UM10506

Greenchip 40 W TEA1731LTS/TS demo board

Rev. 1.1 — 23 October 2012 User manual

Document information

Info	Content
Keywords	Notebook adapter, TEA1731LTS, TEA1731TS, Fixed frequency, TSOP6
Abstract	This manual provides the specification, schematics and PCB layout of the 40 W TEA1731LTS/TS demo board. See the data sheet and application note for more information on the TEA1731LTS/TS IC.

Revision history

Rev	Date	Description
v.1.1	20121023	second revised issue
v.1	20120830	first issue

Contact information

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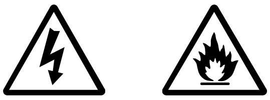
1. Introduction

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.

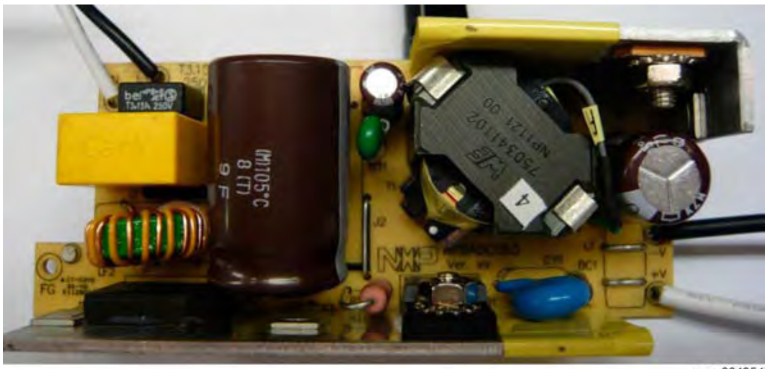


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Fig 1. TEA1731 demo board top view

The TEA1731DB0001 demo board demonstrates the capabilities of the low-cost 6-pin TEA1731LTS/TS Switched-Mode Power Supply (SMPS) controller.

This manual provides the specification, schematics and PCB layout of the 40 W TEA1731LTS/TS demo board. See the data sheet and application note for more information on the TEA1731LTS/TS IC.

Remark: Unless otherwise stated all values are typical.

1.1 Features

- Universal mains supply operation
- OverCurrent Protection (OCP)
- OverPower Protection (OPP)
- High/low line compensation
- Low ripple and noise
- Small form factor
- Low-cost implementation
- ENERGY STAR compliant
- EMI CISPR22 compliant

2. Safety warning

Connect the board to the mains voltage. Avoid touching the board while it is connected to the mains voltage. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation of the mains phase using a variable transformer is always recommended.

a. Isolated

b. Not isolated

Fig 2. Variac isolation symbols

3. Power supply specification

Table 1. Input specification

Symbol	Description	Condition	Specification	Unit
V_i	input voltage		90 to 264	V
f_i	input frequency		47 to 64	Hz
P_i	input power	no-load; 230 V; 50 Hz	< 100	mW

Table 2. Output specification

Symbol	Description	Condition	Specification	Unit
V_O	output voltage		19.5	V
$V_{O(ripple)(p-p)}$	peak-to-peak ripple output voltage	20 MHz bandwidth	≤ 500	mV (p-p)
I_O	output current		0 to 2.05	A
$I_{O(peak)}$	peak output current	60 ms; 115 V (AC)	2.7	A
t_{holdup}	hold-up time	115 V; 60 Hz; full load	5	ms
$V_{line(reg)}$	line voltage regulation	90 V (AC) to 264 V (AC)	±1	%
$V_{L(reg)}$	load voltage regulation	0 A to 2.05 A	±2	%
$t_{startup}$	start-up time	115 V; 60 Hz	≤ 3	s
η	efficiency	according to ENERGY STAR (EPS 2)	≥ 87	%
-	ElectroMagnetic Interference (EMI)	CISPR22 compliant	pass	-

4. Performance

Performance figures based on the following PCB design:

- Schematic version: Wednesday June 06, 2012 rev A (see Figure 14)

4.1 Efficiency

Efficiency measurements are taken using an automated test program containing a temperature stability detection algorithm. The output voltage and current are measured using a 4-wire current sense configuration directly at the PCB connector. Measurements are performed for:

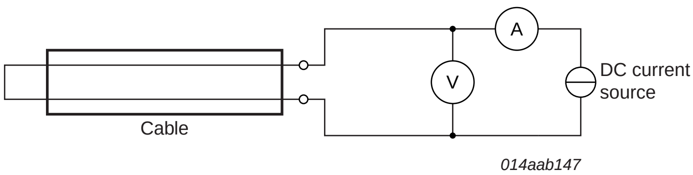
- 115 V; 60 Hz
- 230 V; 50 Hz

Table 3. Efficiency results

Condition	ENERGY STAR 2.0 efficiency requirement	Efficiency (%)							
		Average	100 % load	75 % load	50 % load	25 % load	500 mW load	250 mW load	100 mW load
115 V; 60 Hz	> 87	88.8	89.0	88.3	88.9	87.9	70.9	63.4	49.5
230 V; 50 Hz	> 87	88.8	89.1	88.5	88.0	87.1	69.1	60.3	44.0

[1] Warm-up time: 10 minutes.

