



UM10758

TEA1836DB1094 TEA1836XT + TEA1792T 65 W notebook adapter

Rev. 1 — 4 December 2013

User manual

Document information

Info	Content
Keywords	TEA1836DB1094, TEA1836XT, very low standby power consumption, high peak power, active X-cap discharge, burst mode operation, flyback converter, 65 W, notebook adapter, controller, converter, power supply, demo board
Abstract	<p>The TEA1836XT is a high-featured low-cost DCM/QR flyback converter controller. It provides high efficiency at all power levels including very low no-load power consumption at nominal output voltage in burst mode operation.</p> <p>To minimize the risk of audible noise, burst mode operation is included for the low load range. Switching in the audible frequency range is limited and peak currents are low.</p> <p>The TEA1836XT is intended for power supplies up to 75 W with extra high peak power capabilities to enable supplying high peak power equipment without requiring a PFC.</p> <p>This document describes the 65 W notebook adapter demo board with the TEA1836XT and TEA1792TS. The demo board provides an output of 19.5 V/3.34 A.</p> <p>The average efficiency is above 91 % and the no-load power consumption is below 30 mW.</p>



Revision history

Rev	Date	Description
v.1	20131204	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.

1.1 Scope of this document

This document describes the 65 W notebook adapter TEA1836DB1094 demo board using the TEA18361T and TEA1792TS. It contains a set of measurements that shows the main characteristics.

1.2 TEA1836XT

The TEA1836XT is a controller IC for low-cost Switched Mode Power Supplies (SMPS) intended for flyback topologies. The built-in green functions provide high efficiency at all power levels.

At high power levels the flyback operates in QR mode. When lowering the power levels, the controller switches to DCM or Frequency Reduction (FR) mode. The peak current is reduced to 25 % of the maximum peak current.

At low power levels, when the flyback switching frequency reaches 25 kHz, the flyback converter switches to burst mode. To ensure high efficiency at low power and excellent no-load power performance, a burst mode has been integrated that reduces the optocurrent to a minimum level. As the switching frequency in this mode has a minimum value of 25 kHz while the burst frequency is always below 800 Hz, the frequencies are outside the audible range.

During the non-switching phase of the burst mode, the internal IC supply current is reduced to further optimize efficiency.

Valley switching is used in all operating modes.

The TEA1836XT includes an OverPower Protection (OPP). The OPP enables the controller to deliver 150 % peak power for a limited amount of time (200 ms) in case of overpower situations. If the output is shorted, the output power is limited to 100 % to keep the average power consumption lower than 5 W.

The TEA1836XT is realized in a high-voltage SOI (Silicon-On-Insulator) process. This process combines the advantages of a low-voltage process, like accuracy, high-speed protection functions, and control, while maintaining the high-voltage capabilities like high-voltage start-up and integrated X-cap discharge.

The TEA1836XT enables low-cost, highly efficient and reliable supplies for power requirements up to 75 W to be designed easily and with a minimum number of external components.

1.3 TEA1792TS

The TEA1792TS is a member of the generation of Synchronous Rectifier (SR) controller ICs for switched mode power supplies. Its high level of integration enables the design of a cost-effective power supply with a very low number of external components.

The TEA1792TS is a controller IC dedicated to synchronous rectification on the secondary side of discontinuous conduction mode and quasi-resonant flyback converters

1.4 Setup of the 65 W notebook adapter

The board is designed for universal mains (90 V (AC) to 264 V (AC)). When a DC input voltage is applied, the power consumption is higher due to continuous activation of the X-capacitor discharge function.

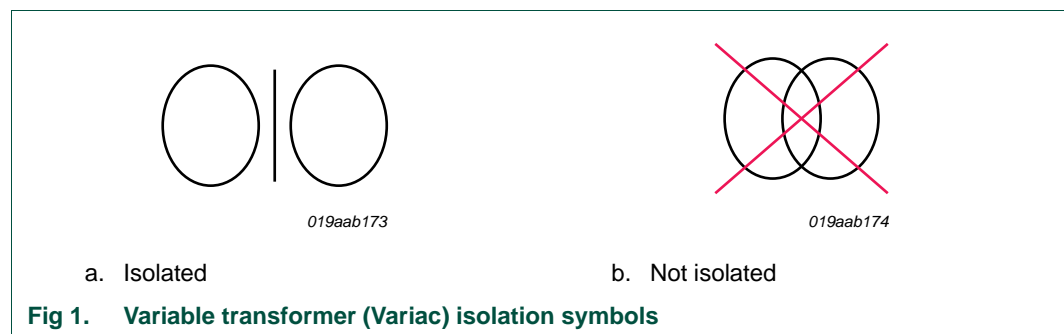
The demo board incorporates two subcircuits:

- A DCM/QR type flyback converter
- A Synchronous Rectifier (SR)

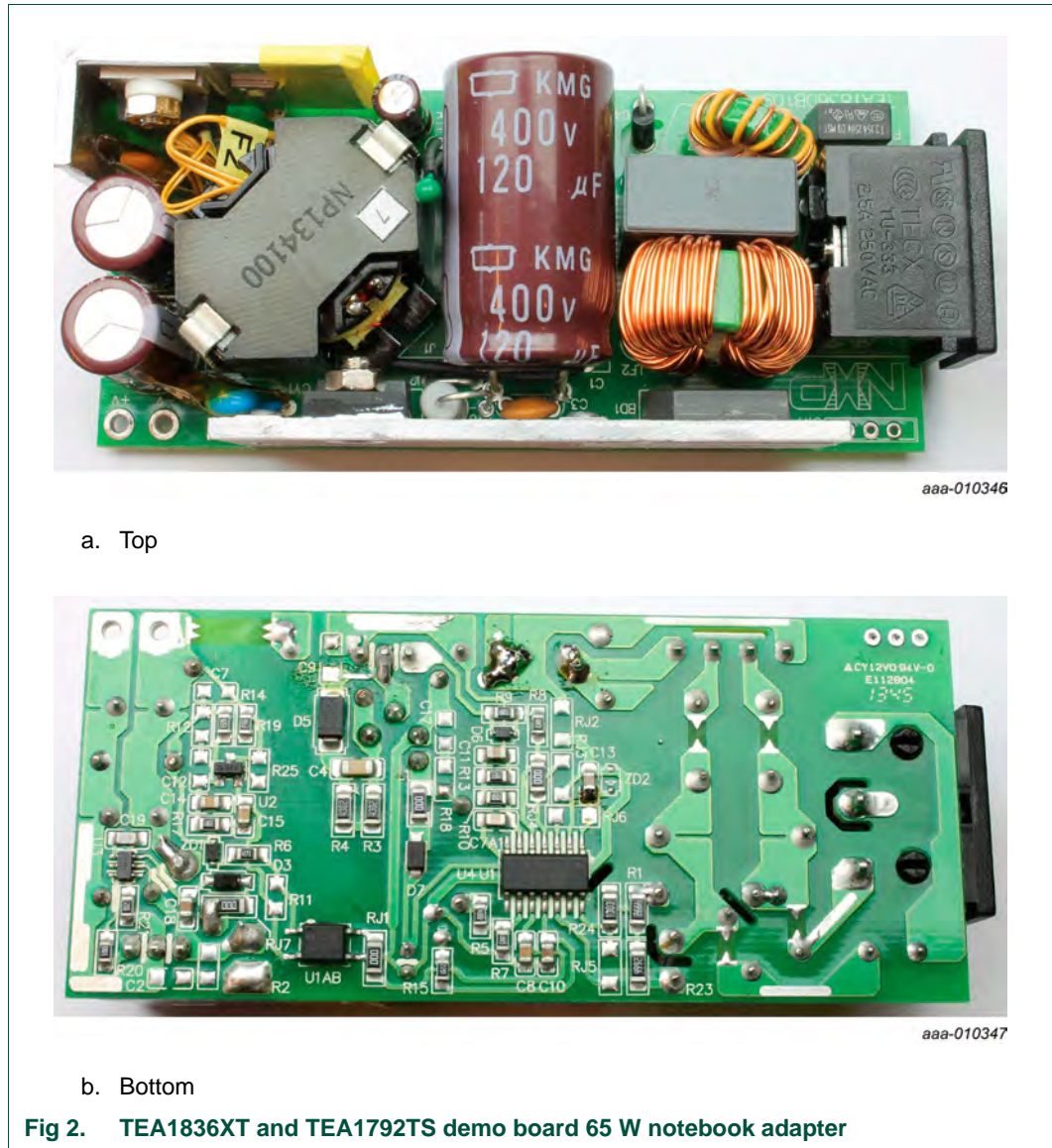
The purpose of the demo board is to show the operation of the TEA1836XT and TEA1792TS in a single output supply. The performance is according today's general standards including the DoE + CoC efficiency requirements. It can be used as a starting point for further product development.

2. Safety warning

The board must be connected to the mains voltage. Touching the board during operation must be avoided at all times. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. A galvanic isolation of the mains phase using a variable transformer is always recommended. [Figure 1](#) shows the symbols by which these devices can be recognized.



3. Board photographs



4. Specifications

Table 1. Input specification

Symbol	Description	Conditions	Value
V_i	input voltage		90 V to 264 V
f_i	input frequency		47 Hz to 64 Hz
$P_{i(\text{no-load})}$	no-load input power	at 230 V/50 Hz	< 30 mW

Table 2. Output specification

Symbol	Description	Condition	Value
V_o	output voltage		19.5 V
I_o	output current		0 A to 3.33 A
$I_{o(\text{peak})}$	peak output current	for 200 ms at $V_i = 90$ V at 60 Hz	5 A
t_{hold}	hold time	at 115 V/60 Hz; full load	> 10 ms
-	line regulation		± 1 %
-	load regulation		± 1 %
t_{startup}	start-up time	at 115 V/60 Hz	≤ 1 s
η	efficiency	DoE: > 88.5 % at cable end (including 0.5 % margin); CoC: > 89.5 % at cable end (including 0.5 % margin)	≥ 90 %
-	ElectroMagnetic Interference (EMI)	CISPR22 compliant	pass

5. Measurements

5.1 Test facilities

- Oscilloscope: Yokogawa DL9140L
- AC Power Source: Agilent 6812B
- Electronic load: Agilent 6063B
- Digital power meter: Yokogawa WT210

5.2 Efficiency

Efficiency measurements are performed at stabilized conditions. The output voltage and output current is measured directly at the PCB connector. Measurements are done for 115 V/60 Hz and 230 V/50 Hz. [Table 3](#) shows the average value of 10 boards.

