UM10421

GreenChip 65 W TEA1733LT/T printer reference board

Rev. 1 — 17 December 2010 **User manual**

Document information

Info	Content
Keywords	Printer adapter, TEA1733LT/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 TEA1733LT/T printer reference board. Refer to application note AN10868 for details on the TEA1733LT/T IC.

Revision history

Rev	Date	Description
v.1	20101217	first issue

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1. Introduction

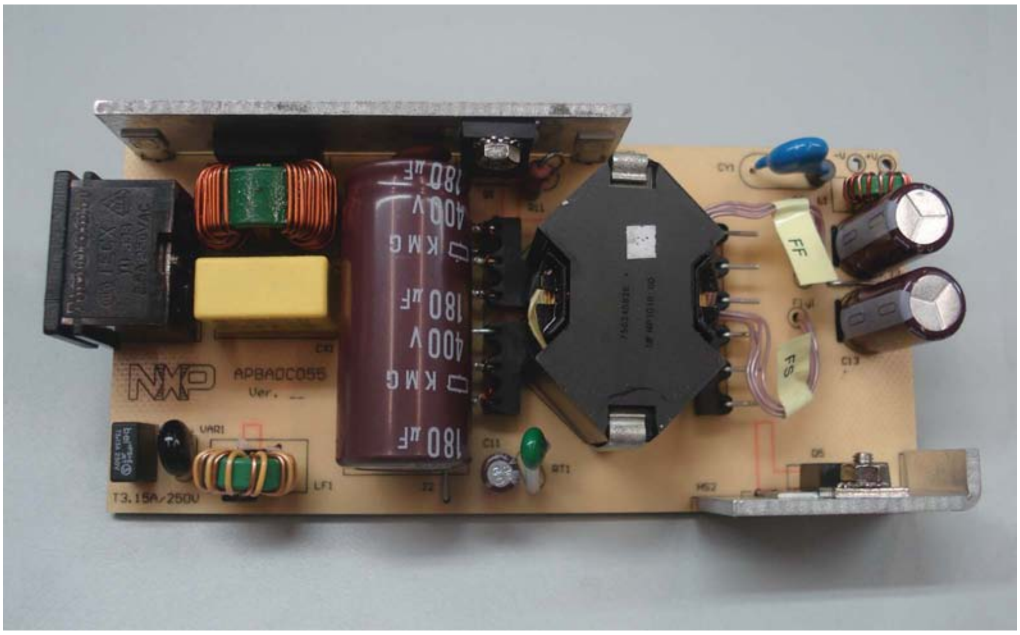

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Fig 1. 65 W TEA1733LT/T reference board

This 65 W TEA1733LT/T printer reference board demonstrates the capabilities of the TEA1733LT/T Switched Mode Power Supply (SMPS) controller. This manual provides the specifications, schematics and PCB layout of the 65 W TEA1733LT/T printer reference board. Refer to application note *AN10868 “GreenChip TEA1733 series fixed frequency flyback controller”* and the *“TEA1733(L)T; TEA1733P GreenChip SMPS control IC”* data sheet for details on the TEA1733LT/T SMPS controller.

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.

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 (< 300 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
$P_{i(no\_load)}$	input power (no load)	at 230 V; 50 Hz	< 300	mW

Table 2. Output specification

Symbol	Description	Conditions	Specification	Unit
V_o	output voltage	-	32	V
$V_{o(ripple)(p-p)}$	peak-to-peak output ripple voltage	20 MHz bandwidth	≤ 100	mV
I_o	output current	continuous	2	A
$I_{o(p)}$	peak output current	for 50 ms	3.75	A
P_o	output power	0 to 40 °C	65	W
t_{holdup}	hold-up time	at 115 V; 60 Hz; full load	5	ms
-	line regulation	-	±1	%
-	load regulation	-	±5	%
$t_{startup}$	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: APBADC055 ver. A

3.1 Efficiency

Efficiency measurements were made 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	89.4	88.4	89.7	89.7	89.7
230 V, 50 Hz	> 87	89.1	86.9	89.3	90.0	90.3