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



DC resistance cable = voltage drop / current = 0.146 / 1.999 = 73 mΩ (two-way)

Fig 3. DC resistance output cable

4.2 No-load power consumption

Power consumption performance measurements of the total application board with no-load connected are taken using an automated test program containing a temperature stability detection algorithm. The results are shown in Table 4. Measurements are performed for:

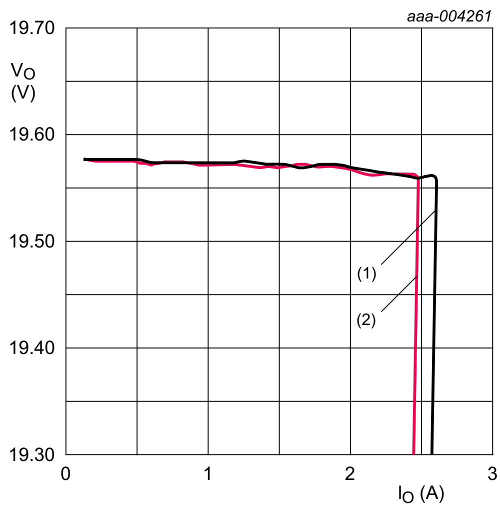
- 90 V; 60 Hz
- 115 V; 60 Hz
- 230 V; 50 Hz
- 264 V; 50 Hz

Table 4. Output voltage and power consumption: no-load

Condition	ENERGY STAR 2.0 requirement (mW)	Output voltage (V)	No-load output power consumption (mW)
90 V; 60 Hz	≤ 300	19.56	59
115 V; 60 Hz	≤ 300	19.57	62
230 V; 50 Hz	≤ 300	19.56	89
264 V; 50 Hz	≤ 300	19.57	103

4.3 Output voltage regulation

The output voltage as a function of load current is measured using a 4-wire current sense configuration at the PCB connector. Measurements are performed without probes attached to the application for 115 V; 60 Hz and 230 V; 50 Hz.



(1) 115 V (AC); 60 Hz

(2) 230 V (AC); 50 Hz

Fig 4. Output voltage regulation as function of load

4.4 Line regulation

The output voltage as a function of mains input voltage is measured using a 4-wire current sense configuration directly at the output connector for full load (2.05 A) condition.

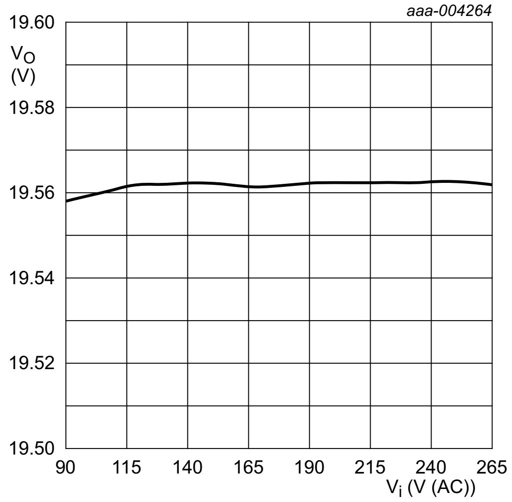


Fig 5. Output voltage as function of mains voltage

4.5 High/low line compensation

Nominal output power is measured directly at the output connector for various mains input voltages.

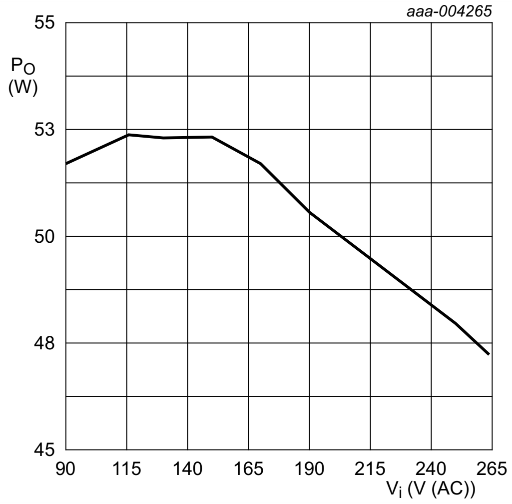


Fig 6. Nominal output power as function of mains voltage

4.6 VCC voltage

The voltage on pin VCC is measured for both no-load and full load (2.05 A) conditions.

Table 5. VCC voltage

Condition	115 V; 60 Hz (V)	230 V; 50 Hz (V)
no-load	16.6	16.4
full load (2.05 A)	23.8	24.0

4.7 Brownout and start level

Brownout and the start level are measured for no-load and full load (2.05 A) conditions.

Table 6. Brownout and start level

Condition	Brownout (V (AC))	Start level (V (AC))
no-load	9	58
full load (2.05 A)	65	67

4.8 OverVoltage Protection (OVP)

Applying a short circuit across the optoLED of the optocoupler (U2) creates an output overvoltage condition. The output voltage is measured directly at the output connector for both full load (2.05 A) and no-load conditions.

Table 7. Maximum output voltage in case of OVP

Condition	115 V; 60 Hz (V)	230 V; 50 Hz (V)
no-load	27.2	27.2
full load (2.05 A)	26.1	26.3

4.9 Start-up time

The start-up time is measured for three mains input voltages and the full load (2.05 A) condition. V_i is measured using a current probe (to avoid adding additional capacitance to the mains input). V_o is measured using a voltage probe grounded at the secondary side.