Table 3. Efficiency results

Condition	ENERGY STAR 2.0 efficiency requirement (%)	Average	100 % load	75 % load	50 % load	25 % load
115 V/60 Hz	> 87	91.3	91.0	91.6	91.6	91.0
230 V/50 Hz	> 87	91.4	92.2	91.7	91.3	90.5

5.3 Standby power consumption

Power consumption performance of the total application board without load connected was measured with a Yokogawa WT210 digital power meter. Integration time was set to 5 minutes to measure the average dissipated power.

Measurements were performed for 115 V/60 Hz, 230 V/50 Hz, and 264 V/50 Hz. [Table 4](#) shows the average value of 10 boards.

Table 4. Standby power consumption: No-load

Condition	ENERGY STAR 2.0 requirement (mW)	No-load power consumption (mW)
115 V/60 Hz	≤ 300	21
230 V/50 Hz	≤ 300	24
264 V/50 Hz	≤ 300	27

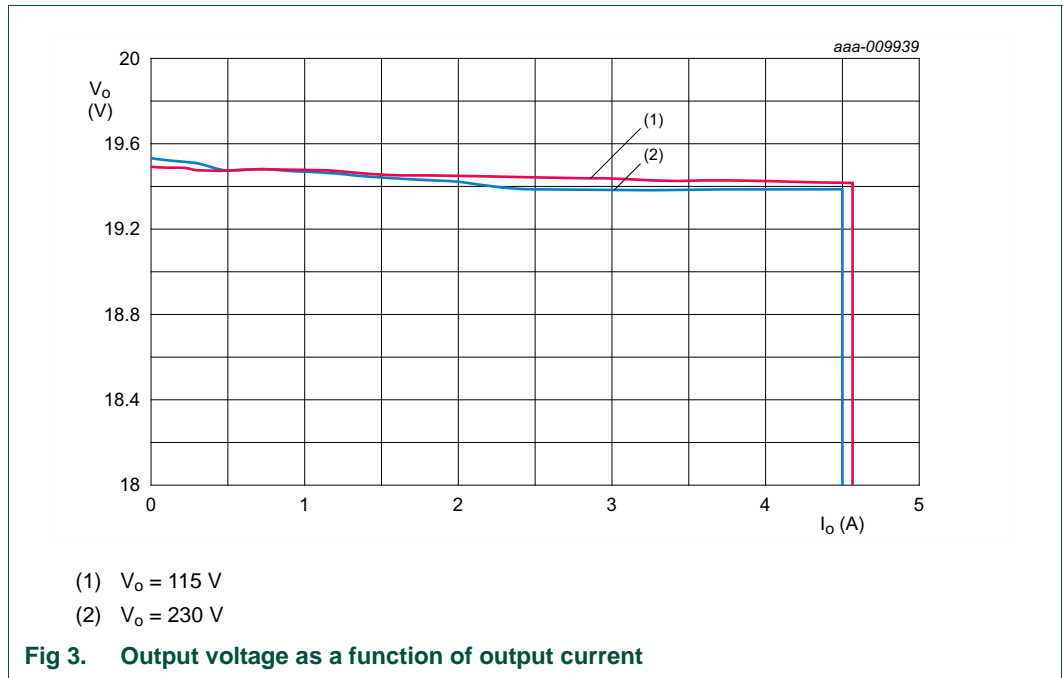
5.4 Current for changing between normal and burst mode operation

Table 5. Current for changing between normal and burst mode operation

Condition	115 V/60 Hz	230 V/50 Hz
From normal mode to burst mode operation		
current (A)	0.630	0.725
power (W)	12.3	14.1
From burst mode to normal mode operation		
current (A)	0.425	0.460
power (W)	8.3	9.0

5.5 Load regulation

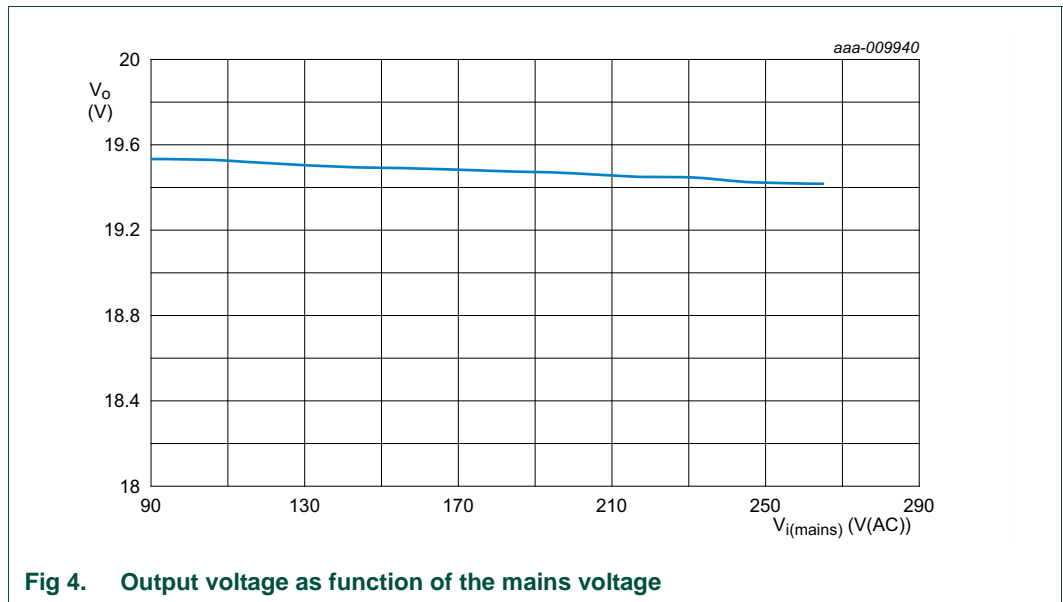
The output voltage versus load current was measured at the PCB connector.



5.6 Line regulation

The output voltage versus mains input voltage was measured directly at the output connector for nominal load condition (3.34 A).

The values remain within the target of $19.5\text{ V} \pm 1\%$.



5.7 Output voltage regulation in standby mode

The output voltage regulation during no load operation was measured for 90 V/60 Hz and 264 V/50 Hz.

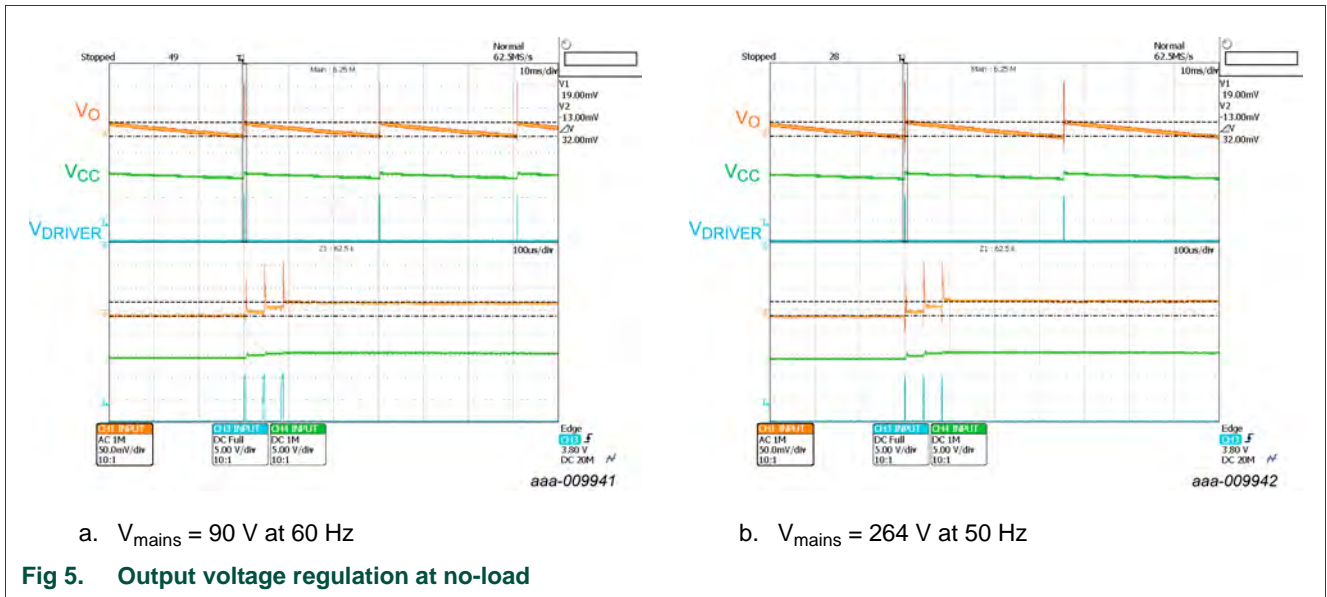
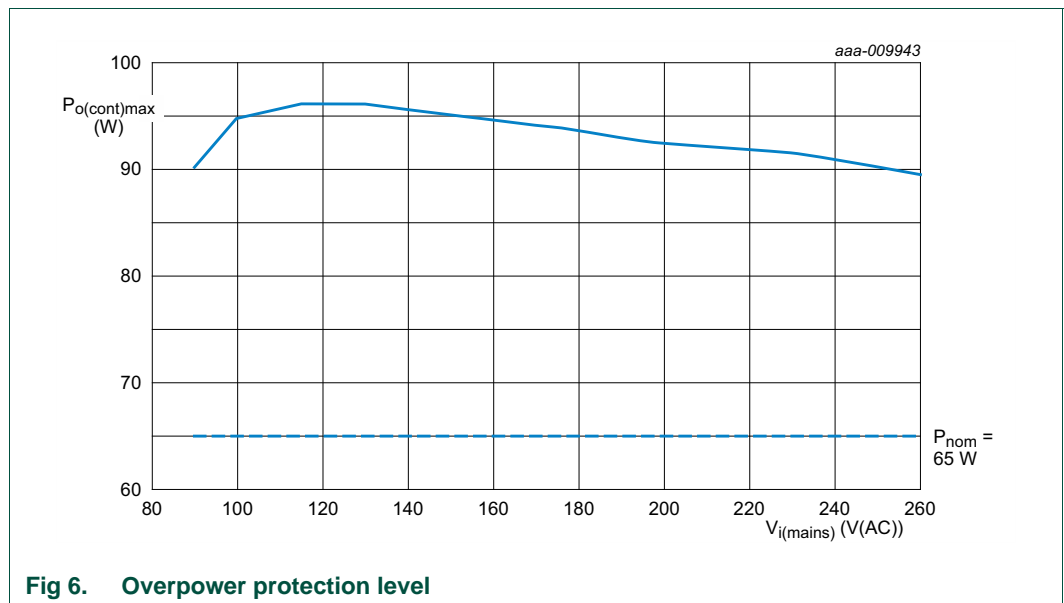


