



UM11397

TEA2017DB1580 240 W demo board

Rev. 1 — 24 February 2022

User manual

Document information

Information	Content
Keywords	TEA2017DB1580, 240 W, 12 V x 20 A, PFC, CCM, LLC, resonant, controller, converter, burst mode, power supply, demo board, programmable settings, I2C
Abstract	<p>The TEA2017AAT is a controller IC for resonant power supplies that include a PFC. It provides high efficiency at all power levels. Together with the TEA2095T dual LLC resonant SR controller, a high performance cost-effective resonant power supply can be made. To reach a high efficiency at all power levels, the TEA2017AAT provides a low-power operation mode (LP) and extensive burst mode configuration options. Parameter settings in an internal multiple times programmable memory can define operation modes and protections. For product development, an IC version is available to make set power good signal. Protections can be configured to provide the correct handling. The efficiency at high power levels is well above 90 %. No-load power consumption is below 100 mW. At 250 mW output power, the input power is well below 500 mW for easily meeting the EUP lot6 standby requirement. The TEA2017DB1580 board shows a single output (12 V) desktop PC application that needs forced cooling (by fan) at high output power (above 120 W)</p>



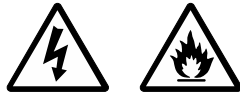
Revision history

Rev	Date	Description
v.1	20220224	Initial version

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 Safety warnings

1.1.1 Open-framed unenclosed PCB

This user manual describes the operation of the TEA2017DB1580. The TEA2017DB1580 is provided as an open framed, unenclosed printed circuit board assembly.

- Use of the TEA2017DB1580 is only intended for development laboratory environments. Only qualified professionals with training, expertise, and knowledge of electrical safety risk in the development and application of high-voltage electrical circuits should use the TEA2017DB1580.
- While the TEA2017DB1580 has been designed with user safety in mind, no agency has formally tested the demo board.
- The TEA2017DB1580 is not intended for and must not be used in a production unit. Any use beyond development and testing is strictly prohibited.

1.1.2 General high-voltage demo board user safety guidelines

- Work area safety:
 - Keep the work area clean and orderly.
 - One or more qualified observers must be present at any time the circuits are energized.
 - Effective barriers and signage must be present in the area where the demo board and its interface electronics are energized, indicating operation of accessible high voltages may be present, for protecting inadvertent access.
 - All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50 V (RMS)/75 V (DC) must be electrically located within a protected emergency power-off (EPO) protected power strip.
 - Use a stable and non-conductive work surface.
 - To attach measurement probes and instruments, use adequately insulated clamps and wires. No freehand testing whenever possible.

- Electrical safety

As a precautionary measure, it is always good engineering practice to assume that the entire demo board may have fully accessible and active high voltages.

 - Deenergize the TEA2017DB1580 and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that the TEA2017DB1580 power has been safely deenergized.
 - With the TEA2017DB1580 confirmed deenergized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
 - When the TEA2017DB1580 readiness is complete, energize the TEA2017DB1580 as intended.
- Personal safety
 - Wear personal protective equipment, for example, latex gloves or safety glasses with side shields, or protect the demo board in an adequate lucent plastic box with interlocks from accidental touch.

1.1.3 Safety warning

The board must be connected to mains voltage. Avoid touching the demo 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. [Figure 1](#) shows the symbols that identify the isolated and non-isolated devices.

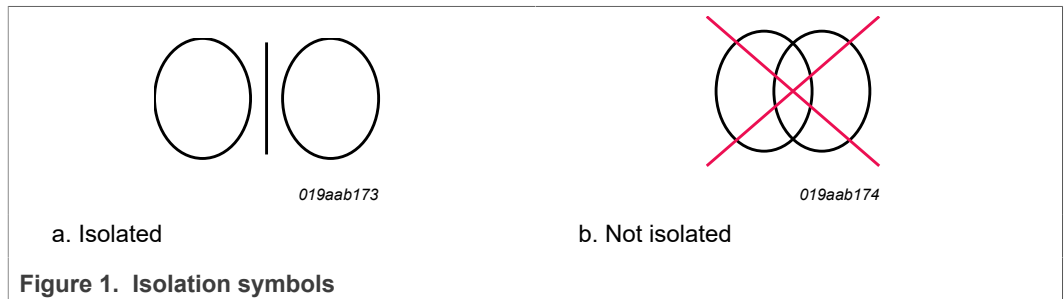


Figure 1. Isolation symbols

Your use of the demo board is conditioned on agreement to and compliance with the terms of use. The terms of use may be found in [Section 13](#).

This product has not undergone formal EU EMC assessment. As a component used in a research environment, it is the responsibility of the user to ensure that the finished assembly does not cause undue interference when used. It cannot be CE marked unless assessed.

1.2 TEA2017AAT

The TEA2017AAT provides high efficiency at all power levels. Together with the TEA2095T, a dual LLC resonant SR controller, a high-performance cost-effective resonant power supply can be designed. The power supply designed can meet the efficiency regulations of Energy Star, the Department of Energy (DoE), the Eco-design Directive of the European Union, the European Code of Conduct, and other guidelines.

In general, resonant converters show an excellent efficiency at high power levels, while at lower levels their efficiency reduces because of the relatively high magnetizing current losses. To reach a high efficiency at all power levels, the TEA2017AAT provides a low-power operation mode (LP) and extensive burst mode configuration options.

Most LLC resonant converter controllers regulate the output power by adjusting the operating frequency. The TEA2017AAT regulates the output power by adjusting the voltage across the primary resonant capacitor for accurate state control and a linear power control.

The primary resonant capacitor voltage provides accurate information about the output power to the controller using a voltage divider. The voltage divider sets the output power levels. It determines when the system switches from the high-power mode to low-power mode and when it switches from low-power mode to burst mode.

The TEA2017 PFC controller has three different operation modes:

- DCM/QR
- DCM/QR/CCM
- Fixed frequency

In DCM/QR and DCM/QR/CCM mode, the frequency is regulated and can be tuned for maximum efficiency. The PFC current is shaped such that the mains current is almost sinusoidal resulting in a low THD and high PF. To optimize EMI performance, the PFC frequency can be jittered. The burst mode with soft start/stop yields high efficiency at low loads without noticeable audible noise.

An extensive number of parameter settings for operation can define operation modes and protections. Protections can be stored/programmed in an internal memory. This feature provides flexibility and ease of design to optimize controller properties to application-specific requirements or even optimize/correct performance during power supply production. At start-up, the IC loads the parameter values for operation. For easy design work during product development, an IC version is available to change settings on the fly.

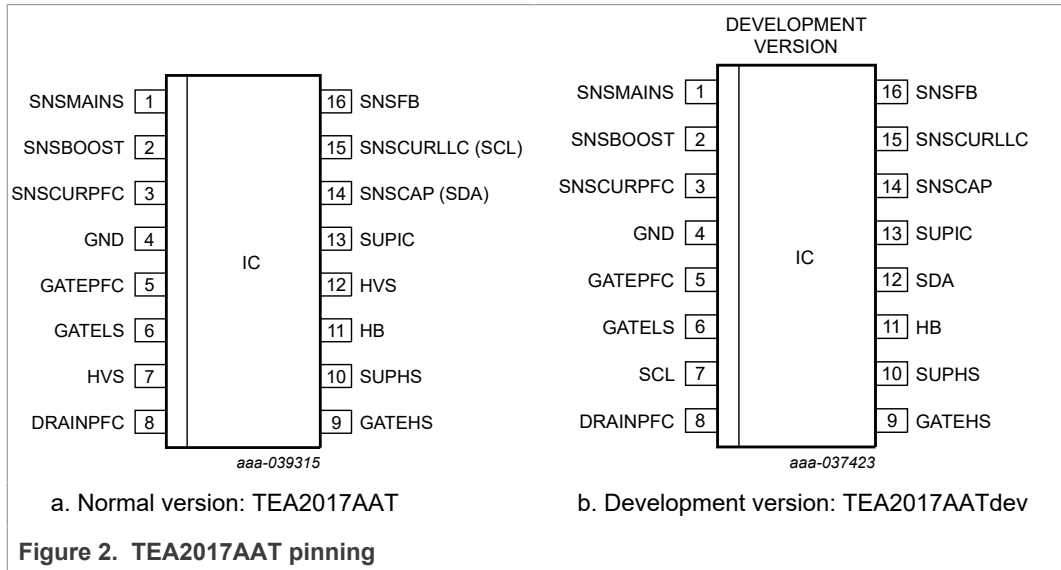


Figure 2. TEA2017AAT pinning

Note: The TEA2017DB1580 demo board contains the development version.

1.3 TEA2095T

The TEA2095T is a synchronous rectifier (SR) controller IC for LLC switched-mode power supplies. It incorporates an adaptive gate drive method for maximum efficiency at any load.

The TEA2095T is a dedicated controller IC for synchronous rectification on the secondary side of resonant converters. It includes two driver stages for driving the SR MOSFETs, which rectify the outputs of the central-tap secondary transformer windings.

The two-gate driver stages have their own sensing inputs and operate independently.

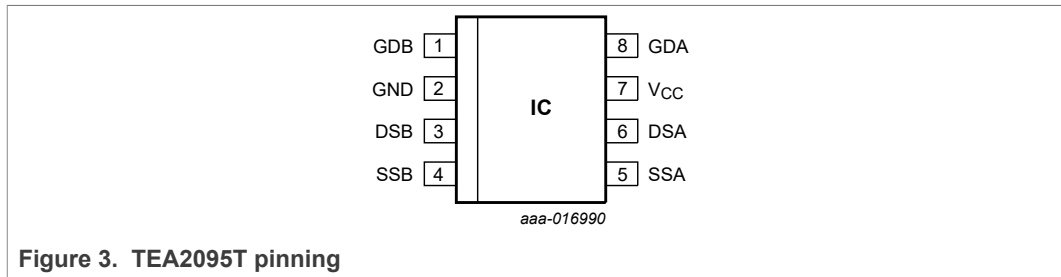


Figure 3. TEA2095T pinning

1.4 Demo board

The TEA2017DB1580 demo board can operate at a mains input voltage between 90 V (RMS) and 264 V (RMS; universal mains).

The TEA2017DB1580 demo board contains three subcircuits (see [Section 7](#)):

- A DCM/BCM/CCM-type PFC converter
- A resonant LLC-type HBC converter
- An SR resonant LLC-type output stage

The purpose of the demo board is to show and evaluate the operation of the TEA2017AAT and TEA2095T in a single output supply, which includes the operation modes in a typical design. The performance passes general standards, including the EuP lot6 requirements. It can be used as a starting point for power supply design using the TEA2017AAT and TEA2095T controller ICs.

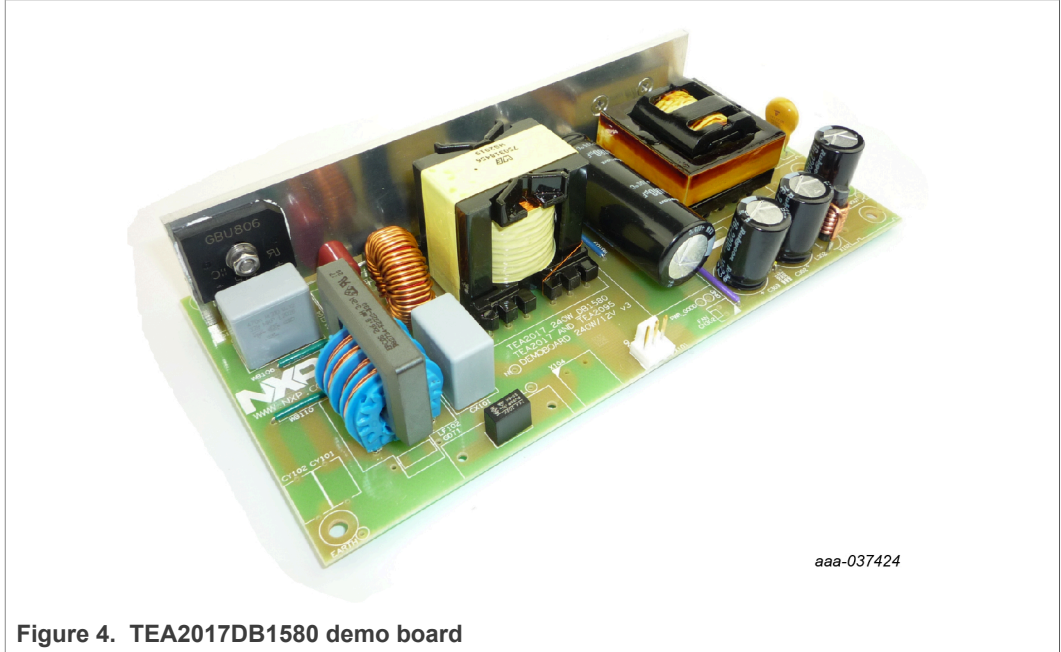


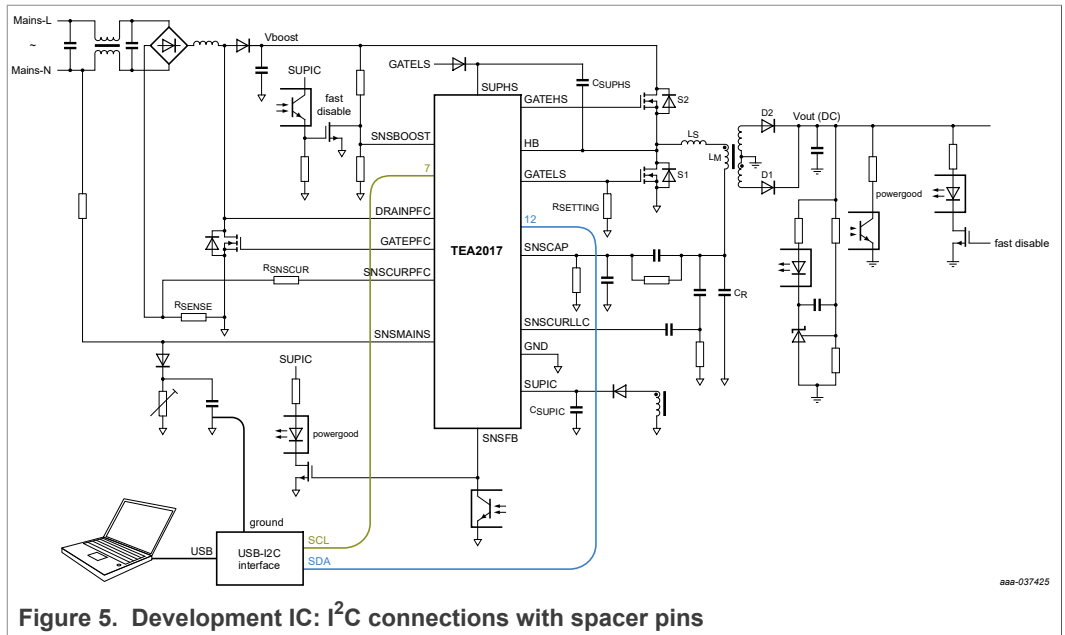
Figure 4. TEA2017DB1580 demo board

1.5 TEA2017AAT GUI and USB-I²C interface

In addition to the normal TEA2017AAT ICs, NXP Semiconductors provides special IC versions for product development. For easy modification of settings, even while the IC is operating ("on the fly" parameter changing), the TEA2017AATdev development samples contain an I²C interface connection on the high-voltage spacer pins. The TEA2017DB1580 demo board uses the development version of the TEA2017AAT.