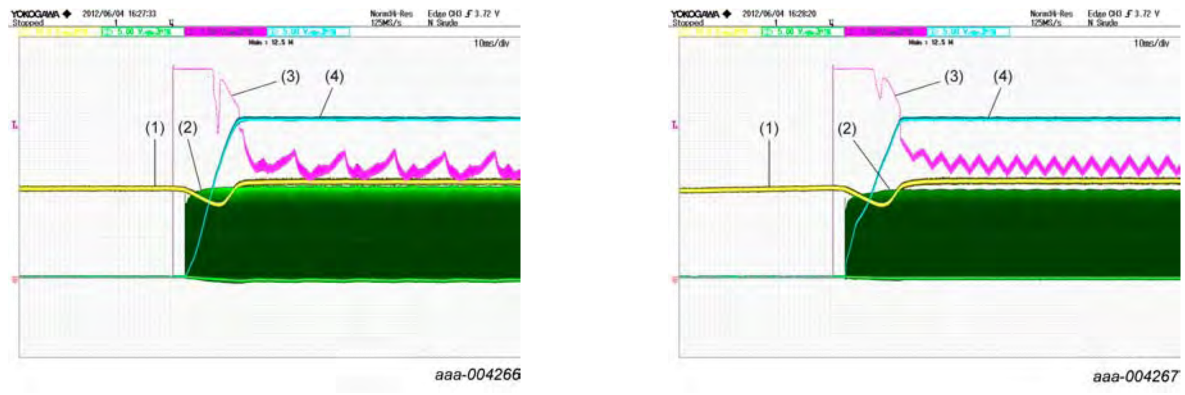
Table 8. Start-up time

Condition	Start-up time (s)
90 V; 60 Hz	4
115 V; 60 Hz	2.7
230 V; 50 Hz	1.1

Change the input circuit as described in *application note AN11123* if the start-up time is considered too long.

4.10 Start-up profile

The shape of the output voltage is measured directly from the output connector under the full load (2.05 A) condition for three mains input voltages during start-up. V_O is measured using a voltage probe grounded at the secondary side.



Signals:

(1) Chan1: VCC

(2) Chan2: gate pulse

(3) Chan3: control voltage

(4) Chan4: V_O

a. 90 V; 60 Hz

b. 264 V; 50 Hz

Fig 7. Full load: start-up profile

Remark: The small discontinuity in the output voltage ramp at 264 V; 50 Hz is caused by the slow start function not limiting the primary current because it is hidden by the leading edge blanking period of 300 ns.

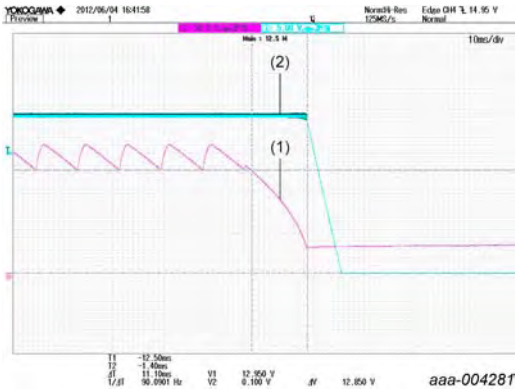
4.11 Hold-up time

The hold-up time is defined as the time between the following moments:

- After mains switch-off: When the lowest bulk cap voltage during a mains cycle is crossed
- When the output voltage starts to drop

The hold-up time is measured for 115 V; 60 Hz under full load (2.05 A) condition. The output voltage duration is measured directly at the output connector.

The hold-up time at 115 V; 60 Hz is 11.1 ms.



Signals:

(1) Chan3: bulk capacitor voltage

(2) Chan4: V_O

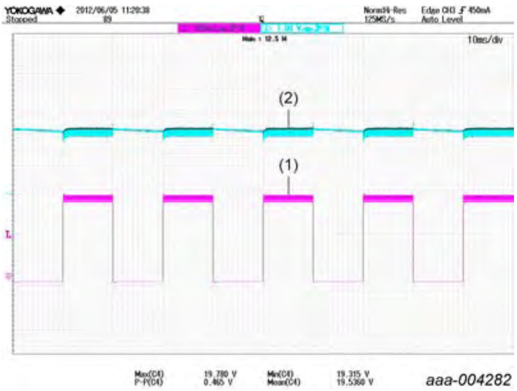
Fig 8. Full load; hold-up time at 115 V; 60 Hz

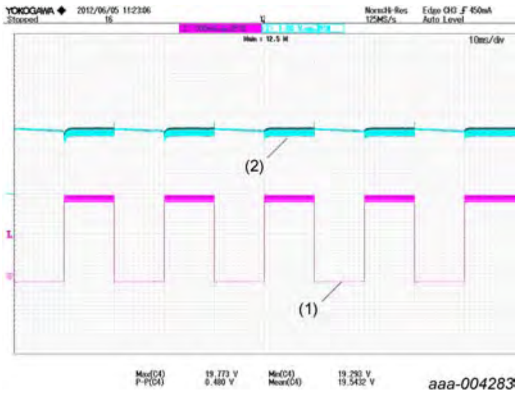
4.12 Dynamic loading

The output voltage is measured at the end of the cable. Both channels of the oscilloscope are set to DC mode.