Table 6. Output voltage ripple at no-load condition

Symbol	90 V/60 Hz	230 V/50 Hz
$V_{ripple} \text{ (mV)}$	32	32

5.8 OverPower Protection (OPP)

The continuous maximum peak output power was measured directly at the output connector for various mains input voltages. When this level is exceeded, the protection (stop and restart) is activated after the internal overpower counter passes 200 ms.



5.9 Voltage on pin VCC

Table 7. VCC voltage

Condition	115 V/60 Hz	230 V/50 Hz
no-load	14.7	14.7
nominal load	18.3	16.8

5.10 Brownout and start-up level

Table 8. VCC voltage

Condition	Brownout (V)	Start level (V)
no-load	77	84
nominal load	77	84

5.11 Short circuit protection

Output short circuit directly at the PCB connectors before switching on the mains voltage or during operation. The system protects and restarts continuously during the short circuit condition.

Table 9. Behavior during output short circuit condition

Condition	Behavior
output short before applying AC mains voltage	restart
output short circuit during operation at full load and no-load	restart

Table 10. Input power at output short circuit condition

Condition	90 V/60 Hz	230 V/50 Hz	264 V/50 Hz
input power	0.71 W	0.56 W	0.58 W

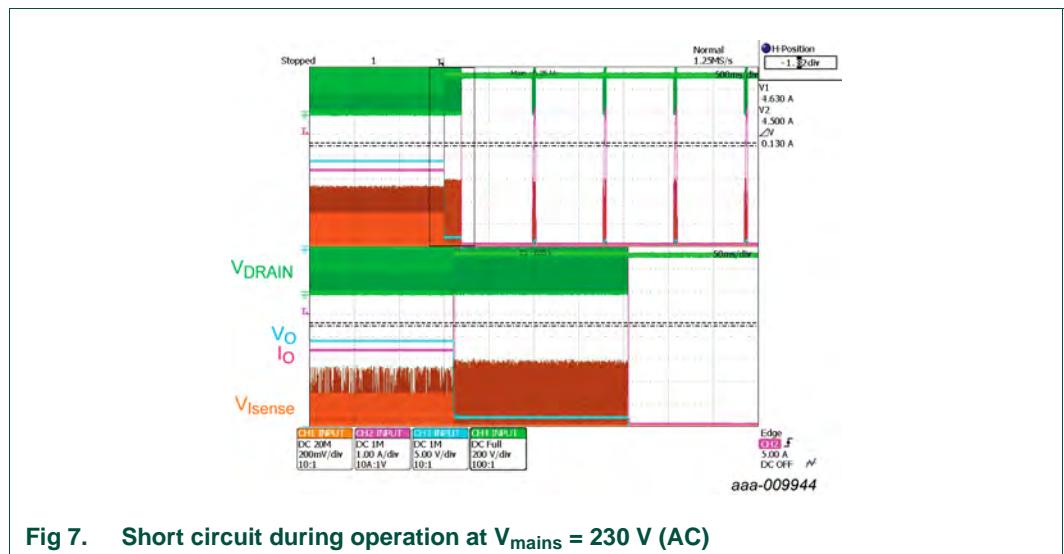


Fig 7. Short circuit during operation at $V_{mains} = 230\text{ V (AC)}$

5.12 Overvoltage protection

Applying a short circuit across the opto-LED of the optocoupler (U1B; see Figure 20) creates an output overvoltage condition. The overvoltage protection is triggered when the AUX pin voltage increases to 3 V during the OVP detection interval. The output voltage was measured directly at the output connector for both a nominal load (3.34 A) and a no-load condition.

Table 11. Maximum output voltage at OVP

Condition	115 V/60 Hz	230 V/50 Hz
no-load	25.6 V	25.6 V
nominal load (3.37 A)	25.1 V	25.1 V