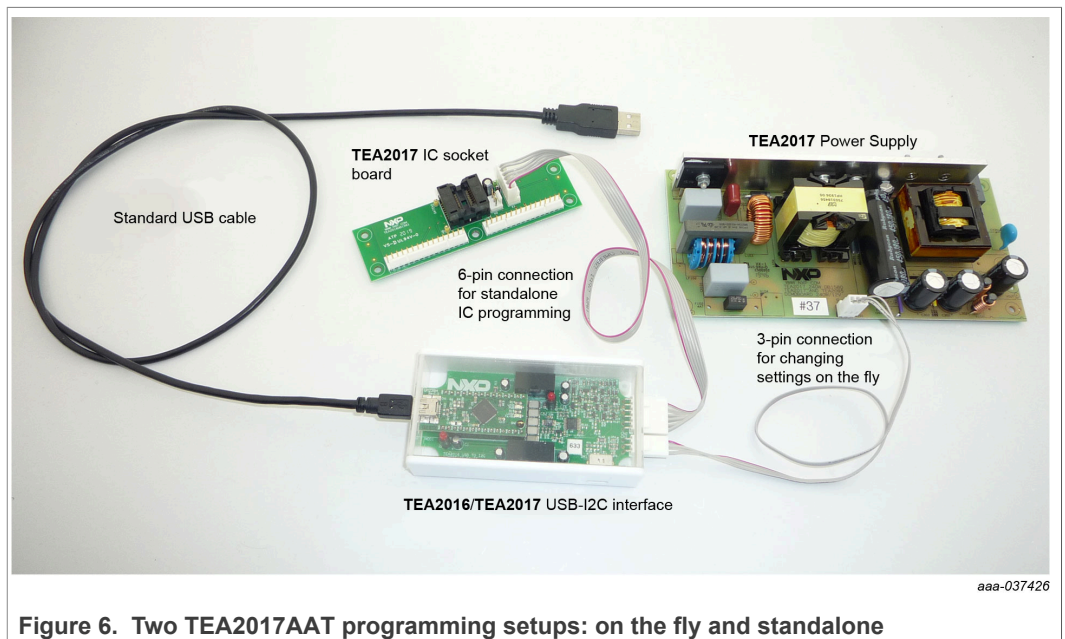
1.5.1 Development IC samples: SDA and SCL on spacer pins

Connections to the IC second I²C interface are provided on high-voltage spacer pins 7 and 12. Normally, these pins are not connected.



1.5.2 Production IC samples: SDA and SCL on combined pins

In the production version of the TEA2017AAT, the I²C interface is available on the combined pins SNSCURLLC (SCL) and SNSCAP (SDA). To program the IC, it must be put in the disabled condition pulling SNSBOOST to GND. During programming, SUPIC must supply the IC.



1.6 Graphical user interface (GUI) and USB-I²C interface

During power supply development, a GUI program on a computer communicates with the IC via a USB-I²C interface. The Ringo TEA2017AAT software with GUI provides the correct protocol and offers several options and tools to work with the IC settings.

The Ringo TEA2017AAT GUI requires Windows 7/8/10 and a 64-bits processor.

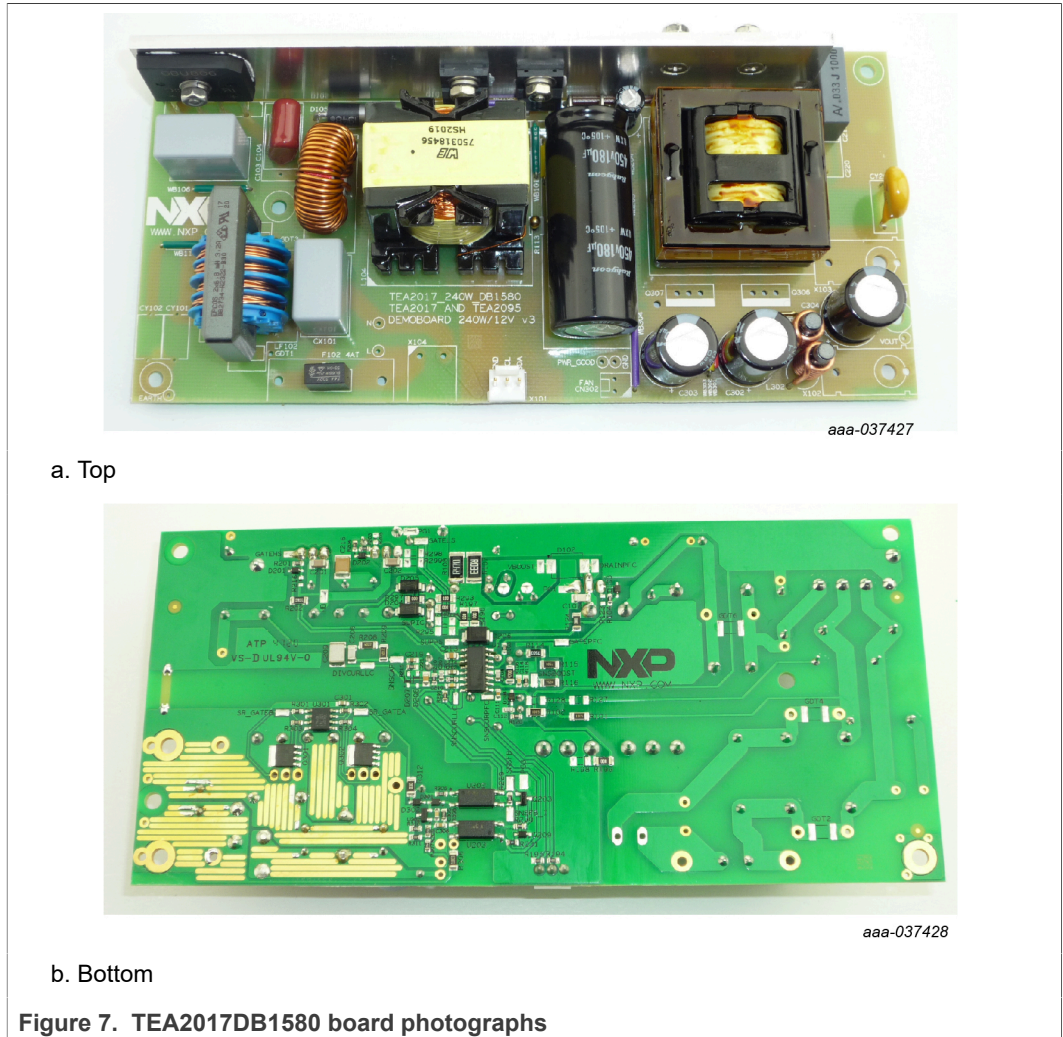
2 Specifications

Table 1. TEA2017DB1580 board specification

Symbol	Description	Value	Conditions
Input			
V_i	input voltage	90 V (RMS) to 264 V (RMS)	AC
f_i	input frequency	47 Hz to 63 Hz	
$P_{i(\text{no-load})}$	no-load input power	< 100 mW	at 230 V/50 Hz
$P_{i(\text{load-250mW})}$	standby power consumption	< 450 mW	at 230 V/50 Hz
Output			
V_o	output voltage	12 V	
I_o	output current	0 A to 20 A	continuous
$I_{o(\text{max})}$	maximum output power	24 A	OPP level
$I_{o(\text{peak})\text{max}}$	maximum peak output current	30 A	$t < 50$ ms; limited by power limit setting (155 %)
t_{hold}	hold time	> 10 ms	at 115 V/60 Hz
t_{start}	start time	< 0.5 s	at 115 V/60 Hz
η	efficiency	≥ 89 %	average according to CoC

Note: The TEA2017DB1580 board shows a single output (12 V) desktop PC application that requires forced cooling (fan) at high output power (when 120 W is exceeded).

3 Board photographs



4 Performance measurements

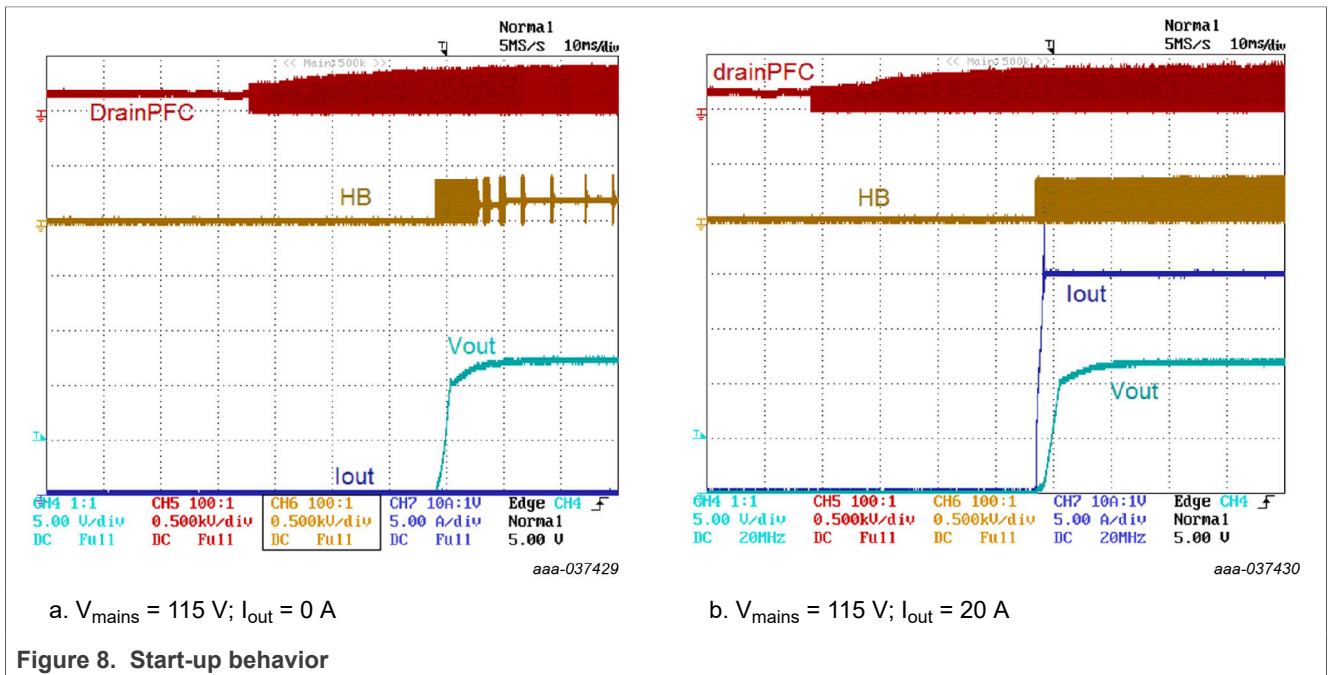
4.1 Test facilities

- Oscilloscope: Yokogawa DL7480
- AC Power Source: Agilent 6812B
- Electronic load: Keithley 2380-120-60
- Digital power meter: Yokogawa WT210

4.2 Start-up and switch-off behavior

4.2.1 Output voltage risetime

The risetime of the output voltage (measured from 10 % to 90 % point of the nominal output) is between 3 ms and 6 ms (see [Figure 8](#)). The risetime depends on the output current load.



4.2.2 Start-up time

The total start-up time from mains switch-on until the output voltage reaches 12 V is approximately 400 ms (see Figure 9).

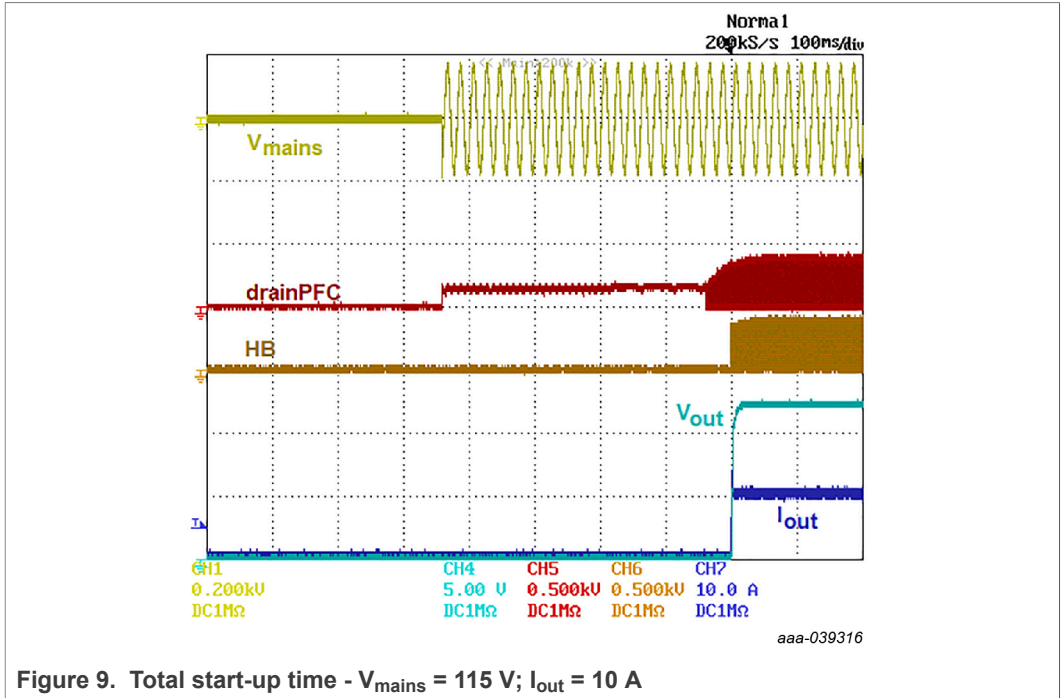


Figure 9. Total start-up time - $V_{mains} = 115\text{ V}$; $I_{out} = 10\text{ A}$