Table 9. Dynamic loading test condition and results

Condition	Loading	$V_{O(ripple)(p-p)}$ (mV)
90 V; 47 Hz	I_O: 0 % to 50 %; frequency = 50 Hz; duty cycle = 50 %	465
264 V; 63 Hz	I_O: 0 % to 50 %; frequency = 50 Hz; duty cycle = 50 %	480





Signals:

(1) Chan3: I_O

(2) Chan4: V_O

a. 90 V; 47 Hz

b. 264 V; 63 Hz

Fig 9. Dynamic loading

4.13 Output ripple and noise

Output ripple and noise are measured at the end of the cable using the measurement setup described in Figure 10. An oscilloscope probe connected to the end of the adapter cable using a probe tip. Capacitors of 100 nF and 1 μF are added between plus and minus to reduce high frequency noise. Output ripple and noise are measured for mains voltages 90 V; 47 Hz and 264 V; 63 Hz, both for the full load (2.05 A) condition.

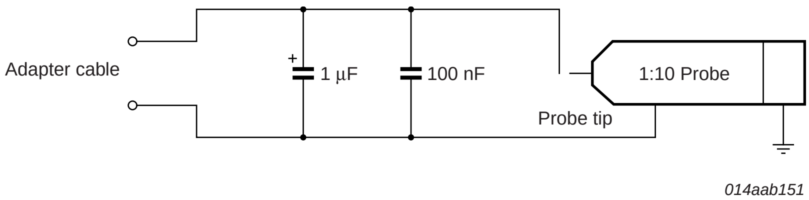
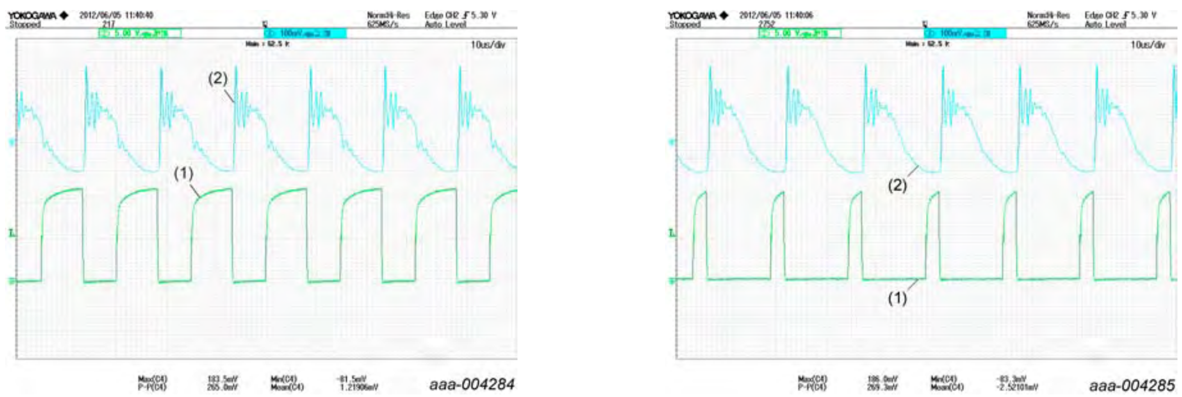


Fig 10. Output ripple and noise measurement setup

Table 10. Output ripple and noise measurements

Condition	$V_{o(ripple)(p-p)}$ (mV)
90 V; 47 Hz	265
264 V; 63 Hz	269



Signals:

(1) Chan2: gate pulse

(2) Chan4: V_O

a. 90 V; 47 Hz

b. 264 V; 63 Hz

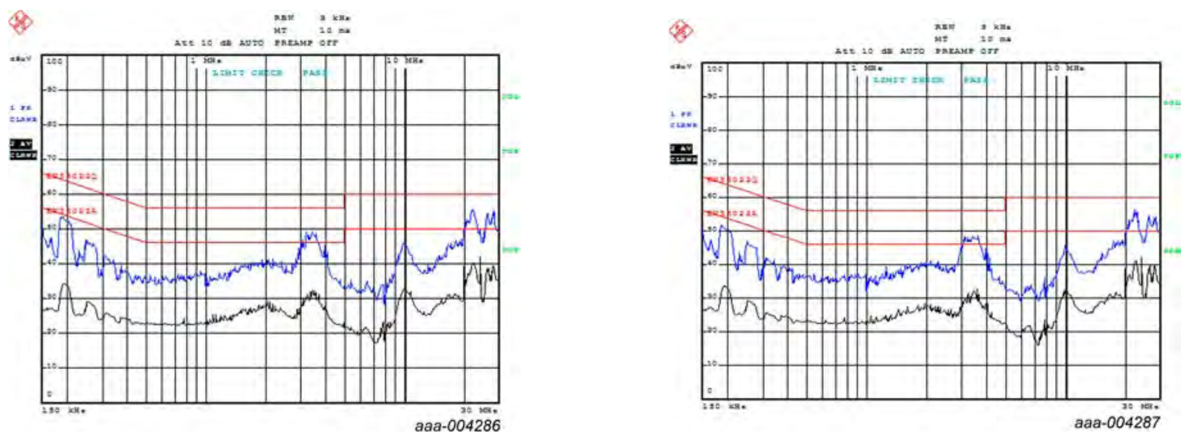
Fig 11. Output ripple and noise

4.14 EMI performance

Conditions:

