



# UM10972

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board

Rev. 1.1 — 8 June 2018

User manual  
COMPANY PUBLIC

### Document information

| Information | Content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Keywords    | TEA1916DB1262, TEA19161T, TEA19162T TEA1995T 240 W, LLC, resonant, half-bridge, PFC, controller, converter, burst mode, power supply, demo board, high efficiency, 80+ certification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Abstract    | <p>The TEA19161T is a digital LLC controller. It is used in combination with the PFC controller TEA19162T. Combining these two ICs with the SR controller TEA1995T at the secondary side results in a high-efficient resonant converter over the whole output power range.</p> <p>This document describes such a resonant power supply design with a 240 W (12 V/20 A) typical output power.</p> <p>It operates in normal mode for high and medium power levels, in low-power mode at medium and low power levels, and in burst mode at (very) low power levels.</p> <p>Low-power mode and burst mode operation provide a reduction of power losses, resulting in a higher efficiency at lower output power levels. Power levels for switching over from one mode to another mode can be selected by adjusting component values.</p> <p>The efficiency at high power levels is well above 90 %.</p> <p>No-load power consumption is well below 100 mW.</p> <p>At 250 mW output power, the input power is well below the 500 mW (complies easily with EUP lot6).</p> |



Table 1. Revision history

| Rev            | Date                                                                                                                                                                                 | Description           |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| v.1.1          | 20180608                                                                                                                                                                             | second, updated issue |
| Modifications: | <ul style="list-style-type: none"><li>• <a href="#">Section 7</a> "Bill of Materials" has been updated.</li><li>• <a href="#">Section 9.2</a> "PFC coil" has been updated.</li></ul> |                       |
| v.1            | 20171201                                                                                                                                                                             | first issue           |

## 1 Introduction

### Warning



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.

This user manual describes the TEA1916DB1262 240 W power supply board using the TEA19161T, TEA19162T, and TEA1995T. The user manual contains a functional description and a set of preliminary measurements to show the main characteristics.

### 1.1 TEA19161T and TEA19162T

The TEA19161T is a Half-Bridge Converter (HBC). The TEA19162T is a controller for Power Factor Correction (PFC). Both ICs provide drive functionality for the related discrete MOSFETs.

The resonant controller part (TEA19161T) is a high-voltage controller for a zero voltage switching LLC resonant converter. The resonant controller includes:

- A high-voltage shift circuit
- A high-voltage internal start-up switch
- Several protection features, like OverCurrent Protection (OCP), Open-Loop Protection (OLP), Capacitive Mode Protection (CMP), and a general purpose latched protection input

The TEA19162T is a PFC controller. To ensure efficient operation of the PFC, the TEA19162T incorporates quasi-resonant operation at high power levels and quasi-resonant operation with valley skipping at lower power levels. OCP, OverVoltage Protection (OVP), and demagnetization sensing ensure safe operation under all conditions. To improve the overall performance significantly, the TEA19161T and TEA19162T work together.

With the TEA1995T as a synchronized rectifier controller at the secondary side, MOSFETs can be used instead of rectifying diodes, improving the overall efficiency of the complete system even more.

The combination of PFC, resonant controller, and SR controller makes these devices suitable for all kinds of applications. Especially for application requiring high efficiency over the whole power range from no load to maximum output load.

1.1.1 Pinning

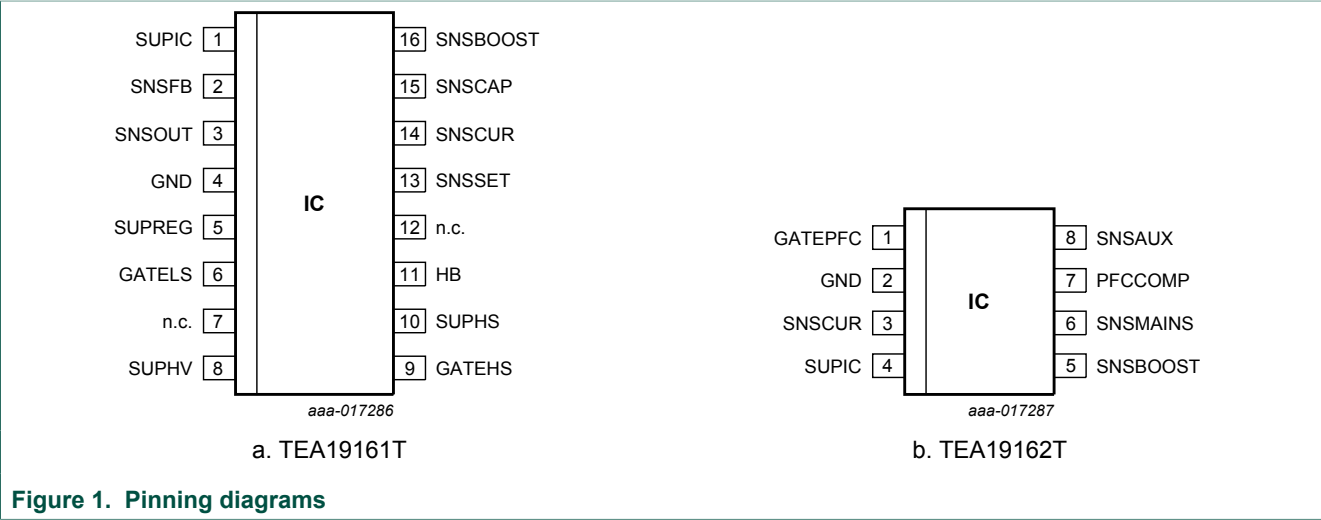


Figure 1. Pinning diagrams

1.2 TEA1995T

The TEA1995T is the first product of a new generation of Synchronous Rectifier (SR) controller ICs for switched-mode power supplies. It incorporates an adaptive gate drive method for maximum efficiency at any load.

The TEA1995T 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.

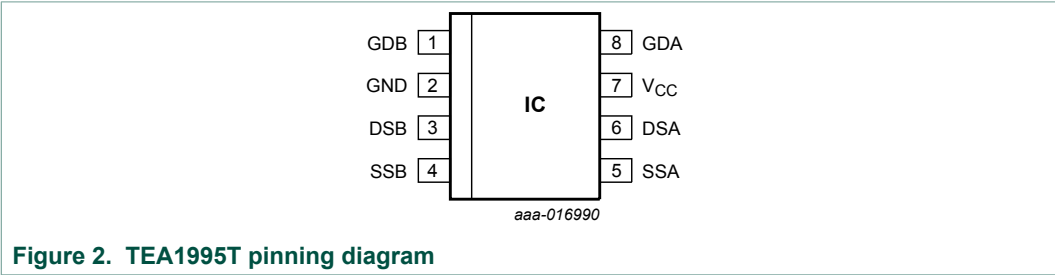
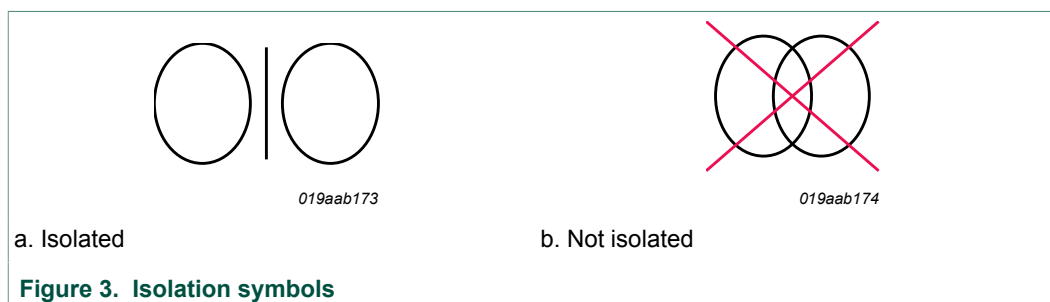


Figure 2. TEA1995T pinning diagram

## 2 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 3](#) shows the symbols that identify the isolated and non-isolated devices.

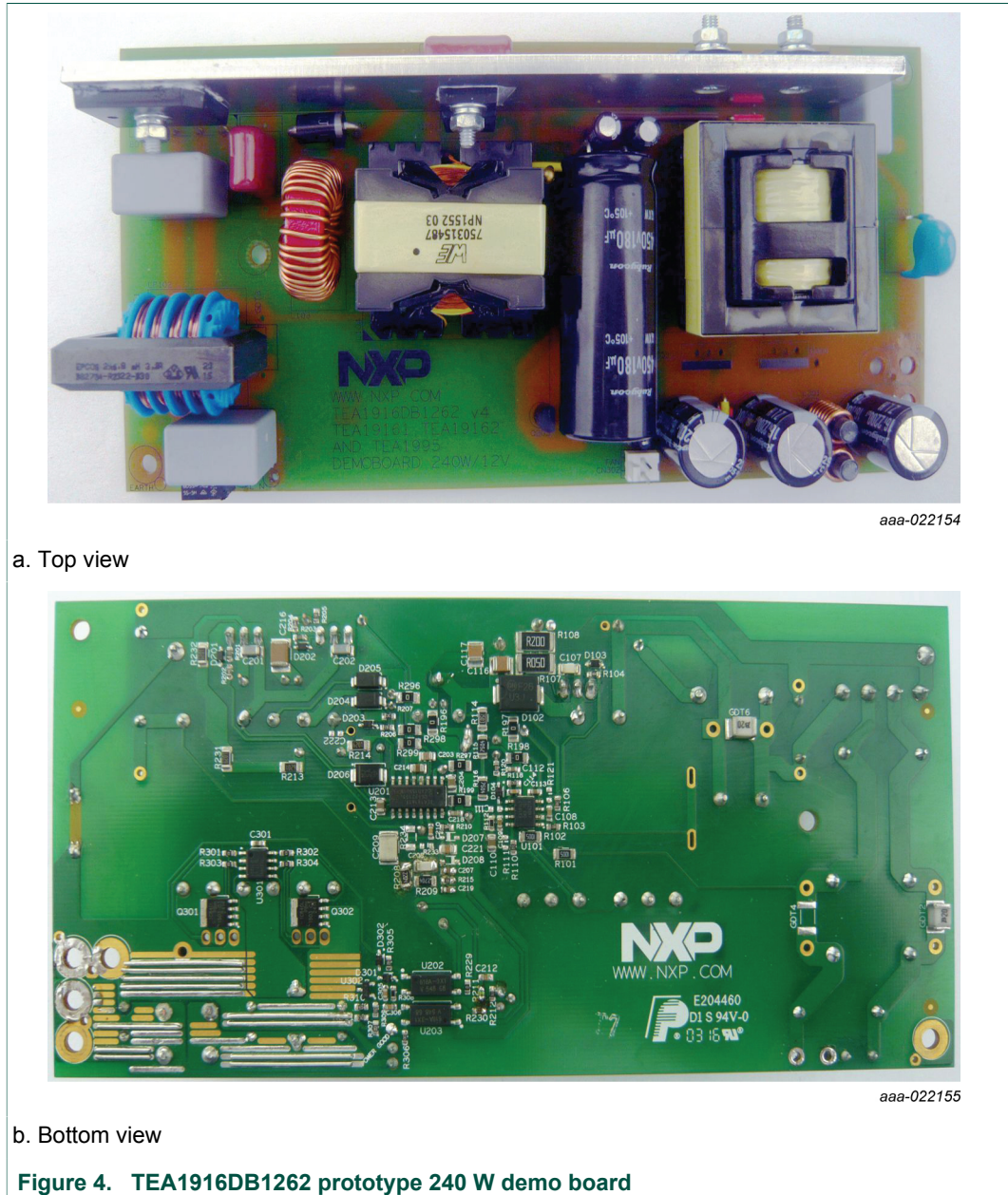


### 3 Specifications

Table 2. Specifications

| Symbol                            | Description                 | Value                     | Conditions                   |
|-----------------------------------|-----------------------------|---------------------------|------------------------------|
| <b>Input</b>                      |                             |                           |                              |
| $V_i$                             | 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               |
| $P_{i(\text{load}=250\text{mW})}$ | standby power consumption   | < 450 mW                  | at 230 V/50 Hz               |
| <b>Output</b>                     |                             |                           |                              |
| $V_o$                             | output voltage              | 12 V                      |                              |
| $I_o$                             | output current              | 0 A to 20 A               | continuous                   |
| $I_{o(\text{max})}$               | maximum output current      | 25 A                      | with OPP                     |
| $I_{o(\text{peak})\text{max}}$    | maximum peak output current | 30 A                      | $t < 50$ ms                  |
| $t_{\text{hold}}$                 | hold time                   | > 10 ms                   | at 115 V/60 Hz;<br>full load |
| $t_{\text{start}}$                | start time                  | $\leq 0.5$ s              | at 115 V/60 Hz               |
| $\eta$                            | efficiency                  | $\geq 89$ %               | average according to CoC     |

## 4 Board photographs



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

The TEA1916DB1262demo board contains two subcircuits:

- A BCM-type PFC converter
- A resonant LLC-type HBC converter

To achieve an optimized resonant power board, the converters are working together.

The purpose of the TEA1916DB1262 prototype demo board is to evaluate the operation of the combination of converters (TEA19161T, TEA19162T, and TEA1995T) in a single output supply, which includes all modes. The performance passes general standards, including the EuP lot6 requirements. It can be used as a starting point for further development.