[1] Warm-up time: 10 minutes

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

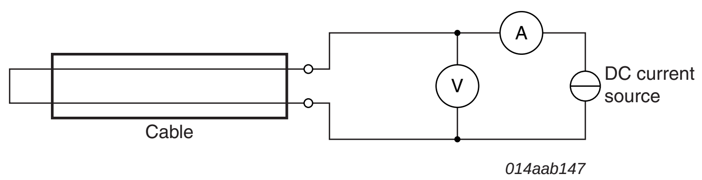


Fig 2. DC resistance output cable

3.2 No-load power consumption

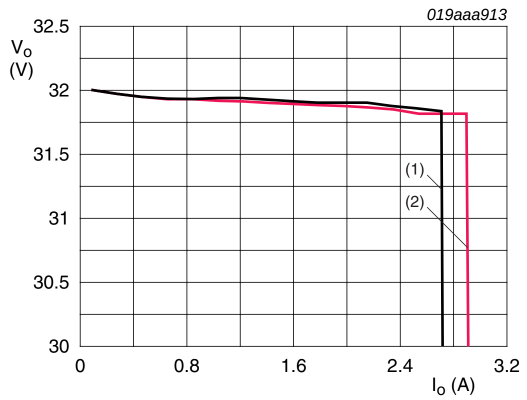
Power consumption performance of the total application board with no-load connected was measured using an automated test program containing a temperature stability detection algorithm. The output voltage and current were measured using a 4-wire current sense configuration directly at the PCB connector. 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	32.03	68
115 V; 60 Hz	≤ 300	32.03	72
230 V; 50 Hz	≤ 300	32.03	111
264 V; 50 Hz	≤ 300	32.03	130

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 current 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	14.2	14.5
Full load (3.34 A)	20.3	20.2

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	64	86
Full load (3.34 A)	75	86

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 (2 A) conditions.

Table 7. Maximum output voltage in case of OVP

Condition	115 V (AC)	230 V (AC)
No load	24.2	24.2
Full load (3.34 A)	23.4	23.5

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	3.6
115 V; 60 Hz	2.5
230 V; 50 Hz	1

If the start-up time is considered too long, it is advised to change the input circuit as described in application note *AN10868, Sections 3.2.3 and 3.2.4*.

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 %	14.2
264 V; 63 Hz	I_o: 0 % - 50 %, frequency 50 Hz; duty cycle 50 %	20.3

