



# UM11048

## TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

Rev. 1 — 6 February 2018

User manual

### Document information

| Information | Content                                                                                                                                                                                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Keywords    | TEA1936xDB1475, Universal Serial Bus (USB), power delivery, USB-PD, quick charge USB-PD, QC2.0, QC3.0, USB type-C                                                                                                                                                               |
| Abstract    | <p>This user manual describes the performance, technical data, and the connections of the TEA1936xDB1475 demo board.</p> <p>The TEA1936xDB1475 demo board operates at mains voltages from 90 V (AC) up to 264 V (AC). It can produce 5 V, 9 V, and 12 V DC output voltages.</p> |



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TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

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## Revision history

| Rev | Date     | Description |
|-----|----------|-------------|
| v.1 | 20180206 | 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 operation of the TEA1936xDB1475 demo board featuring the TEA19361 quasi-resonant controller, the TEA1993 synchronous rectifier controller, and the TEA19051B USB-PD Type-C and QC2.0/3.0 controller.

The TEA1936xDB1475 demo board is designed to deliver a maximum output power of 27 W. The output voltage can be selected at 5 V, 9 V, or 12 V. At 5 V and 9 V output voltage, the maximum output current is 3 A. At 12 V, the maximum output current is 2.3 A.

The TEA1936xDB1475 provides an effective solution with a low output current ripple and high efficiency for USB-PD and quick charge applications.

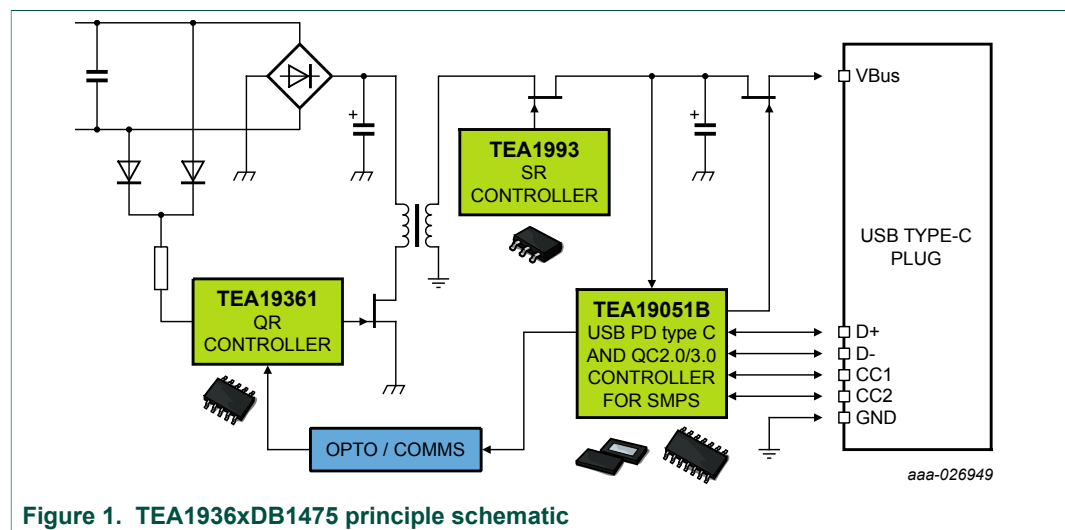


Figure 1. TEA1936xDB1475 principle schematic

## 1.1 Key features

- Multi-protocol support for USB-PD 2.0 & 3.0, Quick Charge 2.0 & 3.0
- Functionality user configurable end of line through the USB type-C interface
- Best-in-class energy efficiency meeting all DOE & EU CoC requirements
- No-load power < 30 mW when the USB (type C) cable is left unconnected
- Low audible noise; low output voltage ripple
- Small size due to high near-full digital integration level;  $\approx 11 \text{ W/inch}^3$  power density
- Best-in-class thermal management
- Safe solution with extensive set of hardware-integrated protection features
- Complete one-stop-shop solution from NXP Semiconductors minimizing development time and research and development cost

## 1.2 Applications

Mobile chargers with Type-C cable for:

- Mobile phones
- Smart phones
- Tablets
- Netbooks

The new smart charger platform of NXP Semiconductors helps designers of travel adapters to maximize power output for the smallest form-factor with the lowest bill of materials.

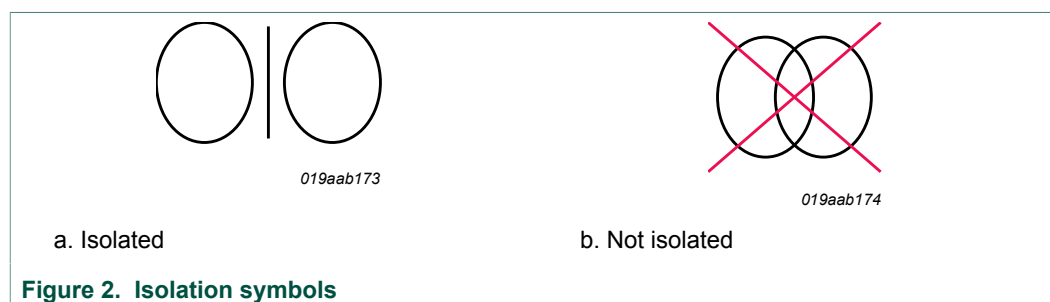
The result is a cost-effective design that meets the requirements published by Energy Star, the Department of Energy (DoE) in the United States, the Ecodesign Directive of the European Union, the European Code of Conduct, and other guidelines.

Supporting hardware (UTC) and software (GUI) for USB-PD available for jump-starting application.

## 2 Safety warning

The TEA1936xDB1475 demo board is connected to the mains voltage. Avoid touching the board while it is connected to the mains voltage and when it is in operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation from the mains phase using a fixed or variable transformer is always recommended.

Figure 2 shows the symbols on how to recognize these devices.



## 3 Specifications

**Table 1. TEA1936xDB1475 specifications**

| Symbol                     | Parameter                                     | Value                            |
|----------------------------|-----------------------------------------------|----------------------------------|
| $V_{\text{mains}}$         | AC mains voltage                              | 90 V (AC) up to 264 V (AC)       |
| $P_{\text{out(max)}}$      | maximum output power                          | 27 W                             |
| $f_{\text{mains}}$         | mains frequency                               | 47 Hz to 63 Hz                   |
| $P_{\text{idle}}$          | no-load input power                           | < 30 mW                          |
| $\eta$                     | efficiency                                    | > 90 %; at $P_{\text{out(max)}}$ |
| $V_{\text{out}}$           | output voltage                                | 5 V (DC), 9 V (DC), 12 V (DC)    |
| $I_{\text{out(max)}}$      | maximum output current                        | 3 A                              |
| $V_{\text{ripple(burst)}}$ | output voltage ripple in burst mode           | < 80 mV (p-p); at board end      |
| $V_{\text{ripple(full)}}$  | output voltage ripple at continuous switching | < 50 mV (p-p); at board end      |
| EMI                        | conducted EMI                                 | typically > 6 dB margin          |
| CMN                        | common-mode noise                             | < 2 V (p-p)                      |