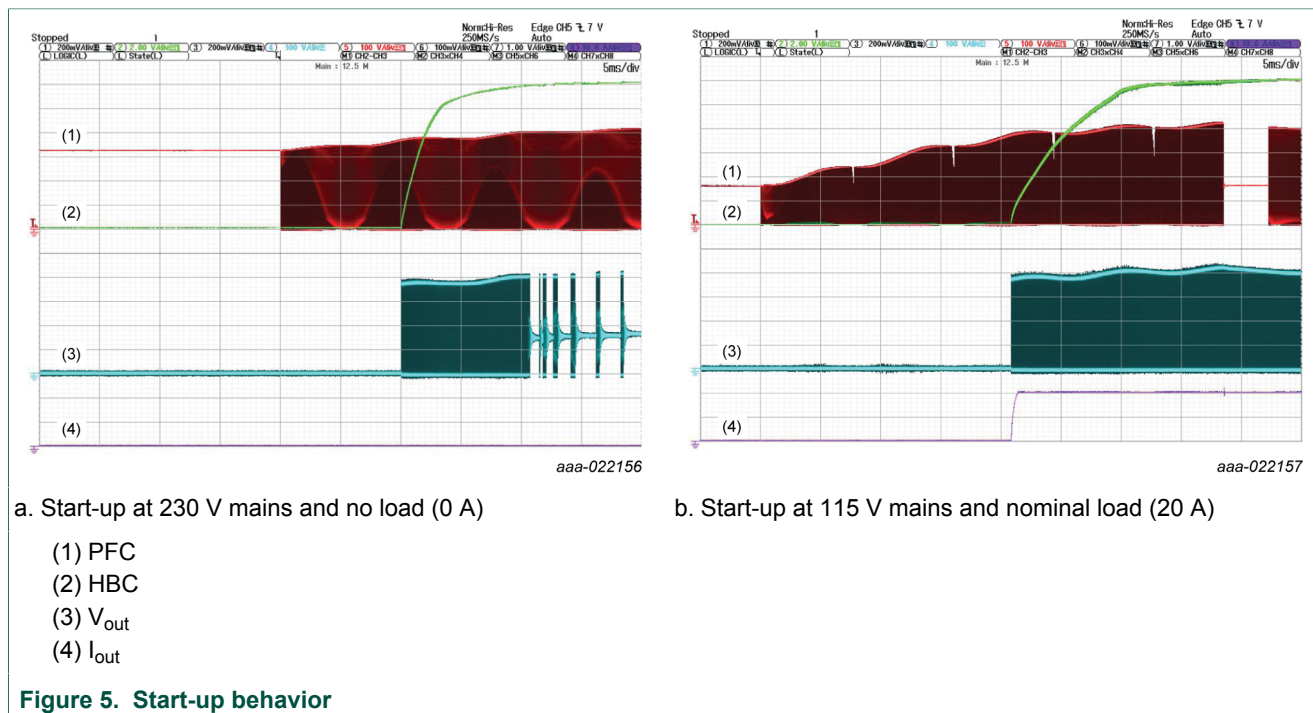
## 5 Performance measurements

### 5.1 Test facilities

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

### 5.2 Start-up behavior

The rise time of the output voltage (measured from 10 % to 90 % point of the nominal output) is between 6 ms and 10 ms. The rise time depends on the output current load.



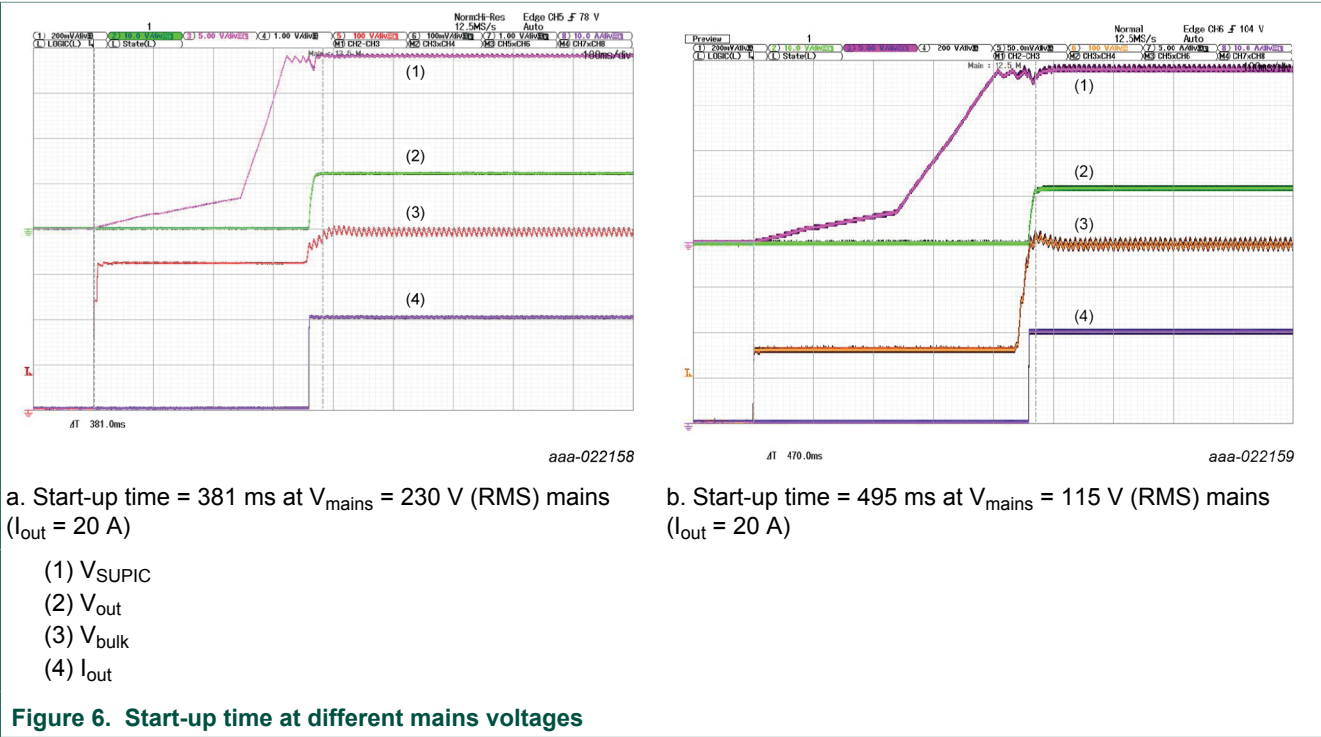


Table 3. Start-up time

| Condition   | Start-up time (ms) |
|-------------|--------------------|
| 115 V/60 Hz | 470                |
| 230 V/50 Hz | 380                |
| requirement | < 500              |

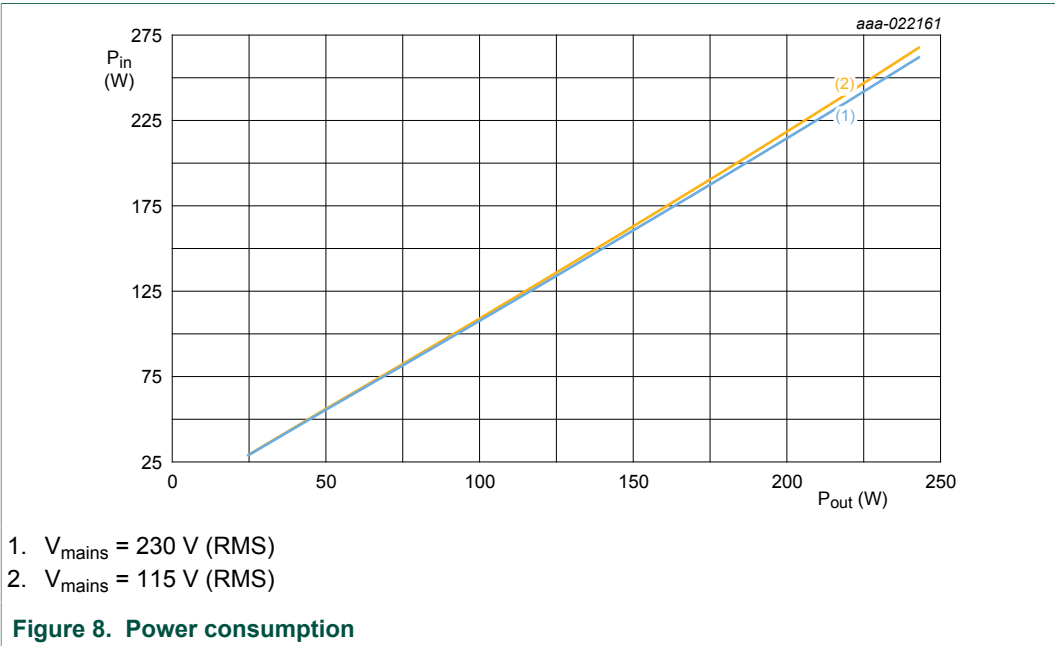
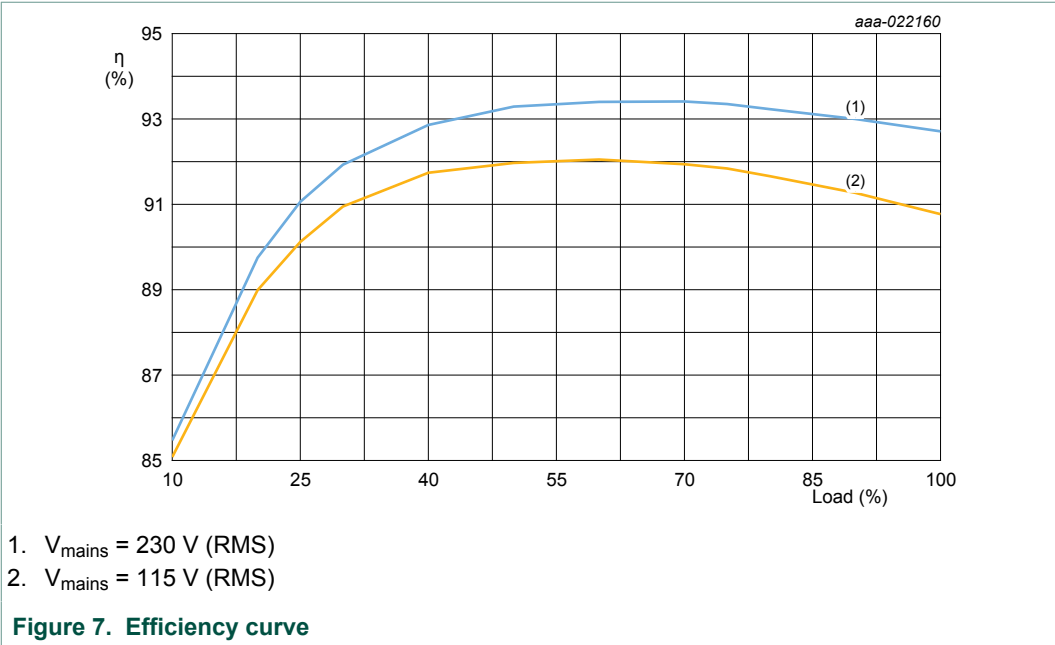
5.3 Efficiency

5.3.1 Efficiency characteristics

To determine the efficiency, the output voltage (not taking into account the losses in an output connection cable) on the TEA1916DB1262 demo board was measured.

Table 4. Efficiency results

| Condition   | CoC efficiency average requirement (%) | Average | 25 % load | 50 % load | 75 % load | 100 % load |
|-------------|----------------------------------------|---------|-----------|-----------|-----------|------------|
| 115 V/60 Hz | > 89                                   | 91.17   | 90.12     | 91.97     | 91.84     | 90.77      |
| 230 V/50 Hz | > 89                                   | 92.6    | 91.06     | 93.29     | 93.2      | 92.71      |



### 5.3.2 No-load power consumption

Power consumption performance of the total application board at no load was measured with a Yokogawa WT210 digital power meter. To measure the power consumption over a long time, the integration time function was used.

**Table 5. Output voltage and power consumption at no load**

| Condition   | ENERGY STAR 2.0 requirement | Output voltage | Power consumption |
|-------------|-----------------------------|----------------|-------------------|
| 115 V/60 Hz | ≤ 500 mW                    | 12.2 V         | 46 mW             |
| 230 V/50 Hz | ≤ 500 mW                    | 12.2 V         | 51 mW             |

### 5.3.3 Standby load power consumption

Power consumption performance of the total application board at standby load was measured with a Yokogawa WT210 digital power meter. To measure the power consumption over a long time, the integration time function was used.

**Table 6. Output voltage and power consumption at no load**

| Condition   | ENERGY STAR 2.0 requirement | Output voltage | Power consumption |
|-------------|-----------------------------|----------------|-------------------|
| 115 V/60 Hz | 250 mW                      | 12.2 V         | 356 mW            |
| 230 V/50 Hz | 250 mW                      | 12.2 V         | 357 mW            |
| Requirement |                             |                | < 500 mW          |

### 5.3.4 Power factor correction

**Table 7. Output voltage and power consumption at no load**

| Condition   | ENERGY STAR 2.0 requirement | Output power | Power factor |
|-------------|-----------------------------|--------------|--------------|
| 115 V/60 Hz | ≥ 0.9 mW                    | 240 W        | 0.992        |
| 115 V/60 Hz | -                           | 120 W        | 0.976        |
| 230 V/50 Hz | -                           | 240 W        | 0.945        |
| 230 V/50 Hz | -                           | 120 W        | 0.911        |

## 5.4 Low-power mode and burst mode operation

To reach a high efficiency at medium/low and standby output power, the low-power mode and burst mode are introduced.

