cost implementation
- Low no-load standby power (< 100 mW at 230 V; 50 Hz)
- ENERGY STAR compliant
- EMI CISPR 22 compliant

2. Power supply specification

Table 1. Input specification

Symbol	Description	Conditions	Specification	Unit
V_i	input voltage	-	90 to 264	V
f_i	input frequency	-	47 to 60	Hz
$P_{i(no\ load)}$	no load input power	at 230 V; 50 Hz	< 100	mW

Table 2. Output specification

Symbol	Description	Conditions	Specification	Unit
V_o	output voltage	-	19.5	V
$V_{o(ripple)(p-p)}$	peak-to-peak output ripple voltage	20 MHz bandwidth	≤ 100	mV
I_o	output current	continuous	0 to 3.34	A
$I_{o(p)}$	peak output current	for 50 ms	-	A
R_{cable}	output cable resistance	-	-	Ω
P_o	output power	0 to 40 °C	-	W
t_{holdup}	hold-up time	at 115 V; 60 Hz; full load	5	ms
-	line regulation	-	±1	%
-	load regulation	-	±2	%
$t_{startup}$	start-up time	at 115 V; 60 Hz	≤ 3	s
η	efficiency	according to ENERGY STAR (EPS 2)	≥ 87	%
-	EMI	CISPR22 compliant	pass	-

3. Performance data

Performance figures based on the following PCB design:

- Schematic version: Tuesday 2 February 2010 rev. A
- PCB marking: APBADC051 ver. A

3.1 Efficiency

Efficiency measurements were taken using an automated test program containing a temperature stability detection algorithm. The output voltage and current were measured using a 4-wire current sense configuration directly at the PCB connector. Measurements were performed for 115 V; 60 Hz and 230 V; 50 Hz.

Table 3. Efficiency results[1][2]

Condition	ENERGY STAR 2.0 efficiency requirement (%)	Efficiency (%)				
		Average	25 % load	50 % load	75 % load	100 % load
115 V, 60 Hz	> 87	89.6	89.6	90.1	89.7	89.3
230 V, 50 Hz	> 87	90.0	87.5	90.2	90.2	90.3

[1] Warm-up time: 10 minutes

[2] There is an approximate 1 % loss of efficiency, when measured at the end of a 1 m output cable.

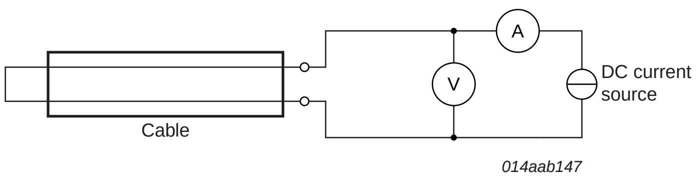


Fig 2. DC resistance output cable

3.2 No load power consumption

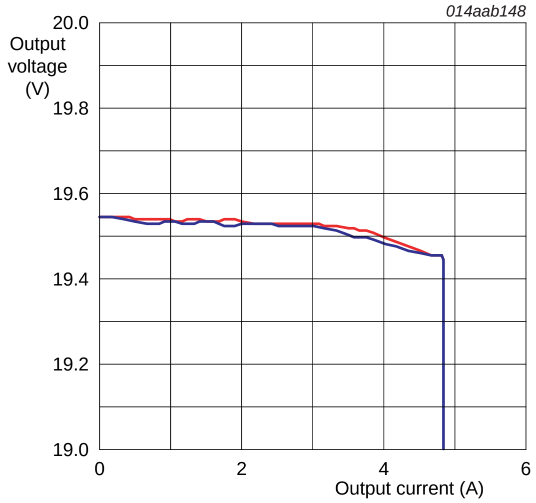
Power consumption performance of the total application board with no load connected was measured using an automated test program containing a temperature stability detection algorithm. The output voltage and current were measured using a 4-wire current sense configuration directly at the PCB connector. Measurements were performed for 90 V; 60 Hz, 115 V; 60 Hz, 230 V; 50 Hz, and 264 V; 50 Hz.