4 Board photographs

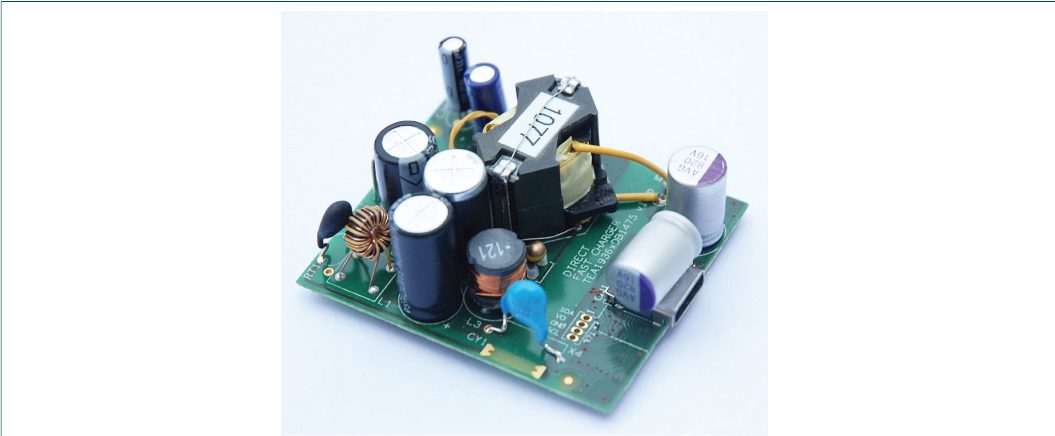
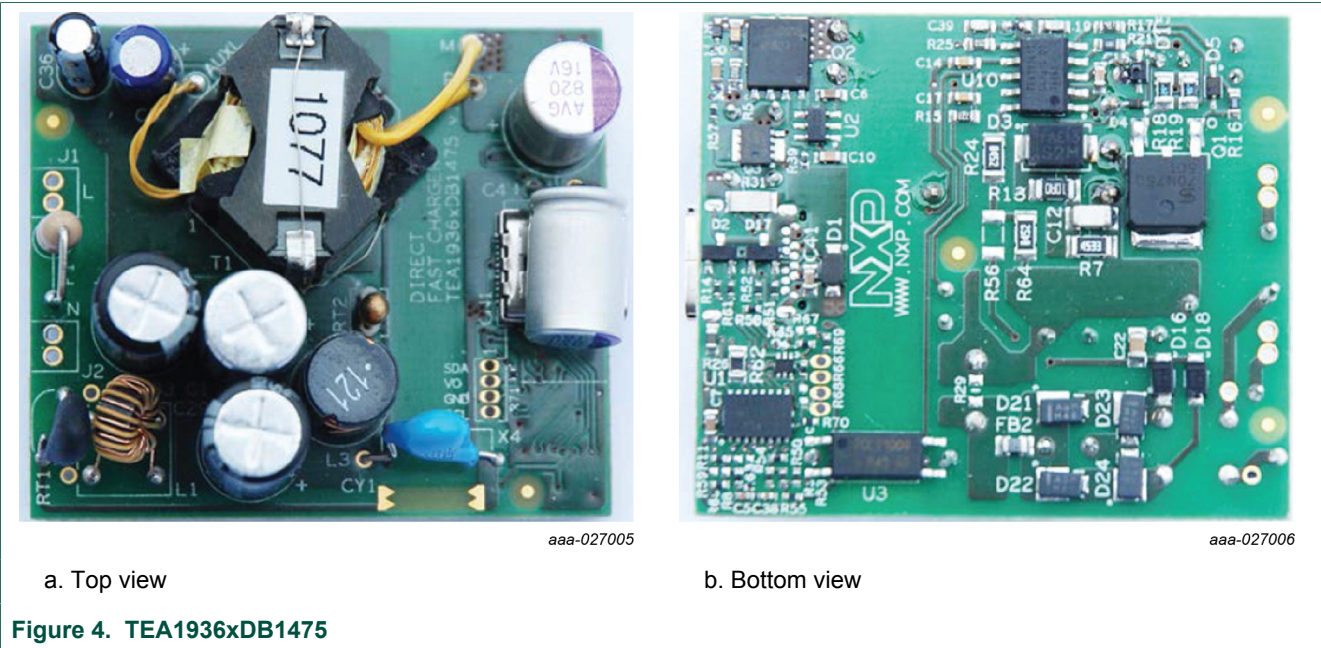


Figure 3. TEA1936xDB1475 demo board



a. Top view

b. Bottom view

Figure 4. TEA1936xDB1475

## TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

## 5 TEA1936xDB1475 demo board connections

The TEA1936xDB1475 demo board is a universal mains supplied application. The output is a USB type-C receptacle. Setting the output voltage is done through the USB type-C interface. Additionally, the TEO II graphical user interface software provides the option to program other output voltages and limit currents into the TEA19051B PD controller IC. [Section 7](#) lists the default settings.

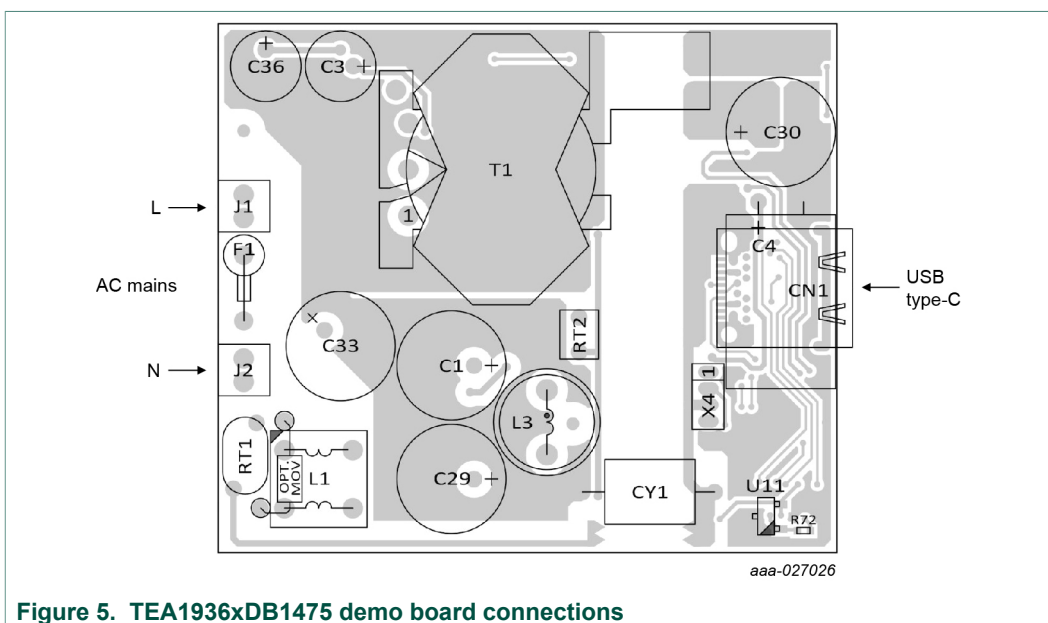


Figure 5. TEA1936xDB1475 demo board connections

## 6 TEA1936xDB1475 demo board performance

### 6.1 Efficiency

Table 2. Efficiency at 5 V output (PCB end)