In low-power mode, the behavior of the half-bridge converter is changed compared to the standard behavior at maximum output power. The result is a higher efficiency that is close to the expected efficiency at maximum load.

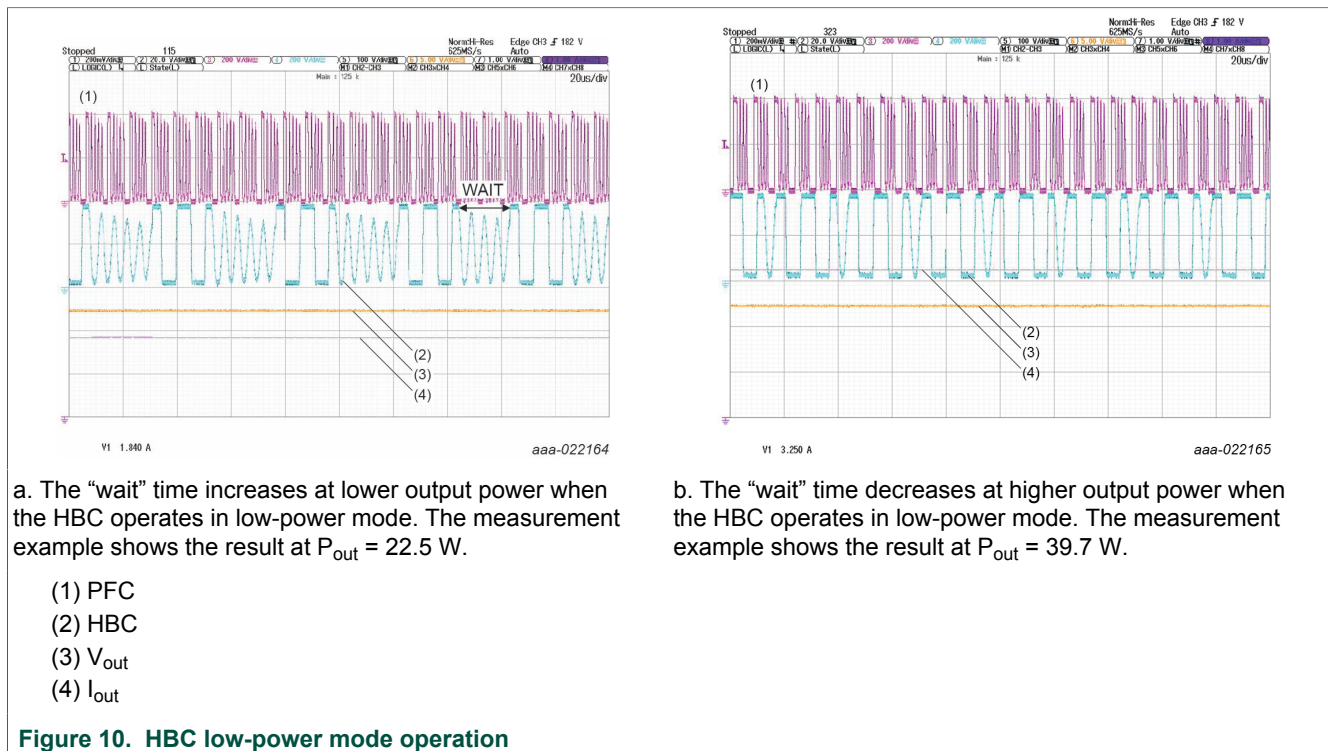
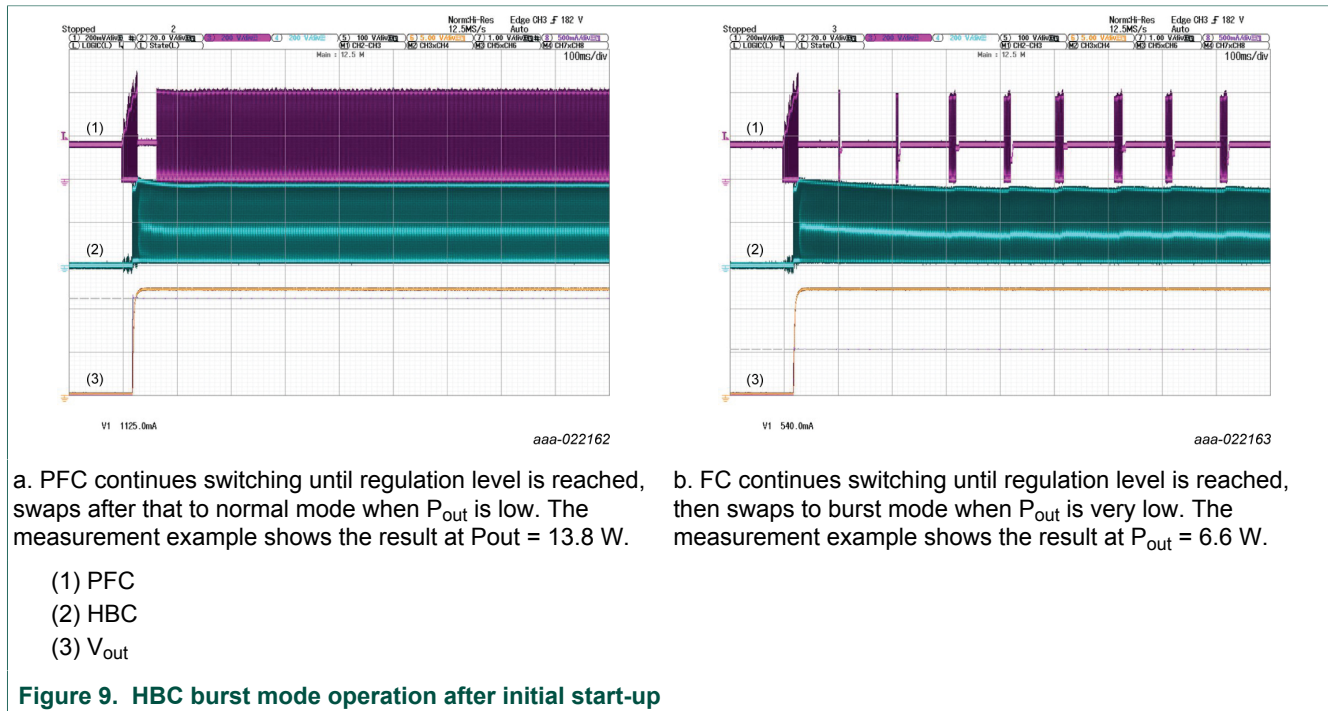
The power level for leaving the high-power mode and entering the low-power mode can be adjusted. Here the power level is set at 53.4 W.

Below 21.3 W, the HBC converter enters burst mode, which improves the overall efficiency at lower output loads.

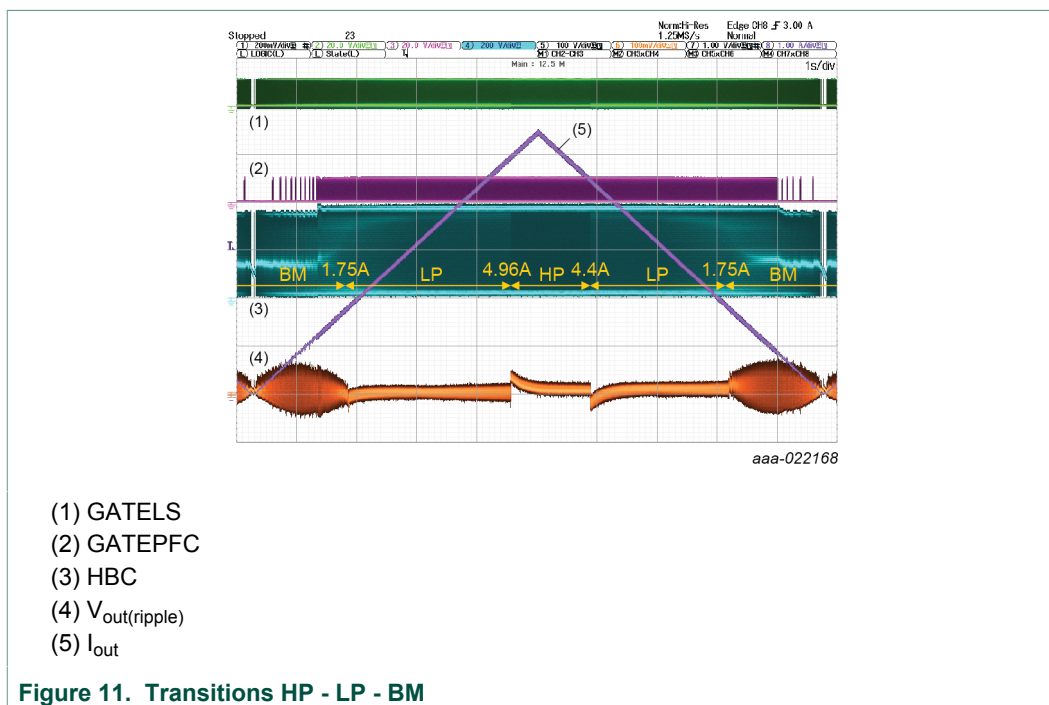
TEA1916DB1262 digital resonant 240 W/12 V power supply demo board

Finally, when the output power level is further reduced, the PFC converter enters burst mode.

The power supply consumes more power without low-power mode and burst mode.



## 5.5 Operation mode transitions

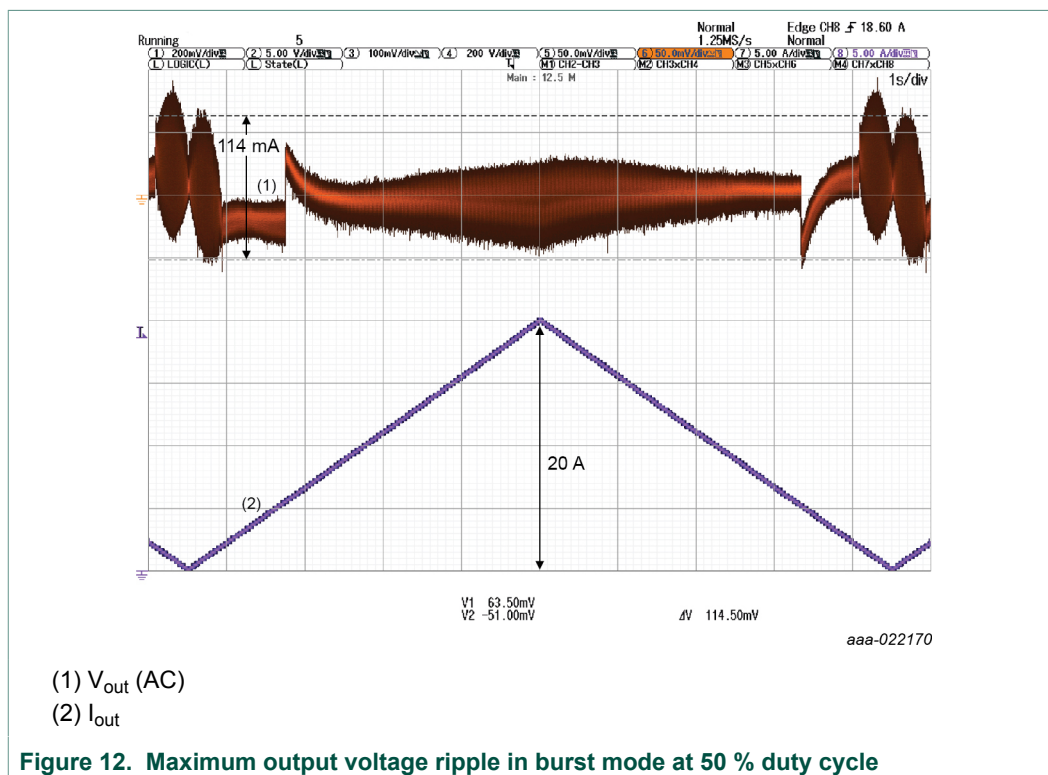


### Figure 11. Transitions HP - LP - BM

### Table 8. Mode transitions

| Transition | Power level |
|------------|-------------|
| HP - LP    | 53.4 W      |
| LP - BM    | 21.3 W      |
| BM - LP    | 21.3 W      |
| LP - HP    | 60.2 W      |