4.2.3 Mains switch-off and X-capacitor discharge

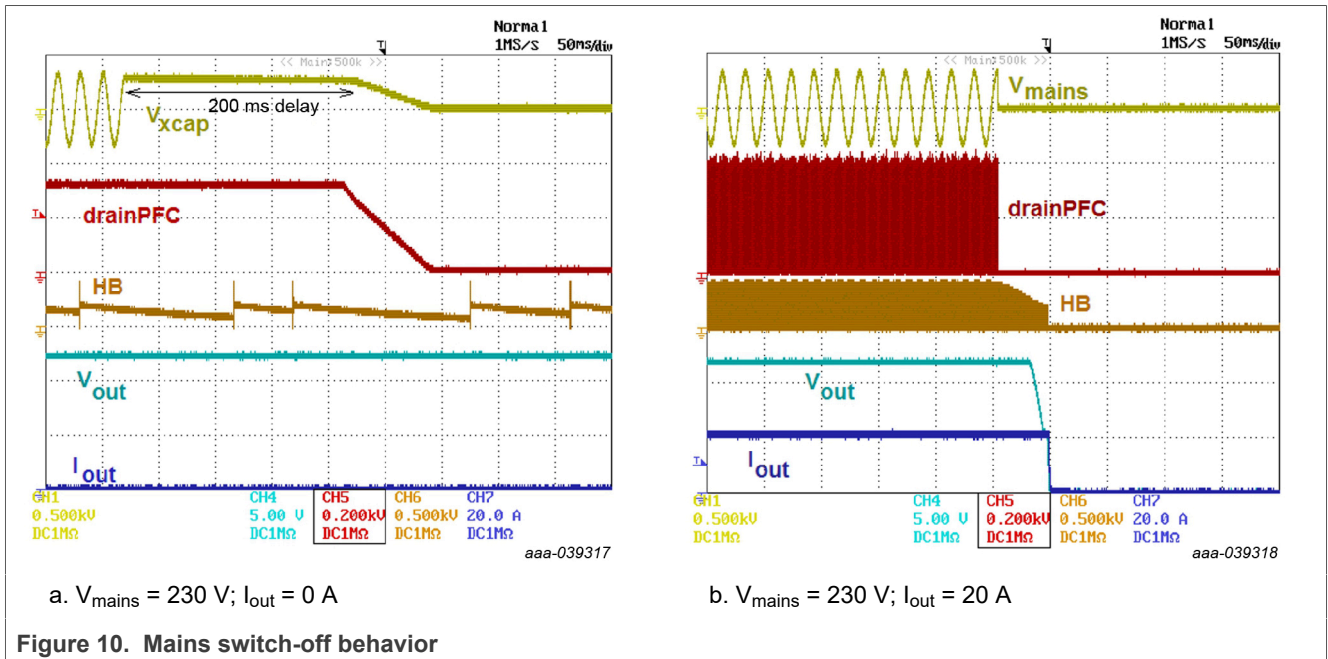


Figure 10. Mains switch-off behavior

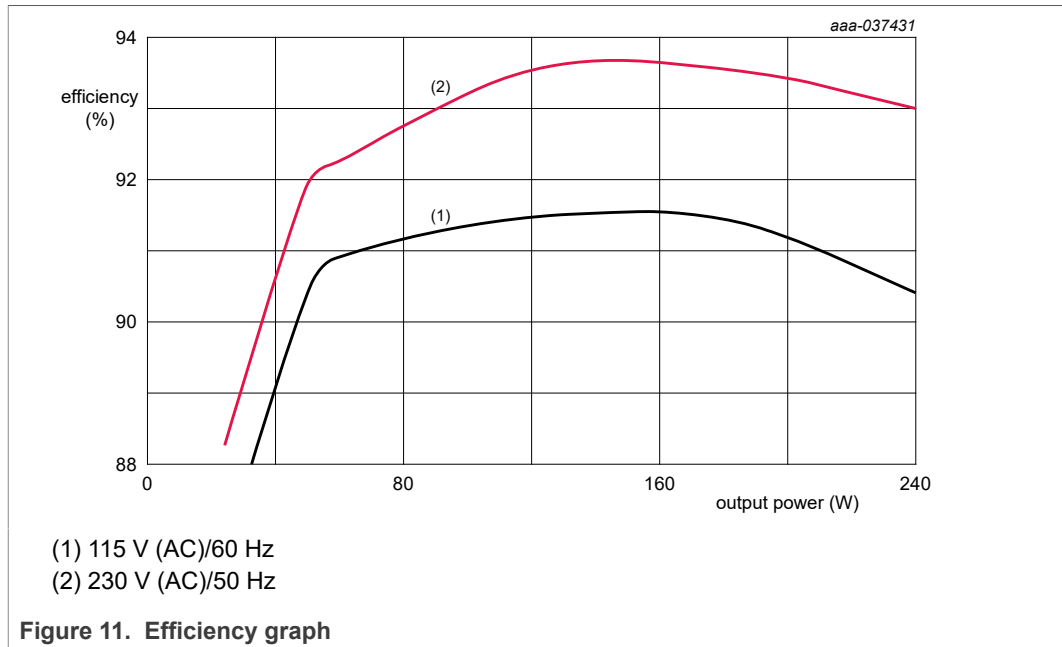
4.3 Efficiency

4.3.1 Efficiency characteristics

To determine the efficiency, the output voltage (not counting the losses in an output connection cable) on the TEA2017DB1580 demo board was measured.

Table 2. Efficiency results

Condition	COC efficiency requirement (%)	Efficiency (%)				
		Average	25 % load	50 % load	75 % load	100 %
115 V/60 Hz	> 89	91	90.9	91.5	91.4	90.3
230 V/50 Hz	> 89	93.1	92.3	93.6	93.6	93



4.3.2 No-load power consumption

Table 3. Output voltage and power consumption at no load

Condition	Requirement (mW)	Output voltage (V)	No load power consumption (mW)
115 V/60 Hz	≤ 100 mW	12.3	50
230 V/50 Hz	≤ 100 mW	12.3	60

4.3.3 Standby power consumption

Results depend on parameter settings for BM operation. A lower LLC BM repetition frequency and a higher energy per cycle result in a lower power consumption. Output voltage ripple increases as a consequence.

Table 4. Output voltage and power consumption at standby

Condition	Output power (mW)	Output voltage (V)	Standby power consumption (mW)
115 V/60 Hz	250 mW	12.3	385
230 V/50 Hz	250 mW	12.3	390
EuP lot6 requirement	250 mW	-	< 500

4.3.4 Power factor

Table 5. Power factor correction

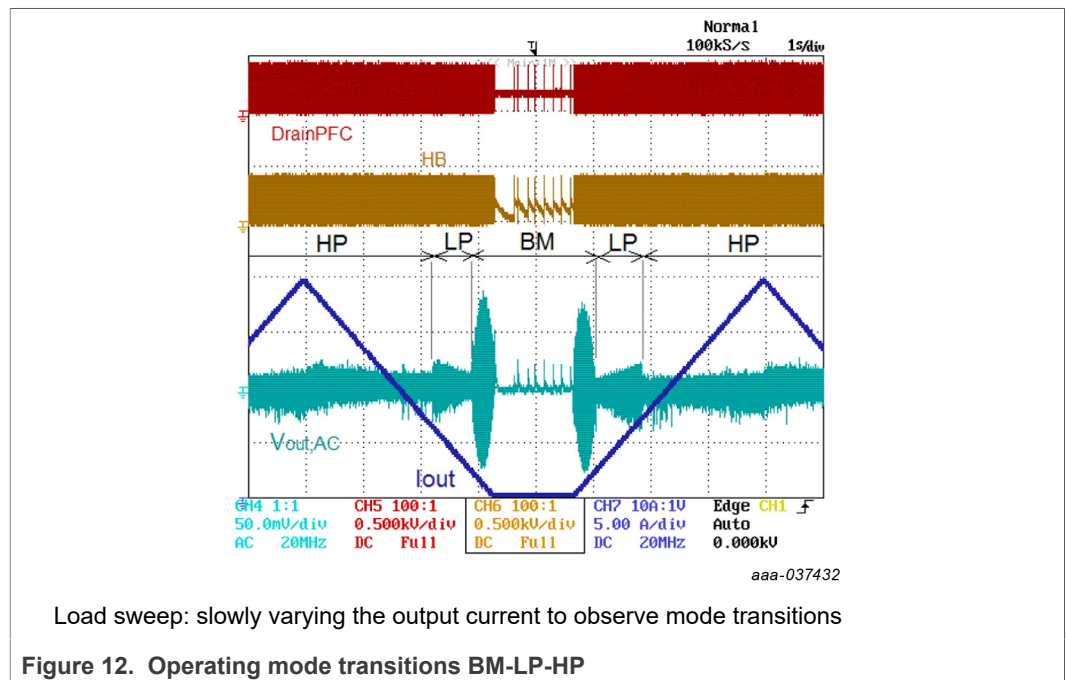
Condition	Requirement	Output Power (W)	Power Factor
115 V/60 Hz	≥ 0.9	240	0.994
230 V/50 Hz		240	0.998

4.4 Operation mode transitions

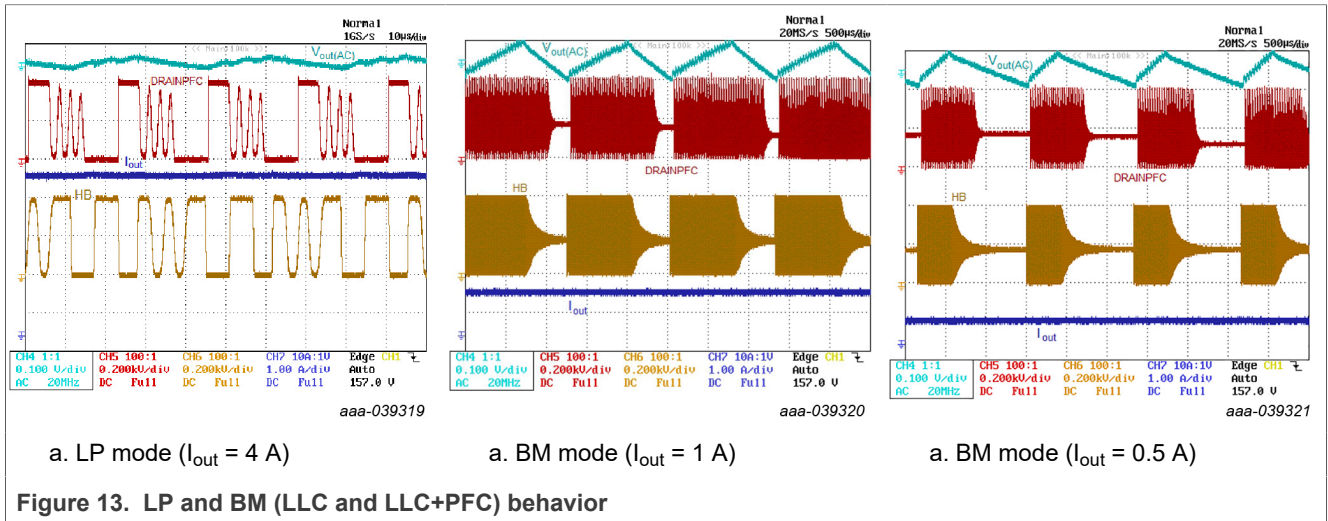
There are three modes of operation:

- High-power mode (HP)
- Low-power mode (LP)
- Burst mode (BM)

A parameter setting can modify the levels of the transition between operation modes.



- HP to LP transition: $I_{out} = 5.9 \text{ A}$
- LP to HP transition: $I_{out} = 7.0 \text{ A}$
- BM transition: $I_{out} = 1.6 \text{ A}$

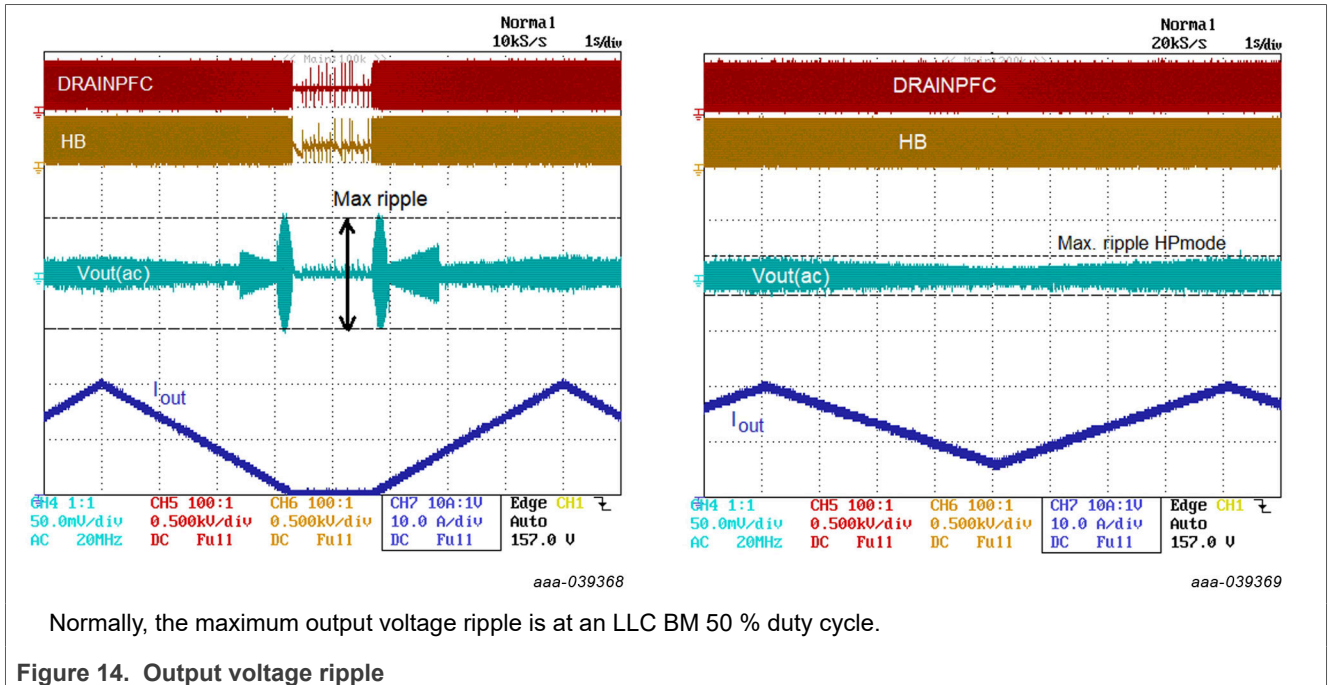


4.5 Output voltage ripple

Maximum output voltage ripple is approximately 100 mVpp during BM operation.

At maximum output power in HP mode, the output voltage ripple is less than 20 mV.

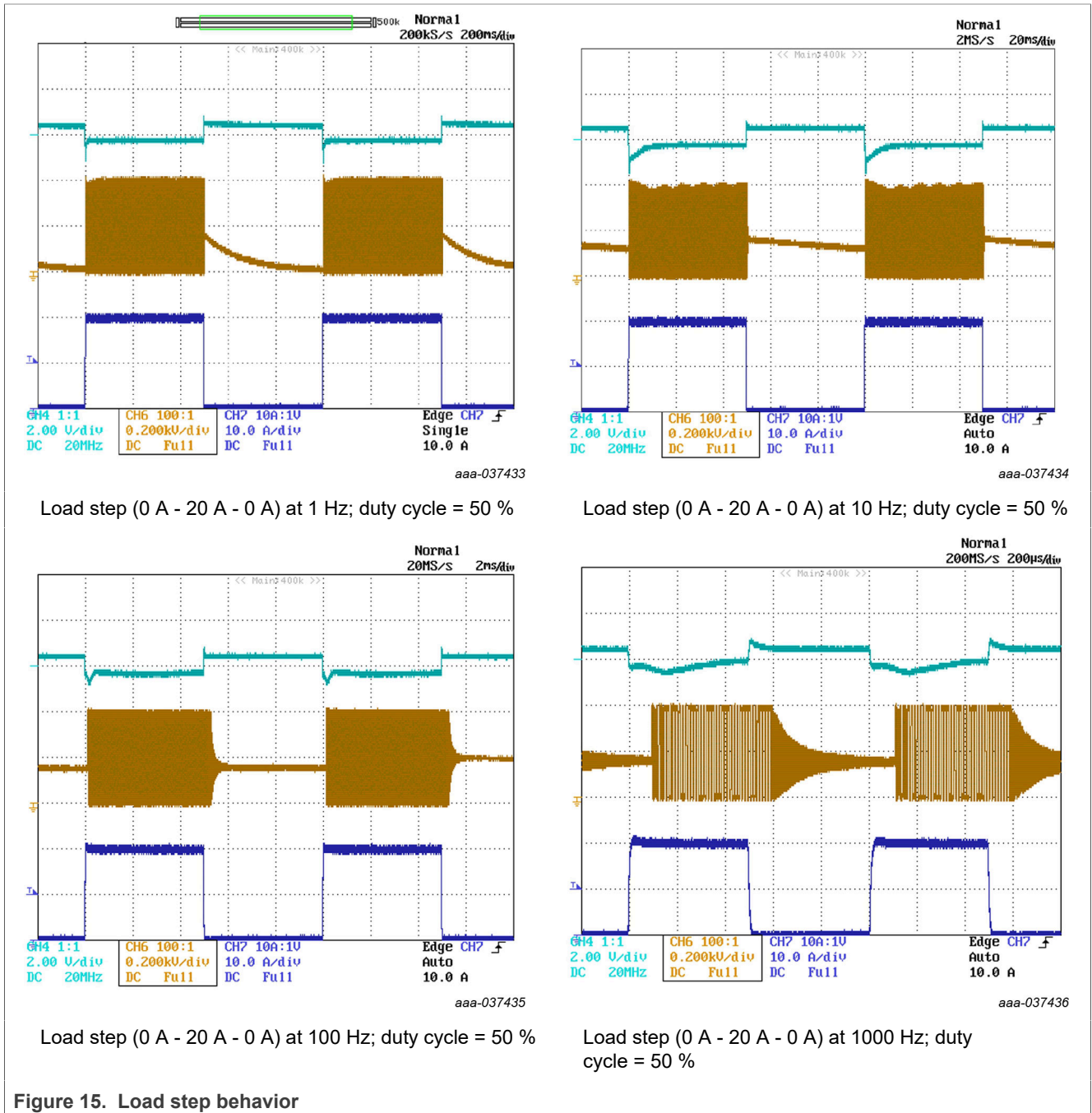
The amount of ripple in BM operation can be modified using parameter settings, for example, BM repetition frequency.