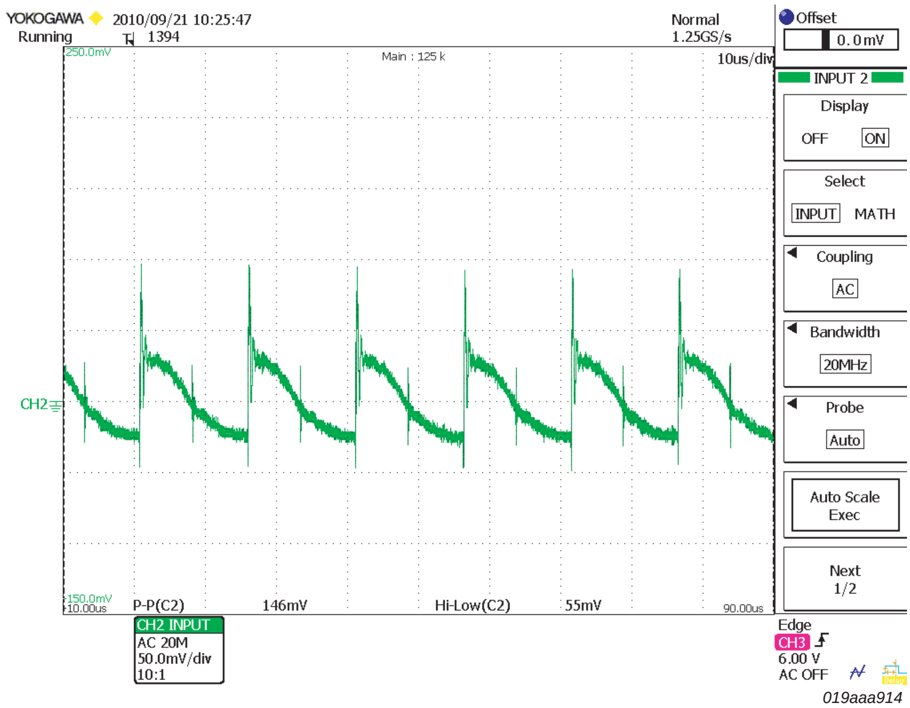


Fig 4. Load transient response 90 V; 47 Hz, ripple and noise

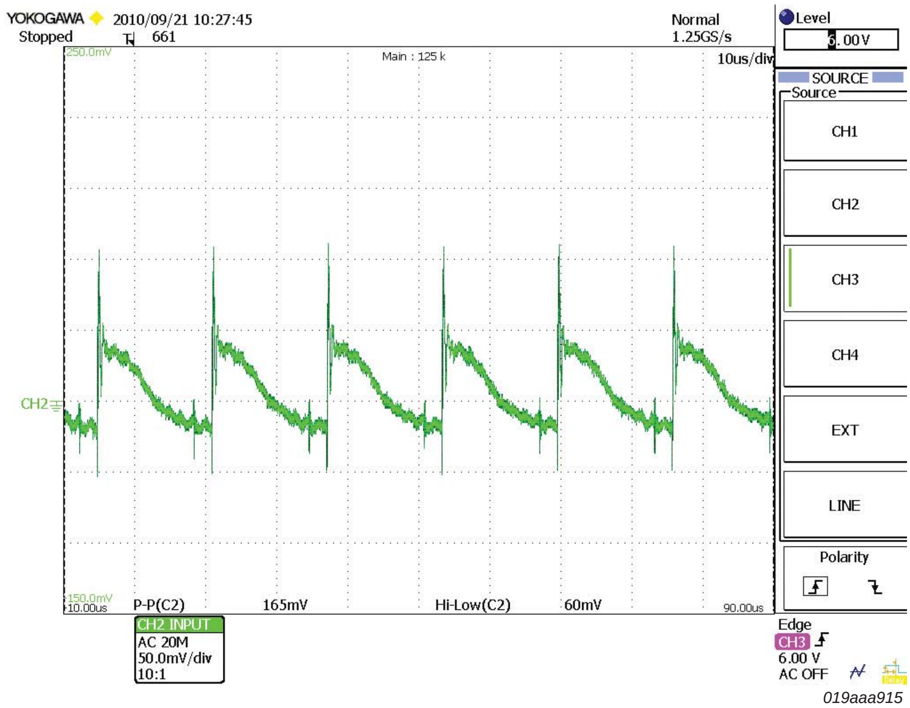
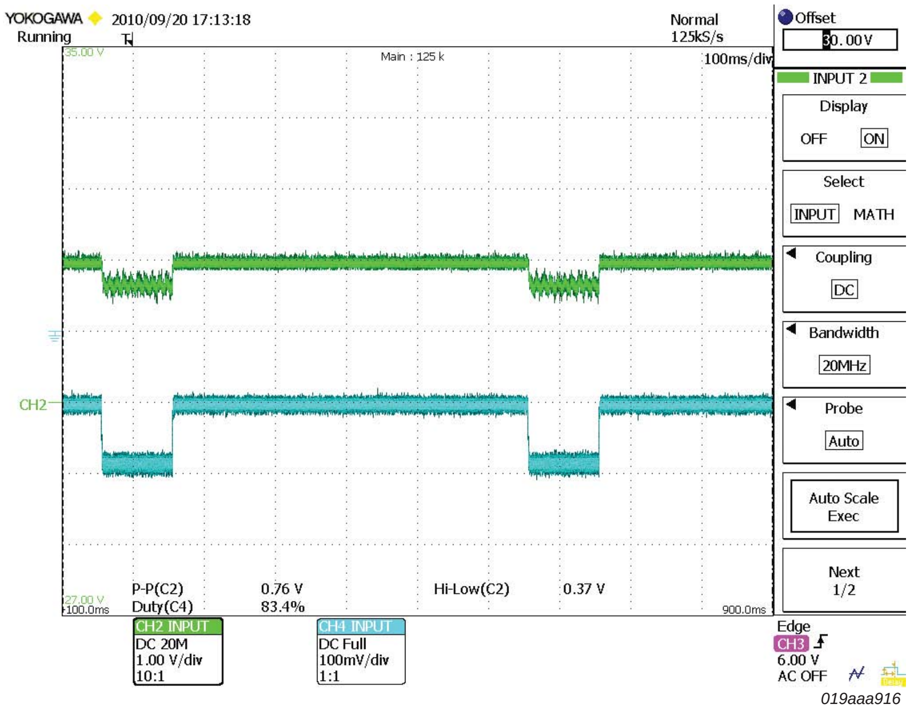
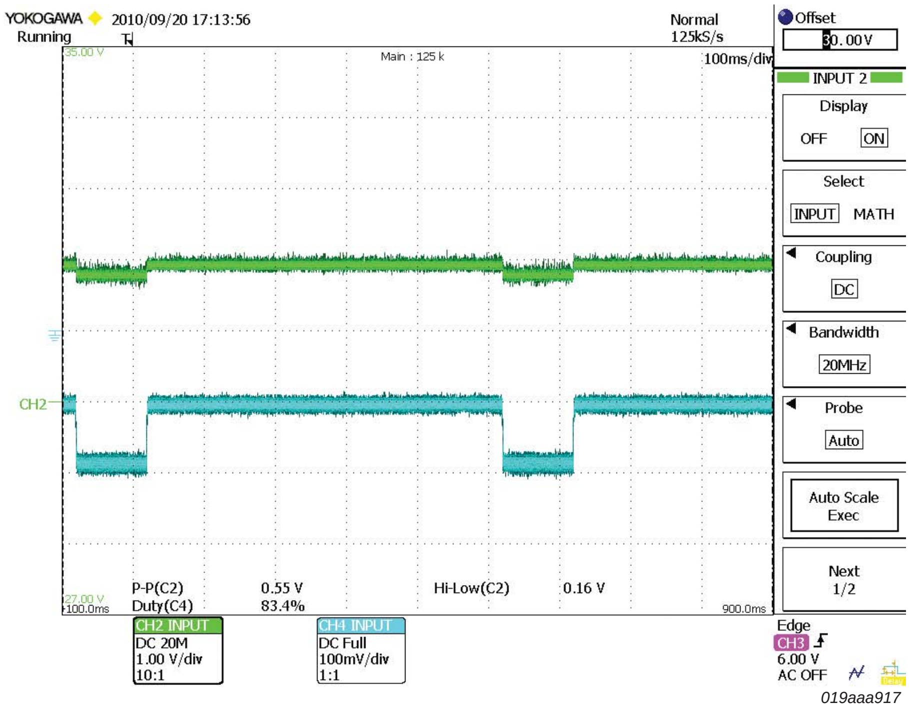


Fig 5. Load transient response 264 V; 63 Hz, ripple and noise



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

Fig 6. Load transient response 115 V; 50 Hz; load pulses 3.75 A; duration 100 ms



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

Fig 7. Load transient response 230 V; 60 Hz; load pulses 3.75 A; duration 100 ms

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 (2 A) output current.