- Type: Conducted ElectroMagnetic Compatibility (EMC) measurement
- Frequency range: 150 kHz to 30 MHz
- Output power: full load condition
- Supply voltage: 110 V (AC) and 230 V (AC)
- Margin: 6 dB below limit
- Measurements performed by NXP Semiconductors, Nijmegen (The Netherlands)

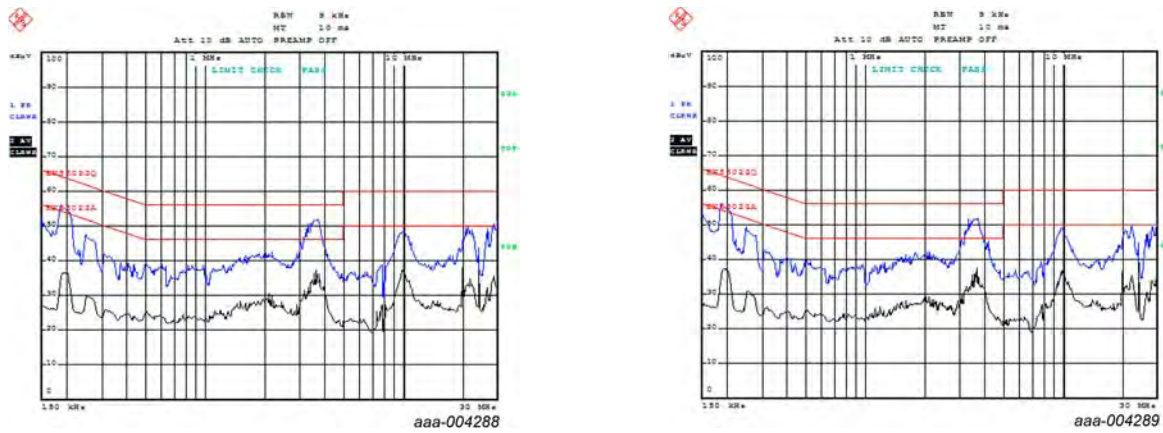
Remark: The blue line is the quasi-peak measurement result in the following graphs. The black line is the average measurement result.