4.6 Dynamic load response

The dynamic load response test shows the result of a series of load steps on the output. The output current of the converter is changed in steps between 0 A and 20 A at a repetition frequency of 1 Hz, 10 Hz, 100 Hz, and 1000 Hz with a duty cycle of 50 %.

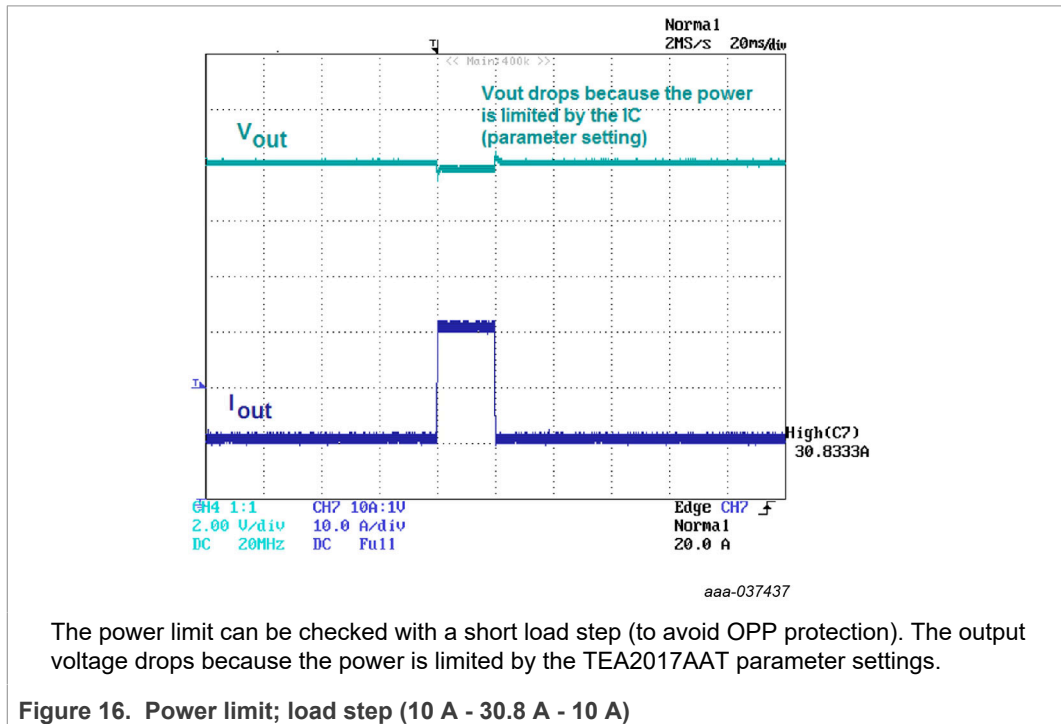
- The maximum voltage varies between 12.49 V and 12.60 V
- The minimum voltage varies between 11.11 V and 11.87 V
- The output voltage can be defined as 12 V (+5 %/-7.5 %)



4.7 Power limit

The output power is limited at 30.8 A at 12 V ($P_{out} = 370 \text{ W} = 154 \%$).

The power limit can be modified with the parameter settings (155 % selected).



4.8 Overpower protection (OPP)

The overpower protection (OPP1) is at 26.1 A. It stands for $26.1 \text{ A} \times 12.3 \text{ V} = 321 \text{ W}$.

The selected setting is on -20 %. It corresponds to $P_{\text{limit}} - 20 \% = 0.8 \times 155 \% = 124 \%$. 124 % power stands for $1.24 \times 240 \text{ W} = 298 \text{ W}$.

The OPP1 level can be modified with parameter settings.

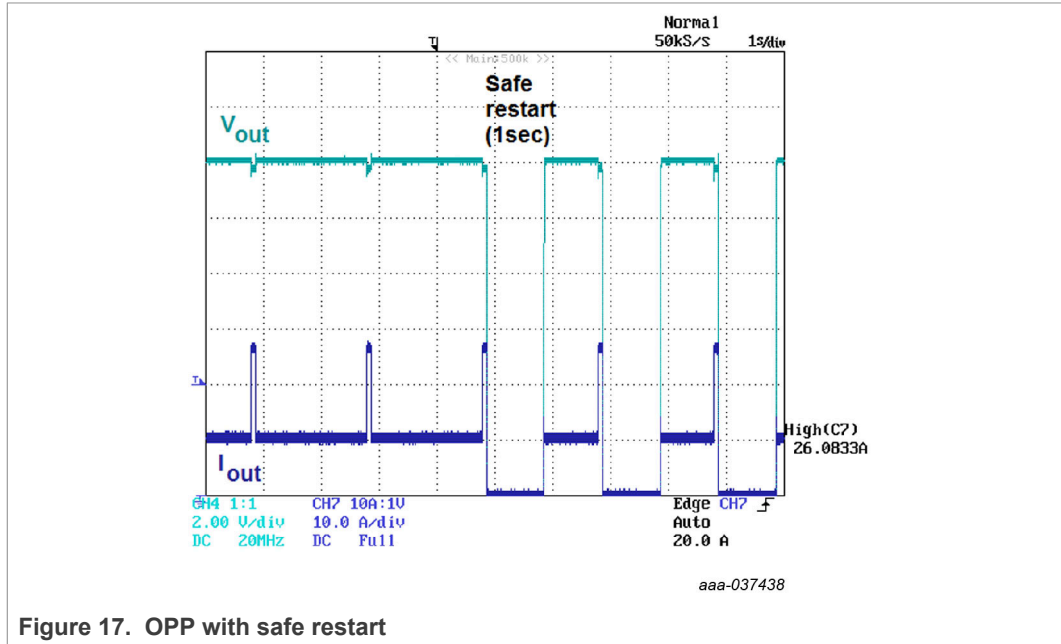


Figure 17. OPP with safe restart

4.9 EMI

The conducted electromagnetic interference (EMI) of the TEA2017DB1580 demo board was measured under the following conditions:

- Load resistor: 0.6 Ω; $V_{out} = 12\text{ V}$; $I_{out} = 20\text{ A}$
- $V_{line} = 230\text{ V}/50\text{ Hz}$ or $115\text{ V}/50\text{ Hz}$

The conducted EMI was measured both in the line and neutral. The product complies with the EMC standard.

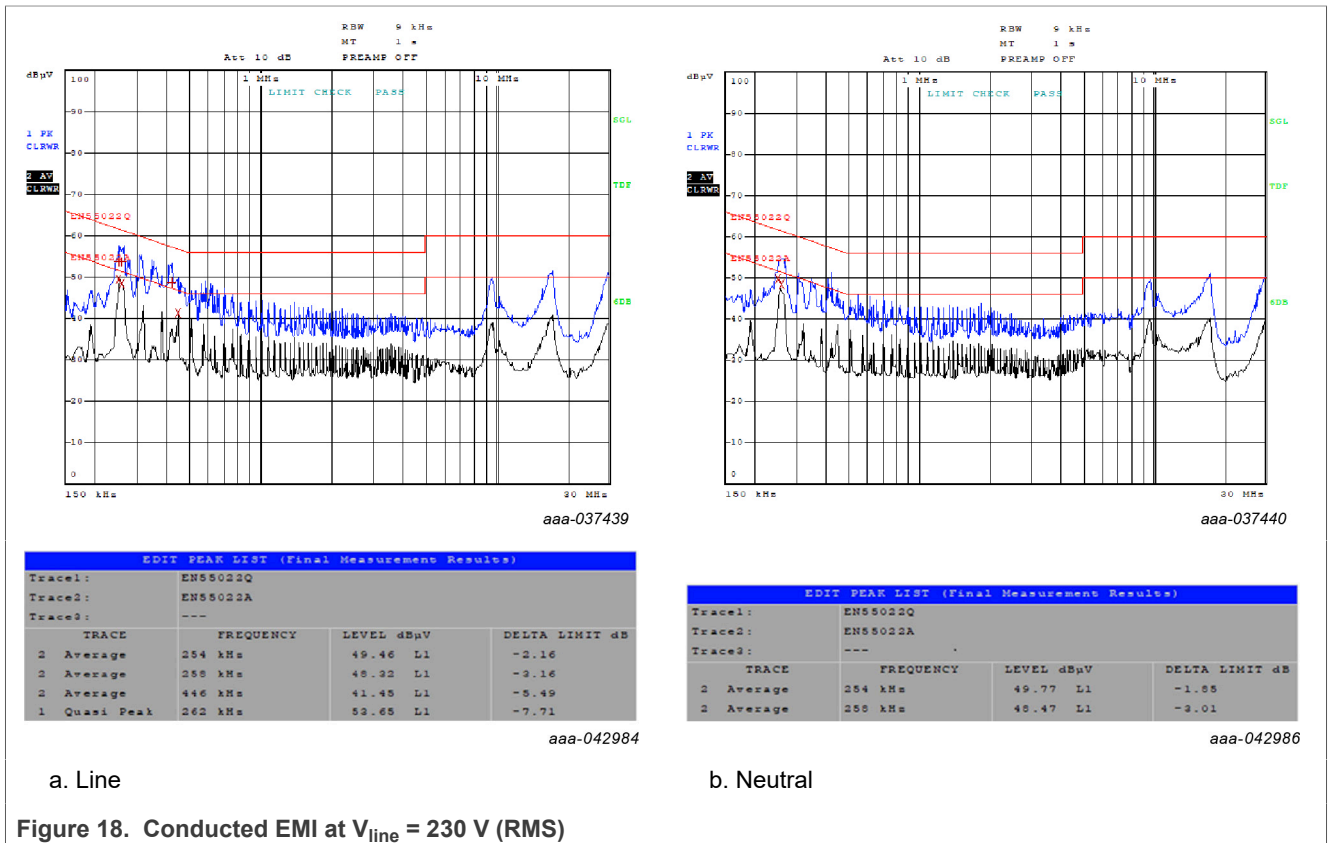
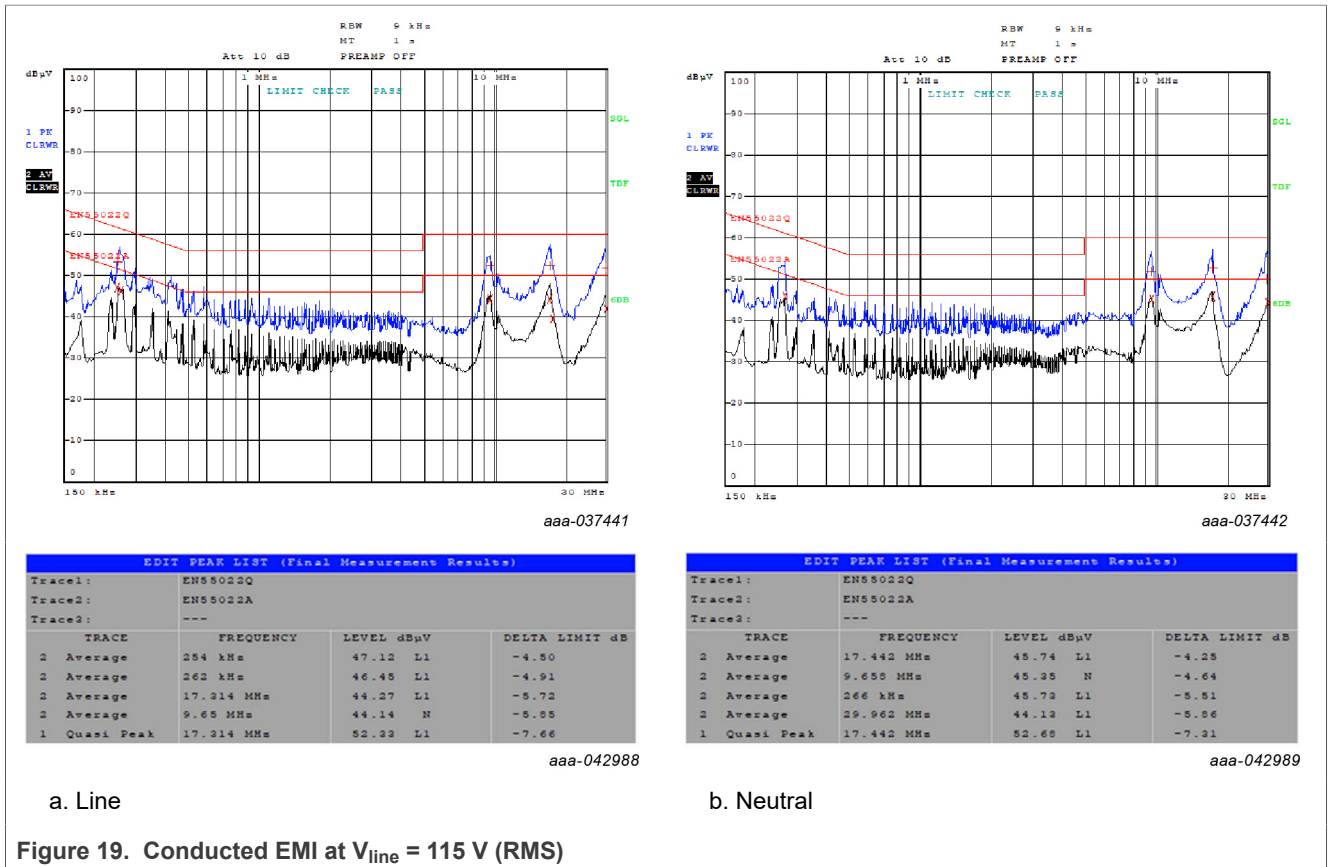


Figure 18. Conducted EMI at $V_{line} = 230\text{ V (RMS)}$



5 MTP settings

For good performance, the IC in the TEA2017DB1580 demo board contains a set of standard settings.