Table 4. Output voltage and power consumption: no load

Condition	ENERGY STAR 2.0 requirement (mW)	Output voltage (V)	No load power consumption (mW)
90 V; 60 Hz	≤ 300 mW	19.53	55
115 V; 60 Hz	≤ 300 mW	19.54	59
230 V; 50 Hz	≤ 300 mW	19.54	90
264 V; 50 Hz	≤ 300 mW	19.54	106

3.3 Output regulation

The output voltage versus load current was measured using a 4-wire current sense configuration directly at the PCB connector. Measurements were performed without probes attached to the application for 115 V; 60 Hz and 230 V; 50 Hz.



(1) V_o = 115 V; 60 Hz

(2) V_o = 230 V; 50 Hz

Fig 3. Output voltage regulation as function of load

3.4 VCC voltage

The IC VCC pin 1 voltage was measured for both no load and full load (3.34 A) conditions.

Table 5. VCC voltage

Condition	115 V; 60 Hz	230 V; 50 Hz
No load	14.4	14.6
Full load (3.34 A)	20.8	20.8

3.5 Brownout and start level

Brownout and start level was measured for no load and full load (3.34 A) conditions.

Table 6. Brownout and start level results

Condition	Brownout V (AC)	Start level V (AC)
No load	63	84
Full load (3.34 A)	77	84

3.6 Overvoltage protection

The maximum output voltage in case of over voltage protection was measured by shortening the optocoupler at the secondary side. The output voltage was measured directly at the output connector for both no load and full load (3.34 A) conditions.

Table 7. Maximum output voltage in case of OVP

Condition	115 V (AC)	230 V (AC)
No load	24.5	24.5
Full load (3.34 A)	23.9	24.0

3.7 Startup time

Startup time was measured for three mains input voltages and full load (3.34 A) condition. V_i input measured using a current probe (to avoid adding additional capacitance to the mains input). V_o was measured using a voltage probe grounded at the secondary side.

Table 8. Startup time

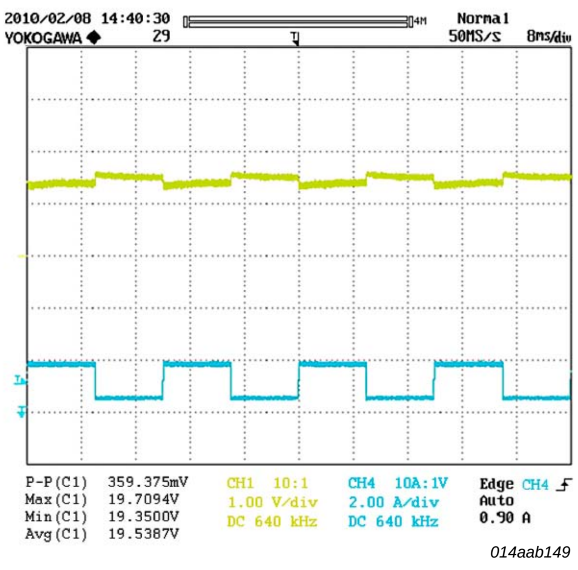
Condition	Startup time (s)
90 V; 60 Hz	3.7
115 V; 60 Hz	2.4
230 V; 50 Hz	0.9

3.8 Dynamic loading

The output voltage was measured at the end of the cable.

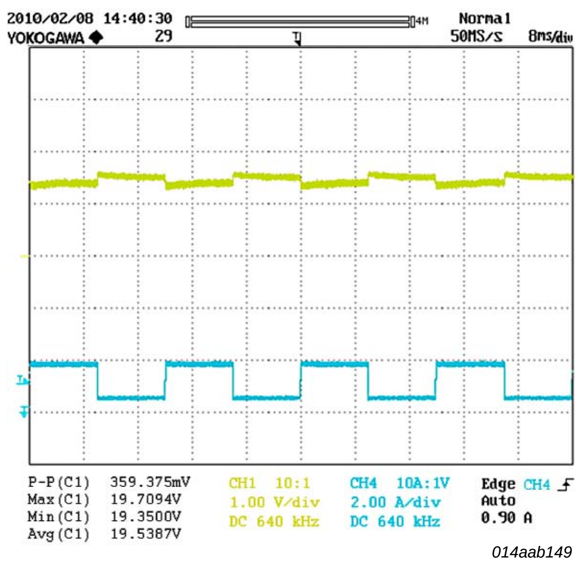
Table 9. Dynamic loading test conditions and results