## 5.6 Output voltage ripple



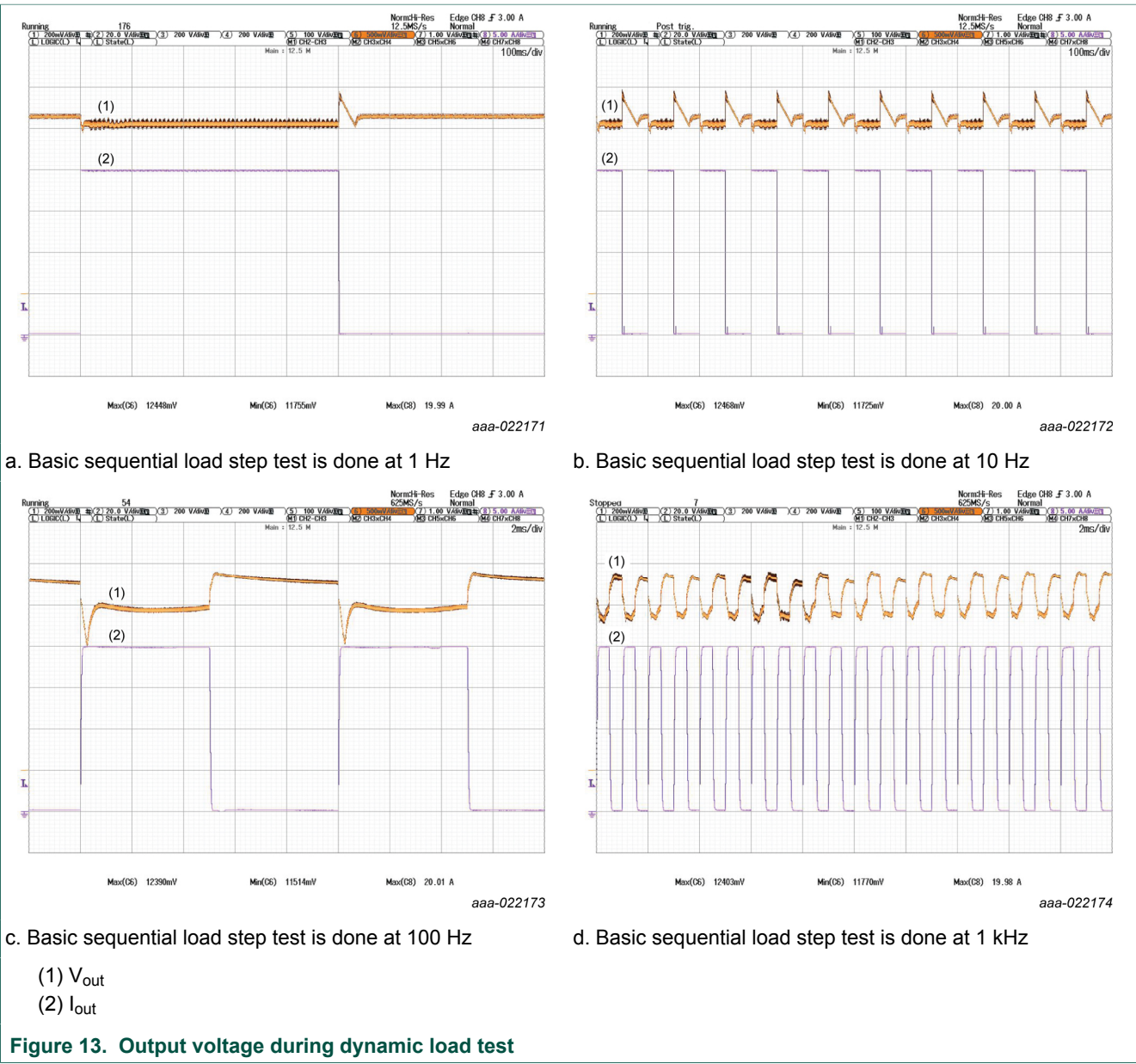
The maximum output voltage ripple is 114 mV (peak-to-peak).

## 5.7 Dynamic load response

The dynamic load response test shows the result of constant load steps across the output. Output current of the converter is changed in steps of between 0 A and 20 A at a repetition frequency of 1 Hz, 10 Hz, 100 Hz, and 1000 Hz.

**Table 9. Minimum and maximum output voltage at minimum-maximum load steps**

| Condition   | Load                          | Minimum to maximum output voltage |
|-------------|-------------------------------|-----------------------------------|
| 115 V/60 Hz | I <sub>o</sub> : 0 % to 100 % | 11.48 V to 12.47 V                |
| 230 V/50 Hz | I <sub>o</sub> : 0 % to 100 % | 11.48 V to 12.47 V                |



## 5.8 OverPower Protection (OPP)

Tested with a higher current (dynamic overload) on the output voltage, OPP is activated when the current exceeds 25 A (300 W). This current corresponds with a load condition that is 25 % higher than the rated power for continuous use.

OPP allows a typical continuously maximum output current of 25 A during 50 ms. Any higher current, intended to run longer than 50 ms, triggers an OPP. After the 50 ms, a safe restart follows (OPP protection is reset).

The SNSCAP function of the TEA19161 detects OPP. This function monitors the voltage across the series capacitor (C211) of the half bridge.

The power capability limitation protection limits the maximum power to 360 W as long as the time is shorter than 50 ms.

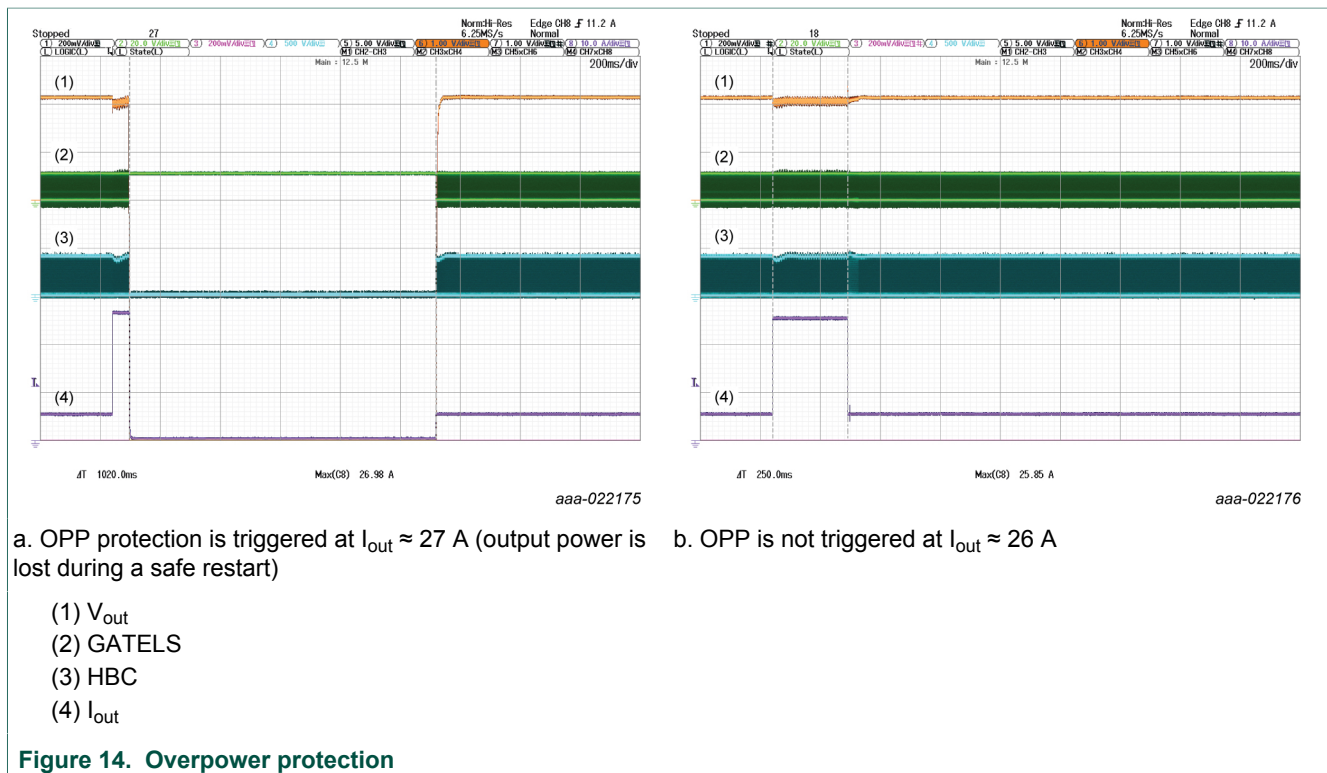
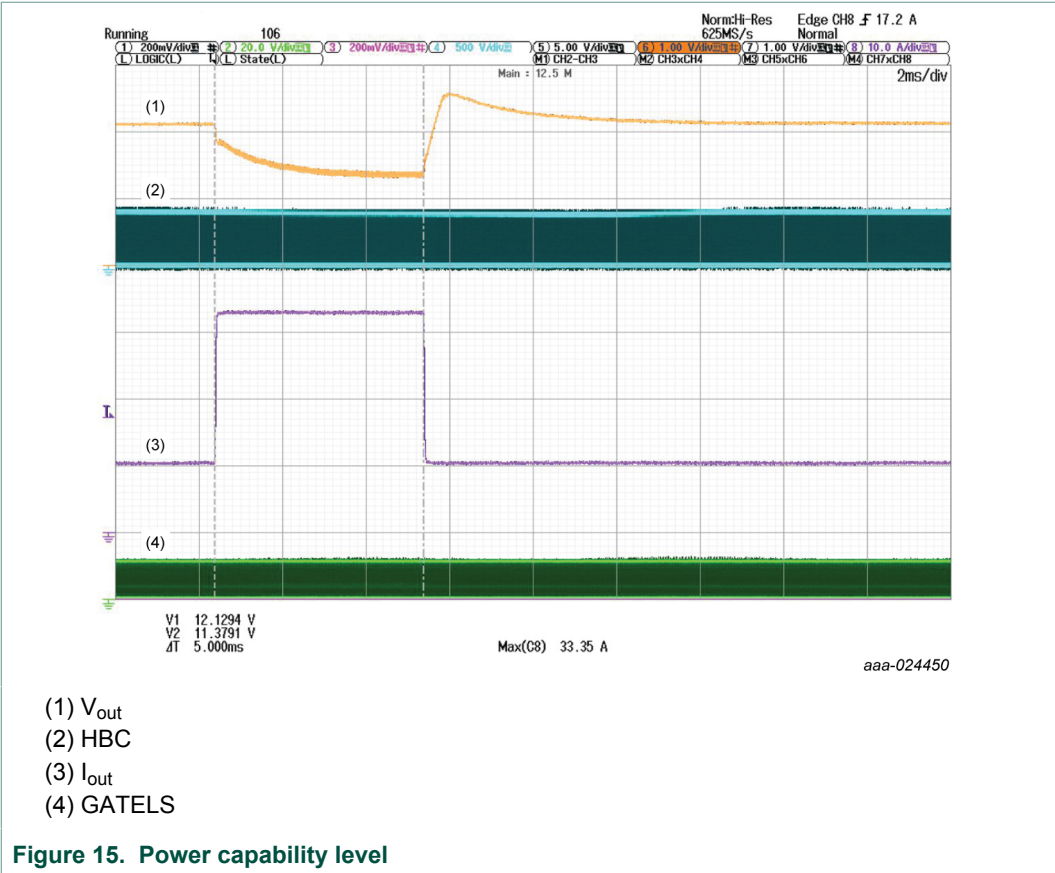


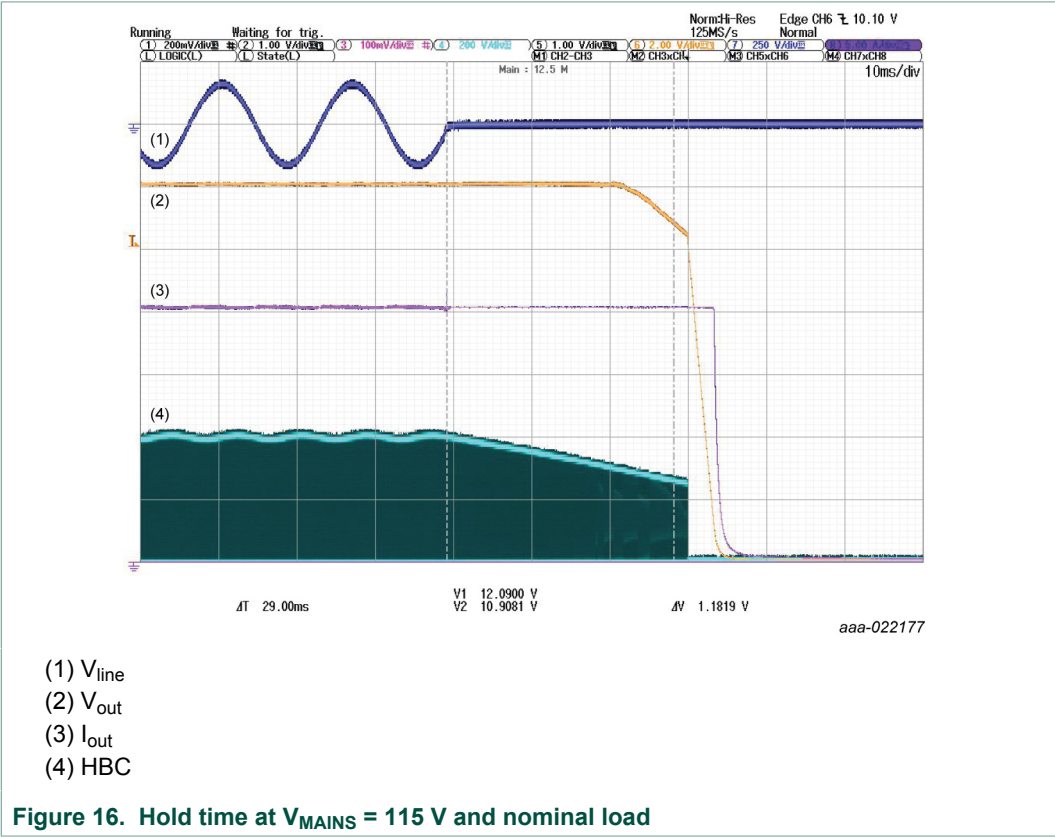
Figure 14. Overpower protection

The power capability limitation level limits the maximum output power to typically 360 W as long as the time fits within the selected OPP timer. In this example, the time is shorter than 50 ms. So, when more output current is requested than accepted by the power capability limitation level, the output voltage drops.



5.9 Hold time

The output was set to full load and the mains supply voltage of 115 V disconnected. The time that passes before the output voltage falls below 90 % of its initial value was measured. The hold time is 29 ms.