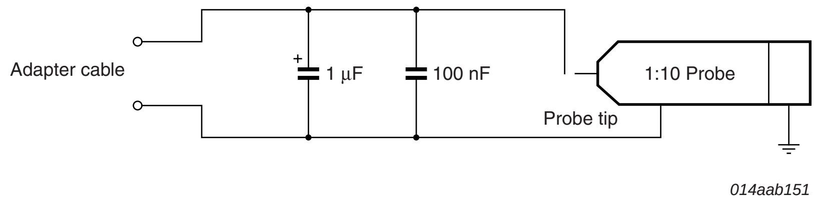
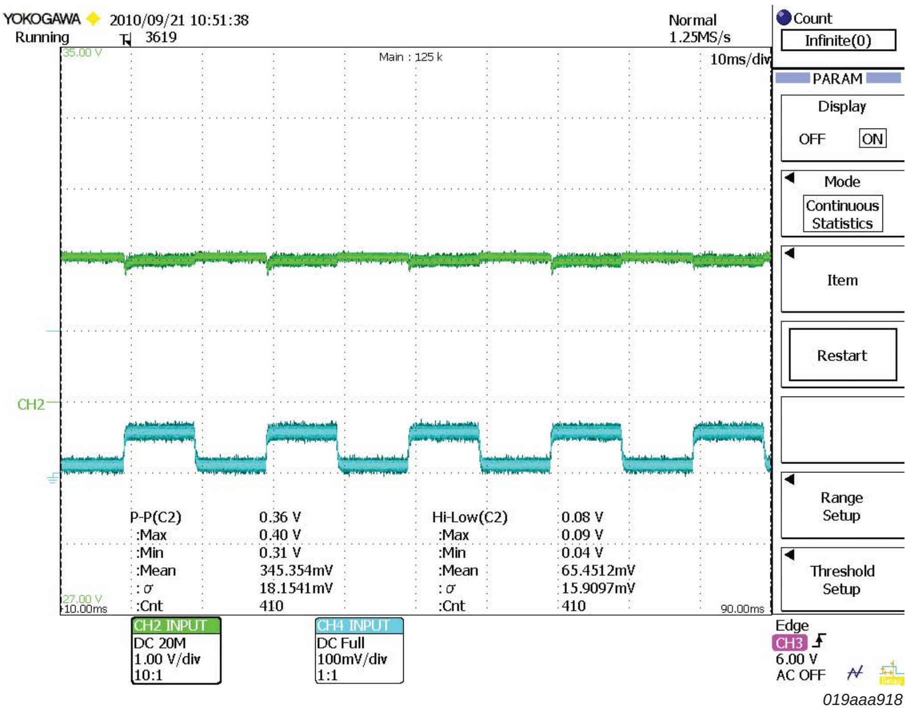
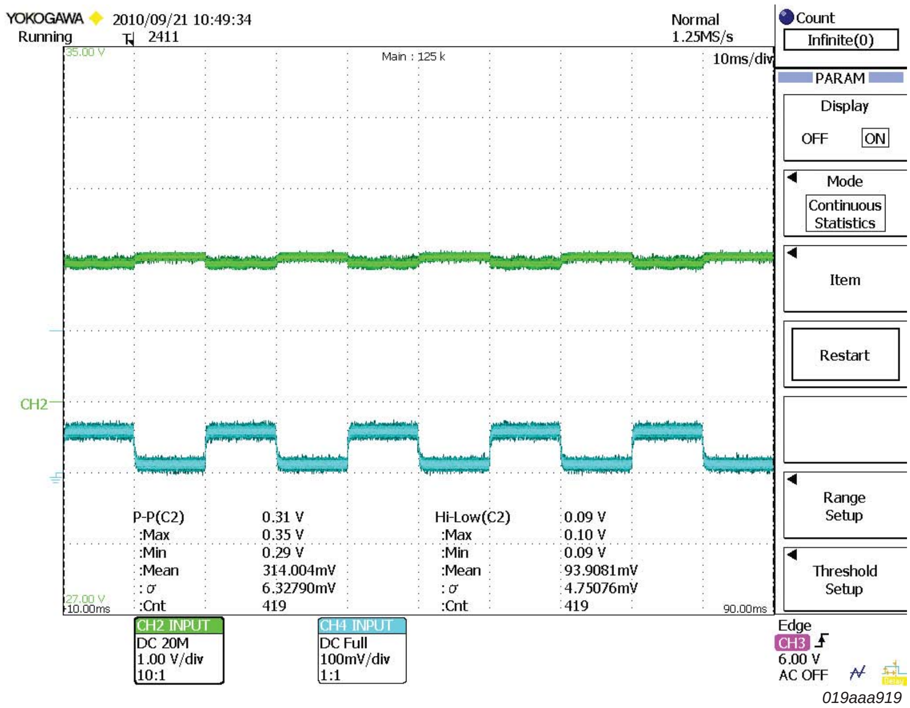