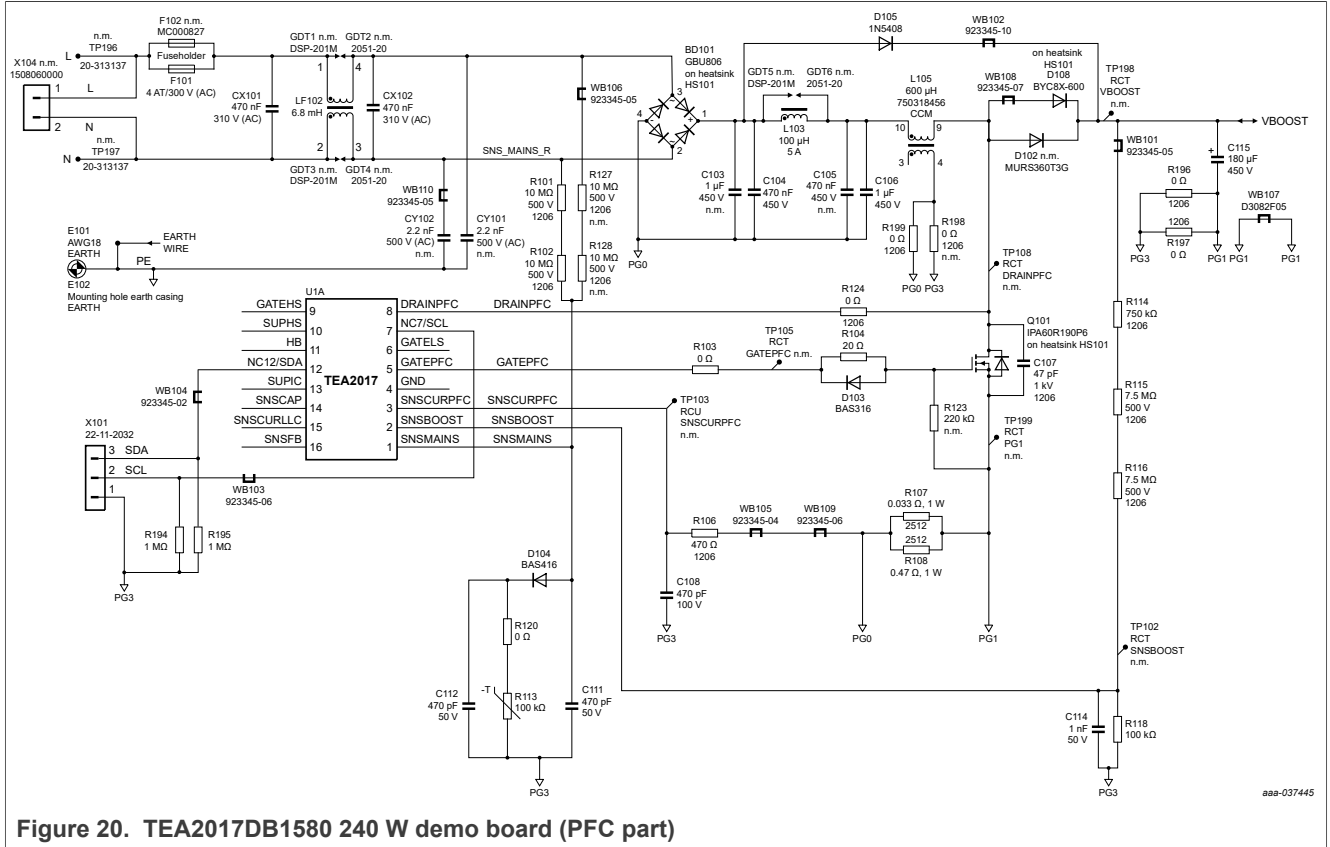
These settings can be modified to improve a certain performance subject. Or, using a file (.mif) that contains the settings information, the Ringo GUI can load and save a set of settings.

In the original board, the settings of the IC are the default TEA2017AATAATdev programming values. [Section 12](#) shows a list of all settings.

6 Thermal information

The TEA2017DB1580 board shows a single output (12 V) desktop PC application that requires forced cooling (fan) at high output power (when 120 W is exceeded).

7 Circuit diagrams



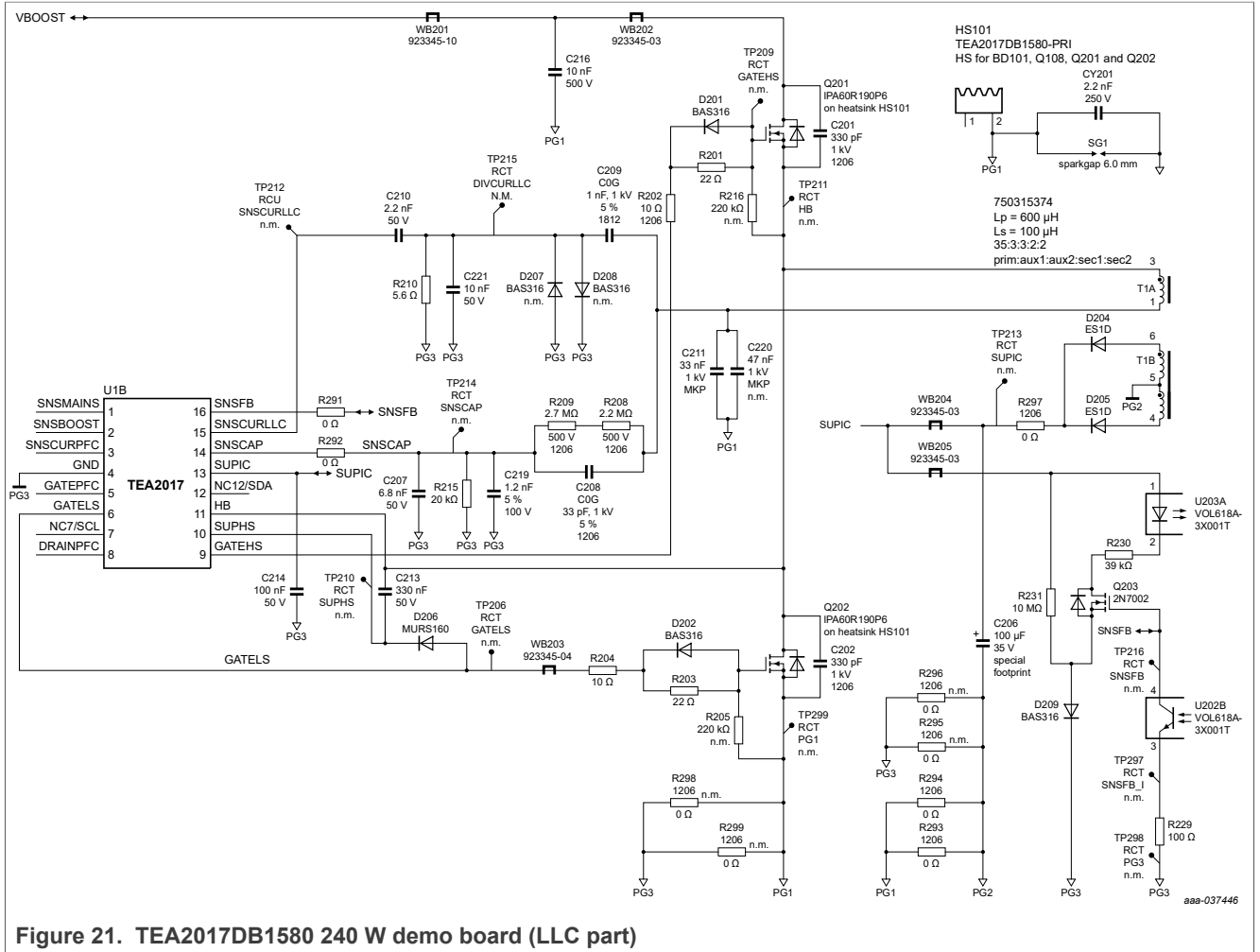
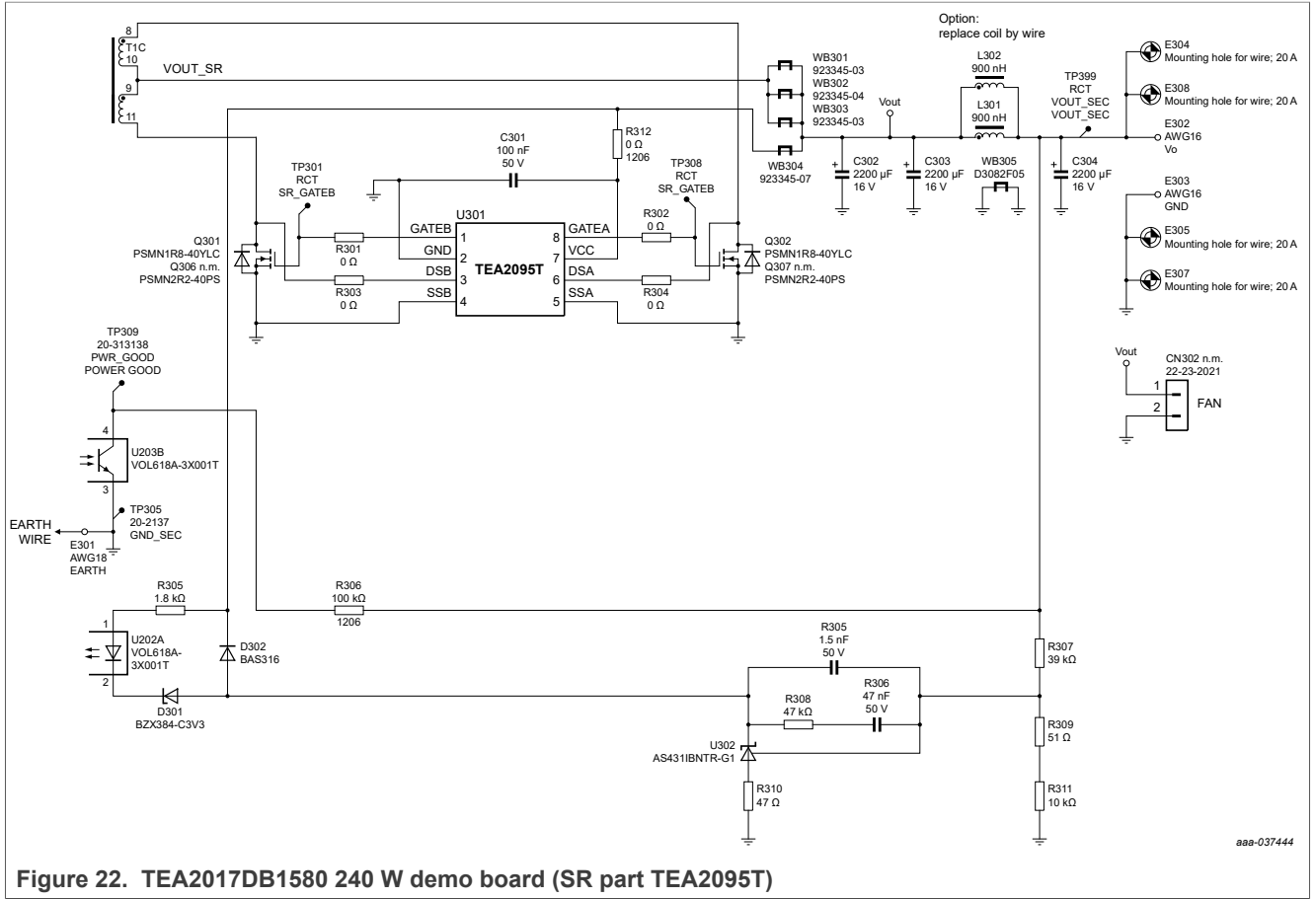
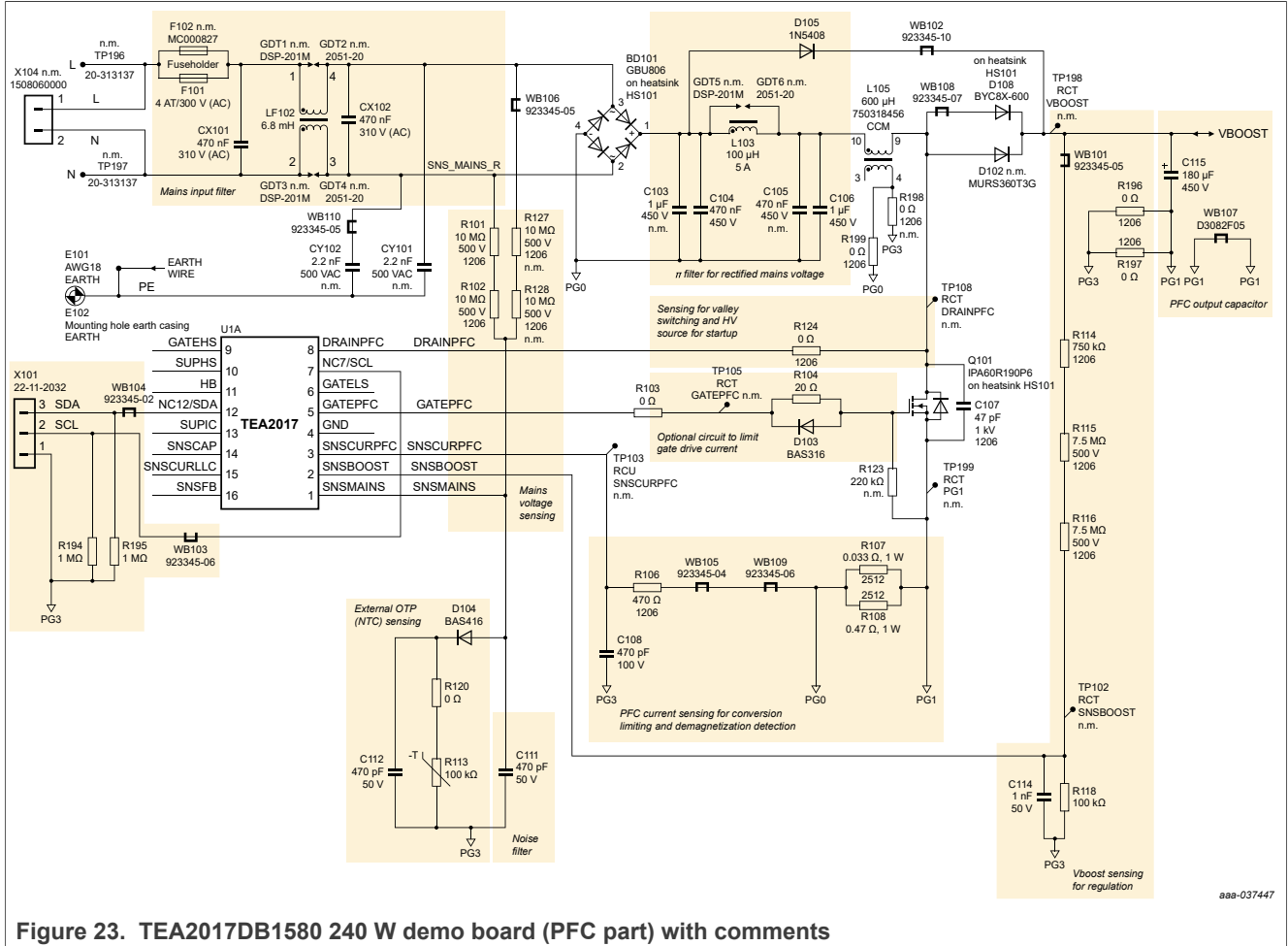


Figure 21. TEA2017DB1580 240 W demo board (LLC part)