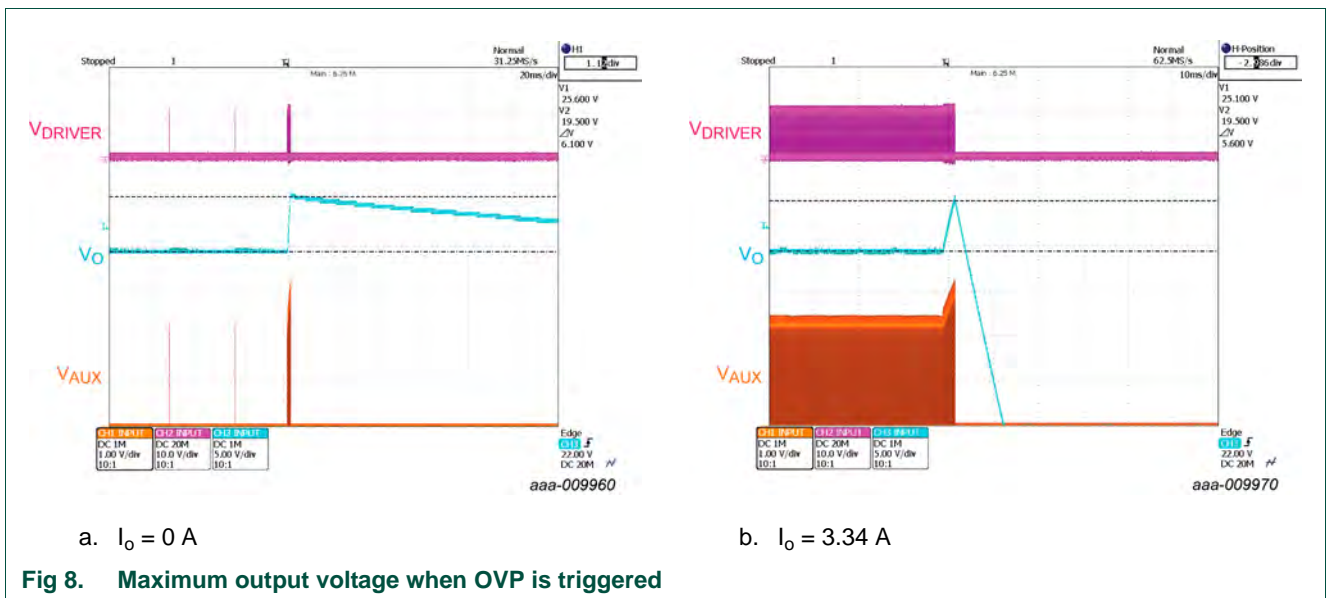


Fig 8. Maximum output voltage when OVP is triggered

5.13 Start-up time

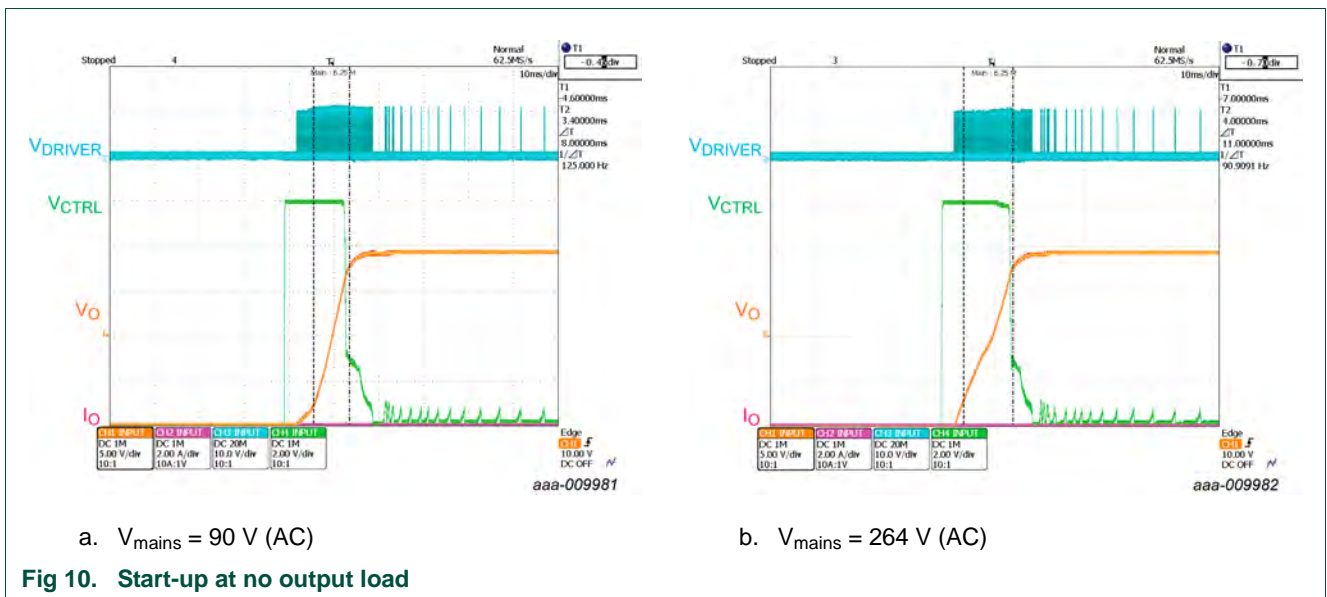
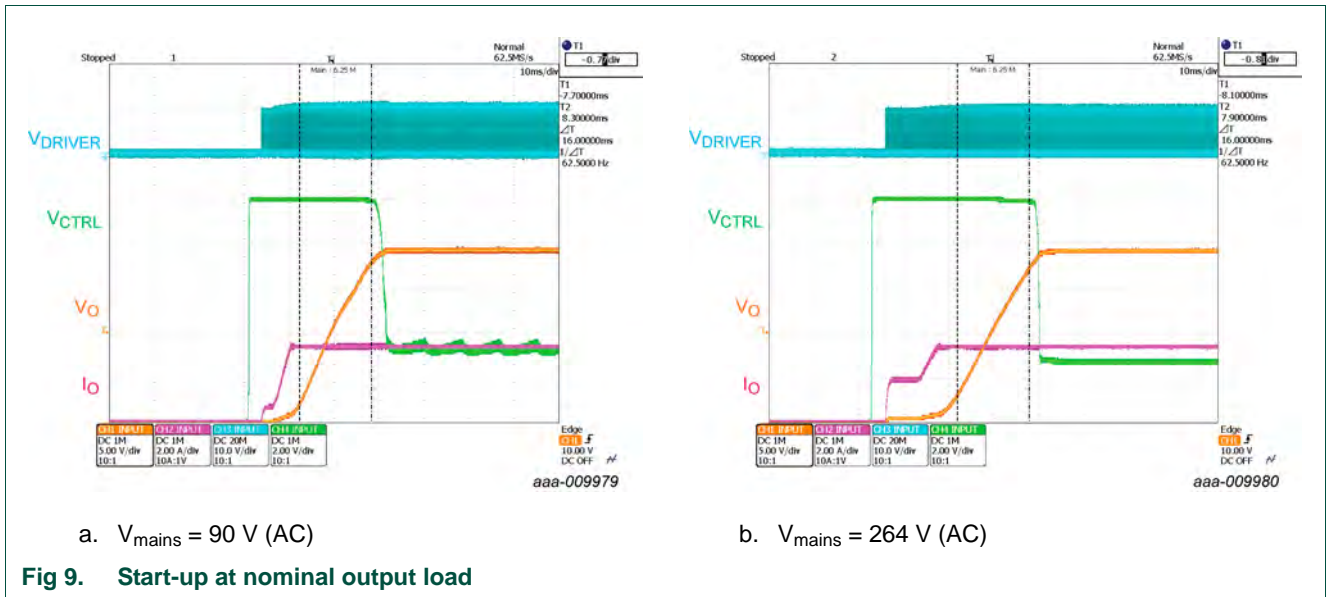
This is the time between the mains voltage switching on and the nominal output power available at the output.

Table 12. Start-up time

Condition	Start-up time
90 V/60 Hz	400 ms
115 V/60 Hz	300 ms
230 V/50 Hz	150 ms

5.14 Start-up profile

The shape of the output voltage during start-up was measured for 90 V/60 Hz and 264 V/50 Hz directly at the output connector for a no-load and a nominal load (3.34 A) condition.



5.15 Hold-up time

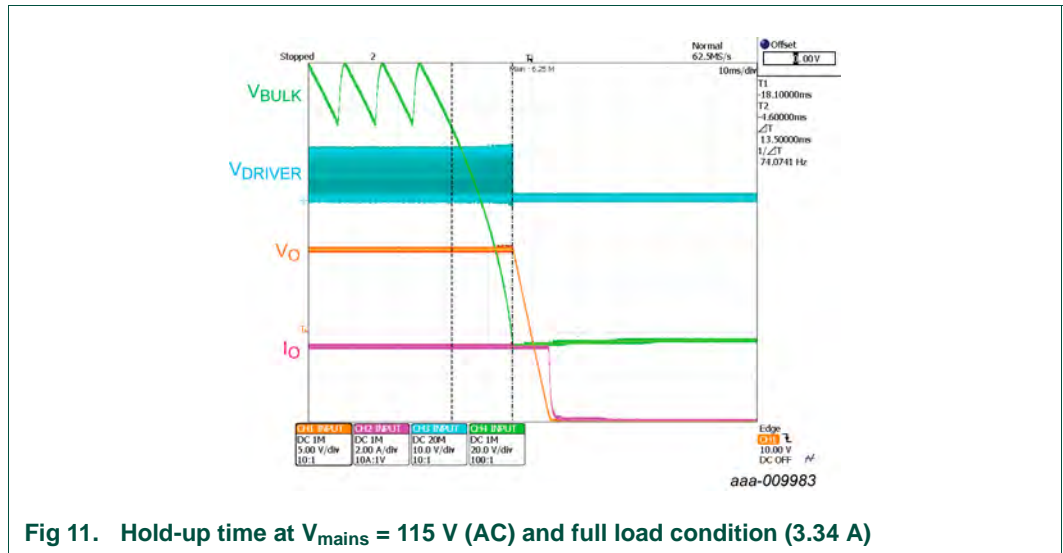
The hold-up time is defined as the time between the following moments:

- After mains switch-off: The moment that the lowest bulk capacitor voltage during a mains cycle is crossed.
- The moment that the output voltage starts to decrease.

The hold-up time is measured for 115 V/60 Hz for a full load (3.34 A) condition. The output voltage was measured directly at the output connector.

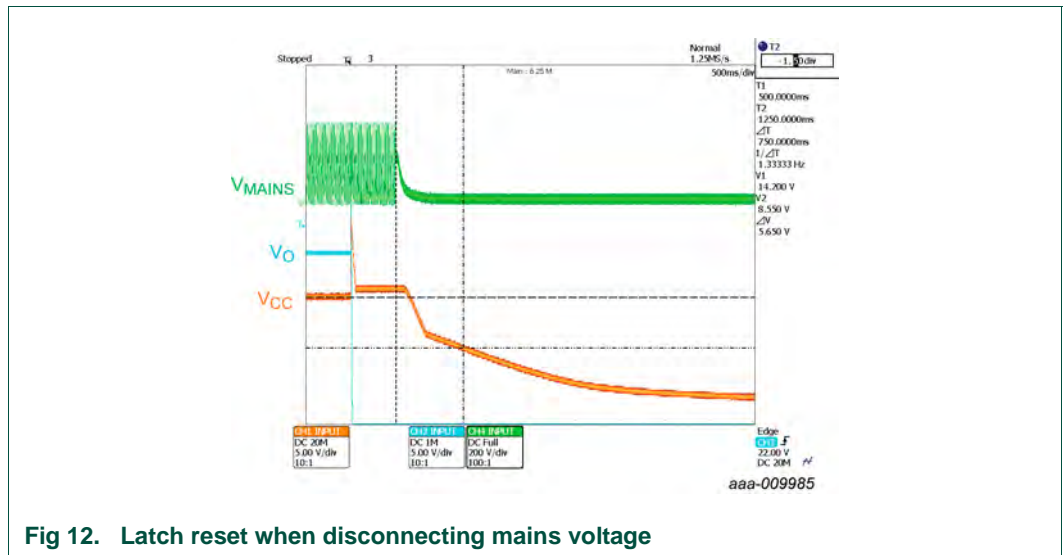
Table 13. Hold-up time

Condition	Hold-up time
115 V/60 Hz	13.5 ms



5.16 Fast latch reset

The fast latch reset time was measured. The fast latch reset time is the time that the voltage on pin VCC requires to drop to the reset level (8.65 V typical) when the mains voltage is disconnected. It is 750 ms.



5.17 X-capacitor discharge time

Unplug the power line at no-load condition and measure the discharge time at the X-capacitor (330 nF).

The discharge time is the time between the moment of disconnecting the mains source and the moment when the voltage reaches a defined voltage value.

Table 14. X-capacitor discharge time test results

Condition	from $264 \text{ V} * \sqrt{2}$ to 135 V	from $264 \text{ V} * \sqrt{2}$ to 60 V
X-capacitor discharge time	55 ms	145 ms

Remark: The discharge can start 100 ms later (worse case) than measured and shown because in burst mode operation the mains measurement interval is approximately 100 ms ($t_{wait(burst)HV}$).