Fig 8. Output ripple and noise measurement set-up



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

Fig 9. Output 90 V; 47 Hz, ripple and noise



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

Fig 10. 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

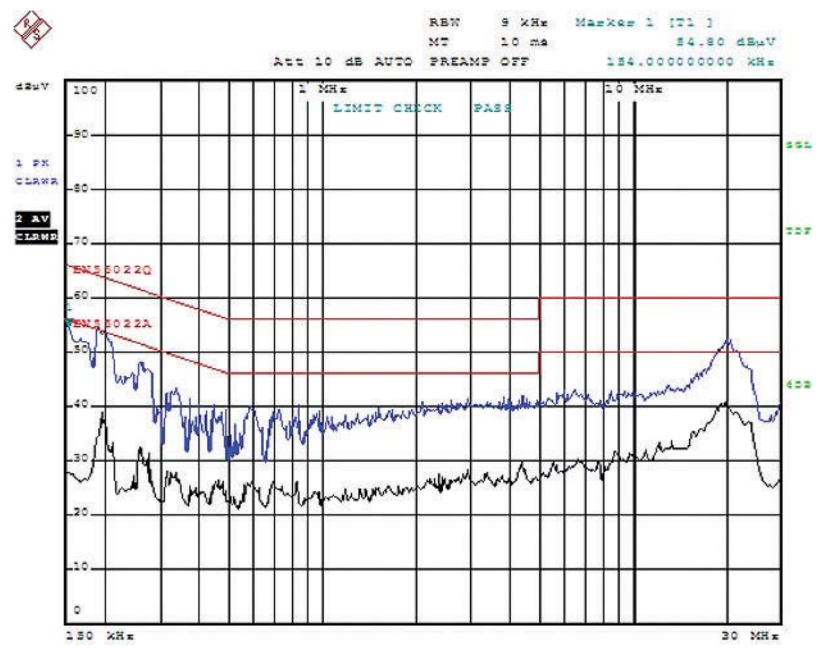


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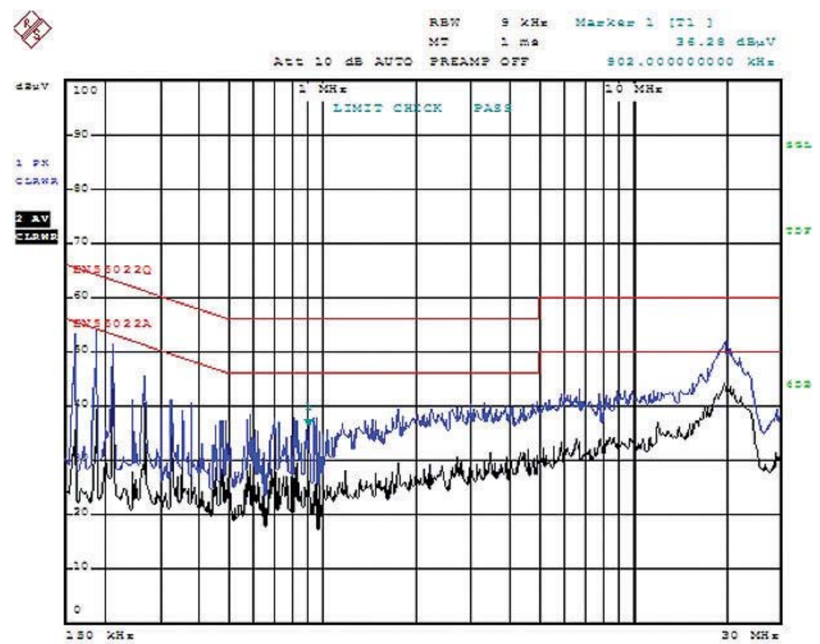
Fig 11. 115 V, 65 W TEA1733LT/T printer demo board phase N