Condition	Loading	$V_{o(ripple)(p-p)}$ (mV)
90 V; 47 Hz	I_o: 0 % - 50 %, frequency 50 Hz; duty cycle 50 %	359
264 V; 63 Hz	I_o: 0 % - 50 %, frequency 50 Hz; duty cycle 50 %	364



Yellow: V_o (V), Cyan: I_o (A)

Fig 4. Load transient response 90 V; 47 Hz, ripple and noise



Yellow: V_o (V), Cyan: I_o (A)

Fig 5. Load transient response 264 V; 63 Hz, ripple and noise

3.9 Output ripple and noise

Output ripple and noise were measured at the end of the cable using the measurement setup described in the picture below. An oscilloscope probe connected to the end of the adapter cable using a probe tip. 100 nF and 1 μF capacitors were added between plus and minus to reduce the high frequency noise. Output ripple and noise were measured for mains voltages 90 V; 47 Hz and 264 V; 63 Hz, both at full load (3.34 A) output current.

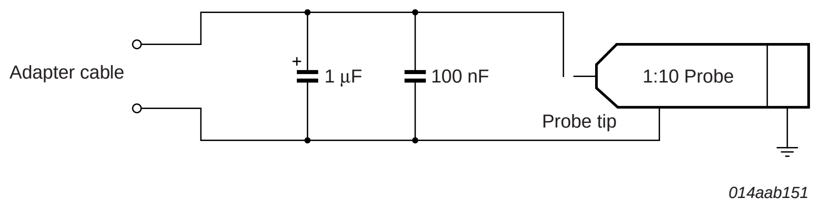


Fig 6. Output ripple and noise measurement setup

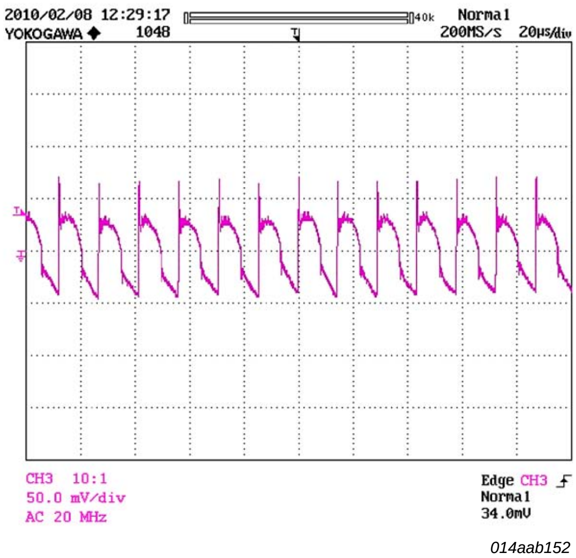


Fig 7. Output 90 V; 47 Hz, Ripple and noise

Fig 8. Output 264 V; 63 Hz, Ripple and noise

3.10 EMI performance

Conditions:

- Type: conducted EMC measurement
- Frequency range: 150 kHz to 30 MHz
- Output power: full load condition
- Supply voltage: 115 V and 230 V
- Margin: 6 dB below limit
- Measuring time: 50 ms
- Secondary ground connected to mains earth ground