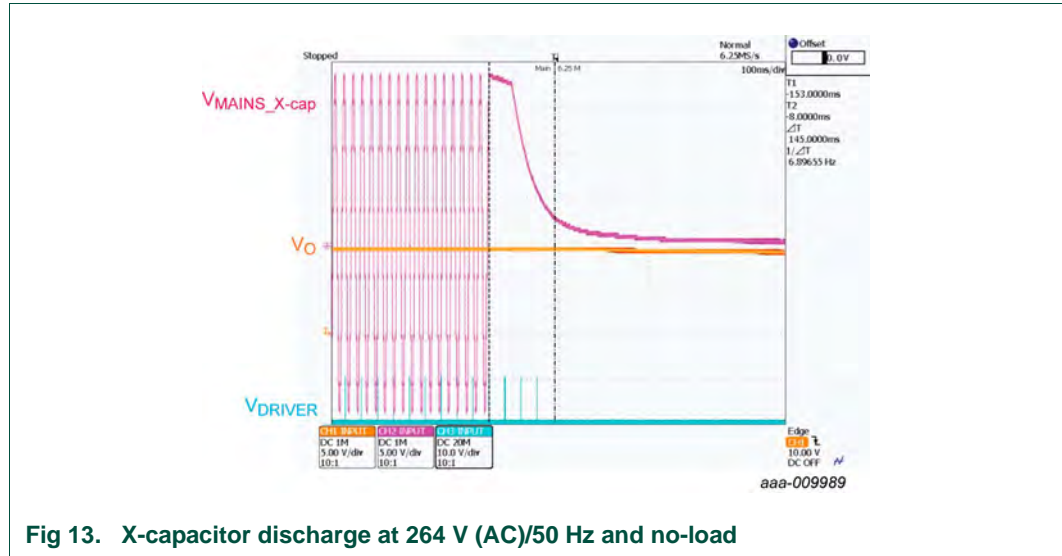


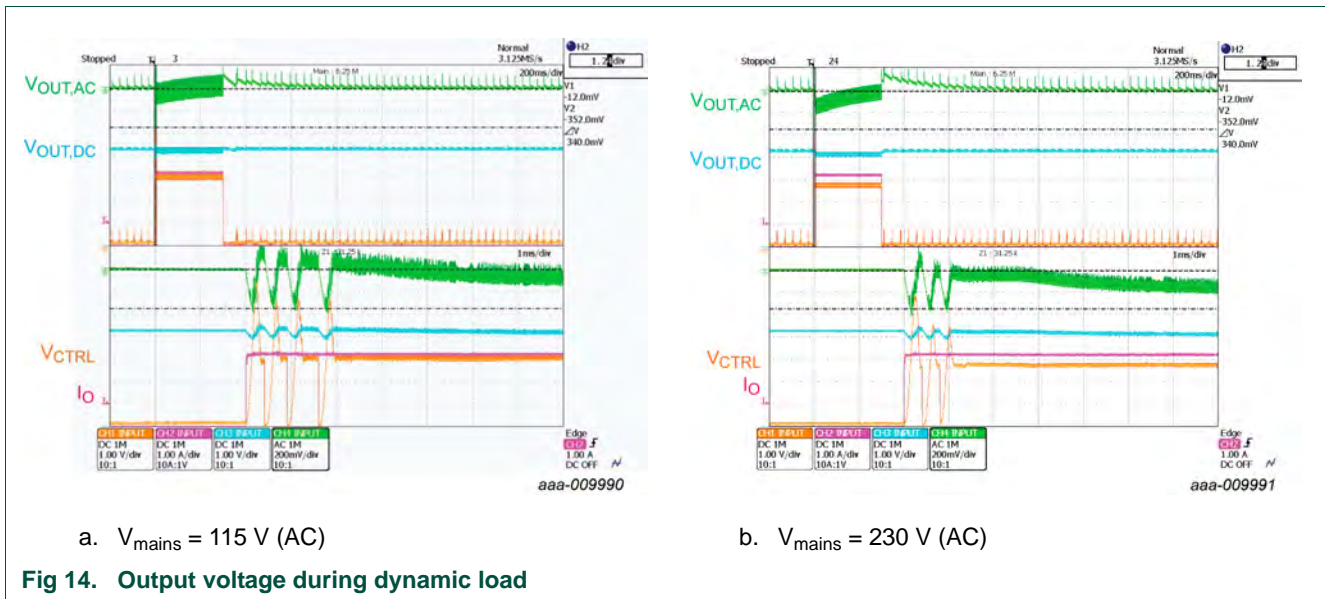
Fig 13. X-capacitor discharge at 264 V (AC)/50 Hz and no-load

5.18 Dynamic load

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

Table 15. Maximum output voltage in case of OVP

Condition	Load	Output voltage ripple (mV)
115 V/60 Hz	I_o : 0 % to 100 %	340
230 V/50 Hz	I_o : 0 % to 100 %	340



a. $V_{mains} = 115 \text{ V (AC)}$

b. $V_{mains} = 230 \text{ V (AC)}$

Fig 14. Output voltage during dynamic load

5.19 Output ripple

Output ripple was measured at the end of the cable using a standard filter of 1 μ F + 100 nF on the probing position. Output ripple and noise was measured at nominal output current (3.34 A) and at no-load condition (0 A).

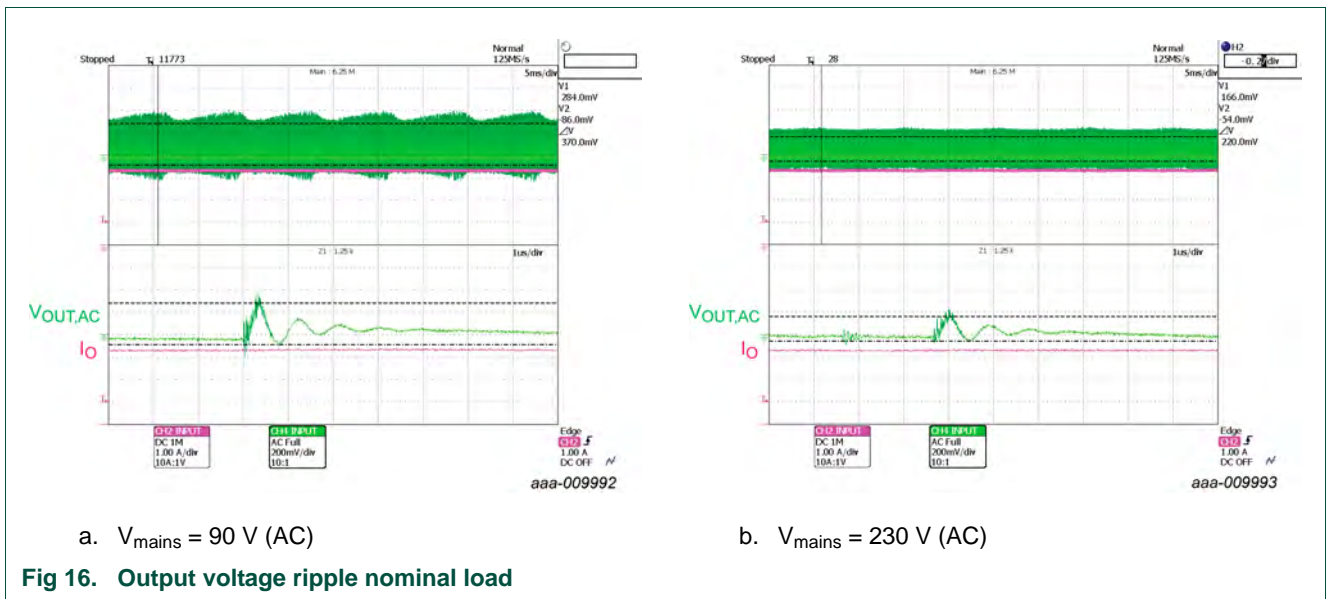
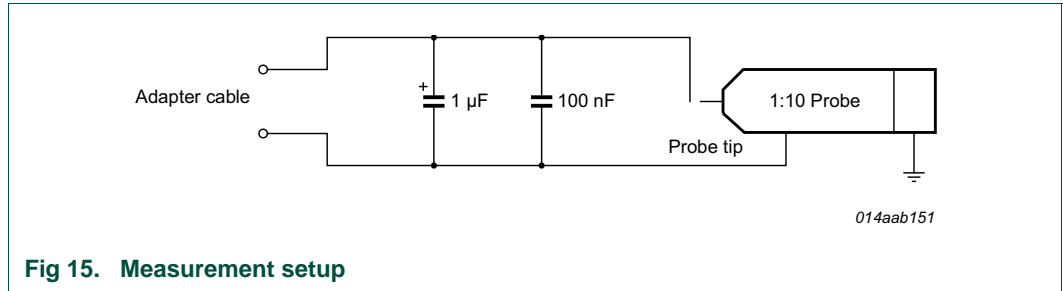


Table 16. Output voltage ripple at nominal load

Condition	peak-to-peak output voltage ripple and noise
90 V/60 Hz	370 mV
230 V/50 Hz	220 mV