8 Circuit diagrams with comments



aaa-037447

Figure 23. TEA2017DB1580 240 W demo board (PFC part) with comments

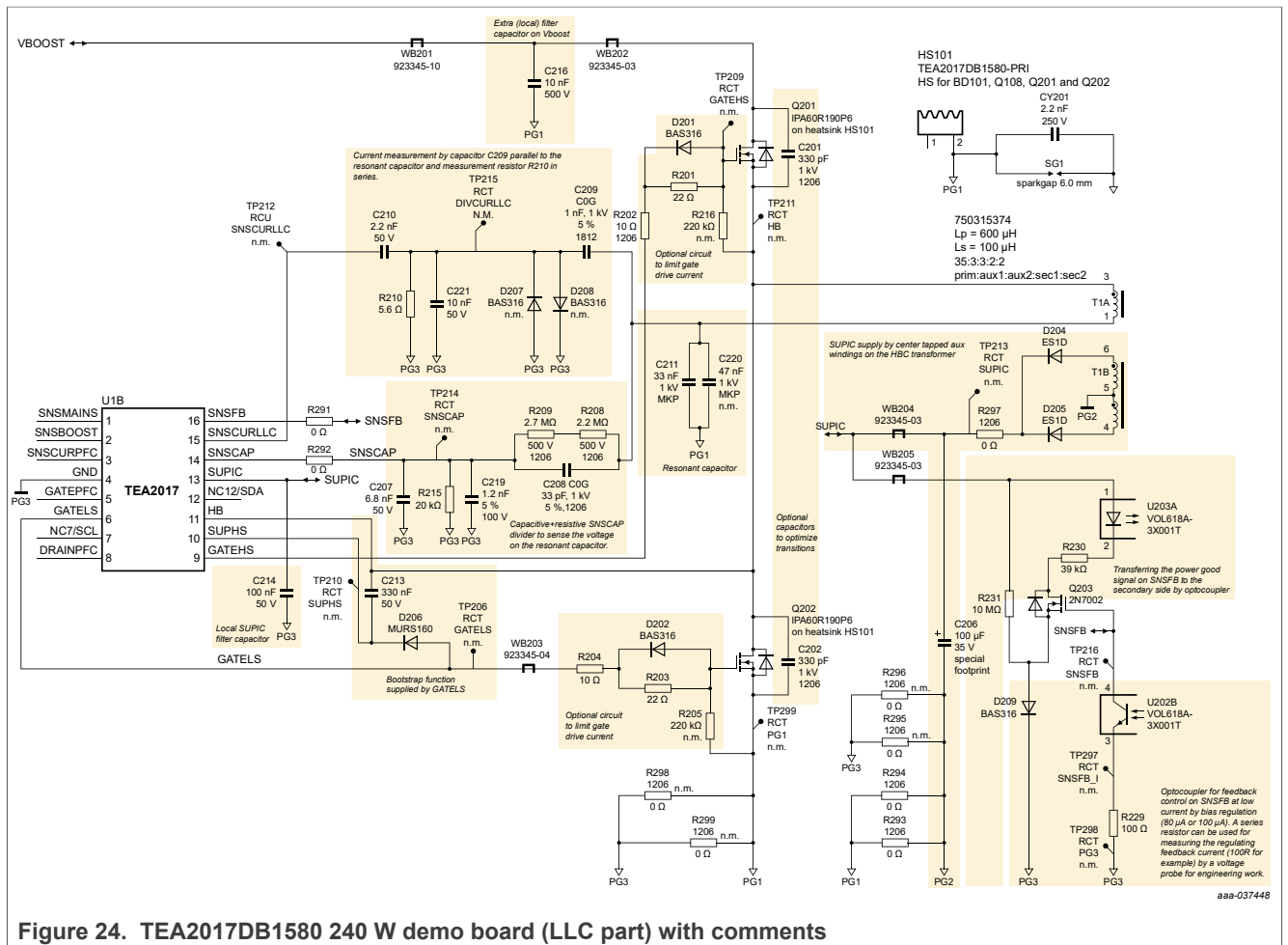
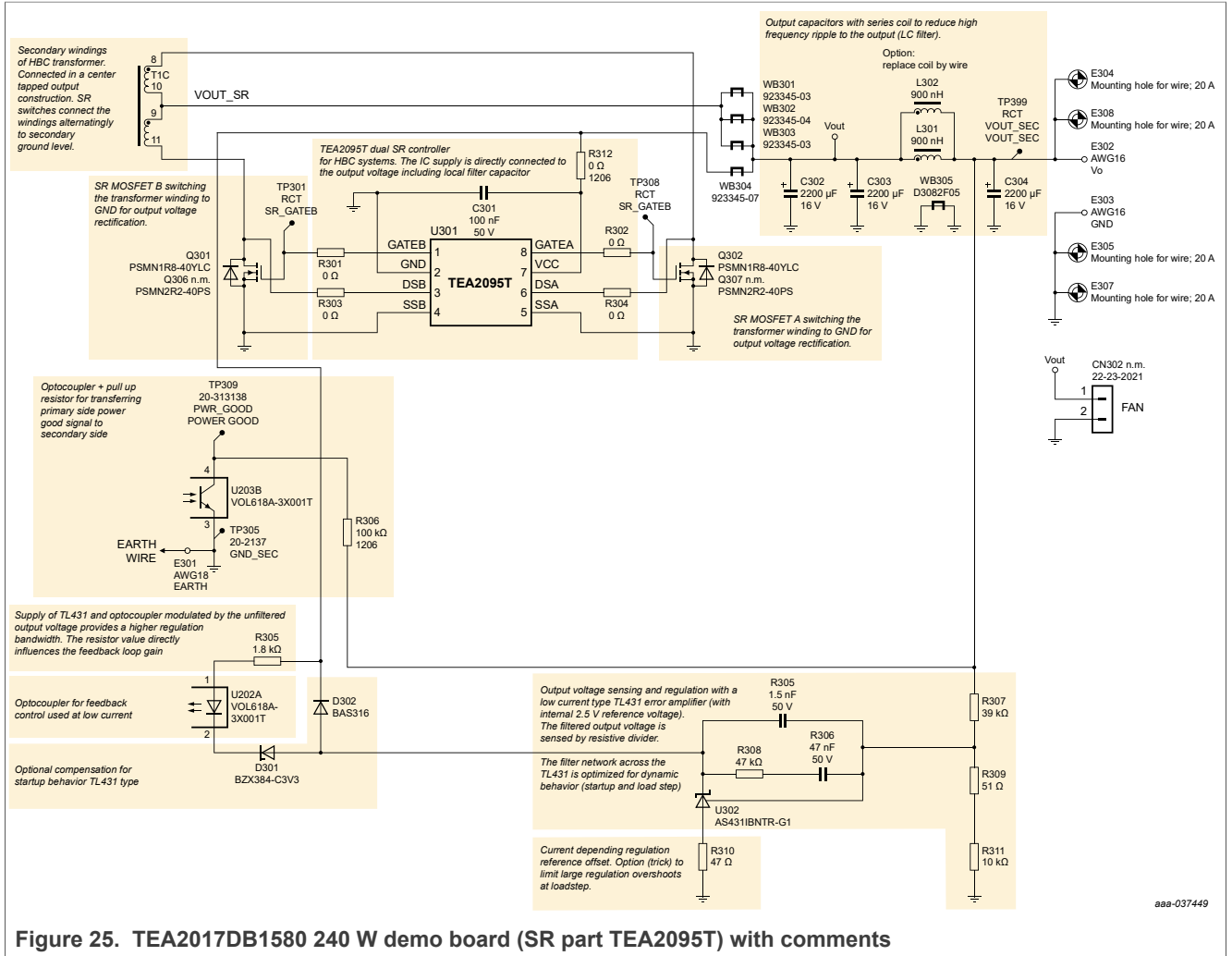


Figure 24. TEA2017DB1580 240 W demo board (LLC part) with comments



aaa-037449

Figure 25. TEA2017DB1580 240 W demo board (SR part TEA2095T) with comments

9 Bill of materials (BOM)

Table 6. TEA2017DB1580 bill of materials

Reference	Description and values	Part number	Manufacturer
BD101	bridge rectifier; 600 V; 8 A	GBU806	Diode Inc.
C103	capacitor; not mounted; 1 μ F; 10 %; 450 V; PET; THT	ECQE2W105KH	Panasonic
C104	capacitor; 470 nF; 10 %; 450 V; PET; THT	ECQE2W474KH	Panasonic
C105	capacitor; not mounted; 470 nF; 10 %; 450 V; PET; THT	ECQE2W474KH	Panasonic
C106	capacitor; 1 μ F; 10 %; 450 V; PET; THT	ECQE2W105KH	Panasonic
C107	capacitor; 47 pF; 5 %; 1 kV; C0G; 1206	GRM31A5C3A470JW01D	Murata
C108	capacitor; 470 pF; 10 %; 50 V; X7R; C0G; 0603	-	-
C111	capacitor; 470 pF; 10 %; 50 V; C0G; 0603	-	-
C112	capacitor; 470 pF; 10 %; 50 V; X7R;	-	-
C114	capacitor; 1 nF; 10 %; 50 V; X7R; 0603	-	-
C115	capacitor; 180 μ F; 20 %; 450 V; ALU; THT	450QXW180MEFC18X45	Rubycon
C201; C202	capacitor; 330 pF; 5 %; 1 kV; C0G; 1206	102R18N331JV4E	Johanson Dielectrics
C206	capacitor; 47 μ F; 20 %; 35 V; ALU; THT	35ZLJ47MTA5X11	Rubycon
C207	capacitor; 6.8 nF; 5 %; 50 V; X7R; 0603	C1608C0G1H682J080AA	TDK
C208	capacitor; 33 pF; 5 %; 1 kV; C0G; 1206	GRM31A5C3A330JW01D	Murata
C209	capacitor; 1 nF; 5 %; 1 kV; C0G; 1812	CC1812JKNPOCBN102	Yageo
C210	capacitor; 2.2 nF; 10 %; 50 V; X7R; 0603	-	-
C211	capacitor; 33 nF; 20 %; 1 kV; MKP	BFC233810333	Vishay
C213	capacitor; 330 nF; 10 %; 50 V; X7R; 0805	-	-
C214; C301	capacitor; 100 nF; 10 %; 50 V; X7R; 0603	-	-
C216	capacitor; 10 nF; 10 %; 500 V; X7R; 1812	C1812C103KCRCTU	KEMET
C219	capacitor; 1.2 nF; 5 %; 100 V; C0G; 0603	C0603C122J1GACTU	KEMET
C220	capacitor; not mounted; 47 nF; 5 %; 1 kV; MKP	BFC237520473	Vishay
C221	capacitor; 10 nF; 10 %; 50 V; X7R; 0805	-	-
C302; C303; C304	capacitor; 2200 μ F; 20 %; 16 V; ALU; THT	16ZLH2200MEFC12.5X20	Rubycon
C305	capacitor; 1.5 nF; 10 %; 50 V; X7R; 0603	-	-
C306	capacitor; 47 nF; 10 %; 50 V; X7R; 0603	-	-
CN302	header; straight; not mounted; 1x2-way; 2.54 mm	22-23-2021	Molex
CX101; CX102	capacitor; 470 nF; 20 %; 310 V (AC); MKP; THT	BFC233922474	Vishay
CY101; CY102	capacitor; 2.2 nF; 20 %; 500 V (AC); Y5V; THT	VY1222M37Y5VQ63V0	Vishay
CY201	capacitor; 2.2 nF; 20 %; 250 V; CER; THT	VY1222M47Y5UQ63V0	Vishay

Table 6. TEA2017DB1580 bill of materials...continued

Reference	Description and values	Part number	Manufacturer
D102	diode; 600 V; 3 A	MURS360T3G	On Semi
D103; D201; D202; D209; D302	diode; 100 V; 250 mA	BAS316	Nexperia
D104	diode; 85 V; 200 mA	BAS416	Nexperia
D105	diode; 1 kV; 3 A	1N5408	Vishay
D108	diode; 600 V; 8 A	BYC8X-600	WeEn Semiconductors
D204; D205	diode; 140 V; 1 A	ES1D-E3	Vishay
D206	diode; 600 V; 1 A	MURS160	Vishay
D207; D208	diode; not mounted; 100 V; 250 mA	BAS316	Nexperia
D301	diode; Zener diode; 3.3 V; 250 mA	BZX384-C3V3	Nexperia
F101	fuse; slow blow; 300 V (AC); 4 A	SS-5H-4A-APH	Cooper Bussmann
F102	fuseholder; 5 mm × 20 mm	MC000827	Multicomp
GDT1; GDT3; GDT5	gas discharge tube; not mounted; 200 V; THT	DSP-201M	Mitsubishi
GDT2; GDT4; GDT6	gas discharge tube; not mounted; 200 V; SMT	2051-20-SM-RPLF	Bourns
HS101	heat sink; primary	DB1580-HS01	NXP Semiconductors
L103	inductor; 100 µH; 5 A	7447070	Würth Elektronik
L105	inductor; 600 µH; 8.5 A	750318456rev1	Würth Elektronik
L301; L302	inductor; 900 nH	APS-13903-NL	Axis Power
LF102	inductor; common mode; 6.8 mH; 3.2 A	B82734R2322B30	EPCOS
MCL2; MCL3; MCL4; MCL5; MCL6	fixing kit; nut and bolt	MK3311	Multicomp
MCL7; MCL8; MCL9; MCL10; MCL11	screw; CSK; POZI; M3X10	M3 10 KRSTMC Z100	TR FASTENINGS
MCL12	fuseholder cover; not mounted; 5 mm × 20 mm	MC000833	Multicomp
MCL13	terminal block; not mounted; BL 5.08/2	1716320000	Weidmüller

Table 6. TEA2017DB1580 bill of materials...continued

Reference	Description and values	Part number	Manufacturer
MCL14	fuse; not mounted; time delay; 5 mm × 20 mm; 4 A; 250 V	MC000840	Multicomp
Q101; Q201; Q202	MOSFET-N; 650 V; 20.2 A	IPA60R190P6	Infineon
Q203	MOSFET-N; 60 V; 300 mA	2N7002	Nexperia
Q301; Q302	MOSFET-N; 40 V; 100 A	PSMN1R8-40YLC	Nexperia
Q306; Q307	MOSFET-N; not mounted; 40 V; 100 A	PSMN2R2-40PS	Nexperia
R101; R102	resistor; 10 MΩ; 1 %; 250 mW; 500 V; 1206	KTR18EZPF1005	ROHM
R103; R120; R291; R292; R301; R302; R303; R304	resistor; jumper; 0 Ω; 63 mW; 0603	-	-
R104	resistor; 20 Ω; 1 %; 63 mW; 0603	-	-
R106	resistor; 470 Ω; 1 %; 250 mW; 1206	-	-
R107	resistor; 0.033 Ω; 1 %; 1 W; 2512	RL2512FK-070R033L	Yageo
R108	resistor; 0.47 Ω; 1 %; 1 W; 2512	RL2512FK-070R47	Yageo
R113	resistor; NTC; 100 kΩ; 5 %; 100 mW; 4190 K	NTCLE100E3104JB0	Vishay
R114	resistor; 750 kΩ; 1 %; 250 mW; 1206	-	-
R115; R116	resistor; 7.5 MΩ; 1 %; 250 mW; 500 V; 1206	KTR18EZPF7504	ROHM
R118	resistor; 100 kΩ; 1 %; 63 mW; 0603	-	-
R123	resistor; not mounted; 220 kΩ; 1 %; 63 mW; 0603	-	-
R124; R196; R197; R199; R293; R294; R297; R312	resistor; jumper; 0 Ω; 250 mW; 1206	-	-
R127; R128	resistor; not mounted; 10 MΩ; 1 %; 250 mW; 500 V; 1206	KTR18EZPF1005	ROHM
R194; R195	resistor; 1 MΩ; 1 %; 63 mW; 0603	-	-