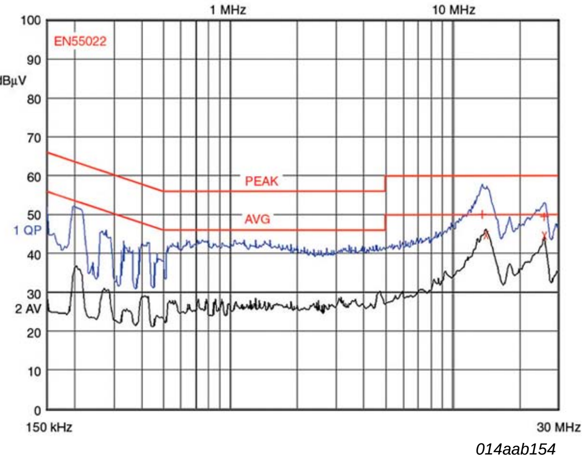


Fig 9. 115 V, 65 W TEA1733(L)T demo board phase N

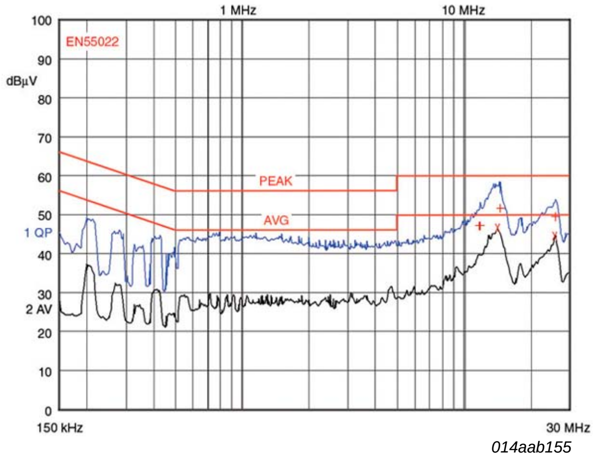


Fig 10. 115 V, 65 W TEA1733(L)T demo board phase L

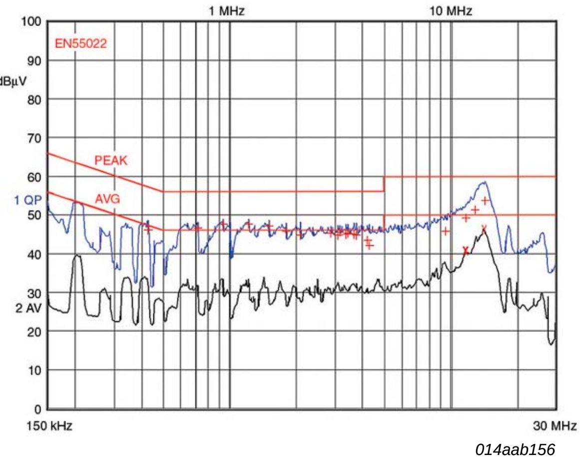


Fig 11. 230 V, 65 W TEA1733(L)T demo board phase N

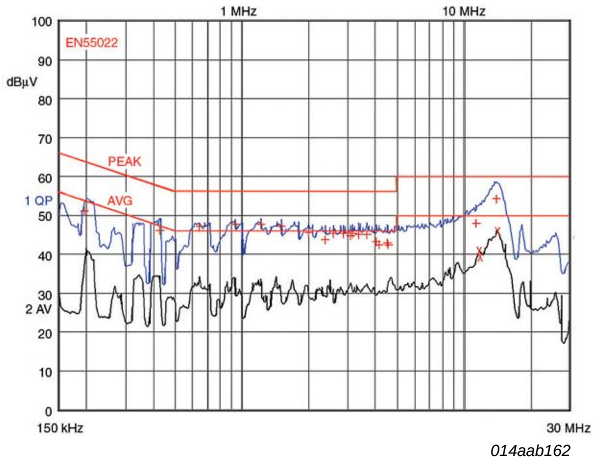


Fig 12. 230 V, 65 W TEA1733(L)T demo board phase L

4. Schematic 65 W TEA1733(L)T demo board

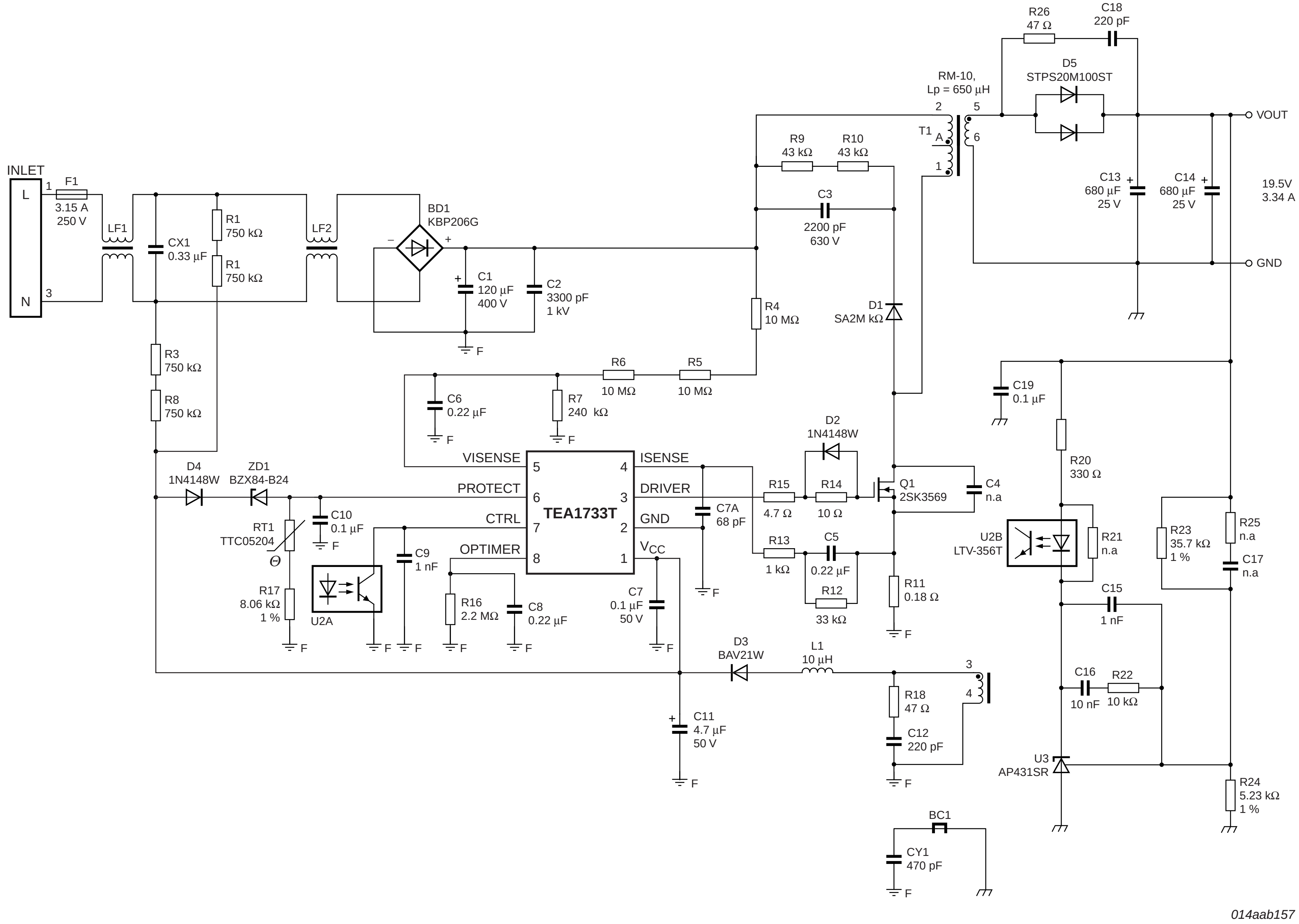


Fig 13. Schematic 65 W TEA1733(L)T demo board

5. Bill of materials

5.1 Components list

Table 10. Bill of materials

Reference	Value	Description	Package
R1	750 kΩ (5 %)	resistor, thin film chip	SMD 1206
R2	750 kΩ (5 %)	resistor, thin film chip	SMD 1206
R3	750 kΩ (5 %)	resistor, thin film chip	SMD 1206
R4	10 MΩ (1 %)	resistor, thin film chip	SMD 1206
R5	10 MΩ (1 %)	resistor, thin film chip	SMD 1206
R6	10 MΩ (1 %)	resistor, thin film chip	SMD 1206
R7	240 kΩ (1 %)	resistor, thin film chip	SMD 0603
R8	750 kΩ (5 %)	resistor, thin film chip	SMD 1206
R9	43 kΩ (5 %)	resistor, thin film chip	SMD 1206
R10	43 kΩ (5 %)	resistor, thin film chip	SMD 1206
R11	0.18 Ω (5 %; 1 W)	resistor, MOF	Axial lead
R12	33 kΩ (1 %)	resistor, thin film chip	SMD 0603
R13	1 kΩ (1 %)	resistor, thin film chip	SMD 0603
R14	10 Ω (5 %)	resistor, thin film chip	SMD 0805
R15	4.7 Ω (5 %)	resistor, thin film chip	SMD 0805
R16	2.2 MΩ (5 %)	resistor, thin film chip	SMD 0603
R17	8.06 kΩ (1 %)	resistor, thin film chip	SMD 0603