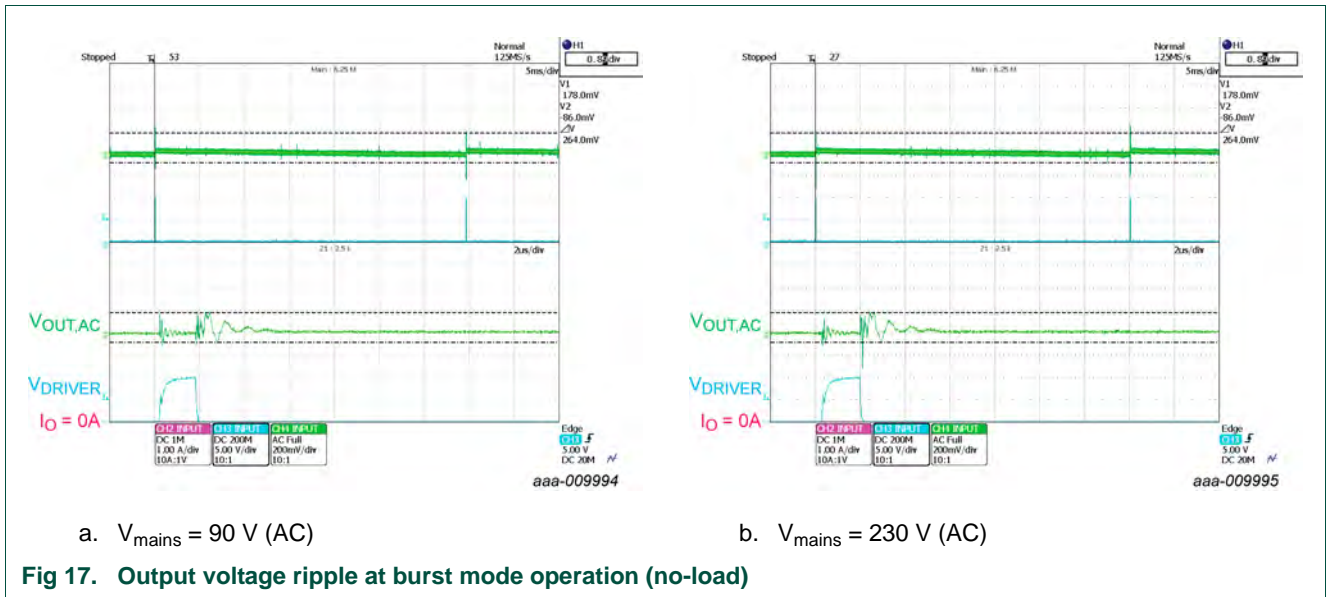


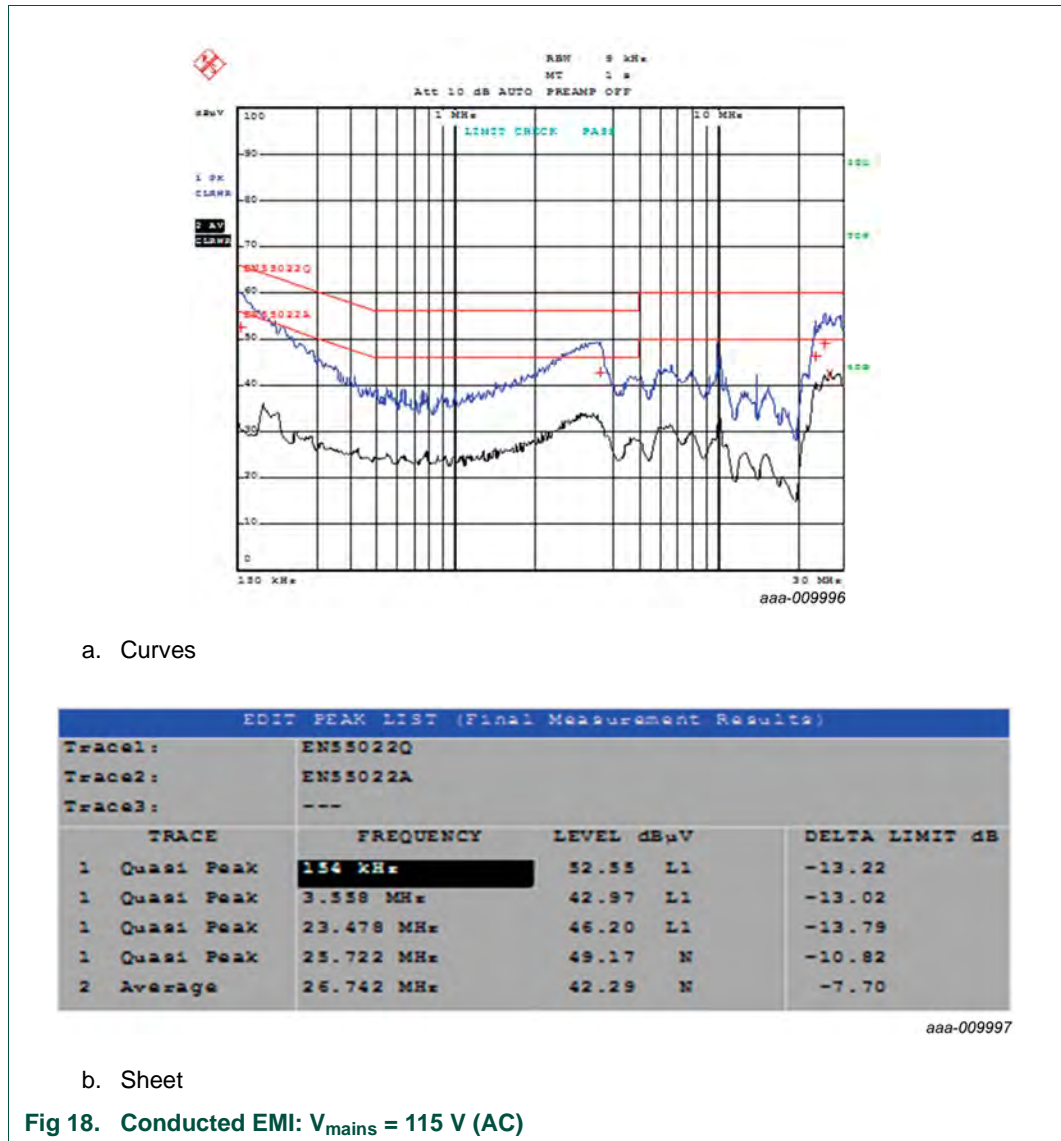
Table 17. Output voltage ripple at no-load

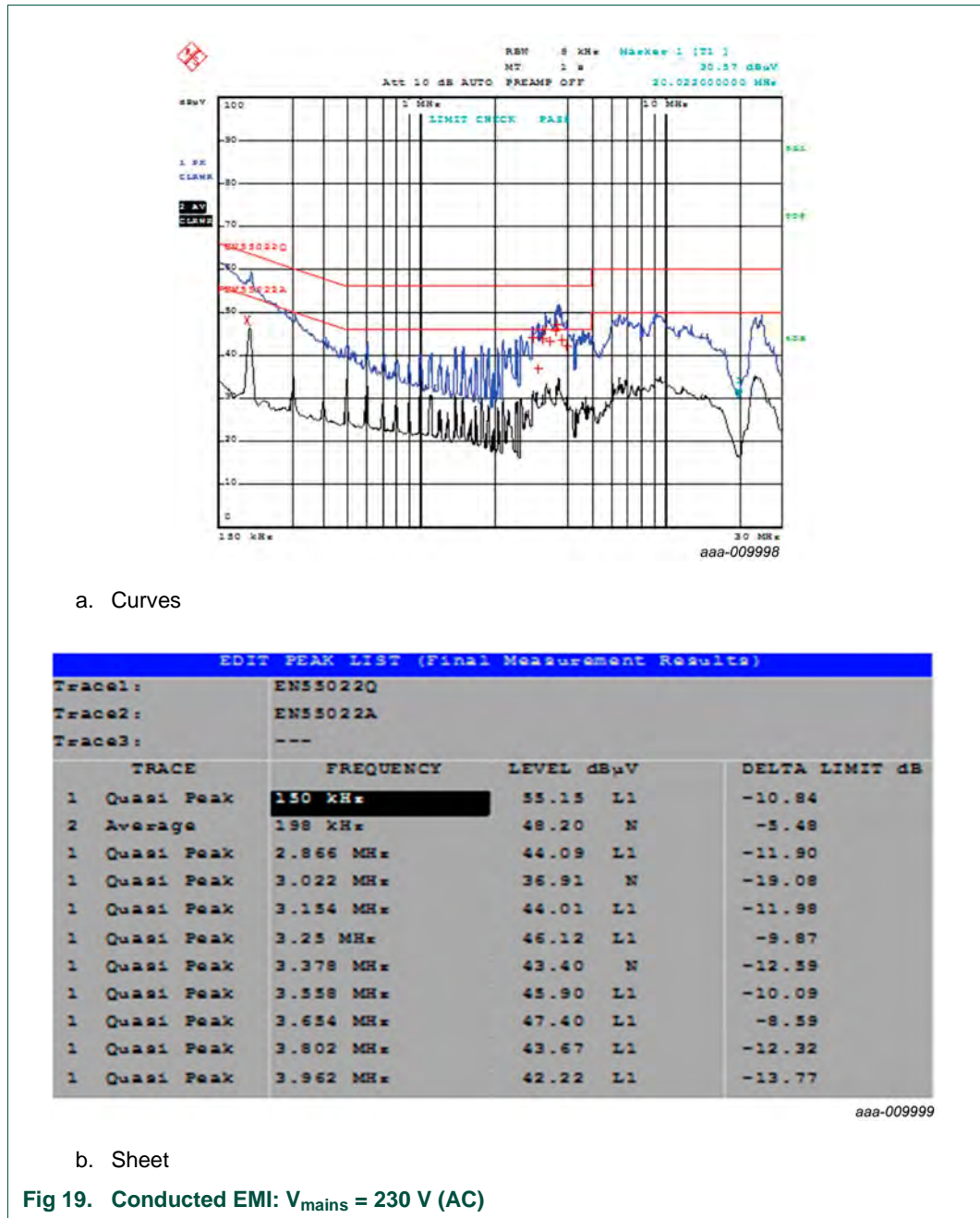
Condition	peak-to-peak output voltage ripple and noise
90 V/60 Hz	264 mV
230 V/50 Hz	264 mV

5.20 EMI performance

Conditions:

- Type: Conducted EMI measurement
- Frequency range: 150 kHz to 30 MHz
- Output power: Full load condition
- Supply voltage: 115 V and 230 V





6. Schematic

Figure 20 shows a set of functional jumper positions that is present on the demo board. By mounting a configuration of jumpers, the demo board can be used for a SO8 or a SO14 package of the TEA1836XT. The table shows the jumpers that require to be mounted for the preferred package. The demo board is standard equipped with a SO14 package and configuration.