| Load            | Efficiency at 115 V (AC) | Efficiency at 230 V (AC) |
|-----------------|--------------------------|--------------------------|
| 10 % (0.3 A)    | 88.2 %                   | 85.9 %                   |
| 25 % (0.75 A)   | 89.5 %                   | 87.4 %                   |
| 50 % (1.5 A)    | 90.1 %                   | 88.3 %                   |
| 75 % (2.25 A)   | 90.3 %                   | 88.7 %                   |
| 100 % (3 A)     | 90 %                     | 90 %                     |
| 4-point average | 90.0 %                   | 88.5 %                   |

Table 3. Efficiency at 9 V output (PCB end)

| Load            | Efficiency at 115 V (AC) | Efficiency at 230 V (AC) |
|-----------------|--------------------------|--------------------------|
| 10 % (0.3 A)    | 87.9 %                   | 86.2 %                   |
| 25 % (0.75 A)   | 90.4 %                   | 89.1 %                   |
| 50 % (1.5 A)    | 91.5 %                   | 90.4 %                   |
| 75 % (2.25 A)   | 91.8 %                   | 91.1 %                   |
| 100 % (3.0 A)   | 91.2 %                   | 91.2 %                   |
| 4-point average | 91.2 %                   | 90.5 %                   |

Table 4. Efficiency at 12 V output (PCB end)

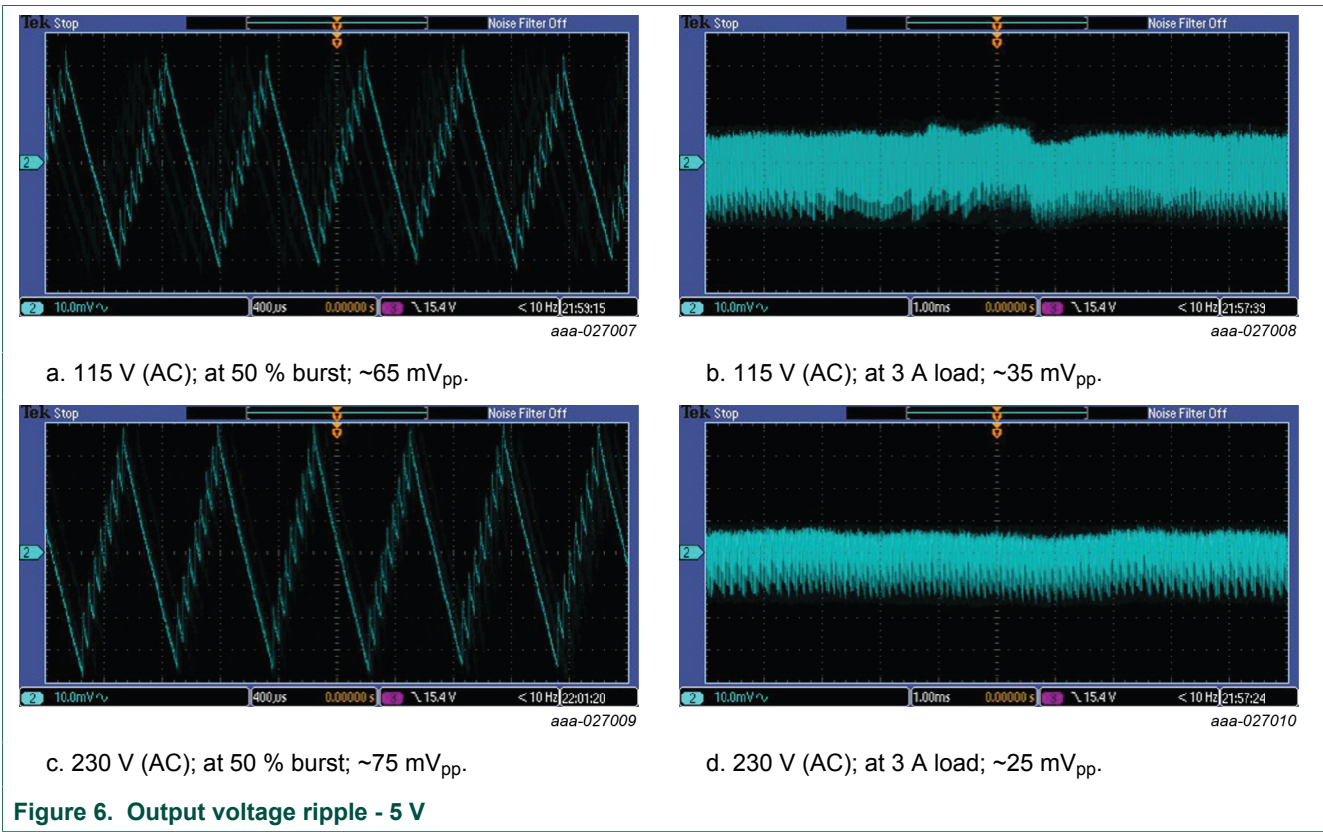
| Load            | Efficiency at 115 V (AC) | Efficiency at 230 V (AC) |
|-----------------|--------------------------|--------------------------|
| 10 % (0.23 A)   | 86.9 %                   | 85.3 %                   |
| 25 % (0.575 A)  | 90.1 %                   | 89.0 %                   |
| 50 % (1.15 A)   | 90.5 %                   | 88.4 %                   |
| 75 % (1.725 A)  | 91.9 %                   | 92.0 %                   |
| 100 % (2.3 A)   | 91.4 %                   | 91.3 %                   |
| 4-point average | 91.0 %                   | 90.1 %                   |