R18	47 Ω (5 %)	resistor, thin film chip	SMD 0805
R20	330 Ω (5 %)	resistor, thin film chip	SMD 0603
R21	not mounted	-	-
R22	10 kΩ (5 %)	resistor, thin film chip	SMD 0603
R23	35.7 kΩ (1 %)	resistor, thin film chip	SMD 0603
R24	5.23 kΩ (1 %)	resistor, thin film chip	SMD 0603
R25	not mounted	-	-
RT1	200 kΩ (5 %)	NTC resistor, D = 5, TTC05204/Thinking	Axial lead
CX1	0.33 μF; 275 V (AC)	MXP, × 2 cap, R46/Arcotronics Nissei	Axial lead
C1	120 μF; 400 V, 105 °C	E/C, KMG/NCC	Radial lead, 18 mm × 30 mm
C2	3300 pF; 1 kV	Ceramic, Z5U	disc, D = 6.5 mm
C3	2200 pF; 630 V	MLCC, Z5U	SMD 1206
C4	not mounted	-	-
C5	0.22 μF; 50 V	MLCC, X7R	SMD 0603
C6	0.22 μF; 50 V	MLCC, X7R	SMD 0603
C7	0.1 μF; 50 V	MLCC, X7R	SMD 0603
C7A	68 pF; 50 V	MLCC, X7R	SMD 0603
C8	0.22 μF; 50 V	MLCC, X7R	SMD 0603
C9	1 nF; 50 V	MLCC, X7R	SMD 0603
C10	0.1 μF; 50 V	MLCC, X7R	SMD 0603

Table 10. Bill of materials *...continued*

Reference	Value	Description	Package
C11	4.7 μF; 50 V, 105 °C	E/C, KY/NCC	Radial lead, 5 mm × 11.5 mm
C12	220 pF; 100 V	MLCC, NPO	SMD 0805
C13	680 μF; 25 V, 105 °C	E/C, KZH/NCC	Radial lead, 10 mm × 12.5 mm
C14	680 μF; 25 V, 105 °C	E/C, KZH/NCC	Radial lead, 10 mm × 12.5 mm
C15	1 nF; 50 V	MLCC, X7R	SMD 0603
C16	10 nF; 50 V	MLCC, X7R	SMD 0603
C17	not mounted	-	-
C18	220 pF; 100 V	MLCC, NPO	SMD 0805
C19	0.1 μF; 50 V	MLCC, X7R	SMD 0603
CY1	470 pF; 400 V (AC)	ceramic Y1 Cap CD/TDK	Disc, D = 8.5 mm
BD1	2 A; 600 V	bridge diode, 2KBP206G/LiteON	Flat/mini
D1	1.5 A; 1000 V	general purpose diode, S2M/LiteON	SMB