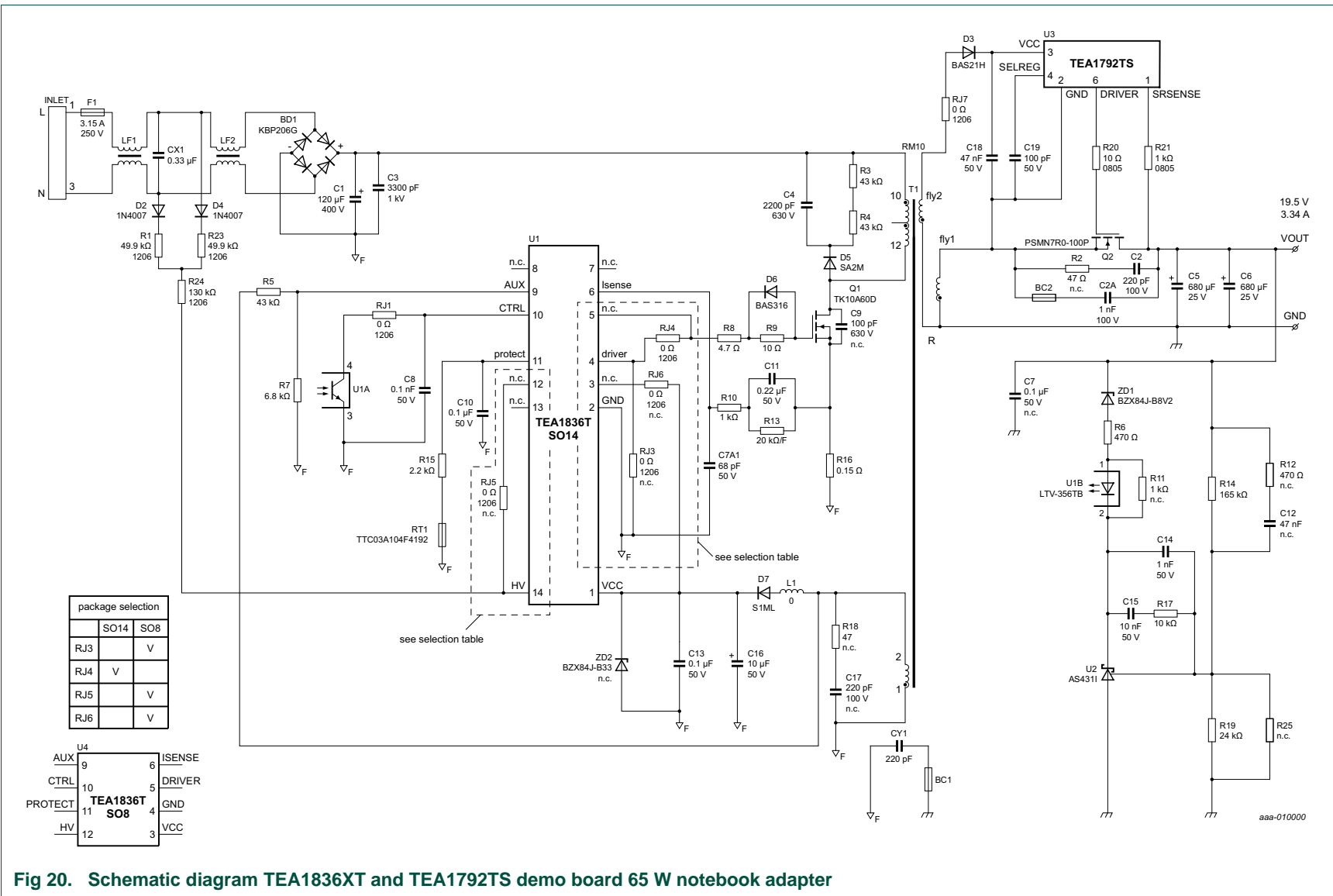
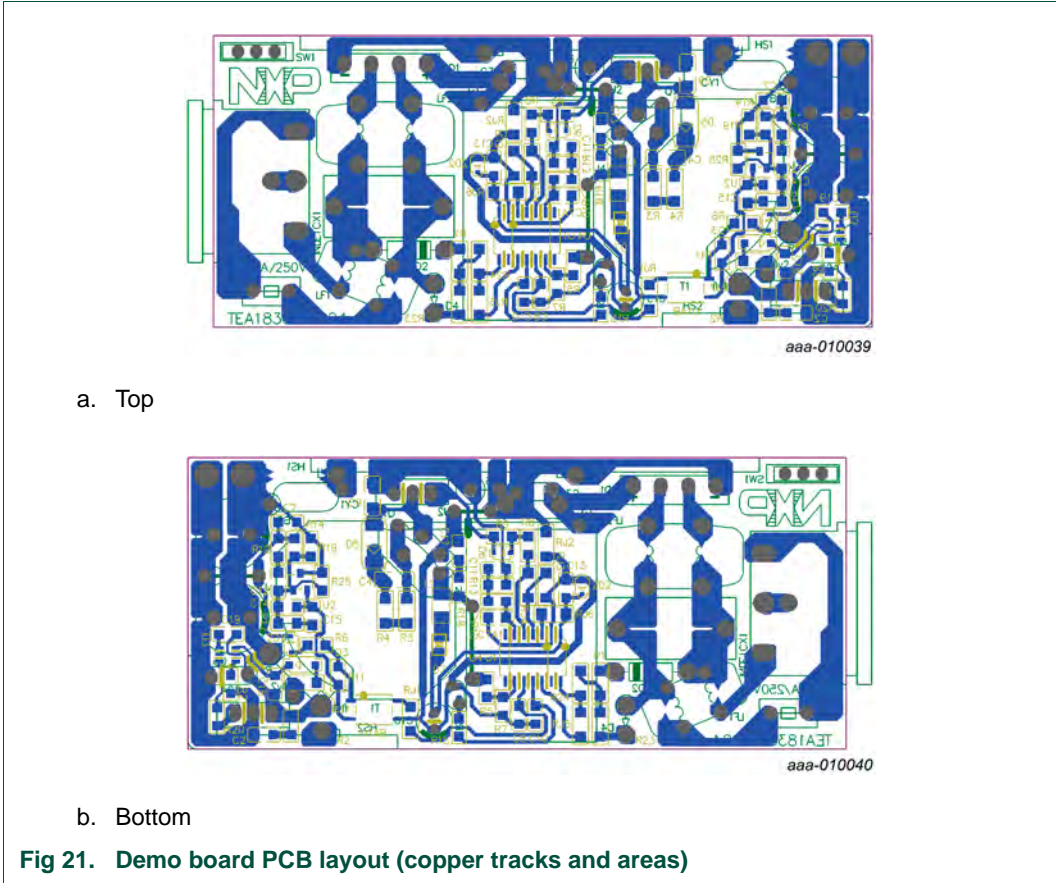


Fig 20. Schematic diagram TEA1836XT and TEA1792TS demo board 65 W notebook adapter

7. PCB layout



8. Bill Of Material (BOM)

Table 18. TEA1836DB1094 bill of material

Reference	Description and values	Part number	Manufacturer
BC1; BC2	bead	-	-
BD1	bridge diode; flat/mini; 2 A; 600 V	2KBP206G	LiteOn
C1	capacitor; 120 μ F; 400 V; 105 $^{\circ}$ C; 18 mm \times 30 mm;	-	KMG/NCC
C2	capacitor; not connected; 220 pF; 100 V; \pm 5 %; 0805; NPO; RoHS compliant	-	-
C2A	capacitor; leaded type; 1 nF; 100 V	-	-
C3	capacitor; DIP; 3300 pF; 1 kV	-	-
C4	capacitor; MLCC; 2200 pF; 630 V; 1206; Z5U	-	-
C5; C6	capacitor; 680 μ F; 25 V; 105 $^{\circ}$ C; 10 mm \times 16 mm	-	KZH/NCC
C7	capacitor; MLCC; not connected; 0.1 μ F; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C7A1	capacitor; MLCC; 68 pF; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C8	capacitor; MLCC; 1 nF; 50 V; \pm 10 %; 0805; X7R; lead free	-	-
C9	capacitor; MLCC; not connected; 100 pF; 2 kV; 1206; Z5U	-	-
C10	capacitor; MLCC; 0.1 μ F; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C11	capacitor; MLCC; 0.22 μ F; 50 V; \pm 10 %; 0805; X7R; lead free	-	-
C12	capacitor; MLCC; not connected; 47 nF; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C13	capacitor; MLCC; 0.1 μ F; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C14	capacitor; MLCC; 1 nF; 50 V; \pm 10 %; 0603; X7R; RoHS compliant	-	-
C15	capacitor; MLCC; 10 nF; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-
C16	capacitor; electrolytic; KY/NCC; 10 μ F; 50 V; 105 $^{\circ}$ C; \pm 20 %; 5 mm \times 11.5 mm;	-	-
C17	capacitor; MLCC; not connected; 220 pF; 100 V; 0805; NPO; RoHS compliant	-	-
C18	capacitor; MLCC; 47 nF; 50 V; \pm 10 %; 0805; NPO; lead free	-	-
C19	capacitor; MLCC; 100 pF; 50 V; \pm 10 %; 0805; X7R; RoHS compliant	-	-