6.2 No-load power consumption

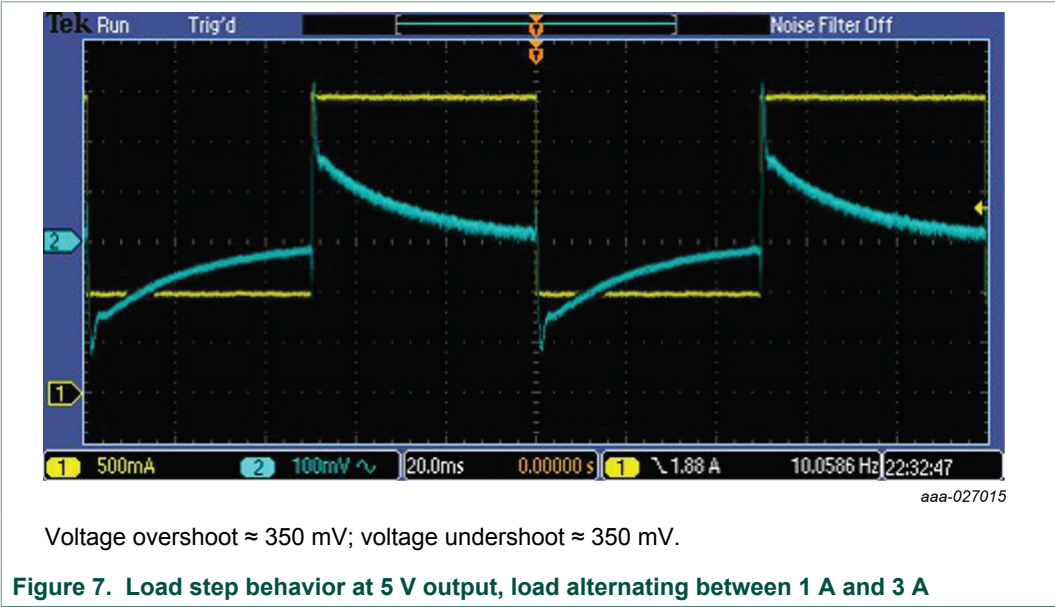
Table 5. No-load power consumption (USB type-C cable disconnected)

| Input voltage    | No-load power |
|------------------|---------------|
| 90 V (AC)/60 Hz  | 24 mW         |
| 115 V (AC)/60 Hz | 23 mW         |
| 230 V (AC)/50 Hz | 23 mW         |
| 264 V (AC)/50 Hz | 32 mW         |

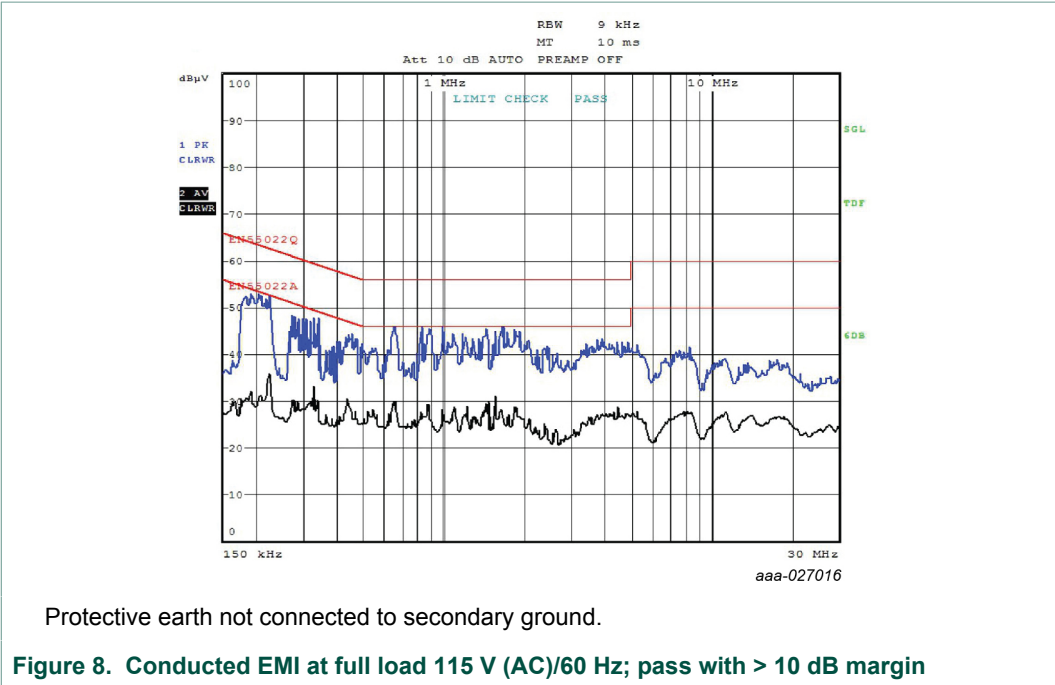
6.3 Output voltage ripple



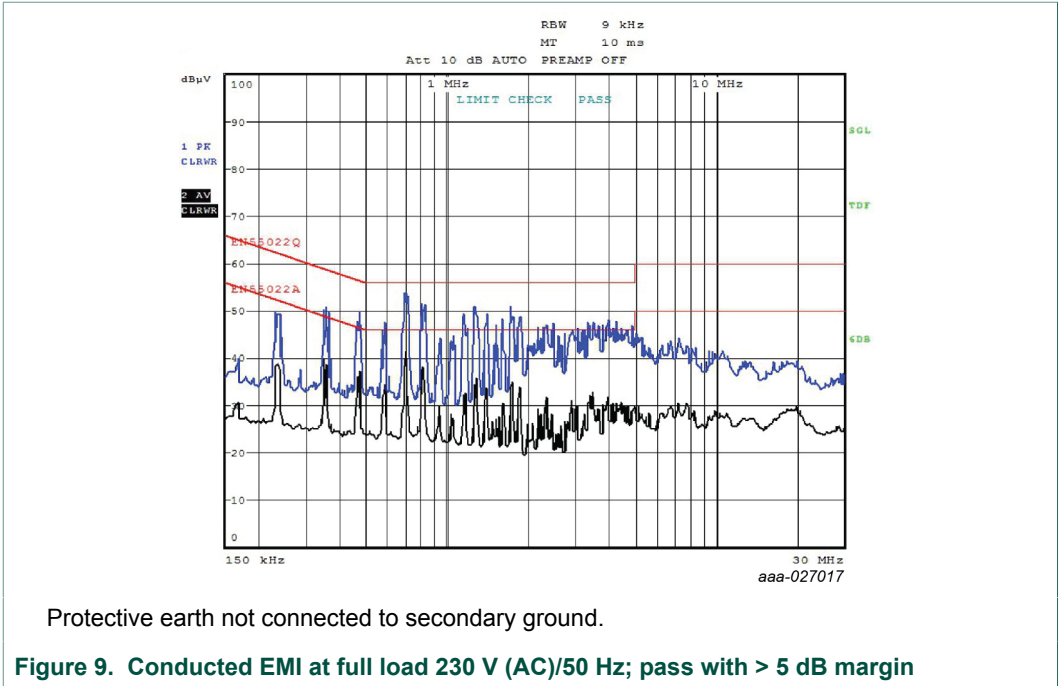
6.4 Load step behavior



6.5 ElectroMagnetic Interference (EMI)



TEA1936xDB1475 multistandard 27 W HV mobile charging demo board



Protective earth not connected to secondary ground.