D2	0.5 A; 75 V	switching diode, 1N4148W/Vishay	SMD SOD-123
D3	0.25 A; 250 V	ultra-fast diode, BAV21W/Vishay	SMD SOD-123
D4	0.5 A; 75 V	switching diode, 1N4148W/Vishay	SMD SOD-123
D5	20 A; 100 V	Schottky diode, STPS20M100ST/ST	SMD TO-23
ZD1	24 V (2 %; 0.25 W)	Zener diode, BZX84-B24/NXP	SMD SOT-123
Q1	10 A; 600 V (0.75 Ω)	MOSFET, 2SK3569/Toshiba, 15p-typical	TO-220F
U1	TEA1733(L)T	GreenChip SMPS control IC, NXP	SO-8
U2	LTV-356T	optocoupler, CTR = 130-260, LiteON	SMD
U3	AP431SR	adjustable precision shunt regulator diodes	SOT-23R
T1	Lp = 650 μH	transformer, YiLiAn	RM10-18.6-6P
LF1	9.5 Ts, 380 μH	line choke, YiLiAn	T12 × 6 mm × 4 mm, D = 0.6 mm + 0.6 mm (3L)
LF2	48 Ts, 7.4 mH	line choke, YiLiAn	T16 × 8-12C, JPH-10, D = 0.6 mm × 2 mm
L1	10 μH	inductor, molded W.W ferrite, WIS252018N-100K/Mingstar	SMD
BC1 for CY1	S6H; JK	bead core, N6/AMAX	RH 3.5 mm × 4.2 mm × 1.3 mm
J1	jumper wire	wire, black	26/1007/TC 10 + 14 + 10
J2	jumper wire	jumper wire	D = 0.6 mm × 10 mm
J3	jumper wire	jumper wire	D = 0.6 mm × 7.5 mm
J4	jumper wire	wire, black	26/1007/TC 10 + 7 + 10
J5	jumper wire	wire, black	26/1007/TC 10 + 22 + 10
For Q1, BD1	heat sink	I-Shape, Al-Original, WD	62 mm × 21 mm, t = 2 mm
For D5	heat sink	L-Shape, Al-Original, WD	34 mm × 21 mm × 8 mm, t = 2 mm
Main PCB	PCB	single side, CEM-3, 1-OZ, APBADC051 Version A	91 mm × 40 mm × 1.2 mm
F1	T3.15 A; 250 V	fuse, Time lag, LT-5/Littlefuse	Axial lead
For Q1	screw	Flat head 5.0, NI Shouh-Pin	M3 × 8