5.10 Short-Circuit Protection (SCP)

The output was shorted before the resonant converter was connected to the mains. A short circuit across the output of the resonant converter increases primary current. The SNSCUR pin detects the increase. When this voltage exceeds  $\pm 1.5\text{ V}$ , the safe-restart protection is triggered. Approximately 4 ms after the HBC is started, the protection level is reached. Removing the short across the output resets the protection.

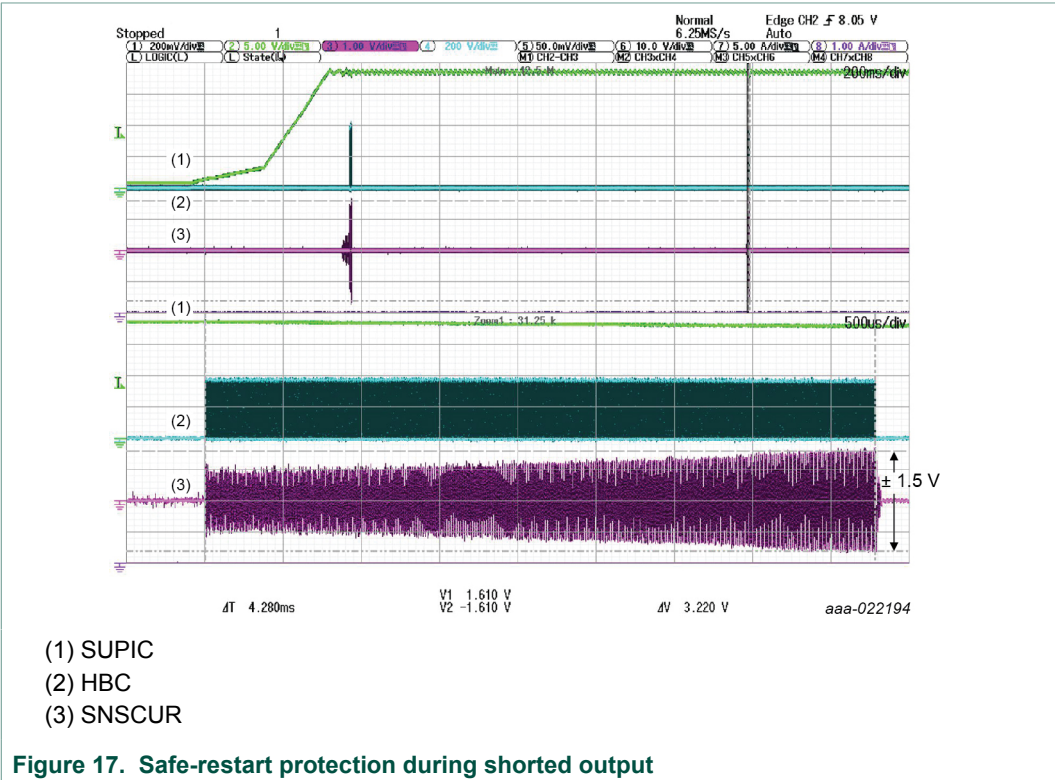
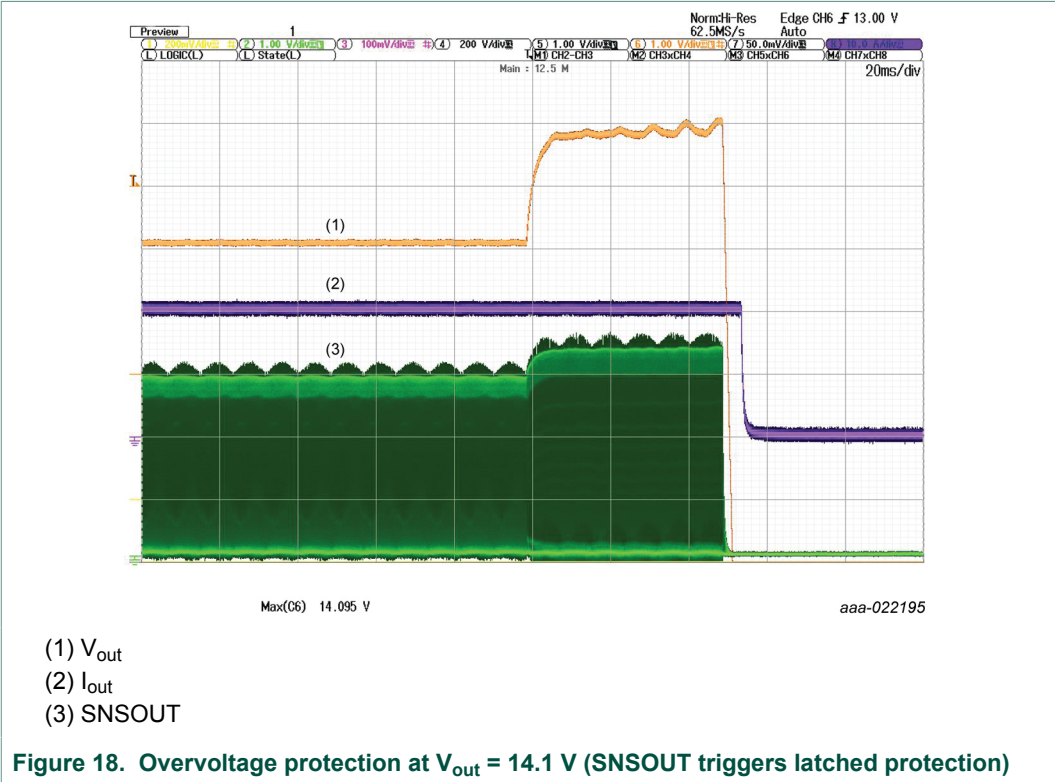


Table 10 shows the input power when the output is shorted.

Table 10. Input power when output power is shorted

| Condition    | P <sub>in</sub> (W) |
|--------------|---------------------|
| 115 V; 60 Hz | 1.75                |
| 230 V; 50 Hz | 1.70                |

5.11 OverVoltage Protection (OVP)



5.12 X-capacitor discharge time

The power line was unplugged at no-load. The discharge time was measured at the X-capacitor (470 nF + 470 nF).

Table 11. X-capacitor discharge time test results

| Condition                  | From 264 * $\sqrt{2}$ to 135 V |
|----------------------------|--------------------------------|
| X-capacitor discharge time | 505 ms                         |

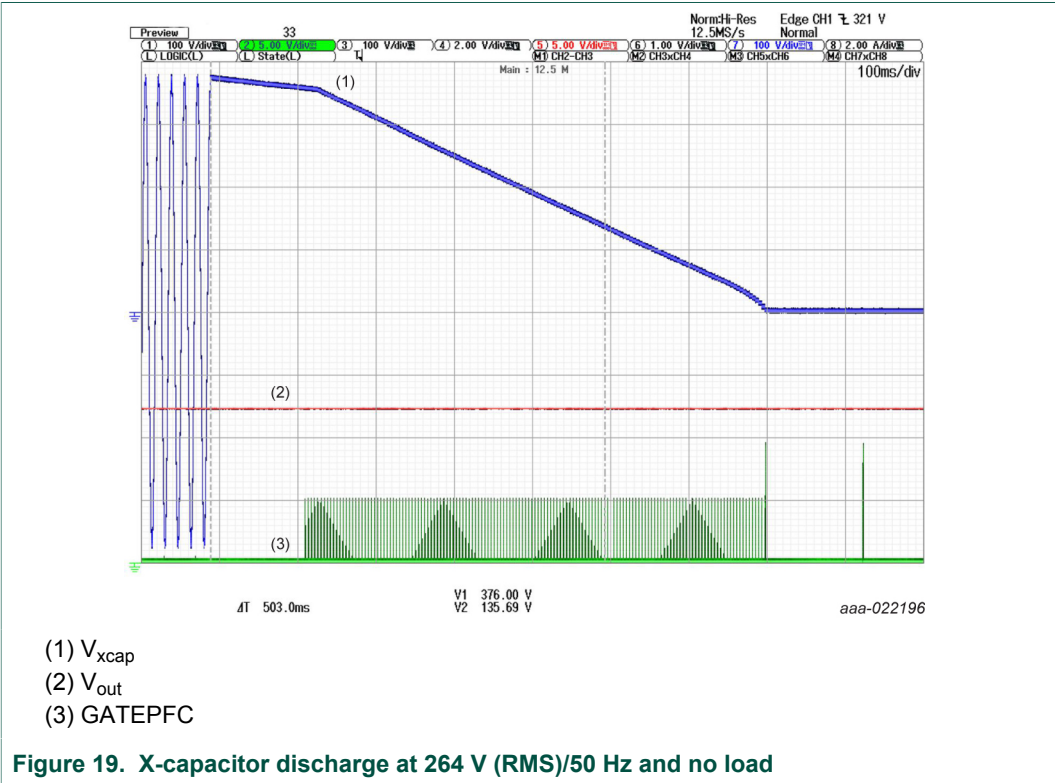


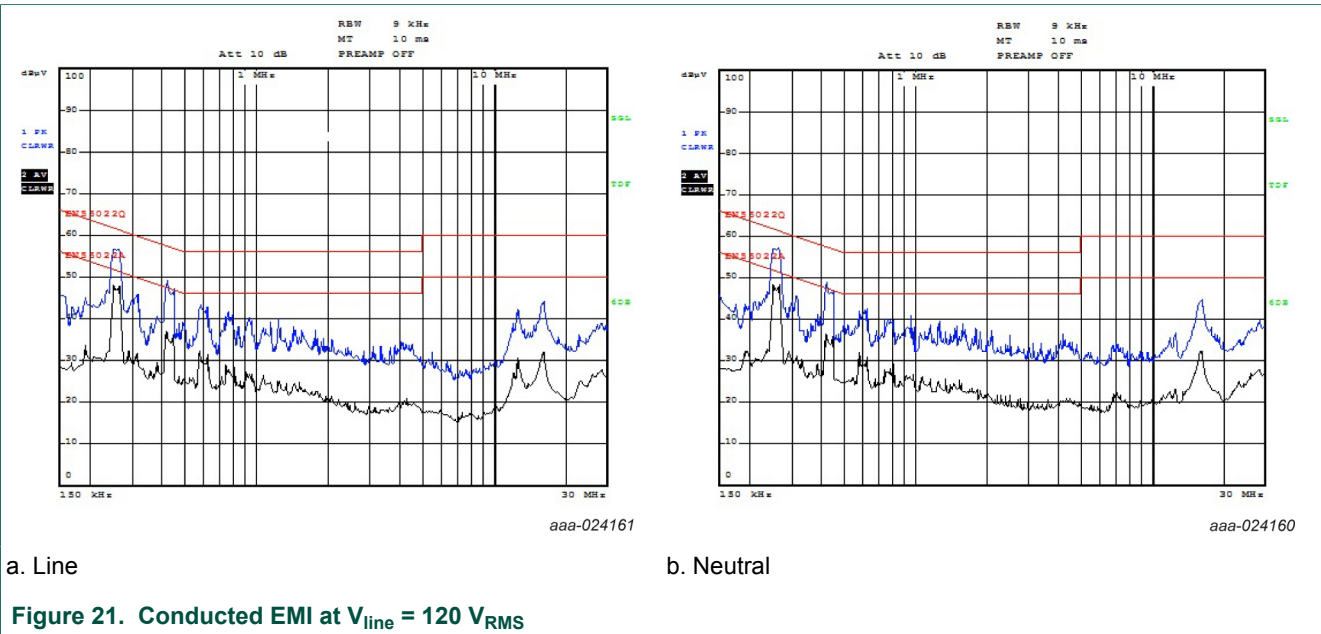
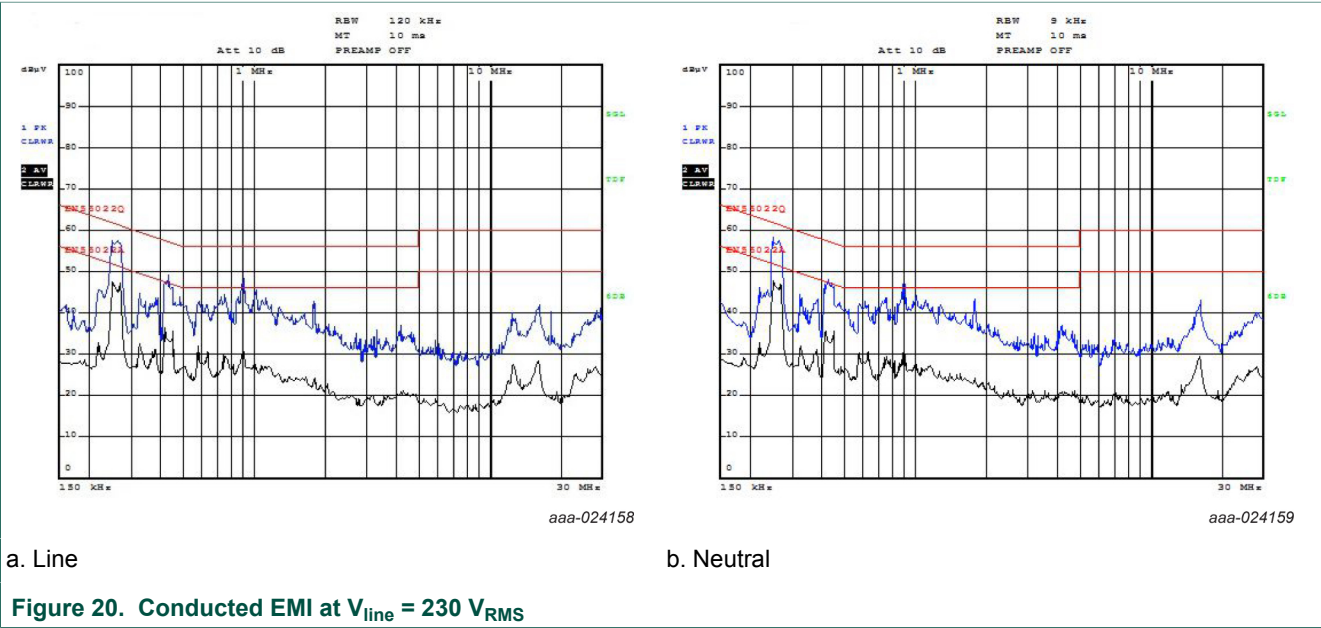
Figure 19. X-capacitor discharge at 264 V (RMS)/50 Hz and no load

5.13 ElectroMagnetic Compatibility (EMC)

The conducted ElectroMagnetic Interference (EMI) of the TEA1916DB1262 prototype demo board was measured under the following conditions:

- Load resistor: 0.6  $\Omega$ ; V<sub>out</sub> = 12.1 V; I<sub>out</sub> = 20.1 A
- V<sub>line</sub> = 230 V/50 Hz or 120 V/50 Hz

The conducted EMI was measured both in the Line and Neutral. The product complies with the EMC standard.