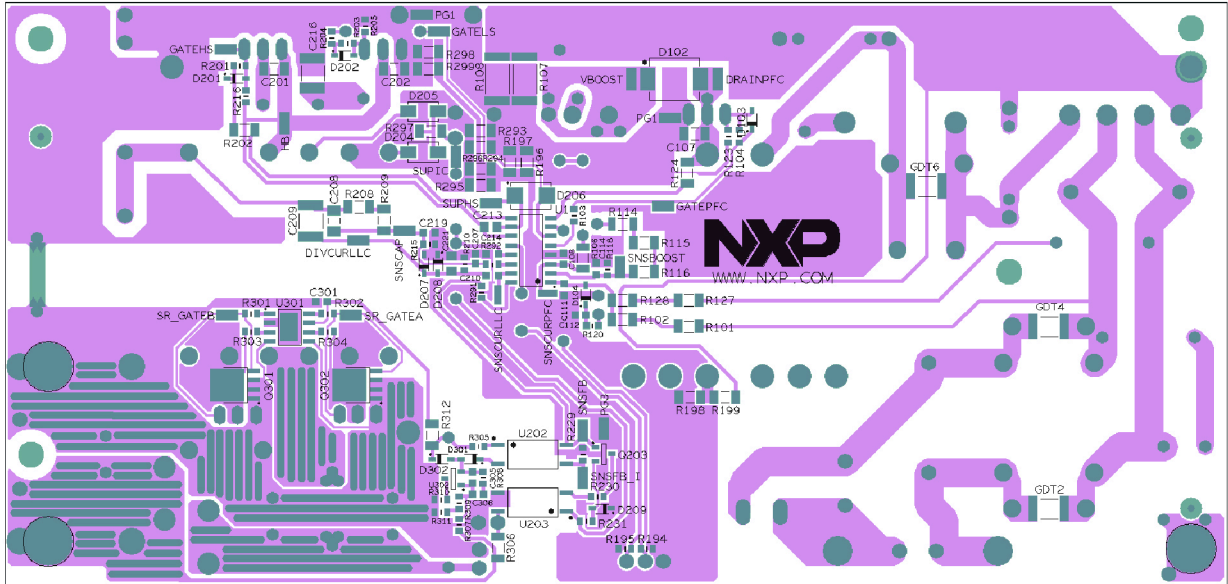
Table 6. TEA2017DB1580 bill of materials...continued

Reference	Description and values	Part number	Manufacturer
R198; R295; R296; R298; R299	resistor; jumper; not mounted; 0 Ω ; 250 mW; 1206	-	-
R201; R203	resistor; 22 Ω ; 1 %; 63 mW; 0603	-	-
R202	resistor; 10 Ω ; 1 %; 250 mW; 1206	RC1206FR-0710RL	Yageo
R204	resistor; 10 Ω ; 1 %; 63 mW; 0603	-	-
R205; R216	resistor; not mounted; 220 k Ω ; 1 %; 63 mW; 0603	-	-
R208	resistor; 2.2 M Ω ; 1 %; 250 mW; 500 V; 1206	KTR18EZPF2204	ROHM
R209	resistor; 2.7 M Ω ; 1 %; 250 mW; 500 V; 1206	KTR18EZPF2704	ROHM
R210	resistor; 5.6 Ω ; 1 %; 63 mW; 0603	-	-
R215	resistor; 20 k Ω ; 1 %; 63 mW; 0603	-	-
R229	resistor; 100 Ω ; 1 %; 63 mW; 0603	-	-
R230; R307	resistor; 39 k Ω ; 1 %; 63 mW; 0603	-	-
R231	resistor; 10 M Ω ; 1 %; 63 mW; 0603	-	-
R305	resistor; 1.8 k Ω ; 1 %; 63 mW; 0603	-	-
R306	resistor; 100 k Ω ; 1 %; 250 mW; 1206	-	-
R308	resistor; 47 k Ω ; 1 %; 63 mW; 0603	-	-
R309	resistor; 51 Ω ; 1 %; 63 mW; 0603	-	-
R310	resistor; 47 Ω ; 1 %; 63 mW; 0603	-	-
R311	resistor; 10 k Ω ; 1 %; 63 mW; 0603	-	-
T1	transformer; ETD34	750315374	Würth Elektronik
TP102; TP105; TP108; TP198; TP199; TP206; TP209; TP210; TP211; TP213; TP214; TP215; TP216; TP297; TP298; TP299; TP301; TP308	test point; not mounted; 0805	RCT-0C	TE Connectivity

Table 6. TEA2017DB1580 bill of materials...continued

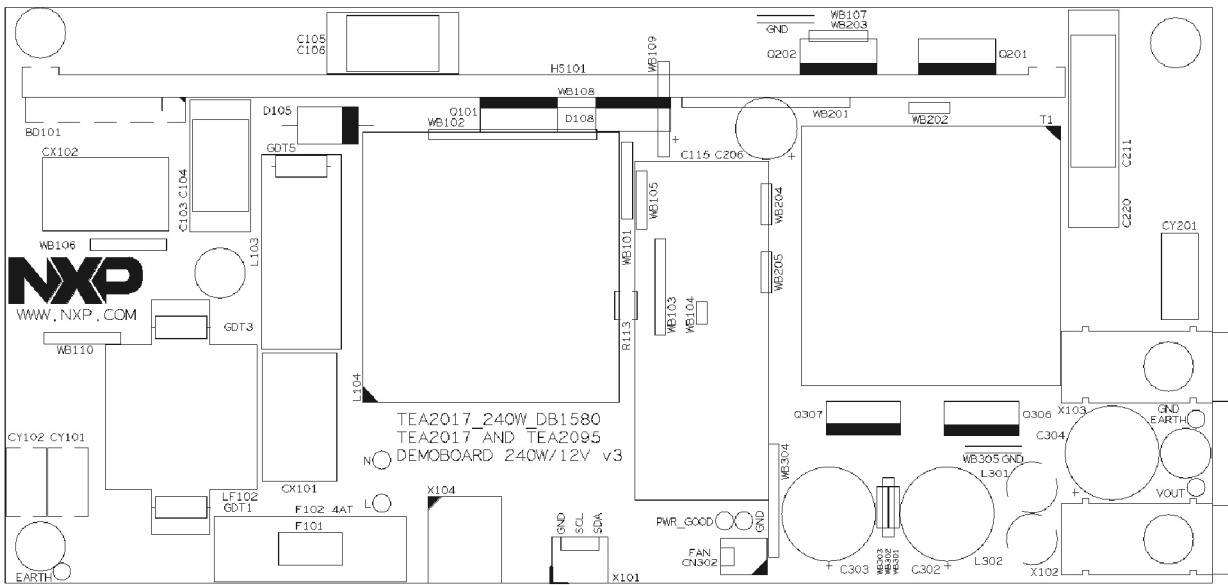
Reference	Description and values	Part number	Manufacturer
TP103; TP212	test point; not mounted; 0603	RCU-0C	TE Connectivity
TP196; TP197; TP310	test point; not mounted; isolated; 1.02 mm; red	20-313137	Vero Technologies
TP305	test point; not mounted; isolated; 1.02 mm; black	20-2137	Vero Technologies
TP309	test point; not mounted; isolated; 1.02 mm; green	20-313138	Vero Technologies
U1	PFC + LLC controller	TEA2017AATdev	NXP Semiconductors
U202; U203	optocoupler; NPN; 80 V; 60 mA	VOL618A-3X001T	Vishay
U301	synchronous rectifier Controller; dual	TEA2095T	NXP Semiconductors
U302	regulator; AS431	AS431IBNTR-G1	Diodes Inc.
WB101; WB106; WB110	wire bridge; 0.8 mm; P = 12.10 mm	923345-05	3M
WB102; WB201	wire bridge; 0.8 mm; P = 25.40 mm	923345-10	3M
WB103; WB109	wire bridge; 0.8 mm; P = 15.24 mm	923345-06	3M
WB104	wire bridge; 0.8 mm; P = 5.08 mm	923345-02	3M
WB105; WB203; WB302	wire bridge; 0.8 mm; P = 10.16 mm	923345-04	3M
WB107; WB305	wire bridge; bare; 1 mm; P = 10.16 mm	D3082F05	Harwin
WB108; WB304	wire bridge; 0.8 mm; P = 17.18 mm	923345-07	3M
WB202; WB204; WB205; WB301; WB303	wire bridge; 0.8 mm; P = 7.62 mm	923345-03	3M
X101	header; straight; 1 x 3-way; 2.54 mm	22-11-2032	Molex
X102	receptacle; not mounted; R/A; 4 mm; 1 x 2-way; red; 10 A	571-0500-01	Deltron Components Ltd.
X103	receptacle; not mounted; R/A; 4 mm; 1 x 2-way; black; 10 A	571-0100-01	Deltron Components Ltd.
X104	header; not mounted; terminal block; 1 x 2-way; 5.08 mm	1508060000	Weidmüller

10 PCB layout



aaa-037452

a. PCB layout



aaa-037453

b. PCB components

Figure 26. TEA2017DB1580 PCB layout and components

Board dimensions:

- Length = 168 mm
- Width = 80 mm
- Thickness copper layer = 75 µm
- Number of copper layers = 1

11 Transformer specifications

11.1 LLC transformer

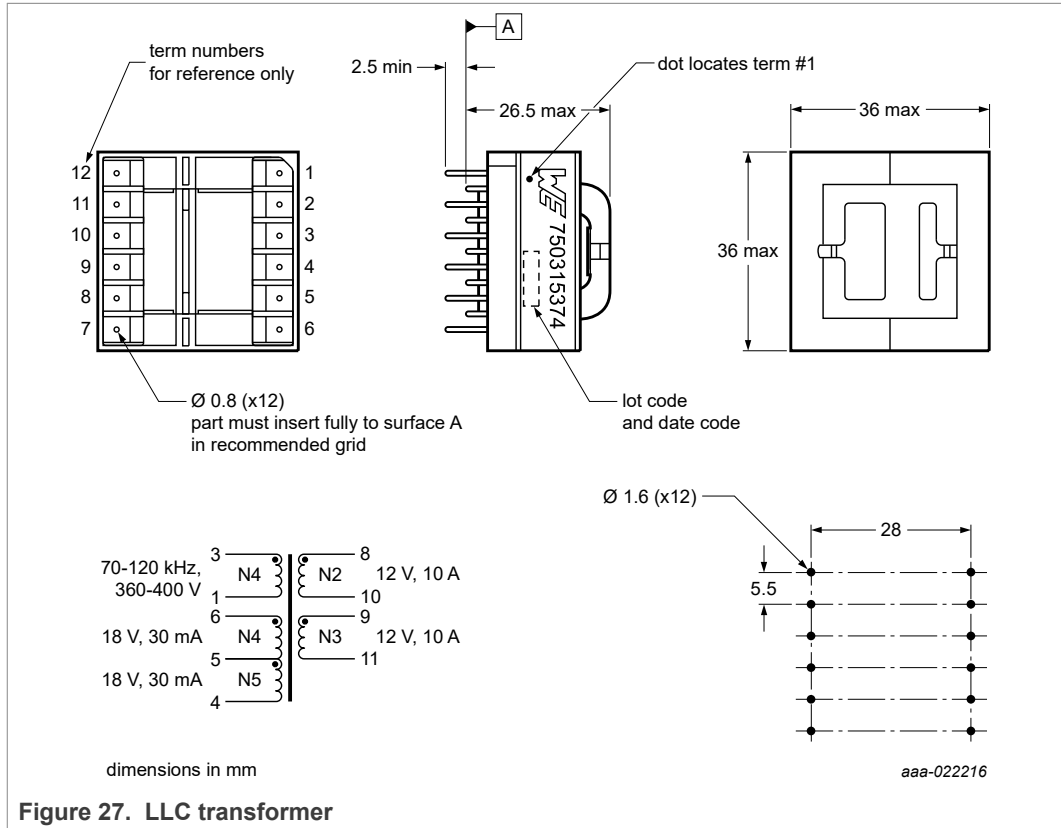


Figure 27. LLC transformer

Table 7. LLC transformer specifications

Parameter	Values	Test conditions
DC resistance; 3-1	0.152 Ω; ±10	at 20 °C
DC resistance; 8-10	maximum 0.005 Ω	at 20 °C
DC resistance; 9-11	maximum 0.005 Ω	at 20 °C
DC resistance; 6-5	0.122 Ω; ±10 %	at 20 °C
DC resistance; 5-4	0.122 Ω; ±10 %	at 20 °C
inductance; 3-1	600 μH; ±10 %	10 kHz; 100 mV; L _s
saturation current; 3-1	1.7 A	20 % roll-off from initial
leakage inductance; 3-1	100 μH; ±10 %	tie(4+5+6, 8+9+10+11); 100 kHz; 100 mA; L _s
dielectric; 1-11	3200 V (AC); 1 minute	tie(3=4, 10+11); 4000 V (AC); 1 s

11.2 PFC coil

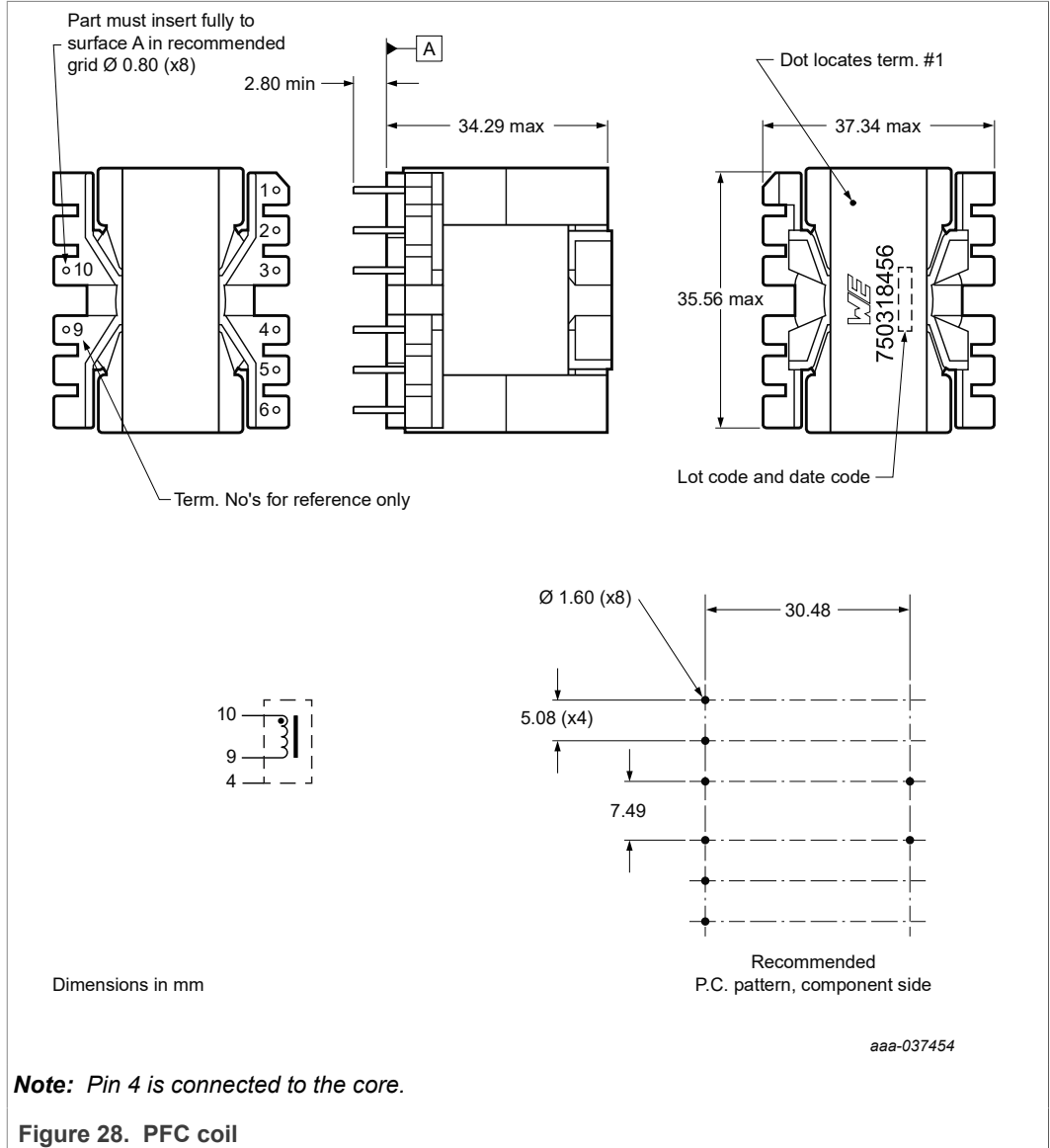


Table 8. PFC coil specifications

Parameter	Value	Conditions
Electric specifications		
DC resistance; 9-10	0.24 Ω ; ± 10 %	at 20 °C
inductance; 9-10	600 μH ; ± 10 %	10 kHz; 100 mV; L_s
saturation current; 9-10	8.25 A	20 % roll-off from initial
General specifications		
operating temperature	-40 °C to +125 °C	including temperature rise

12 TEA2017AAT parameter settings

[Section 12](#) shows a list of the parameters in the MTP. It shows the Ringo GUI parameter names, the NXP Semiconductors parameter names, and their values.