Table 10. Bill of materials *…continued*

Reference	Value	Description	Package
For D5	screw	Flat head 5.0, NI Shouh-Pin	M3 × 8
For Q1	nut	HEX/GW, LF, NI Shouh-Pin	M3 × 8
For D5	nut	HEX/GW, LF, NI Shouh-Pin	M3 × 8
Inlet	inlet	TU-333-BZ-315-P3D/TECK	L3P
Cable	cable	16AWG/1571	2.5 × 5.5 × 12 (kk,fk), L = 1200 mm

6. Transformer specification

6.1 Transformer schematic diagram

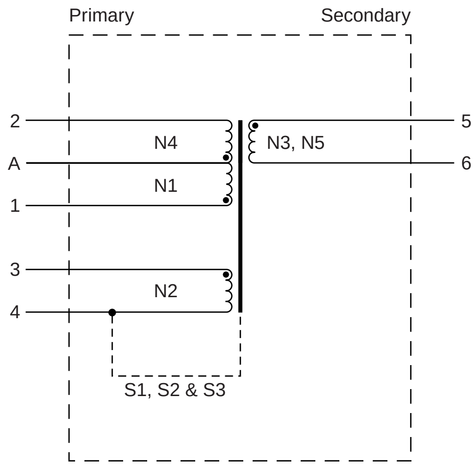


Fig 14. Transformer winding diagram

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Fig 15. Transformer side view

6.2 Winding specification

Table 11. Winding table

Winding order[1]		Pin		Wire	Turns	Turns / Layer	Winding Method	Insulation	
		Start	Finish					Turn	Width
1	N1	1	A	0.4 mm θ × 1	22	22		1	10 mm
2	N2	3	4	0.15 mm θ × 3	8	8		1	10 mm
3	S1		4	0.025 mm × 7 mm	1	1		1	10 mm
4	N3	5	6	0.35 mm θ (3L) × 2	8	8		1	10 mm
5	S2		4	0.025 mm × 7 mm	1	1		1	10 mm
6	N4	A[2]	2	0.4 mm θ × 1	22	22		1	10 mm
7	S3		4	0.025 mm × 7 mm	1	1		1	10 mm
8	N5	5	6	0.35 mm θ (3L) × 2	8	8		1	10 mm

[1] S1, S2, S3 are copper shields connected to the primary ground (pin4).