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

Fig 12. 115 V, 65 W TEA1733LT/T printer demo board phase L

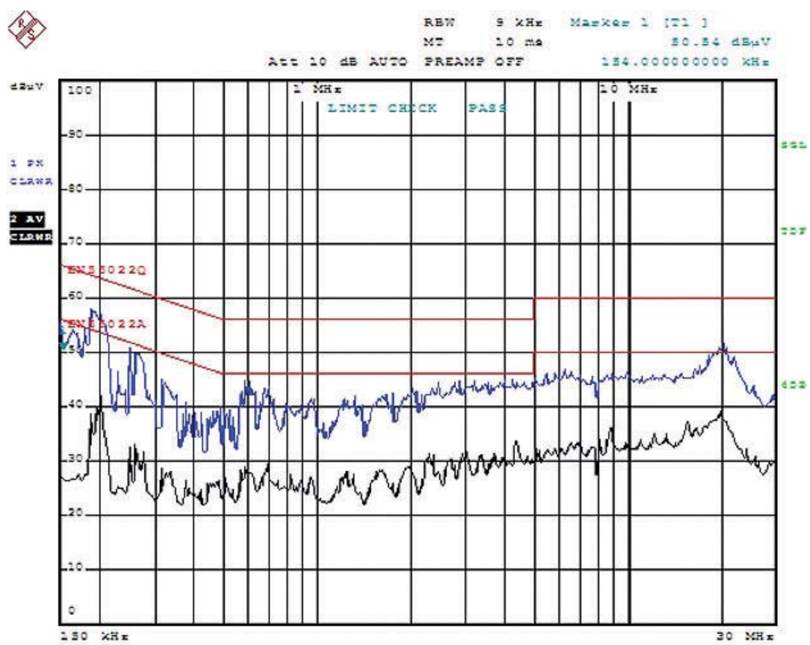

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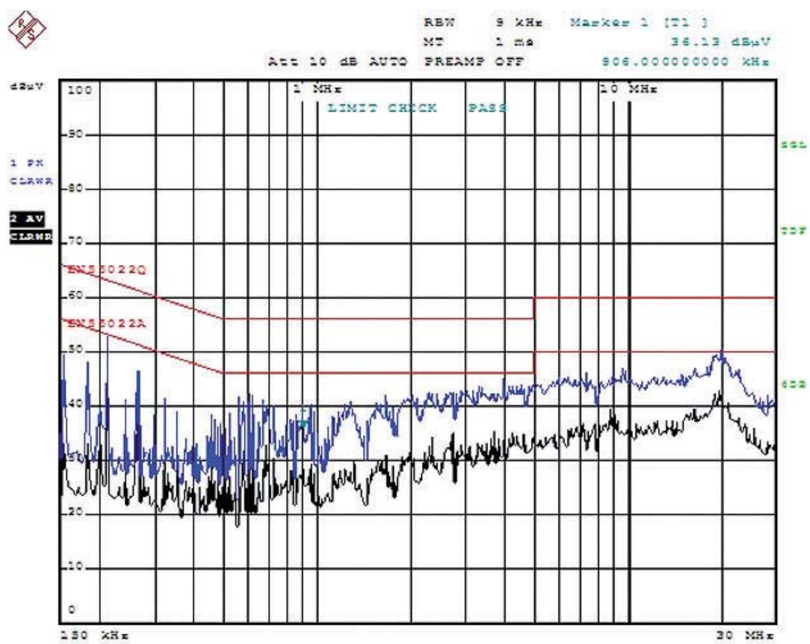
Fig 13. 230 V, 65 W TEA1733LT/T printer demo board phase N