a. Phase N

b. Phase L

Fig 12. EMI performance: 115 V



a. Phase N

b. Phase L

Fig 13. EMI performance: 230 V

5. Schematic 40 W TEA1731LTS/TS demo board

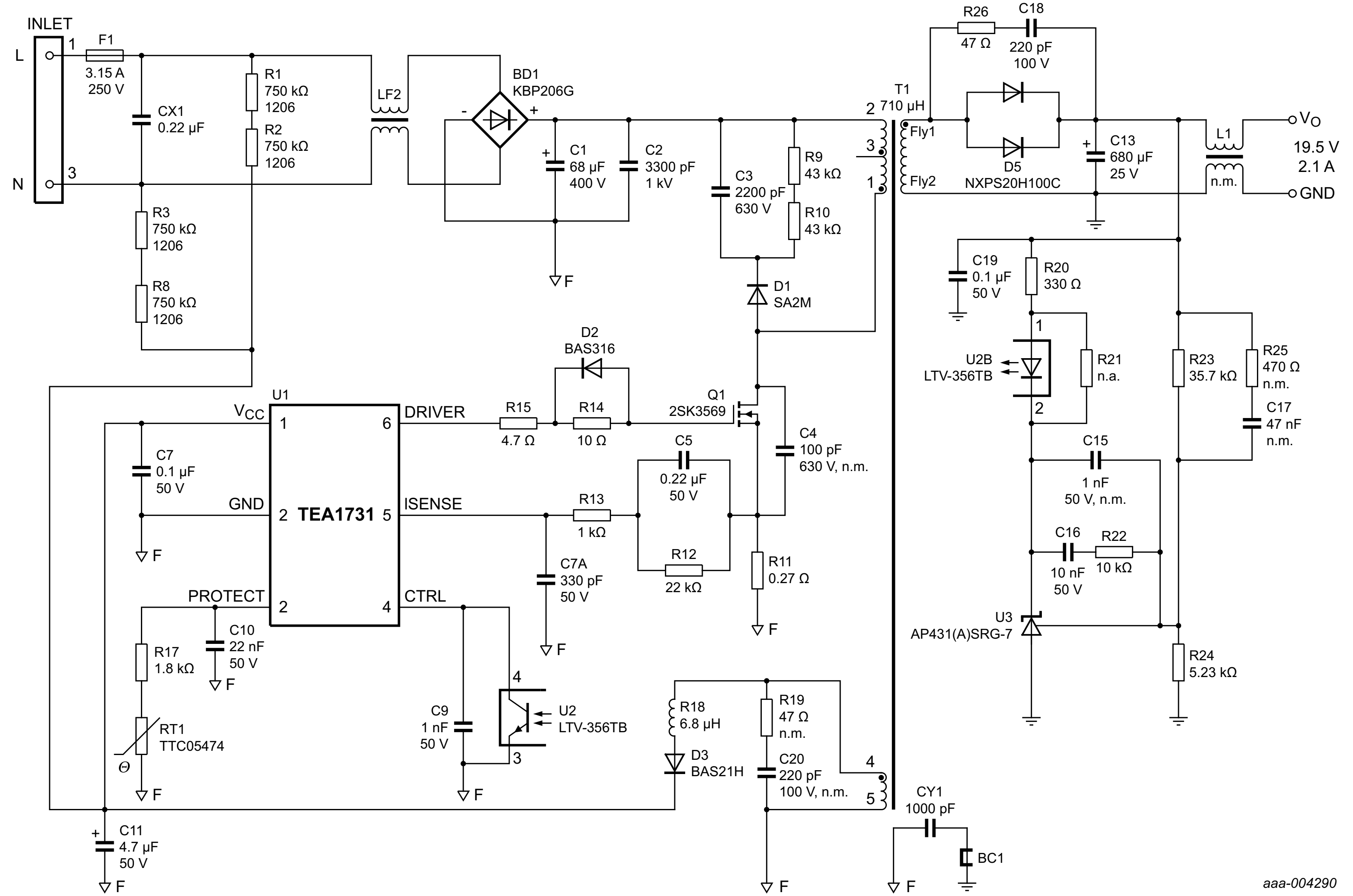


Fig 14. Schematic 40 W TEA1731LTS/TS demo board

6. Bill of materials

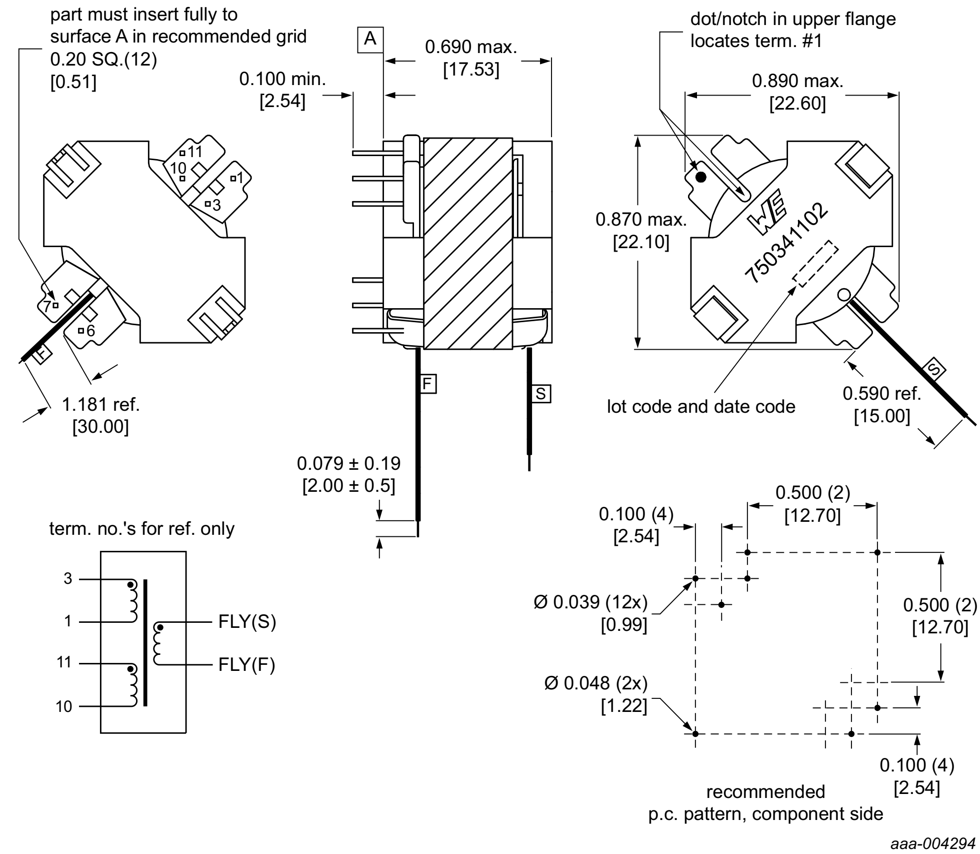
Table 11. Bill of materials

Reference	Description and value	Part number	Manufacturer
BC1	bead	-	-
BD1	bridge diode; 2 A; 600 V; flat/mini	2KBP206G	Lite-On
C1	capacitor; 68 μF; 400 V; 105 °C; electric; radial lead	-	-
C2	capacitor; 3300 pF; 1 kV; MLCC; Z5U; 1206; SMD	-	-
C3	capacitor; 2200 pF; 630 V; MLCC; Z5U; 1206; SMD	-	-
C4	capacitor; not mounted; 100 pF 630 V; MLCC; Z5U; 1206; SMD	-	-
C5	capacitor; 0.22 μF; 50 V; ±10 %; MLCC; X7R; lead free; 0603; SMD	-	-
C7	capacitor; 0.1 μF; 50 V; ±10 %; MLCC; X7R; 0603; SMD	-	-
C7A	capacitor; 330 pF; 50 V; ±10 %; MLCC; X7R; 0603; SMD	-	-
C9	capacitor; 1 nF; 50 V; ±10 %; MLCC; X7R; lead free; 0603; SMD	-	-
C10	capacitor; 22 nF; 50 V; ±10 %; MLCC; X7R; 0603; SMD	-	-
C11	capacitor; 4.7 μF; 50 V; 105 °C; electric; ±20 %; KY/NCC; 5 mm × 11.5 mm	-	-
C13	capacitor; 680 μF; 25 V; 105 °C; electric; ±20 %, KZH; radial lead; 10 mm × 12.5 mm	-	-
C15	capacitor; not mounted; 1 nF; 50 V; ±5 %; MLCC; X7R; 0603; SMD	-	-
C16	capacitor; 10 nF; 50 V; ±10 %; MLCC; X7R; 0603; SMD	-	-
C17	not mounted	-	-
C18	capacitor; 220 pF; 100 V; ±5 %; MLCC; NPO; 0805; SMD	-	-
C20	capacitor; not mounted; 220 pF; 100 V; ±5 %; MLCC; NPO; 0805; SMD	-	-
CX1	×2 capacitor; 0.22 μF; 275 V (AC); 105 °C; 9 mm (L) × 13 mm (H) × 8 mm (W)	P12.5 MKP/R46	KEMET
D1	diode; I_f = 2 A; V_R = 1000 V; t_{rr} = 2 μs; general-purpose diode; MCC; SMT; SMA	SA2M	-
D2	switching diode; I_f = 0.15 A; V_R = 100 V; t_{rr} = 4 ns; SMT	BAS316	NXP Semiconductors
D3	diode; I_f = 0.2 A; V_R = 200 V; t_{rr} = 50 ns; SMT	BAS21H	NXP Semiconductors
D5	Schottky rectifier; I_f = 20 A; V_R = 100 V; V_f = 0.75 V; TO220	NXPS20H100C	NXP Semiconductors
F1	fuse; 3.15 AT; 250 V; DIP; MST; 8.35 mm × 4.3 mm × 7.7 mm	-	-
L1	choke; not mounted; jumper wire × 2; D = 0.6 mm × 5 mm	-	-
LF2	L = 30 mH; u_i = 100000; N = 60	-	-
Q1	n-channel MOSFET; R_{DSon} = 0.5 Ω; $V_{gs(on)}$ = 3 V; I_d = 15 A; C_{iss} = 1600 pf; V_{ds} = 600 V; V_{gs} = ±30 V; TO220	2SK3569	Toshiba
R1	resistor; 750 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-
R2	resistor; 750 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-