[2] Intermediate connection A is not connected to a pin.

6.3 Electrical characteristics

Table 12. Electrical characteristics

Description	Pin	Specification	Remark
Inductance	1 to 2	650 µH ± 5 %	65 kHz; 1 V
Leakage inductance	1 to 2	10 µH	secondary side all shorted

6.4 Core and bobbin

Core: RM-10 (A-Core, JPP-95 or equivalent)

Bobbin: RM-10 (TBI, RM10-18.6-6P-TH-H-12, 6 pin, vertical type)

A_e : 96.6 mm^2

6.5 Marking

Marking: APBADC051

7. Layout of the 65 W TEA1733(L)T demo board

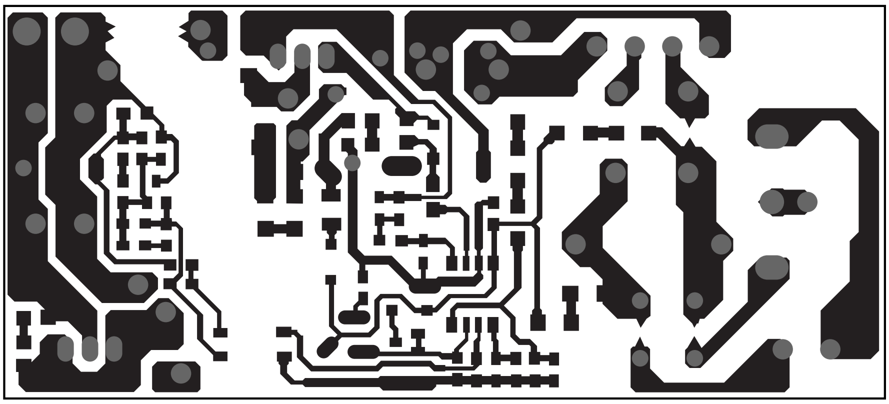

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Fig 16. Copper layout (bottom view)

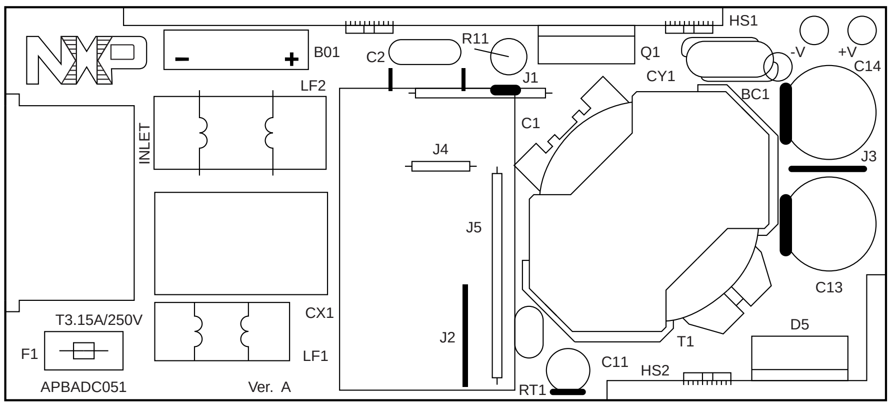

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Fig 17. Silk screen component side (top view)

8. Alternative circuit options

8.1 Changing the output voltage

By changing the following components, the output voltage can be changed. For additional information on this topic please refer to the *TEA1733(L) application note*.

R23/R24

The resistor dividers R23 and R24 determine the output voltage.

$$V_o = 2.5\ V \times (R23 + R24) / (R24)$$

C13/C14

The voltage rating of these electrolytic capacitors must be chosen higher than the output voltage. For lower output currents the capacity value can be decreased.

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Safety of high-voltage evaluation products — 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 that is qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits.

The product does not comply with IEC 60950 based national or regional safety standards. NXP Semiconductors does not accept any liability for damages incurred due to inappropriate use of this product or related to non-insulated high voltages. Any use of this product is at customer's own risk and liability. The customer shall fully indemnify and hold harmless NXP Semiconductors from any liability, damages and claims resulting from the use of the product.

9.3 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.

10. Contents

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