## 6 Schematic

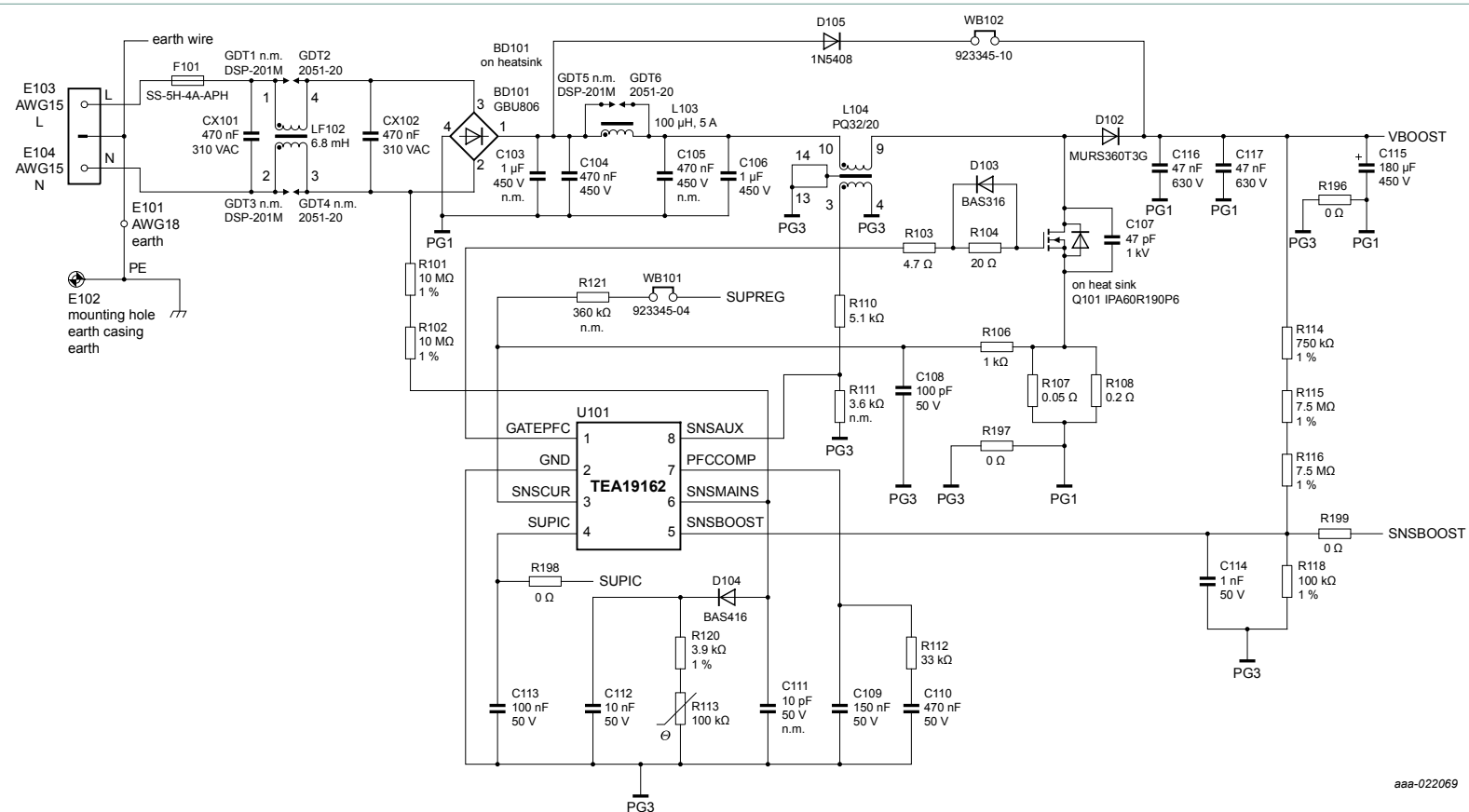
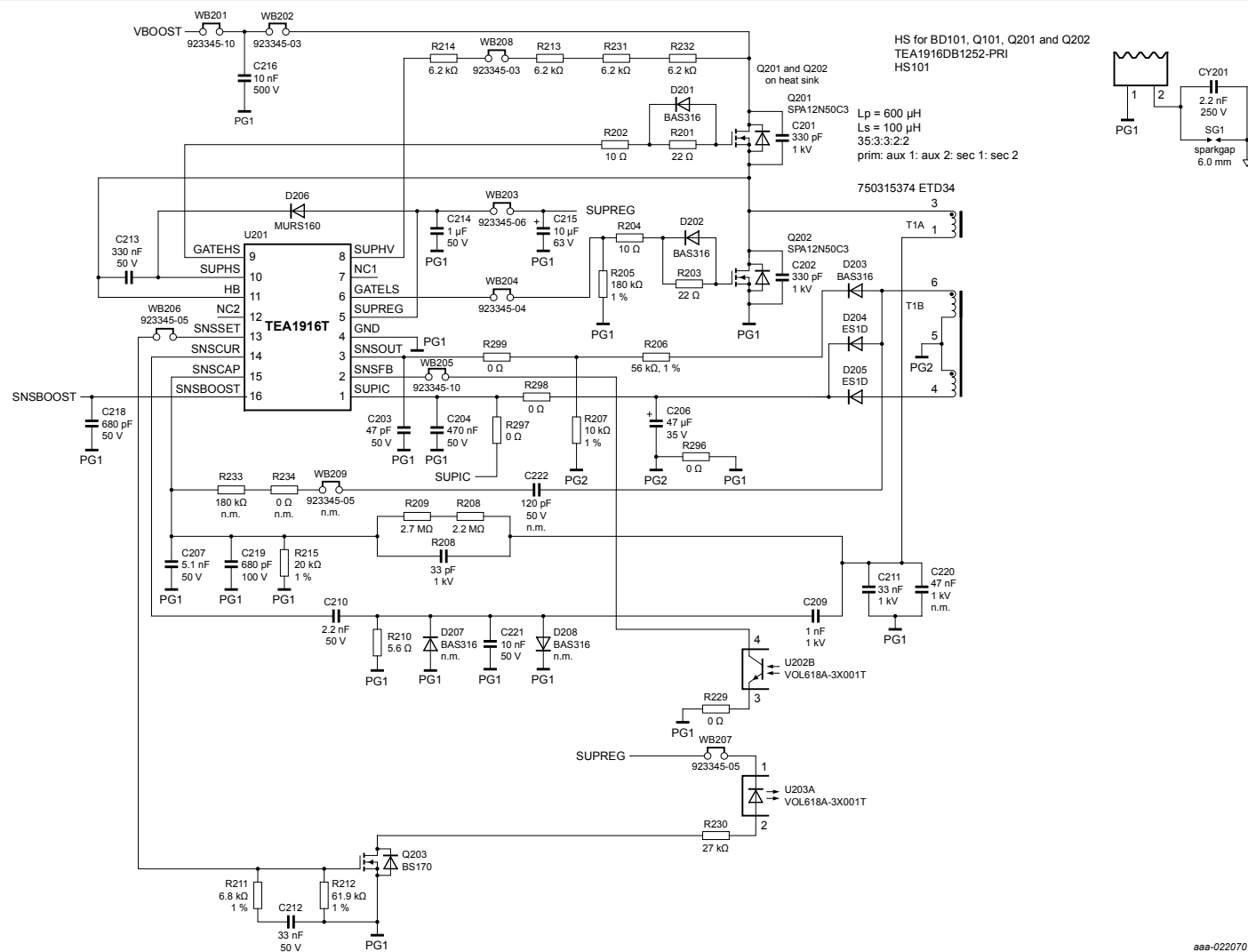


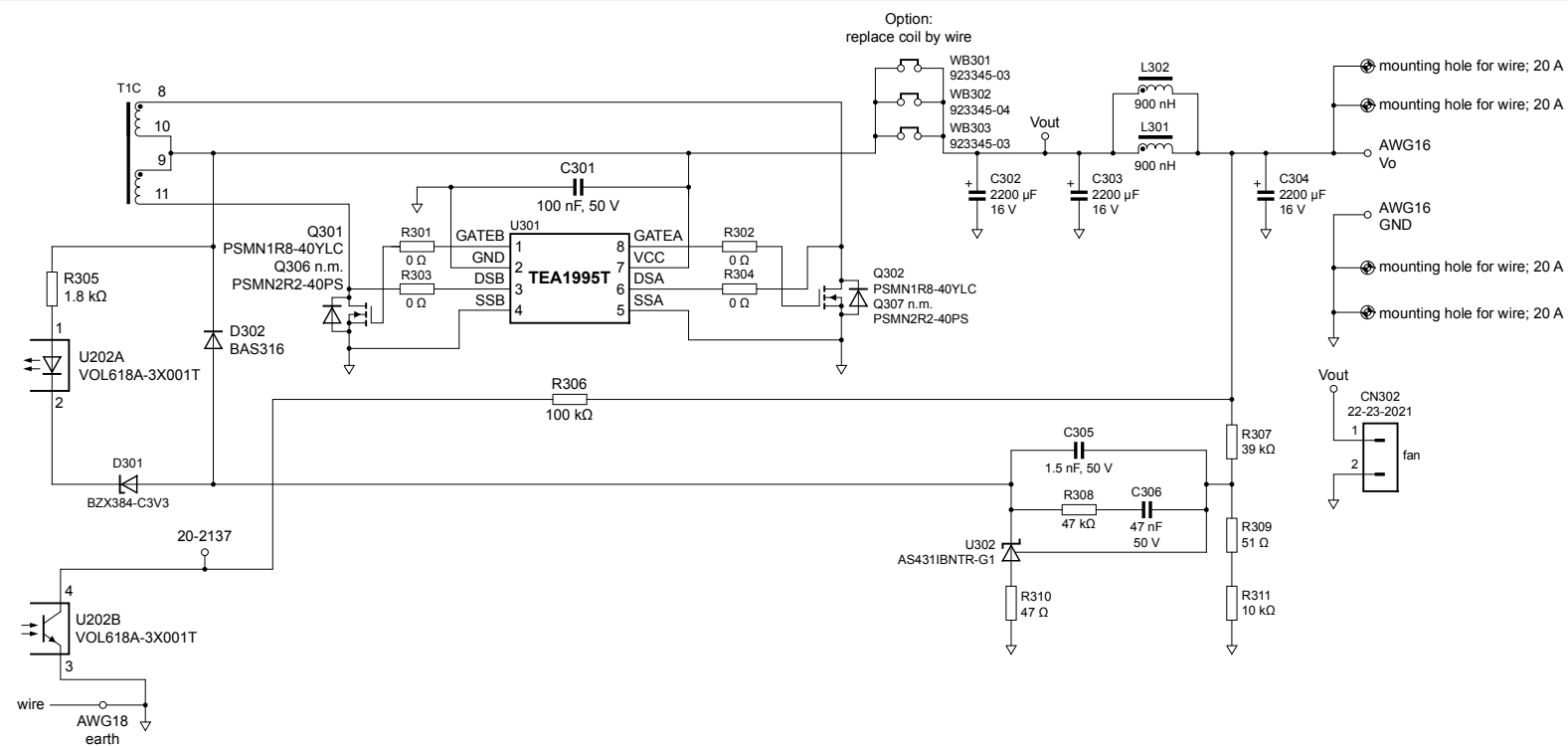
Figure 22. Schematic TEA1916DB1262 240 W prototype demo board (PFC)