Figure 9. Conducted EMI at full load 230 V (AC)/50 Hz; pass with > 5 dB margin

6.6 Common-mode noise cf. IEC62684

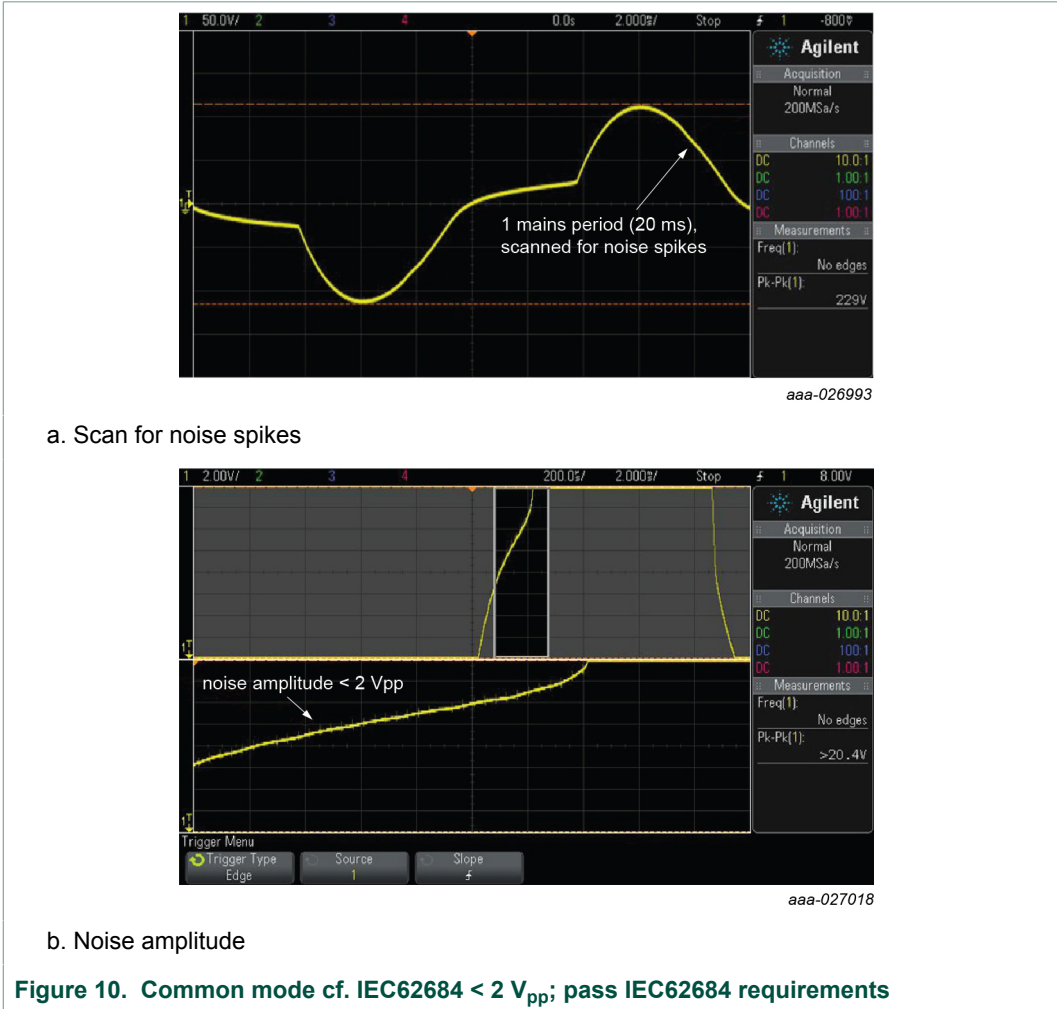
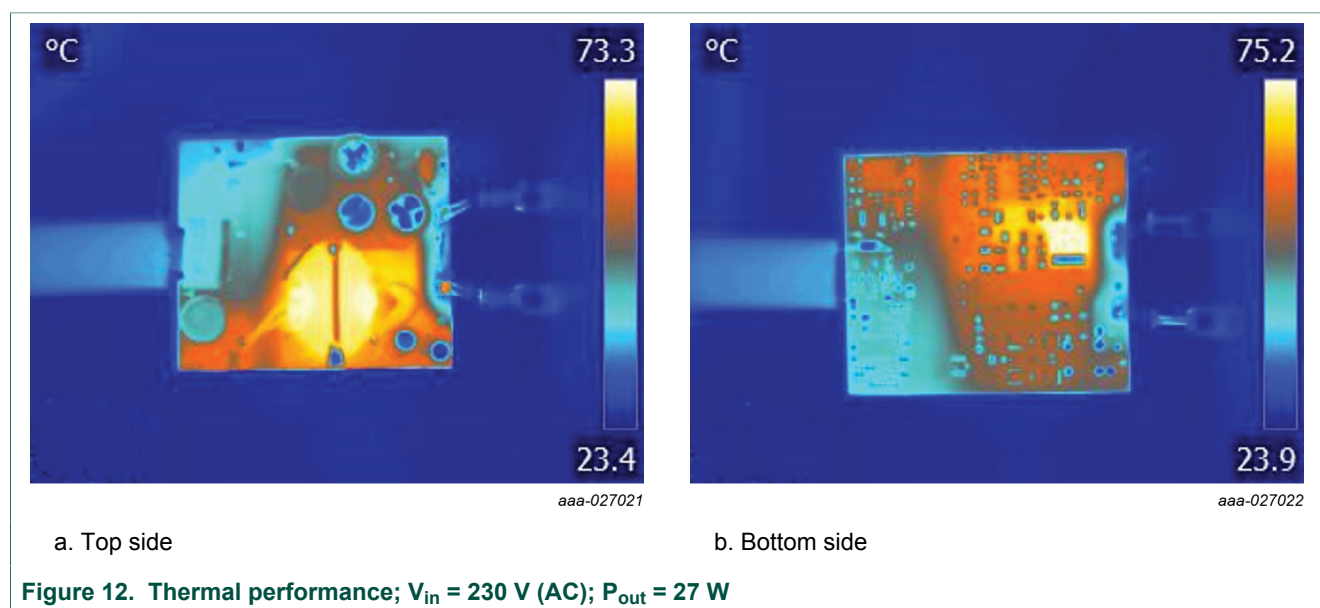
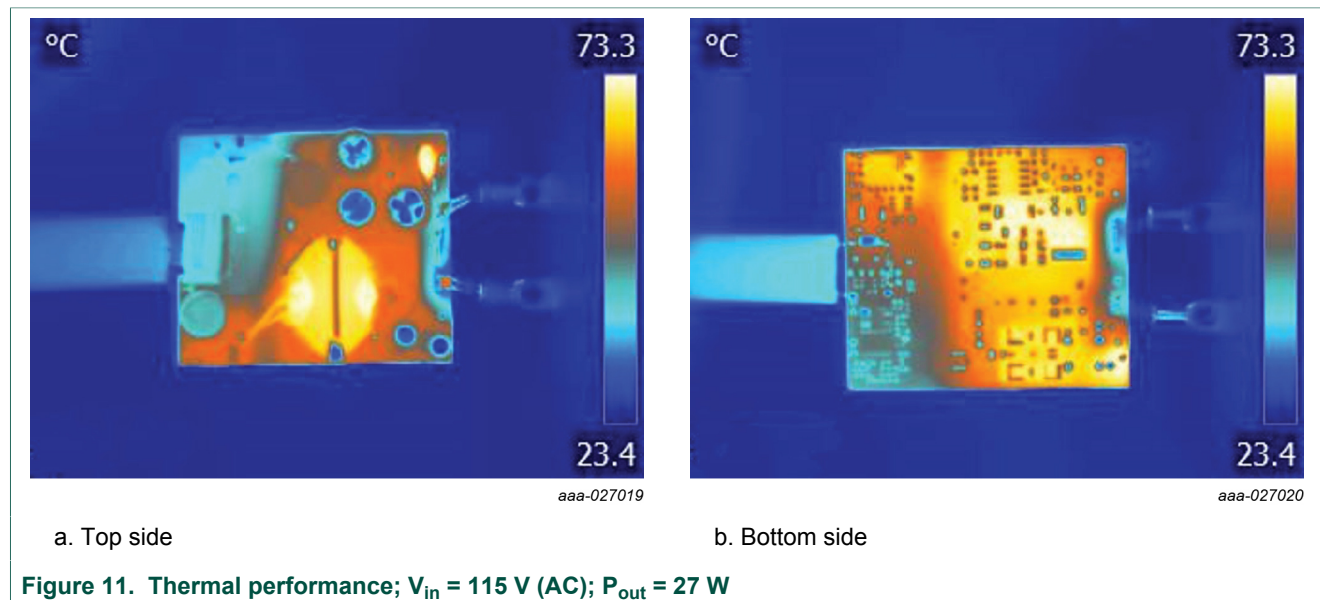