The Ringo GUI export function can generate a list with the MTP settings of an IC. It provides an overview of the selected values and can be used for comparison, checking, or sharing the information. In addition to this list, the settings can be stored as a .mif file. This file can be reloaded in the Ringo GUI software later or shared to others.

Table 9. Ringo parameter/IC parameter settings

	Ringo parameter name	IC parameter name	Value	Unit	Binary value
1	NXP ID code	nxp_id_code	0x02	-	2
2	PFC OCP	pfc_ocp	OK	-	0
3	PFC OVP (DRAINPFC)	pfc_ovp_pfcdrain	OK	-	0
4	PFC OVP (SNSBOOST)	pfc_ovp_snsboost	OK	-	0
5	LLC OPP 1	llc_opp1	OK	-	0
6	LLC OPP 2	llc_opp2	OK	-	0
7	LLC maximum start-up time	llc_max_startup_time	OK	-	0
8	LLC OCP	llc_ocp	OK	-	0
9	LLC OVP	llc_ovp_prot	OK	-	0
10	External OTP	ext_otp	OK	-	0
11	Internal OTP	int_otp	OK	-	0
12	Fast disable	fast_disable	OK	-	0
13	LLC maximum on-time	llc_max_on_time	OK	-	0
14	LLC maximum lopto	llc_max_iopto	OK	-	0
15	LLC capacitive mode	llc_cap_mode	OK	-	0
16	MTP read failure	mtp_read_fail	OK	-	0
17	OPP via SUPIC UVP	opp_via_supic_uvp	OK	-	0
18	PFC soft-start time	t_start	25	ms	0
19	PFC gain	pfc_gain	0.5	-	8
20	PFC current scaler	pfc_cur_scaler	1.138	-	4
21	Write lock	write_lock	write enabled	-	0
22	Read lock	read_lock	read enabled	-	0
23	PFC burst mode level	pfc_burstmode_lvl	50	%	0
24	PFC burst mode level hysteresis	pfc_burstmode_lvl_hyst	25	%	0
25	PFC burst mode SNSBOOST ripple	vburst_ripple	70	mV	1
26	PFC minimum off-time	tmin_off	500	ns	0
27	Brownin level	brownin_lvl	5.5	μA	0
28	Brownin/brownout hysteresis	brownin_hys	0.75	μA	0
29	Brownout delay	t_brownout	50	ms	0

Table 9. Ringo parameter/IC parameter settings...continued

	Ringo parameter name	IC parameter name	Value	Unit	Binary value
30	PFC valley detection	pfc_valley_disable	enabled	-	0
31	dV/dt ratio switch-on/maximum	ratio_valley_detect	0.5	-	0
32	Mains resistor value	rmains	20	MΩ	0
33	PFC minimum switching frequency	min_pfc_freq	40	kHz	0
34	PFC maximum switching frequency	max_pfc_freq	75	kHz	1
35	PFC mode	pfc_mode	DCM/QR/CCM	-	1
36	PFC jitter frequency modulation	freq_jitter_mod	disabled	-	0
37	PFC jitter frequency amplitude	freq_jitter_ampl	15	%	0
38	PFC gamma value	pfc_gamma	0x24	-	36d
39	Mains SNS resistors	nr_mains_resistors	1	resistor	0
40	PFC phase factor	pfc_phase	0.9375	-	15d
41	LLC soft-start speed	llc_tsoftstart	7	X	0
42	SUPIC control near UVP	dis_vlow	enabled	-	0
43	SUPIC start level	sup_start	19	V	0
44	LLC converter	llc_disable	enabled	-	0
45	Vdump level	vdump	2.55	V	1
46	Capacitive mode regulation level	capm_lvl	100	mV	0
47	Maximum on-time	llc_max_on	20	μs	0
48	LLC LP mode	lpmode_dis	enabled	-	0
49	OTP/external burst mode select	ext_burstmode	Ext OTP	-	0
50	LLC non-overlap mode	llc_non_overlap	adaptive	-	0
51	Maximum non-overlap time	t_no_max	1.1	μs	0
52	Minimum non-overlap time	t_no_min	230	ns	0
53	Opto current level	iopto	80	μA	0
54	Burst-on end by opto current	iopto_bm_end	2.5	-	0
55	SNSBOOST compensation	snsb_comp	-1.4	-	0
56	HP-LP transition level	hp_lp_lev	30	%	0
57	HP-LP hysteresis	hp_lp_hys	20	%	0
58	Opto regulation gain increase	opto_reg_gain_incr	96	-	0
59	LP number of peaks	lp_nr_peaks	2	-	0
60	LP-BM transition level	lp_bm_lev	10	%	0
61	BM-LP hysteresis	bm_lp_hys	50	%	7
62	BM LP hysteresis filter	bm_lp_filt	4	-	0
63	LP-BM delay time	lp_bm_del	0	s	0
64	Zero power slope	min_slope	6	mV/μs	0
65	dVcap offset	vcap_offset	0	mV	0

Table 9. Ringo parameter/IC parameter settings...continued

	Ringo parameter name	IC parameter name	Value	Unit	Binary value
66	BM frequency	bm_freq	800	Hz	0
67	BM energy-per-cycle increase	bm_incr	1	-	0
68	Minimum cycles in burst	min_nr_cycl	3	-	0
69	Number of BM soft-start cycles	nr_bm_sstart	2	-	2
70	Number of BM soft-stop cycles	nr_bm_sstop	2	-	2
71	Burst mode exit delay	bm_exit_del	4000	µs	0
72	Allow CCM at demag timeout	allow_ccm_demag_to	disable	-	0
73	PFC current gain	pfc_cur_gain	344	-	344d
74	Slope of 4th BM soft-start cycle	start_cycle4	2	-	0
75	Slope of 3rd BM soft-start cycle	start_cycle3	6	-	0
76	Slope of 2nd BM soft-start cycle	start_cycle2	10	-	5
77	Slope of 1st BM soft-start cycle	start_cycle1	96	-	0
78	Slope of 4th BM soft-stop cycle	stop_cycle4	96	-	0
79	Slope of 3rd BM soft-stop cycle	stop_cycle3	24	-	0
80	Slope of 2nd BM soft-stop cycle	stop_cycle2	10	-	4
81	Slope of 1st BM soft-stop cycle	stop_cycle1	4	-	2
82	External OTP current level	eotp_lvl	600	µA	0
83	External OTP delay time	t_eotp	4	s	0
84	OTP mode	otp_ltch	safe restart	-	0
85	OTP number of restarts to latch	otp_nr_rest	0	-	0
86	Fast disable by SNSBOOST	llc_fast_disable	latched	-	3
87	X-cap discharge delay time	t_xcap_disch	200	ms	0
88	Fast latch reset delay time	t_flr	50	ms	0
89	Safe restart timer	sr_time	1	s	0
90	PFC OVP level (SNSBOOST)	ovp_lvl	2.63	V	0
91	PFC OVP (DRAINPFC)	ovpprot_lvl	475	V	0
92	OVP-DRAINPFC protection delay	t_ovpprot	250	cycles	0
93	OVP-DRAINPFC mode	ovp_ltch	safe restart	-	0
94	OVP-DRAINPFC no. of restarts	ovp_nr_rest	0	-	0
95	PFC short-winding delay	pfc_shortwinding_delay	5000	-	0
96	PFC maximum ringing time	max_tring_pfc	7	µs	3
97	LLC soft-start current limit	max_llc_istartup	0.75	V	0
98	Maximum (start-up) frequency	max_llc_freq	350	kHz	0
99	Maximum start-up time	t_start_max	100	ms	0
100	LLC maximum ringing time	max_tring_llc	5	µs	0
101	LLC OCP filter	llc_tocp	5	-	0

Table 9. Ringo parameter/IC parameter settings...continued

	Ringo parameter name	IC parameter name	Value	Unit	Binary value
102	LLC OCP mode	llc_ocp_ltch	safe restart	-	0
103	OCP restarts to latch	llc_ocp_nr_rest	0	-	0
104	LLC (SUPIC) OVP level	llc_ovp	10	V	0
105	LLC (SUPIC) OVP delay	llc_tovp	50	µs	0
106	Down-counts/up-count (SUPIC) OVP	llc_ovp_nr_dwn	1	-	0
107	(SUPIC) OVP mode	llc_ovp_ltch	safe restart	-	0
108	OVP restarts to latch	llc_ovp_nr_rest	0	-	0
109	LLC brownin level (SNSBOOST)	snsb_start	2.3	V	6
110	LLC brownout level (SNSBOOST)	snsb_stop	1.65	V	3
111	Disable LLC after SNSBOOST OVP	dis_ovp_snsb	off	-	3
112	Disable LLC after mains brownout	llc_dis_bo	250	ms	0
113	OPP1 level	opp1_lvl	-20	%	0
114	OPP1 time delay	opp1_time	50	ms	0
115	OPP2 level	opp2_lvl	-10	%	0
116	OPP2 time delay	opp2_time	infinite	-	0
117	Down-counts/up-count OPP	opp_nr_dwn	1	-	0
118	OPP mode	opp_ltch	safe restart	-	0
119	OPP restarts to latch	opp_nr_rest	0	-	0
120	LLC power limitation level	pow_lim	155	%	0
121	Power good inverted	pgood_inv	disabled	-	0
122	Power good SNSBOOST reset level	pgd_lvl	1.75	V	0
123	Power good at mains brownout	pgd_bo	enabled	-	0
124	Power good at OPP	pgd_opp	enabled	-	0
125	Power good at OTP	pgd_otp	enabled	-	0
126	Power good signal at SNSBOOST OVP	pgd_ovp_sbo	enabled	-	0
127	Power good signal edge (SNSFB)	pgd_tr	1.8	ms	0
128	Power good delay	pgd_del	5	ms	0
129	Power good time to protection	pgd_tim	4	ms	0
130	Vendor code	mtp_code	0	-	0
131	PFC soft-start time burst mode	-	short	-	-
132	PFC soft-stop time burst mode	-	normal	-	-

13 Appendix: Terms of use

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This Agreement is governed by and construed in accordance with the laws of The Netherlands without regard to any principle of conflicts of law. Any dispute arising hereunder shall be resolved in the competent courts in Amsterdam, The Netherlands, and You agree that venue and jurisdiction for any related proceedings lies exclusively with such courts; provided, however, that each party may enforce its and its Affiliates' intellectual property rights in any court, and similar governing body, of competent jurisdiction, including but not limited to equitable relief. The UN Convention on Contracts for the International Sale of Goods shall not apply to this Agreement.

7. COMPLIANCE WITH LAW

You are responsible to comply with all applicable laws and regulations including but not limited to any E.U. Directives or FCC regulations. Each Party shall comply with all applicable laws and regulations, including but not limited to applicable export and import control laws and regulations including but not limited to the US Export Administration Regulation (including restrictions on certain military end uses and military end users as specified in Section 15 C.F.R. § 744.21 and prohibited party lists issued by other federal governments), Catch-all regulations and all national and international embargoes. Each Party further agrees that it will not knowingly transfer, divert, export or re-export, directly or indirectly, any product, software, including software source code, or technology restricted by such regulations or by other applicable national regulations, received from the other party under this Agreement, or any direct product of such software or technical data to any person, firm, entity, country or destination to which such transfer, diversion, export or re-export is restricted or prohibited, without obtaining prior written authorization from the applicable competent government authorities to the extent required by those laws. This provision shall survive termination or expiration of this Agreement.

8. SEVERABILITY

If any provision of this agreement is or becomes, at any time or for any reason, unenforceable or invalid, no other provision of this agreement shall be affected thereby, and the remaining provisions of this agreement shall continue with the same force and effect as if such unenforceable or invalid provisions had not been inserted in this Agreement. In addition, any unenforceable or invalid provision shall be deemed replaced by a provision that is valid and enforceable and that comes closest to expressing the intention of the unenforceable or invalid provision.

9. WAIVER

The waiver by either You or NXP of any breach of any provision of this Agreement will not operate or be construed as a waiver of any other or a subsequent breach of the same or a different provision.

10. RELATIONSHIPS AND PARTIES

Nothing in this Agreement shall create, or be deemed to create, any joint venture, partnership, principal-agent, employer- employee or other relationship between You and NXP, except that of independent contractors. Neither You nor NXP has the authority or power to bind, to contract in the name of, or to create a liability for the other in any way or for any purpose.

11. TERM AND TERMINATION

These terms are effective upon Your purchase or use of the Demo Board whichever is first. Any provision of this Agreement which imposes an obligation after termination of this Agreement shall survive the termination of this Agreement.

14 Abbreviations

Table 10. Abbreviations

Acronym	Description
BCM	boundary conduction mode
BM	burst mode
CCM	continuous conduction mode
EMI	electromagnetic interference
GUI	graphical user interface
HBC	half-bridge converter
HP	high power
LLC	resonant tank or converter (Lm+Lr+Cr in series)
LP	low power
MOSFET	metal–oxide–semiconductor field-effect transistor
MTP	multi times programmable
OPP	overpower protection
OTP	overtemperature protection
OVP	overvoltage protection
PCB	printed-circuit board
PFC	power factor correction
QR	quasi-resonant (= BCM mode)
SR	synchronous rectification

15 References

- [1] **TEA2017AAT data sheet** — Digital controller for high-efficiency resonant power supply; 2021, NXP Semiconductors
- [2] **AN13140 application note** — TEA2017 CCM/DCM/QR PFC + LLC controller IC; 2021, NXP Semiconductors
- [3] **UM11235 user manual** — TEA2016DB1514 USB to I²C hardware interface; 2019, NXP Semiconductors
- [4] **UM11657 user manual** — TEA2017 Ringo development software with GUI; 2021, NXP Semiconductors

16 Legal information

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