Table 18. TEA1836DB1094 bill of material ...continued

Reference	Description and values	Part number	Manufacturer
CX1	X2-capacitor; MKP/R46; 0.33 μ F; 275 V (AC); 105 $^{\circ}$ C; 18 mm \times 8.5 mm \times 14.5 mm; R46	-	Arcotronics
CY1	Y2-capacitor; 220 pF; 400 V (AC)	-	Murata
D2; D4	single diode; DIS; 1000 V (RMS)	1N4007,DIP/DO41	-
D3	single diode; DIS; 200 V (RMS)	BAS21H,SMT/SOD123F	NXP Semiconductors
D5	single diode; DIS; 1000 V (RMS)	SA2M,SMT/SMA	Vishay
D6	single diode; DIS; 100 V (RMS)	BAS316,SMT/SOD323	NXP Semiconductors
D7	single diode; DIS; 1000 V (RMS); current = 1 A; trr = 1.8 μ s	S1ML	Taiwan Semiconductor
F1	fuse; DIP; 3.15 AT; 250 V; 8.35 mm \times 4.3 mm \times 7.7 mm; MST	-	-
INLET1	inlet	S3P,TU-333-BZ-315-P3D	Texc-Unions
L1	resistor; 0 Ω ; 5 %; 0.25 W; 0805	-	-
LF1	CM choke; T12*6*4 (380 μ H) 0.6 ϕ 9.5T:9.5T	-	-
LF2	CM choke; T16*12*8(16.5 mH) 0.6 ϕ 60T:60T	-	-
Q1	n-channel MOSFET; R _{DSon} = 0.62 Ω ; V _{gs(on)} = 4 V; I _d = 10 A; C _{iss} = 1350 pF; V _{ds} = 600 V; V _{gs} = \pm 30 V	TK10A60D,SMT/TO220	Toshiba
Q2	n-channel MOSFET; R _{DSon} = 5.4 m Ω ; V _{gs(on)} = 3 V; I _d = 100 A; C _{iss} = 6686 pF; V _{ds} = 100 V; V _{gs} = \pm 20 V	PSMN7R0-100P,DIP/TO220	NXP Semiconductors
R1; R23	resistor; 50 k Ω ; 1 %; 0.25 W; 1206	-	-
R2	resistor; not connected; 47 Ω ; 5 %; 1/8 W; 0805	-	-
R3; R4	resistor; 43 k Ω ; 5 %; 0.25 W; 1206	-	-
R5	resistor; 43 k Ω ; 1 %; 1/8 W; 0805	-	-
R6	resistor; 470 Ω ; 5 %; 1/8 W; 0805	-	-
R7	resistor; 6.8 k Ω ; 1 %; 1/8 W; 0805	-	-
R8	resistor; 4.7 Ω ; 5 %; 1/8 W; 0805	-	-
R9	resistor; 10 Ω ; 5 %; 1/8 W; 0805	-	-
R10	resistor; 1 k Ω ; 1 %; 1/8 W; 0805	-	-
R11	resistor; not connected; 1 k Ω ; 5 %; 1/8 W; 0805	-	-
R12	resistor; not connected; 470 Ω ; 5 %; 1/8 W; 0805	-	-
R13	resistor; 20 k Ω ; 1 %; 1/8 W; 0805	-	-
R14	resistor; 165 k Ω ; 1 %; 1/8 W; 0805	-	-
R15	resistor; 2.2 k Ω ; 1 %; 1/8 W; 0805	-	-
R16	resistor; DIP; 0.15 Ω ; 1 %; 1 W; arial lead; MOF	-	-
R17	resistor; 10 k Ω ; 5 %; 1/8 W; 0805	-	-
R18	resistor; not connected; 47 Ω ; 5 %; 1/8 W; 0805	-	-

Table 18. TEA1836DB1094 bill of material ...continued

Reference	Description and values	Part number	Manufacturer
R19	resistor; 24 k Ω ; 1 %; 1/8 W; 0805	-	-
R20	resistor; 10 Ω ; 5 %; 1/8 W; 0805	-	-
R21	resistor; 1 k Ω ; 5 %; 1/8 W; 0805 (modified connection)	-	-
R24	resistor; 130 k Ω ; 1 %; 0.25 W; 1206	-	-
R25	resistor; <td> Ω ; 1 %; 1/8 W; 0805	-	-
RJ1; RJ4; RJ7	resistor; 0 Ω ; 5 %; 0.25 W; 1206	-	-
RJ3; RJ5; RJ6; R22	resistor; not connected; 0 Ω ; 0.25 W; 1206	-	-
RT1	-	TTC03A104F4192	-
T1	transformer; flyback;	RM10	-
U1	QR flyback controller IC	TEA18361T/SO14	NXP Semiconductors
U2	IC Shunt regulator; adjustable precision shunt regulators	AS4311,SMT/SOT23R	BCD
U3	DIS,SR,TEA1792TS	TEA1792TS	NXP Semiconductors
U5	Photocoupler; 4-pins SOP; CTR = 130 %~ 260 %; 1 channel	LTV-356TB	LiteOn
VOUT1	cable, 2.5 mm \times 5.5 mm \times 12 mm (kk,fk), L = 1200 mm	16AWG/1571	-
ZD1	zener diode	BZX84J-B8V2	-
ZD2	zener diode; not connected	BZX84J-B32	-

9. Transformer data

9.1 Introduction

For this demo board, requirements were set to show high performance in a standard 65 W form factor board using a basic circuit configuration. To reach this goal, the transformer design requires extra attention to support the combination of high-efficiency performance while still being EMI compliant using a 220 pF Y-capacitor. At the same time the concept must deliver 65 W nominal output power and generate a peak output power that is 50 % higher.

An RM10 core was used in combination with a customized bobbin type to build the transformer.

9.2 Transformer data

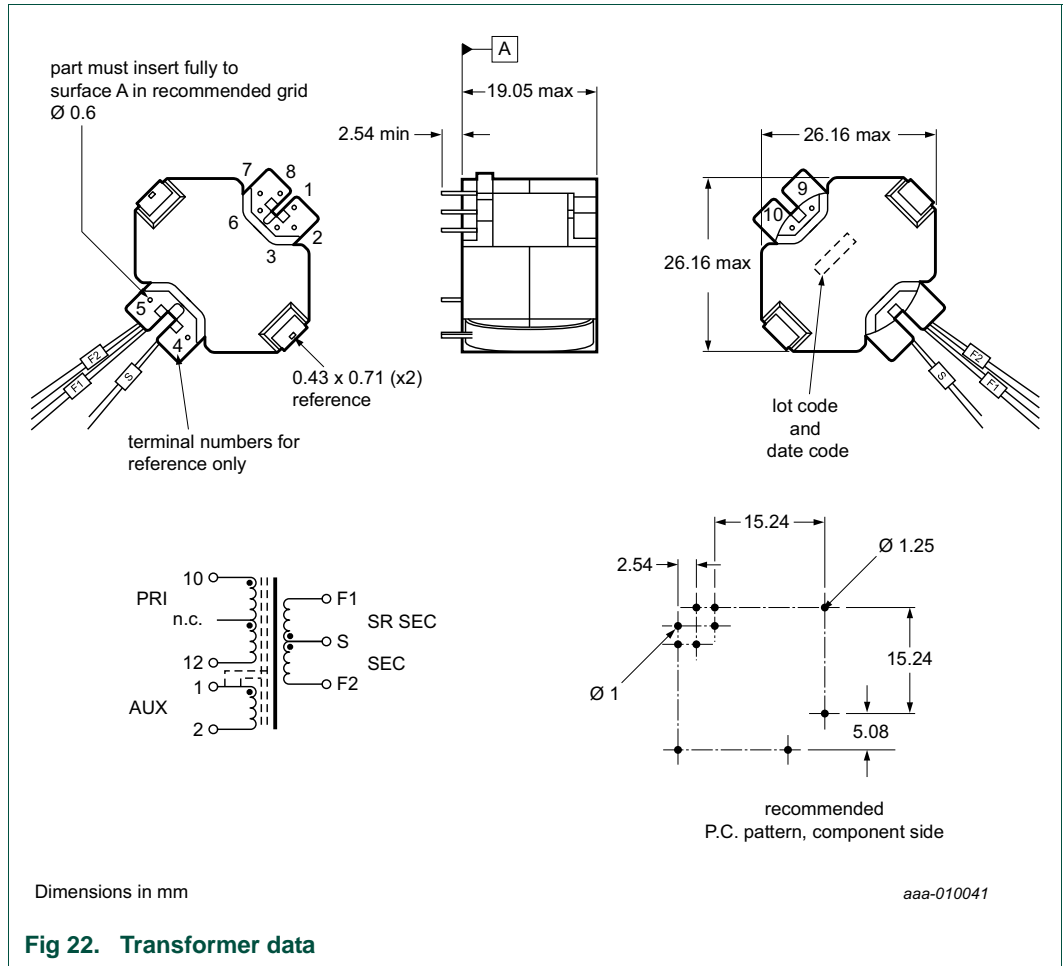


Fig 22. Transformer data

Table 19. Transformer electrical specifications at 25 °C unless otherwise noted

Feature	Value	Comment
DC resistance (at 20 °C)	1 to 2: 0.440 Ω; ±10 %	
	10 to 12: 0.282 Ω; ±10 %	
	S to F1: 0.178 Ω; ±10 %	
	S to F2: 0.033 Ω; ±20 %	
dielectric rating	3000 V (AC)	tested 1 minute by applying 3750 V (AC) for 1 s between pins 1 and S (tie 2 + 10)
	500 V (AC)	tested 1 minute by applying 625 V (AC) for 1 s between pins 1 and 12
inductance	340 μH; ±3 %; 10 kHz; 100 mV (AC); 0 mA (DC); 10 to 12; L _s	
saturation current	5 A	saturation current that causes 20 % rolloff from initial inductance

Table 19. Transformer electrical specifications at 25 °C unless otherwise noted ...continued

Feature	Value	Comment
leakage inductance	7.5 μ H (maximum); 100 kHz; 100 mV (AC)	10 to 12 (tie 1 + 2, S + F1 + F2); L _s
turns ratio	(10 to 12) : (1 to 2), (6.29) : (1.00), ± 1 %	
	(10 to 12) : (S to F1), (3.67) : (1.00); ± 1 %	
	(10 to 12) : (S to F2), (5 to 5) : (1.00); ± 1 %	

9.3 Transformer winding construction



Fig 23. Transformer winding construction

10. Abbreviations

Table 20. Abbreviations

Acronym	Description
BCM	Boundary Conduction Mode
DCM	Discontinuous Conduction Mode
EMI	ElectroMagnetic Interference
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
OCP	OverCurrent Protection
OPP	OverPower Protection
OVP	OverVoltage Protection
OLP	Open-Loop Protection
PCB	Printed-Circuit Board
QR	Quasi Resonant
RMS	Root Mean Square
SOI	Silicon-On-Insulator
SR	Synchronous Rectification

11. References

- [1] **TEA18361LT** — Data sheet - GreenChip SMPS control IC
- [2] **TEA18361T** — Data sheet - GreenChip SMPS control IC
- [3] **TEA18362LT** — Data sheet - GreenChip SMPS control IC
- [4] **TEA18362T** — Data sheet - GreenChip SMPS control IC
- [5] **TEA18363LT** — Data sheet - GreenChip SMPS control IC
- [6] **TEA18363T** — Data sheet - GreenChip SMPS control IC
- [7] **AN11403** — Application note TEA1836X
- [8] **TEA1792TS** — Data sheet - GreenChip synchronous rectifier controller
- [9] **AN11149** — Application note - TEA1792 GreenChip synchronous rectifier controller

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