Figure 10. Common mode cf. IEC62684 < 2 V<sub>pp</sub>; pass IEC62684 requirements

## 6.7 Thermal



**Note:** Typical temperature distribution at  $T_{amb} = 25\text{ °C}$ ; PCB in free air, natural convection, and radiation only.

## 7 PDO settings

The output voltages and currents for the efficiency measurement were set as shown in [Table 6](#).

**Table 6. PDO settings**

*Default values for demo board TEA1936xDB1475*

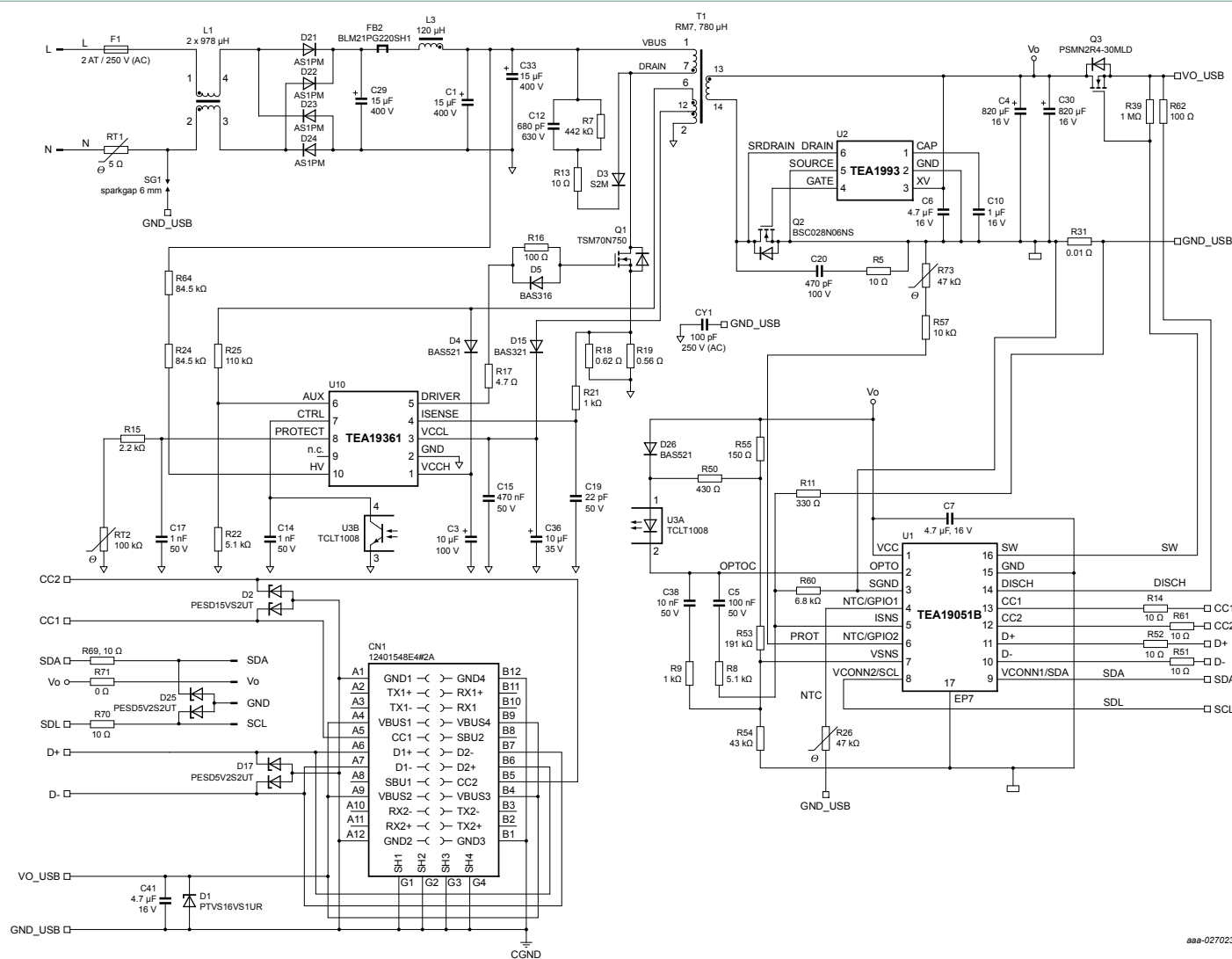
| PDO (#) | V <sub>out</sub> (V) | I <sub>out</sub> (A) |
|---------|----------------------|----------------------|
| 0       | 5                    | 3                    |
| 1       | 9                    | 3                    |
| 2       | 12                   | 2.3                  |

PDO settings can be changed by reprogramming the MTP settings of the TEA19051B via the USB type-C connector using the TEO II software. However, for the TEA1936xDB1475 demo board, the voltage levels must not exceed 12 V. Current limit levels must not exceed 3 A. Power limit levels must not exceed 27 W (see the TEA190x Evaluation Overdrive (TEO) user manual ([Ref. 1](#))).

**Note:** The PDOs must have an ascending voltage and power in order to work correctly. So,  $V(\text{PDO}, i + 1) > V(\text{PDO}, i)$  and also  $P(\text{PDO}, i + 1) > P(\text{PDO}, i)$ .

## TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

## 8 Schematic



**Figure 13. TEA1936xDB1475 schematic diagram**

## TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

## 9 Bill Of Materials (BOM)

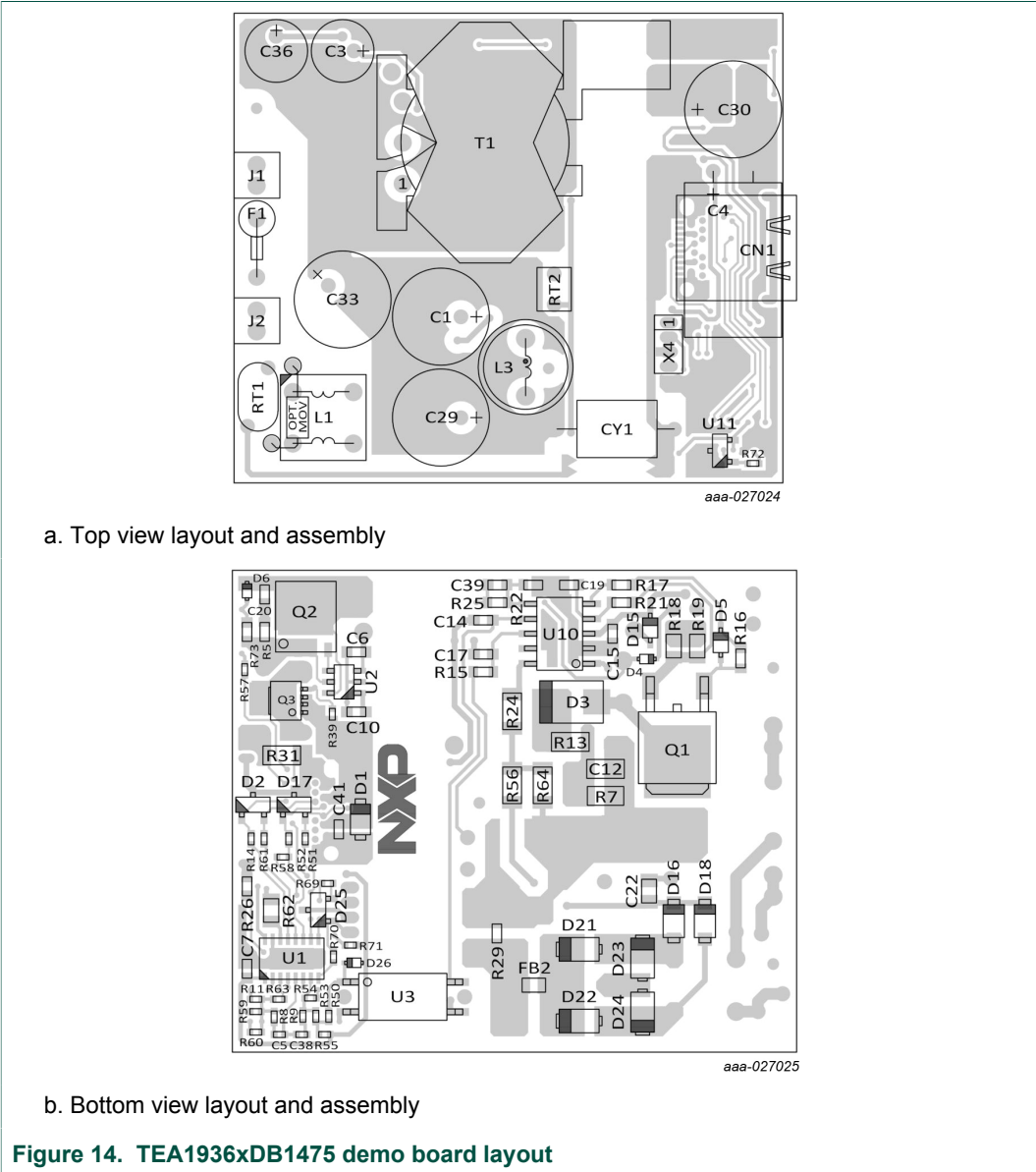
Table 7. TEA1936xDB1475 BOM

| Reference             | Description and values                             | Part number                | Manufacturer                            |
|-----------------------|----------------------------------------------------|----------------------------|-----------------------------------------|
| C1                    | capacitor; 15 $\mu$ F; 20 %; 400 V; ALU; THT       | EKM156M2GF16RR             | Samxon                                  |
| C3                    | capacitor; 10 $\mu$ F; 20 %; 100 V; ALU; THT       | 100YXJ10M5X11              | Rubycon                                 |
| C4                    | capacitor; 820 $\mu$ F; 20 %; 16 V; ALU; THT       | 827AVG016MFBJ              | Illinois Capacitors                     |
| C5                    | capacitor; 100 nF; 10 %; 50 V; X7R; 0402           | C1005X7R1H104K050BB        | TDK                                     |
| C6; C7                | capacitor; 4.7 $\mu$ F; 10 %; 16 V; X5R; 0603      | C1608X5R1C475K080AC        | TDK                                     |
| C10                   | capacitor; 1 $\mu$ F; 10 %; 16 V; X7R; 0603        | -                          | -                                       |
| C12                   | capacitor; 680 pF; 10 %; 630 V; X7R; 1206          | C1206C681KBRAC             | KEMET                                   |
| C14                   | capacitor; 1 nF; 10 %; 50 V; X7R; 0603             | -                          | -                                       |
| C15                   | capacitor; 470 nF; 10 %; 50 V; X7R; 0603           | C1608X7R1H474K             | TDK                                     |
| C17                   | capacitor; 1 nF; 10 %; 50 V; X7R; 0603             | -                          | -                                       |
| C19                   | capacitor; 22 pF; 5 %; 50 V; C0G; 0603             | -                          | -                                       |
| C20                   | capacitor; 470 pF; 10 %; 100 V; X7R; 0603          | -                          | -                                       |
| C29; C33              | capacitor; 15 $\mu$ F; 20 %; 400 V; ALU; THT       | EKM156M2GF16RR             | Samxon                                  |
| C30                   | capacitor; 820 $\mu$ F; 20 %; 16 V; ALU; THT       | 827AVG016MFBJ              | Illinois Capacitors                     |
| C36                   | capacitor; 10 $\mu$ F; 20 %; 35 V; ALU; THT        | UVR1V100MDD6TP             | Nichicon                                |
| C38                   | capacitor; 10 nF; 10 %; 50 V; X7R; 0402            | -                          | -                                       |
| C41                   | capacitor; 4.7 $\mu$ F; 10 %; 16 V; X5R; 0603      | C1608X5R1C475K080AC        | TDK                                     |
| CN1                   | connector; USB 3.1 type-C receptacle R/A           | 12401548E4#2A              | Amphenol                                |
| CY1                   | capacitor; 100 pF; 10 %; 250 V (AC); B; THT; X1/Y2 | DE2B3KY101KA2BM01F         | Murata                                  |
| D1                    | diode; TVS; unidirectional; 16 V; 400 W            | PTVS16VS1UR                | NeXperia USA Inc                        |
| D2                    | diode; ESD protection; 30 kV; 3 A                  | PESD15VS2UT                | NeXperia USA Inc                        |
| D3                    | diode; 1 kV; 2 A                                   | S2M                        | Fairchild                               |
| D4; D26               | diode; 300 V; 250 mA                               | BAS521                     | NeXperia USA Inc                        |
| D5                    | diode; 100 V; 250 mA                               | BAS316                     | NXP Semiconductors                      |
| D15                   | diode; 200 V; 250 mA                               | BAS321                     | NeXperia USA Inc                        |
| D17; D25              | diode; ESD protection; 30 kV; 3 A                  | PESD5V2S2UT                | NeXperia USA Inc                        |
| D21; D22;<br>D23; D24 | diode; 1 kV; 1.5 A                                 | AS1PM-M3/84A               | Vishay                                  |
| F1                    | fuse; slow blow; 250 V; 2 A                        | MCPMP2A250V                | Multicomp                               |
| FB2                   | fbead; 0.009 $\Omega$ ; 6 A; 0805                  | BLM21PG220SH1D             | Murata                                  |
| L1                    | Inductor CM; EE7.0; Cu = 0.27 mm; 18T:18T          | -                          | NXP Semiconductors                      |
| L3                    | Inductor; 120 $\mu$ H                              | TEA1936xDB1475(L3)/7447721 | NXP Semiconductors/<br>Würth Elektronik |
| Q1                    | MOSFET-N; 700 V; 0.75 $\Omega$ ; 6 A               | TSM70N750CP                | Taiwan Semiconductor                    |
| Q2                    | MOSFET-N; 60 V; 100 A; TDSO                        | BSC028N06NS                | Infineon                                |