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board



**Figure 23. Schematic TEA1916DB1262 240 W prototype demo board (LLC)**

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board



**Figure 24. Schematic TEA1916DB1262 240 W prototype demo board (synchronous rectifier)**

## 7 Bill Of Materials (BOM)

Table 12. Bill Of Materials (BOM)

| Reference  | Description and values                                   | Part number | Manufacturer |
|------------|----------------------------------------------------------|-------------|--------------|
| BD101      | bridge rectifier; 600 V; 8 A                             | -           | -            |
| C103       | capacitor; not mounted; 1 $\mu$ F; 10 %; 450 V; PET; THT | -           | -            |
| C104       | capacitor; 470 nF; 10 %; 450 V; PET; THT                 | -           | -            |
| C105       | capacitor; not mounted; 470 nF; 10 %; 450 V; PET; THT    | -           | -            |
| C106       | capacitor; 1 $\mu$ F; 10 %; 450 V; PET; THT              | -           | -            |
| C107       | capacitor; 47 pF; 5 %; 1 kV; C0G; 1206                   | -           | -            |
| C108       | capacitor; 100 pF; 10 %; 50 V; X7R; 0603                 | -           | -            |
| C109       | capacitor; 150 nF; 10 %; 50 V; X7R; 0603                 | -           | -            |
| C110       | capacitor; 470 nF; 10 %; 50 V; X7R; 0805                 | -           | -            |
| C111       | capacitor; not mounted; 10 pF; 10 %; 50 V; X7R; 0603     | -           | -            |
| C112       | capacitor; 10 nF; 10 %; 50 V; X7R; 0603                  | -           | -            |
| C113       | capacitor; 100 nF; 10 %; 50 V; X7R; 0603                 | -           | -            |
| C114       | capacitor; 1 nF; 10 %; 50 V; X7R; 0603                   | -           | -            |
| C115       | capacitor; 180 $\mu$ F; 20 %; 450 V; ALU; THT            | -           | -            |
| C116; C117 | capacitor; 47 nF; 10 %; 630 V; X7R; 1210                 | -           | -            |
| C201; C202 | capacitor; 330 pF; 5 %; 1 kV; C0G; 1206                  | -           | -            |
| C203       | capacitor; 47 pF; 10 %; 50 V; X7R; 0805                  | -           | -            |
| C204       | capacitor; 470 nF; 10 %; 50 V; X7R; 0805                 | -           | -            |
| C206       | capacitor; 47 $\mu$ F; 20 %; 35 V; ALU; THT              | -           | -            |
| C207       | capacitor; 5.1 nF; 5 %; 50 V; COG; 0603                  | -           | -            |
| C208       | capacitor; 33 pF; 5 %; 1 kV; C0G; 1206                   | -           | -            |
| C209       | capacitor; 1 nF; 5 %; 1 kV; C0G; 1812                    | -           | -            |

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board

| Reference                    | Description and values                               | Part number | Manufacturer |
|------------------------------|------------------------------------------------------|-------------|--------------|
| C210                         | capacitor; 2.2 nF; 10 %; 50 V; X7R; 0603             | -           | -            |
| C211                         | capacitor; 33 nF; 20 %; 1 kV; MKP                    | -           | -            |
| C212                         | capacitor; 33 nF; 10 %; 50 V; X7R; 0603              | -           | -            |
| C213                         | capacitor; 330 nF; 10 %; 50 V; X7R; 0805             | -           | -            |
| C214                         | capacitor; 1 $\mu$ F; 10 %; 50 V; X7R; 0805          | -           | -            |
| C215                         | capacitor; 10 $\mu$ F; 20 %; 63 V; ALU; THT          | -           | -            |
| C216                         | capacitor; 10 nF; 10 %; 500 V; X7R; 1812             | -           | -            |
| C218                         | capacitor; 680 pF; 10 %; 50 V; X7R; 0603             | -           | -            |
| C219                         | capacitor; 680 pF; 5 %; 50 V; COG; 0603              | -           | -            |
| C220                         | capacitor; not mounted; 47 nF; 5 %; 1 kV; MKP        | -           | -            |
| C221                         | capacitor; 10 nF; 10 %; 50 V; X7R; 0805              | -           | -            |
| C222                         | capacitor; not mounted; 120 pF; 5 %; 50 V; COG; 0603 | -           | -            |
| C301                         | capacitor; 100 nF; 10 %; 50 V; X7R; 0603             | -           | -            |
| C302; C303; C304             | capacitor; 2200 $\mu$ F; 20 %; 16 V; ALU; THT        | -           | -            |
| C305                         | capacitor; 1.5 nF; 10 %; 50 V; X7R; 0603             | -           | -            |
| C306                         | capacitor; 47 nF; 10 %; 50 V; X7R; 0603              | -           | -            |
| CN302                        | header; straight; 2-way                              | -           | -            |
| CX101; CX102                 | capacitor; 470 nF; 20 %; 310 V (AC); MKP; THT        | -           | -            |
| CY201                        | capacitor; 2.2 nF; 20 %; 250 V; CER; THT             | -           | -            |
| D102                         | diode; 600 V; 3 A                                    | -           | -            |
| D103; D201; D202; D203; D302 | diode; 100 V; 250 mA                                 | -           | -            |
| D104                         | diode; 85 V; 200 mA                                  | -           | -            |
| D105                         | diode; 1 kV; 3 A                                     | -           | -            |
| D204; D205                   | diode; 140 V; 1 A                                    | -           | -            |
| D206                         | diode; 600 V; 1 A                                    | -           | -            |

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board

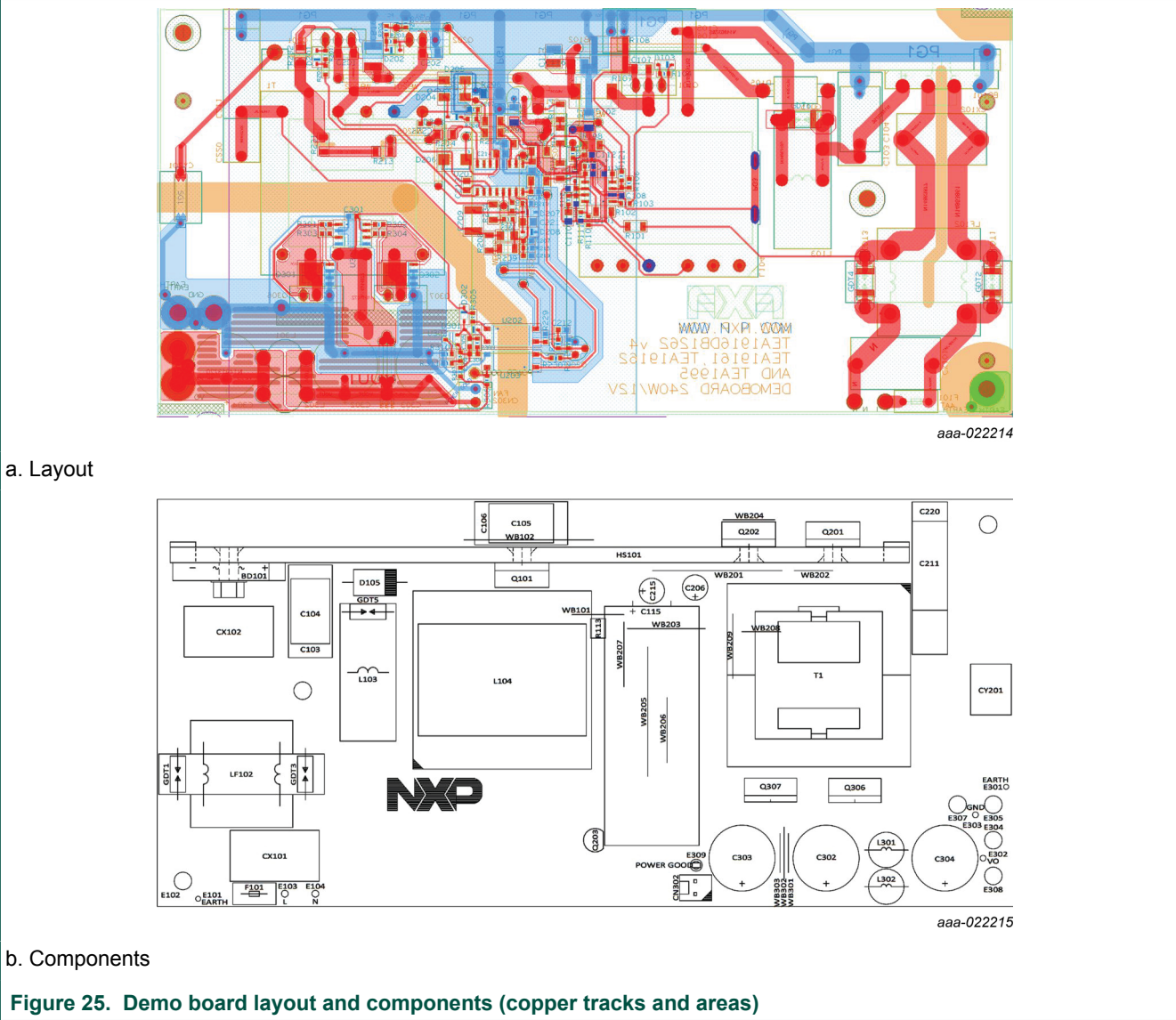
| Reference                 | Description and values                                   | Part number | Manufacturer     |
|---------------------------|----------------------------------------------------------|-------------|------------------|
| D207; D208                | diode; not mounted; 100 V; 250 mA                        | -           | -                |
| D301                      | diode; Zener; 3.3 V; 250 mA                              | -           | -                |
| F101                      | fuse; slow blow; 300 V (AC); 4 A                         | -           | -                |
| GDT2; GDT6                | gas discharge tube; 200 V; THT                           | -           | -                |
| GDT4                      | gas discharge tube; not mounted                          | -           | -                |
| HS101                     | heat sink; primary                                       | -           | -                |
| L103                      | inductor; 100 $\mu$ H; 5 A                               | 7447070     | Würth Elektronik |
| L104                      | coil former; PQ32/20                                     | 750315487   | Würth Elektronik |
| L301; L302                | inductor; 900 nH                                         | -           | -                |
| LF102                     | inductor; common mode; 6.8 mH; 3.2 A                     | -           | -                |
| Q101                      | MOSFET-N; 600 V; 20.2 A                                  | -           | -                |
| Q201; Q202                | MOSFET-N; 560 V; 11.6 A                                  | -           | -                |
| Q203                      | MOSFET-N; 60 V; 500 mA                                   | -           | -                |
| Q301; Q302                | MOSFET-N; 40 V; 100 A                                    | -           | -                |
| Q306; Q307                | MOSFET-N; not mounted; 40 V; 100 A                       | -           | -                |
| R101; R102                | resistor; 10 M $\Omega$ ; 1 %; 250 mW; 1206              | -           | -                |
| R103                      | resistor; 4.7 $\Omega$ ; 1 %; 63 mW; 0603                | -           | -                |
| R104                      | resistor; 20 $\Omega$ ; 1 %; 63 mW; 0603                 | -           | -                |
| R106                      | resistor; 1 k $\Omega$ ; 1 %; 63 mW; 0603                | -           | -                |
| R107                      | resistor; 0.05 $\Omega$ ; 1 %; 1 W; 2512                 | -           | -                |
| R108                      | resistor; 0.2 $\Omega$ ; 1 %; 1 W; 2512                  | -           | -                |
| R110                      | resistor; 5.1 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                |
| R111                      | resistor; not mounted; 3.6 k $\Omega$ ; 1 %; 63 mW; 0603 | -           | -                |
| R112                      | resistor; 33 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                |
| R113                      | resistor; NTC; 100 k $\Omega$ ; 5 %; 500 mW              | -           | -                |
| R114                      | resistor; 750 k $\Omega$ ; 1 %; 250 mW; 1206             | -           | -                |
| R115; R116                | resistor; 7.5 M $\Omega$ ; 1 %; 250 mW; 1206             | -           | -                |
| R118                      | resistor; 100 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                |
| R120                      | resistor; 3.9 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                |
| R121                      | resistor; not mounted; 360 k $\Omega$ ; 1 %; 63 mW; 0603 | -           | -                |
| R196; R197;<br>R198; R199 | resistor; jumper; 0 $\Omega$ ; 250 mW; 1206              | -           | -                |
| R201; R203                | resistor; 22 $\Omega$ ; 1 %; 63 mW; 0603                 | -           | -                |
| R202; R204                | resistor; 10 $\Omega$ ; 1 %; 63 mW; 0603                 | -           | -                |
| R205                      | resistor; 180 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                |