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

Fig 14. 230 V, 65 W TEA1733LT/T printer demo board phase L

4. Schematic 65 W TEA1733LT/T reference board

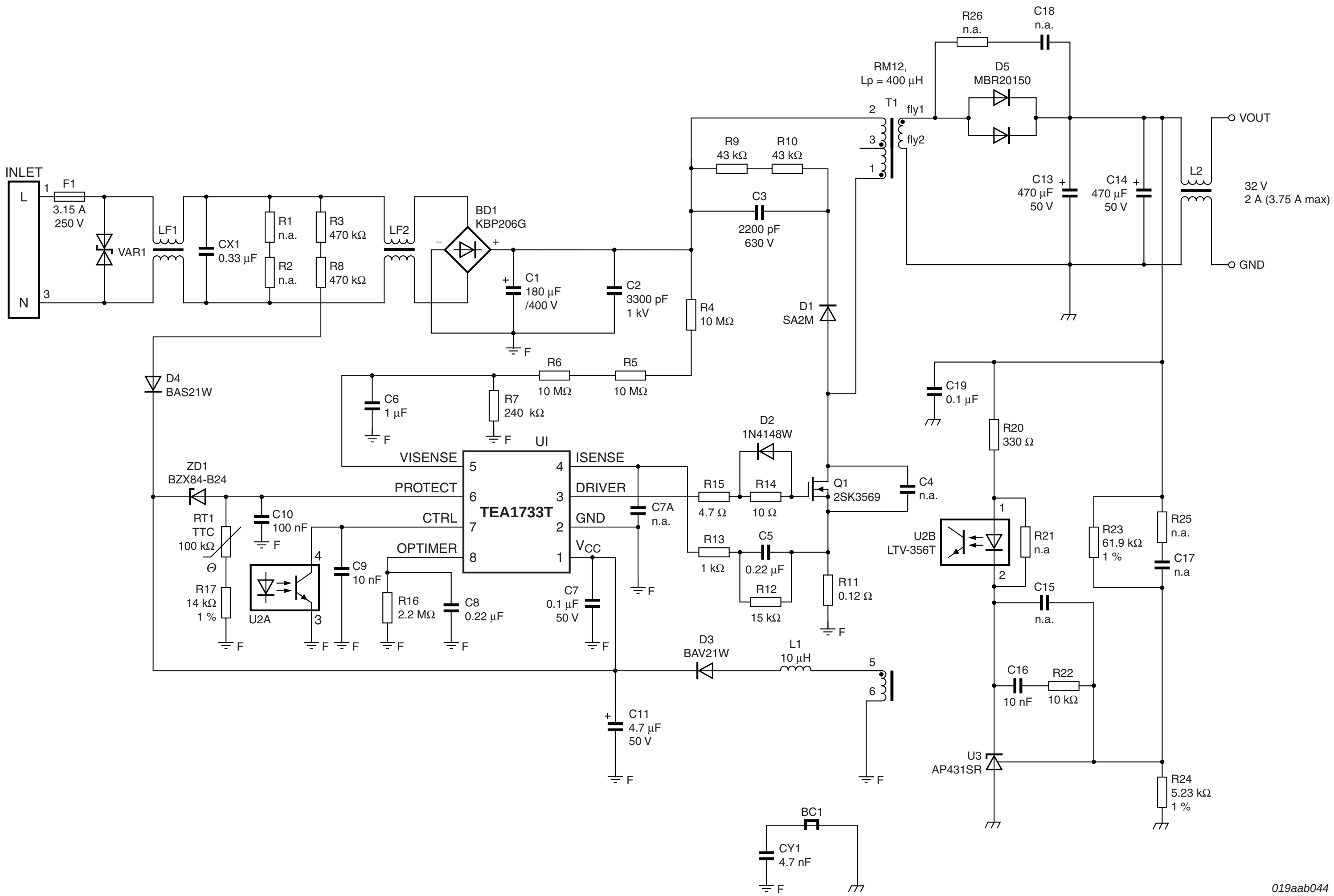

Fig 15. Schematic 65 W TEA1733LT/T reference board

5. Bill of materials

5.1 Components list

Table 10. Bill of materials

Reference	Value	Description	Package
R1	-	not mounted	-
R2	-	not mounted	-
R3	470 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	470 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	0.12 Ω (5 %; 1 W)	resistor; MOF	axial lead
R12	15 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	14 kΩ (1 %)	resistor; thin film chip	SMD 0603
R20	330 Ω (5 %)	resistor; thin film chip	SMD 0603
R21	-	not mounted	-
R22	10 kΩ (5 %)	resistor; thin film chip	SMD 0603
R23	61.9 kΩ (1 %)	resistor; thin film chip	SMD 0603
R24	5.23 kΩ (1 %)	resistor; thin film chip	SMD 0603
R25	-	not mounted	-
R26	-	not mounted	-
RT1	100 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	180 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	1 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	10 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	-	not mounted	-
C13	470 μF; 50 V; 105 °C	E/C; KZH/NCC	radial lead; 10 mm × 12.5 mm
C14	470 μF; 50 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	-	not mounted	-
C19	0.1 μF; 50 V	MLCC; X7R	SMD 0603
CY1	4.7 nF; 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 Semiconductors	SMD SOT-123
Q1	10 A; 600 V (0.75 Ω)	MOSFET; 2SK3569/Toshiba; 15p-typical	TO-220F
U1	TEA1733LT/T	GreenChip SMPS control IC; NXP Semiconductors	SO-8
U2	LTV-356T	optocoupler; CTR = 130-260; LiteON	SMD
U3	AP431SR	adjustable precision shunt regulator diodes	SOT-23R
T1	Lp = 400 μH	transformer; Midcom No. 750340828	RM12-18.6-6P
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-6R8K/Mingstar	SMD
L2	8.5 Ts; 325 μH	line choke; YiLiAn	T10 × 4mm; D = 0.6mm + 0.6 mm
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
Main PCB	PCB	single side; CEM-3; 1-OZ; APBADC051 Version A	123 mm × 55 mm × 1.2 mm
F1	T3.15 A; 250 V	fuse; Time lag; LT-5/Littlefuse	axial lead
For Q1; BD1	heat sink	I-Shape; Al-Original; WD	72 mm × 21 mm; t = 2 mm
For D5	heat sink	L-Shape; Al-Original; WD	34 mm × 21 mm × 8 mm; t = 2 mm
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