R3	resistor; 750 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-
R8	resistor; 750 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-

Table 11. Bill of materials *…continued*

Reference	Description and value	Part number	Manufacturer
R9	resistor; 43 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-
R10	resistor; 43 kΩ; ±5 %; 0.25 W; 1206; SMD	-	-
R11	resistor; 0.27 Ω; ±1 %; 1 W; axial lead	-	-
R12	resistor; 22 kΩ; ±1 %; 0.1 W; 0603; SMD	-	-
R13	resistor; 1 kΩ; ±1 %; 0.1 W; 0603; SMD	-	-
R14	resistor; 10 Ω; ±5 %; 1/8 W; 0805; SMD	-	-
R15	resistor; 4.7 Ω; ±5 %; 1/8 W; 0805; SMD	-	-
R17	resistor; 1.8 kΩ; ±1 %; 0.1 W; 0603; SMD		
R18	choke; 6.8 μH; ±10 %; 210 mA; DCR = 1.69 Ω; SMT; 2.5 mm × 2 mm × 1.8 mm	-	-
R19	resistor; not mounted; 47 Ω; ±5 %; 1/8 W; 0805; SMD	-	-
R20	resistor; 330 Ω; ±5 %; 0.1 W; 0603; SMD	-	-
R21	not mounted	-	-
R22	resistor; 10 kΩ; ±5 %; 0.1 W; 0603; SMD	-	-
R23	resistor; 35.7 kΩ; ±1 %; 0.1 W; 0603; SMD	-	-
R24	resistor; 5.23 kΩ; ±1 %; 0.1 W; 0603; SMD	-	-
R25	not mounted	-	-
R26	resistor; 47 Ω; ±5 %; 1/8 W; 0805; SMD	-	-
RT1	NTC resistor; 470 kΩ; ±5 %; axial lead; D = 5 mm	TTC05474	Thinking Electronic
T1	transformer; L_p = 710 μH; RM8	750341102	Wurth Electronics Midcom
U1	GreenChip SMPS control IC; TSOP6	TEA1731LTS/TS	NXP Semiconductors
U2	optocoupler; CTR = 130 ~ 260 %; 4-pin SOP	LTV-356TB	Lite-On
U3	adjustable precision shunt regulator; SOT23R	AP431(A)SRG7	Diodes Incorporated
cable	cable	16AWG/1571	-
inlet	inlet; 2P	-	-

7. Transformer specification



Tolerances unless otherwise specified:

Angle: ±1°

Fractions: ±1/64

Decimals: ±0.0005 [0.13]

This graphic is two-dimensional. Dimensions in brackets are in millimeters.

Fig 15. Transformer specification

7.1 Electrical characteristics

Table 12. Electrical characteristics

Item	Specification
DC resistance (at 20 °C)	3 to 1; maximum 0.45 Ω
	11 to 10; maximum 0.21 Ω
	Fly(S) - Fly(F); maximum 0.04 Ω
dielectric rating (at 25 °C)	3750 V (AC) for 1 s between primary and secondary
inductance (at 25 °C)	710 μH ±10 %; 63 kHz; 0.1 V; 3 to 1; L_S

Table 12. Electrical characteristics *...continued*

Item	Specification
leakage inductance (at 25 °C)	maximum 10 μH; 100 kHz; 100 mV; 3 to 1 (tie 11 + 10 + Fly(S) + Fly(F)); L_S
turns ratio (at 25 °C)	(3 to 1) : (11 to 10) = 5.27 : 1 ±2 % (3 to 1) : (Fly(S) to Fly(F)) = 5.80 : 1 ±2 %