## TEA1916DB1262 digital resonant 240 W/12 V power supply demo board

| Reference                 | Description and values                                   | Part number | Manufacturer       |
|---------------------------|----------------------------------------------------------|-------------|--------------------|
| R206                      | resistor; 56 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| R207                      | resistor; 10 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| R208                      | resistor; 2.2 M $\Omega$ ; 1 %; 250 mW; 1206             | -           | -                  |
| R209                      | resistor; 2.7 M $\Omega$ ; 1 %; 250 mW; 1206             | -           | -                  |
| R210                      | resistor; 5.6 $\Omega$ ; 1 %; 63 mW; 0603                | -           | -                  |
| R211                      | resistor; 6.8 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                  |
| R212                      | resistor; 61.9 k $\Omega$ ; 1 %; 63 mW; 0603             | -           | -                  |
| R213; R214;<br>R231; R232 | resistor; 6.2 k $\Omega$ ; 1 %; 250 mW; 1206             | -           | -                  |
| R215                      | resistor; 20 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| R229                      | resistor; jumper; 0 $\Omega$ ; 63 mW; 0603               | -           | -                  |
| R230                      | resistor; 27 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| R233                      | resistor; not mounted; 180 k $\Omega$ ; 63 mW; 0603      | -           | -                  |
| R234                      | resistor; jumper; not mounted; 0 $\Omega$ ; 250 mW; 1206 | -           | -                  |
| R296; R297;<br>R298; R299 | resistor; jumper; 0 $\Omega$ ; 250 mW; 1206              | -           | -                  |
| R301; R302;<br>R303; R304 | resistor; jumper; 0 $\Omega$ ; 63 mW; 0603               | -           | -                  |
| R305                      | resistor; 1.8 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                  |
| R306                      | resistor; 100 k $\Omega$ ; 1 %; 63 mW; 0603              | -           | -                  |
| R307                      | resistor; 39 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| R308                      | resistor; 47 k $\Omega$ ; 1 %; 100 mW; 0603              | -           | -                  |
| R309                      | resistor; 51 $\Omega$ ; 1 %; 63 mW; 0603                 | -           | -                  |
| R310                      | resistor; 47 $\Omega$ ; 1 %; 63 mW; 0603                 | -           | -                  |
| R311                      | resistor; 10 k $\Omega$ ; 1 %; 63 mW; 0603               | -           | -                  |
| SG1                       | spark gap; 6.0 mm                                        | -           | -                  |
| T1                        | transformer; ETD3                                        | 750315374   | Würth Elektronik   |
| U101                      | PFC driver; TEA19162T; SO8                               | -           | NXP Semiconductors |
| U201                      | LLC controller; TEA19161T; SO16                          | -           | NXP Semiconductors |
| U202; U203                | optocoupler; NPN; 80 V; 60 mA                            | -           | -                  |
| U301                      | synchronous rectifier controller; dual; TEA1995T; SO8    | -           | NXP Semiconductors |
| U302                      | Regulator; AS431                                         | -           | -                  |
| WB102; WB201;<br>WB205    | wire bridge; 0.8 mm; P = 25.40 mm                        | -           | -                  |
| WB101; WB204;<br>WB302    | wire bridge; 0.8 mm; P = 10.16 mm                        | -           | -                  |

| Reference                     | Description and values                            | Part number | Manufacturer |
|-------------------------------|---------------------------------------------------|-------------|--------------|
| WB202; WB208;<br>WB301; WB303 | wire bridge; 0.8 mm; P = 7.62 mm                  | -           | -            |
| WB203                         | wire bridge; 0.8 mm; P = 15.24 mm                 | -           | -            |
| WB206; WB207                  | wire bridge; 0.8 mm; P = 12.10 mm                 | -           | -            |
| WB209                         | wire bridge; not mounted; 0.8 mm;<br>P = 12.10 mm | -           | -            |

8 Layout



9 Transformer specifications

9.1 Resonant transformer

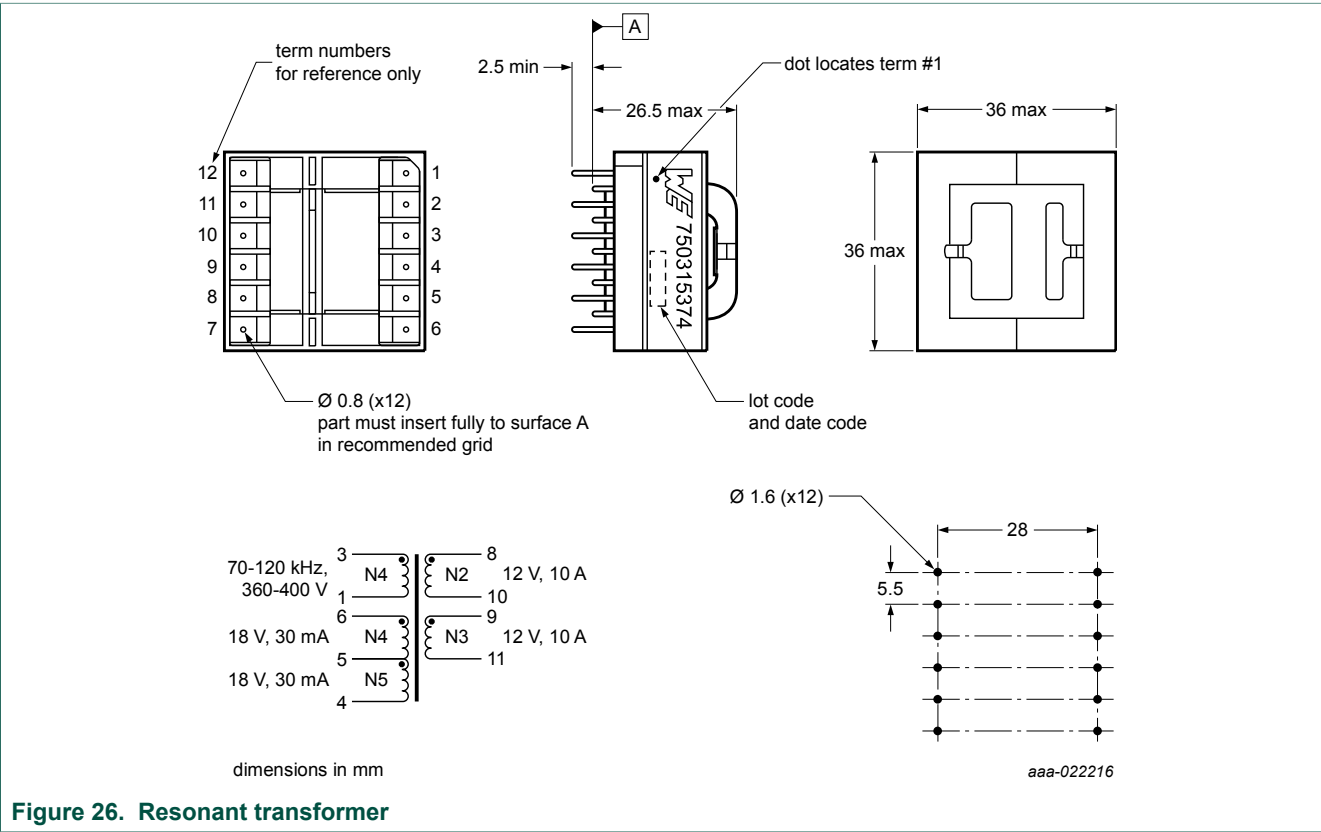


Figure 26. Resonant transformer

Table 13. Resonant transformer specifications

| Parameter               | Values                         | Test conditions                               |
|-------------------------|--------------------------------|-----------------------------------------------|
| DC resistance; 3-1      | 0.152 $\Omega$ ; $\pm 10$ %    | at 20 $^{\circ}\text{C}$                      |
| DC resistance; 8-10     | maximum 0.005 $\Omega$         | at 20 $^{\circ}\text{C}$                      |
| DC resistance; 9-11     | maximum 0.005 $\Omega$         | at 20 $^{\circ}\text{C}$                      |
| DC resistance; 6-5      | 0.122 $\Omega$ ; $\pm 10$ %    | at 20 $^{\circ}\text{C}$                      |
| DC resistance; 5-4      | 0.122 $\Omega$ ; $\pm 10$ %    | at 20 $^{\circ}\text{C}$                      |
| inductance; 3-1         | 600 $\mu\text{H}$ ; $\pm 10$ % | 10 kHz; 100 mV; $L_s$                         |
| saturation current; 3-1 | 1.7 A                          | 20 % roll-off from initial                    |
| leakage inductance; 3-1 | 100 $\mu\text{H}$ ; $\pm 10$ % | tie(4+5+6, 8+9+10+11); 100 kHz; 100 mV; $L_s$ |
| dielectric; 1-11        | 3200 V (AC); 1 minute          | tie(3+4, 10+11); 4000 V (AC); 1 s             |

| Parameter   | Values        | Test conditions |
|-------------|---------------|-----------------|
| turns ratio | 17.5:1; ±1 %  | (3-1):(9-11)    |
|             |               | (3-1):(8-10)    |
| turns ratio | 11.67:1; ±1 % | (3-1):(6-5)     |
|             |               | (3-1):(5-4)     |

9.2 PFC coil

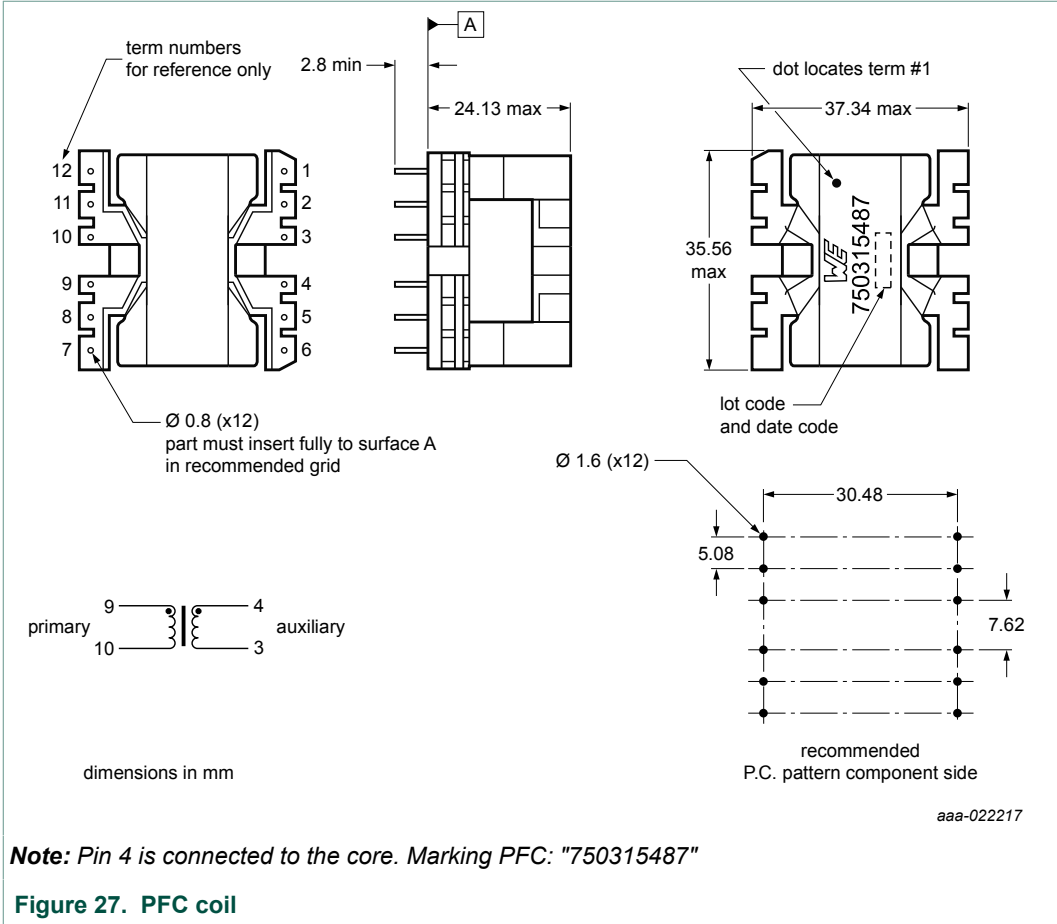


Table 14. PFC coil specifications

| Parameter                      | Value                                                   | Condition                        |
|--------------------------------|---------------------------------------------------------|----------------------------------|
| <b>Electric specifications</b> |                                                         |                                  |
| DC resistance; 3-4             | 0.048 $\Omega$ ; $\pm 20$ %                             | at 20 °C                         |
| DC resistance; 9-10            | 0.060 $\Omega$ ; $\pm 20$ %                             | at 20 °C                         |
| inductance; 9-10               | 130 $\mu\text{H}$ ; $\pm 5$ %                           | 10 kHz; 100 mV; $L_s$            |
| saturation current; 9-10       | 13 A                                                    | 20 % roll-off from initial       |
| leakage inductance; 9-10       | 52 $\mu\text{H}$ (typical);<br>maximum 75 $\mu\text{H}$ | tie(3+4); 100 kHz; 100 mV; $L_s$ |
| dielectric; 3-10               |                                                         | 1500 V (AC); 1 s                 |
| turns ratio                    | 30:1; $\pm 1$ %                                         | (9-10):(4-3)                     |
| <b>General specifications</b>  |                                                         |                                  |
| operating temperature          | -40 °C to +125 °C                                       | including temperature rise       |

## 10 Abbreviations

Table 15. Abbreviations

| Acronym | Description                                       |
|---------|---------------------------------------------------|
| BCM     | Boundary Conduction Mode                          |
| CMP     | Capacitive Mode Protection                        |
| EMC     | ElectroMagnetic Compatibility                     |
| EMI     | ElectroMagnetic Interference                      |
| HBC     | Half-Bridge Converter                             |
| MOSFET  | Metal-Oxide Semiconductor Field-Effect Transistor |
| OCP     | OverCurrent Protection                            |
| OPP     | OverPower Protection                              |
| OVP     | OverVoltage Protection                            |
| OLP     | Open-Loop Protection                              |
| PCB     | Printed-Circuit Board                             |
| PFC     | Power Factor Correction                           |
| RMS     | Root Mean Square                                  |
| SOI     | Silicon-On Insulator                              |
| ZVS     | Zero-Voltage Switching                            |

## 11 References

- |   |                             |                                                                                        |
|---|-----------------------------|----------------------------------------------------------------------------------------|
| 1 | <b>TEA19161T data sheet</b> | Digital controller for high-efficiency resonant power supply; 2016, NXP Semiconductors |
| 2 | <b>TEA19162T data sheet</b> | PFC controller; 2016, NXP Semiconductors                                               |
| 3 | <b>TEA1995T data sheet</b>  | GreenChip dual synchronous rectifier controller; 2015, NXP Semiconductors              |

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