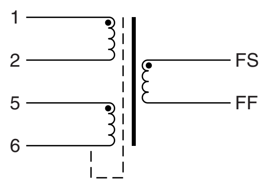

Fig 16. Transformer winding diagram

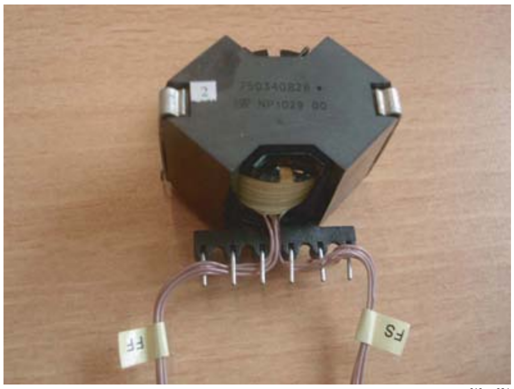

Fig 17. Transformer side view

6.2 Winding specification

Table 11. Winding table

Winding order[1]	Pin		Wire[2]	Turns	Layers	Winding Method	Insulation	
	Start	Finish					Turn	Width
N1	1	3	0.4 mm ∅ × 1	18	1	distributed	1	14.3 mm
S1		6	0.025 mm × 12 mm	1	1	distributed	1	14.3 mm
N2	5	6	0.25 mm ∅ × 3	6	1	distributed	1	14.3 mm
N3	fly 1	fly 2	0.4 mm ∅ (3L) × 2	10	1	distributed	1	14.3 mm
N3	fly 1	fly 2	0.4 mm ∅ (3L) × 2	10	1	distributed	1	14.3 mm
S2		6	0.025 mm × 12 mm	1	1	distributed	1	14.3 mm
N4	3	2	0.4 mm ∅ × 1	18	1	distributed	1	14.3 mm

[1] S1 and S2 are copper shields connected to the primary ground (pin 6). Pin 4 is not used

[2] Secondary winding to be wound with triple insulated wire and flying leads.

6.3 Electrical characteristics

Table 12. Electrical characteristics

Description	Pin	Specification	Remark
Inductance	1 to 2	400 μH ± 5 %	65 kHz; 1 V
Leakage inductance	1 to 2	10 μH	secondary side all short circuited

6.4 Core and bobbin

Core: RM-12 (A-Core, JPP-95 or equivalent).

Bobbin: RM-12 (TBI, RM10-18-6P-TH-12, 6-pin, vertical type).

A_e : 96.6 mm^2

6.5 Marking

Main board: APBADC055

Transformer: Midcom750340828

7. Layout of the 65 W TEA1733LT/T reference board

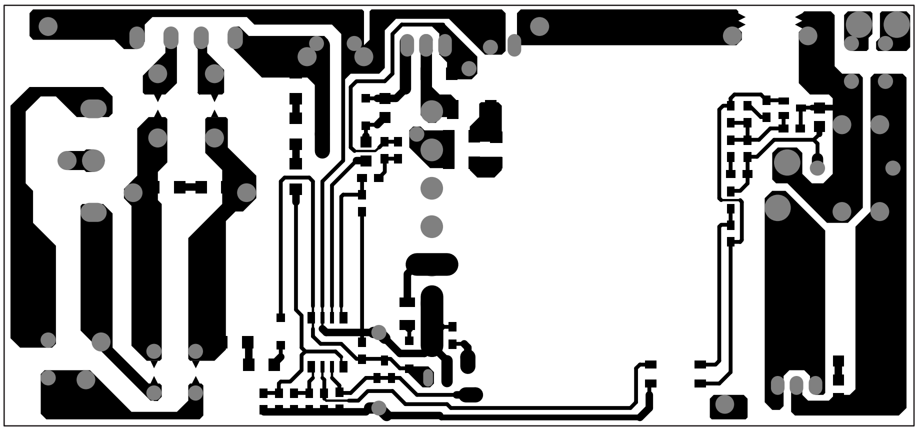

Fig 18. Copper layout (bottom view)

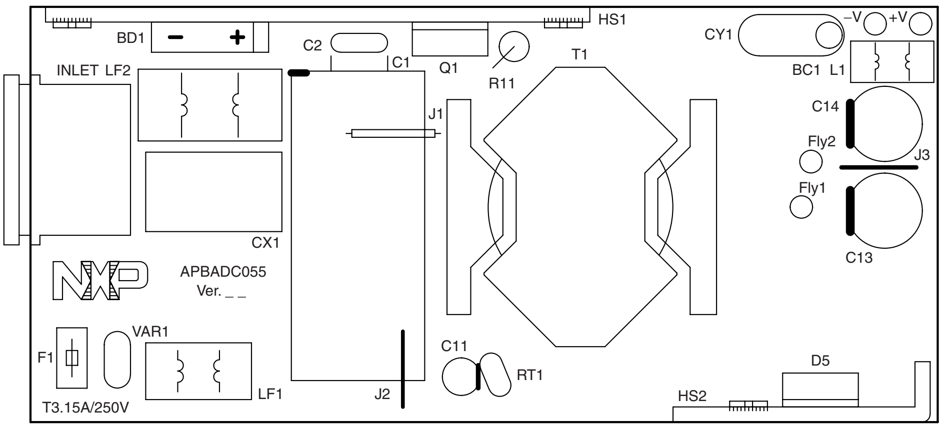

Fig 19. Silk screen component side (top view)

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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10. Contents

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