## TEA1936xDB1475 multistandard 27 W HV mobile charging demo board

| Reference                          | Description and values                      | Part number         | Manufacturer       |
|------------------------------------|---------------------------------------------|---------------------|--------------------|
| Q3                                 | MOSFET-N; 30 V; 2.4 mΩ; 70 A                | PSMN2R4-30MLD       | NXP Semiconductors |
| R5                                 | resistor; 10 Ω; 1 %; 63 mW; 0603            | -                   | -                  |
| R7                                 | resistor; 442 kΩ; 1 %; 660 mW; 1206         | ERJP08F4423V        | Panasonic          |
| R8                                 | resistor; 5.1 kΩ; 1 %; 63 mW; 0402          | -                   | -                  |
| R9                                 | resistor; 1 kΩ; 1 %; 63 mW; 0402            | -                   | -                  |
| R11                                | resistor; 330 Ω; 1 %; 63 mW; 0402           | -                   | -                  |
| R13                                | resistor; 10 Ω; 1 %; 250 mW; 1206           | -                   | -                  |
| R14; R51;<br>R52; R61;<br>R69; R70 | resistor; 10 Ω; 1 %; 100 mW; 0402;          | ERJ2RKF10R0X        | Panasonic          |
| R15                                | resistor; 2.2 kΩ; 1 %; 63 mW; 0603          | -                   | -                  |
| R16                                | resistor; 100 Ω; 1 %; 100 mW; 0603          | -                   | -                  |
| R17                                | resistor; 4.7 Ω; 1 %; 100 mW; 0603          | -                   | -                  |
| R18                                | resistor; 0.62 Ω; 1 %; 250 mW; 0805         | ERJS6QFR47V         | Panasonic          |
| R19                                | resistor; 0.56 Ω; 1 %; 250 mW; 0805         | ERJS6QFR56V         | Panasonic          |
| R21                                | resistor; 1 kΩ; 1 %; 63 mW; 0603            | -                   | -                  |
| R22                                | resistor; 5.1 kΩ; 1 %; 63 mW; 0603          | -                   | -                  |
| R24                                | resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206 | ERJP08F8452V        | Panasonic          |
| R25                                | resistor; 110 kΩ; 1 %; 63 mW; 0603          | -                   | -                  |
| R26                                | resistor; NTC; 47 kΩ; 5 %; 180 mW; 3980 K   | B57321V2473J060     | EPCOS              |
| R31                                | resistor; 0.006 Ω; 1 %; 1 W; 1206           | TLR2B10DR006FTDG    | TE Connectivity    |
| R39                                | resistor; 1 MΩ; 1 %; 63 mW; 0402            | CRCW04021M00FKED    | Vishay             |
| R50                                | resistor; 430 Ω; 1 %; 100 mW; 0402          | ERJ2RKF4300X        | Panasonic          |
| R53                                | resistor; 191 kΩ; 1 %; 63 mW; 0402          | -                   | -                  |
| R54                                | resistor; 43 kΩ; 1 %; 63 mW; 0402           | -                   | -                  |
| R55                                | resistor; 150 Ω; 1 %; 100 mW; 0402          | ERJ2RKF1500X        | Panasonic          |
| R60                                | resistor; 6.8 kΩ; 1 %; 63 mW; 0402          | -                   | -                  |
| R62                                | resistor; 100 Ω; 1 %; 500 mW; 0805          | ERJP6WF1000V        | Panasonic          |
| R64                                | resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206 | ERJP08F8452V        | Panasonic          |
| R71                                | resistor; jumper; 0 Ω; 100 mW; 0402         | ERJ2GE0R00X         | Panasonic          |
| R73                                | resistor; NTC; 47 kΩ; 5 %; 180 mW; 2980 K   | B57321V2473J060     | EPCOS              |
| RT1                                | ICL 5 Ω; 25 %; 1 A; 6 mm                    | SL05 5R001-A        | Ametherm           |
| RT2                                | resistor; NTC; 100 kΩ; 5 %; 100 mW; 4190 K  | NTCLE100E3104JB0    | Vishay             |
| T1                                 | transformer; RM7; TR1077                    | RM7, TR1077         | NXP Semiconductors |
| U1                                 | TEA19051B; HVSON16                          | TEA19051B (HVSON16) | NXP Semiconductors |
| U2                                 | synchronous rectifier controller; TEA1993   | TEA1993             | NXP Semiconductors |
| U10                                | SMTP controller; TEA19361                   | TEA19361            | NXP Semiconductors |
| U3                                 | optocoupler; NPN; 70 V; 50 mA               | TCLT1008            | Vishay             |

10 Layout



## 11 Abbreviations

Table 8. Abbreviations

| Acronym | Description                  |
|---------|------------------------------|
| CMN     | Common-Mode Noise            |
| EMI     | ElectroMagnetic Interference |
| GUI     | Graphical User Interface     |
| MTP     | Multiple Times Programmable  |
| PCB     | Printed-Circuit Board        |
| PD      | Power Delivery               |
| PDO     | Power Data Object            |
| QC      | Quick Charge                 |
| TEO     | TEA190x Evaluation Overdrive |
| USB     | Universal Serial Bus         |
| UTC     | Universal Type-C Controller  |

## 12 References

- 1 **UM11014 user manual** — TEA190x Evaluation Overdrive (TEO); 2017, NXP Semiconductors

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