7.2 Winding specification

Table 13. Winding specification

Wire/Material		Winding data					Insulation	
		Turns	Layers	Turns/Layer	Start	Finish	After winding	Sleeving
N0			1				tape 1 T	
N1	0.25 ∅ mm × 2	30	2	15/15	3	A	tape 1 T	Teflon
N2[3]	0.025T × 7 mm[1]	1	1	1	-	10	tape 1 T	Teflon
N3	0.6 ∅ mm × 1[2]	10	1	10	FLY1 (top)[4]	FLY2 (bottom)[4]	tape 1 T	Teflon
N4	0.15 ∅ mm × 3	11	1	11	11	10	tape 1 T	Teflon
N5[3]	0.025T × 7 mm[1]	1	1	1	-	10	tape 1 T	Teflon
N6	0.25 ∅ mm × 2	28	2	14/14	A[5]	1	tape 1 T	Teflon
N7[3][6]	7 mm × 12 mm	1PAD	1	1PAD	-	10	tape 1 T	Teflon

[1] Copper foil.

[2] N3 is triple insulated wire.

[3] N2, N5 and N7 copper foil connected with 0.15 ∅ × 3 lead wire.

[4] FLY1 (top): 15 mm (bare copper: 2 mm); FLY2 (bottom): 30 mm (bare copper: 2 mm).

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

[6] 3M #1181

7.3 Part number and vendor

- Part number: 750341102
- Company: Würth Elektronik

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8. Layout 40 W TEA1731LTS/TS demo board

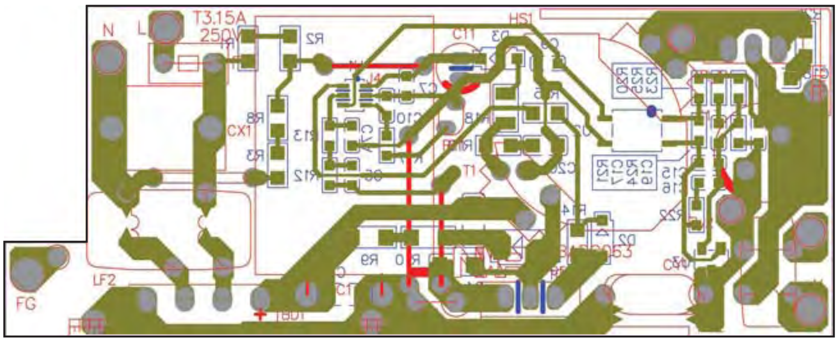

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Fig 16. Copper layout bottom side (top view)

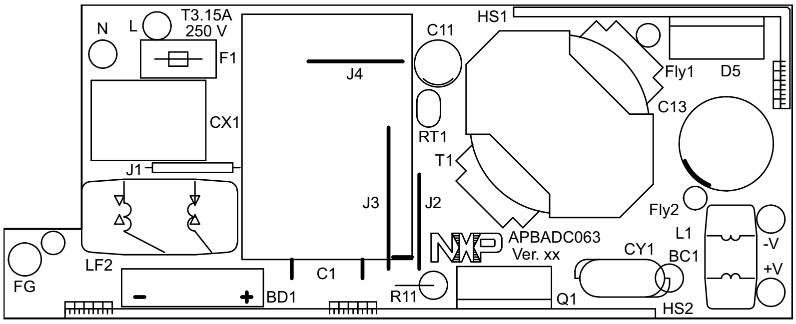

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Fig 17. Component placing top side (top view)

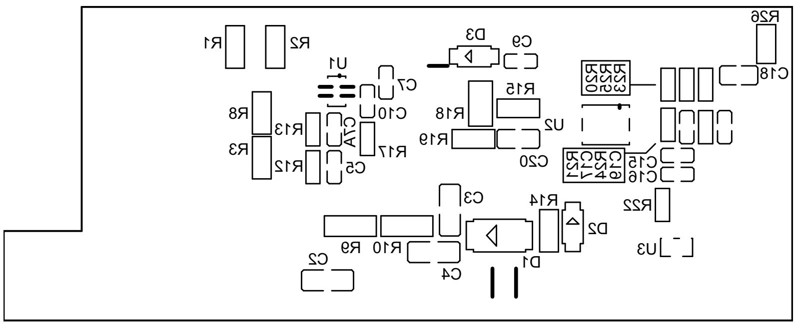

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Fig 18. Component placing bottom side (top view)

9. Alternative circuit options

9.1 Changing the output voltage

The output voltage can be changed (±30 %) by changing the following components. See the *TEA1731LTS/TS application note* for more information on this topic. Make sure that the auxiliary voltage remains within its operation limits (12.5 V to 30 V) and it is high enough to start up (21.3 V).

R23/R24:

The resistor divider (R23 and R24) determines the output voltage.

$$V_O = 2.5\ V \cdot \frac{(R23 + R24)}{(R24)}$$

C13:

Select a voltage rating of the 1

electrolytic capacitor that is higher than the output voltage. Decrease the capacity for lower output currents.

9.2 High/low line compensation

The amount of compensation can be changed by changing the value of capacitor C7A between 100 pF and 470 pF. See the *TEA1731LTS/TS application note* for additional information on this topic.

10. Legal information

10.1 Definitions

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11. Contents

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