UM11064

TEA1936xDB1520 USB-PD 27 W HV mobile charging demo board

Rev. 1 — 16 May 2018 User manual

Document information

Information	Content
Keywords	TEA1936xDB1520, Universal Serial Bus (USB), power delivery, USB-PD, USB type-C
Abstract	This user manual describes the performance, technical data, and the connections of the TEA1936xDB1520 demo board. The TEA1936xDB1520 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.

Revision history

Rev	Date	Description
v.1	20180516	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 TEA1936xDB1520 demo board featuring the TEA19361 quasi-resonant controller, the TEA1993 synchronous rectifier controller, and the TEA19031 USB-PD Type-C controller.

The TEA1936xDB1520 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 TEA1936xDB1520 provides an effective solution with a low output current ripple and high efficiency for USB-PD and quick charge applications.

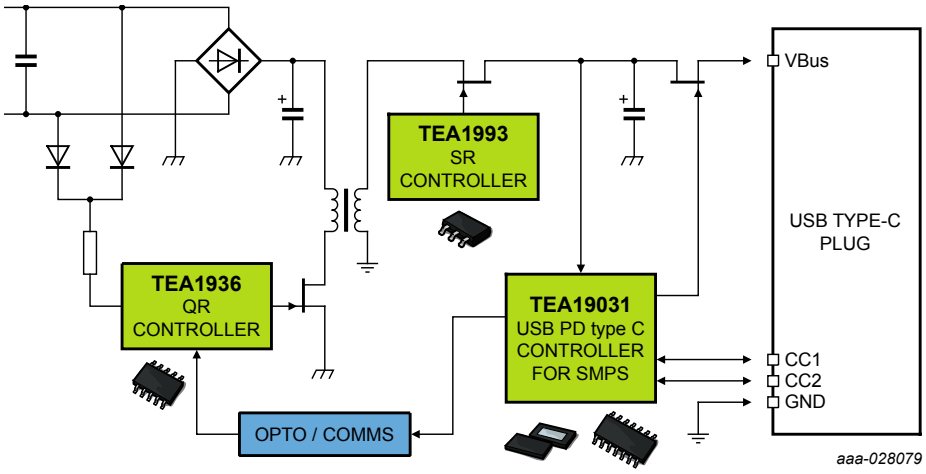


Figure 1. TEA1936xDB1520 principle schematic

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; ≈ 11 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.

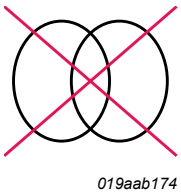
Supporting hardware (UTC) and software (GUI) for USB-PD available for jump-starting application.

2 Safety warning

The TEA1936xDB1520 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.

a. Isolated



b. Not isolated

Figure 2. Isolation symbols

3 Specifications

Table 1. TEA1936xDB1520 specifications

Symbol	Parameter	Value
V_{mains}	AC mains voltage	90 V (AC) up to 264 V (AC)
$P_{out(max)}$	maximum output power	27 W
f_{mains}	mains frequency	47 Hz to 63 Hz
P_{idle}	no-load input power	< 30 mW
η	efficiency	> 90 %; at $P_{out(max)}$
V_{out}	output voltage	5 V (DC), 9 V (DC), 12 V (DC)
$I_{out(max)}$	maximum output current	3 A
$V_{ripple(burst)}$	output voltage ripple in burst mode	< 80 mV (p-p); at board end
$V_{ripple(full)}$	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

aaa-029872

Figure 3. TEA1936xDB1520 demo board

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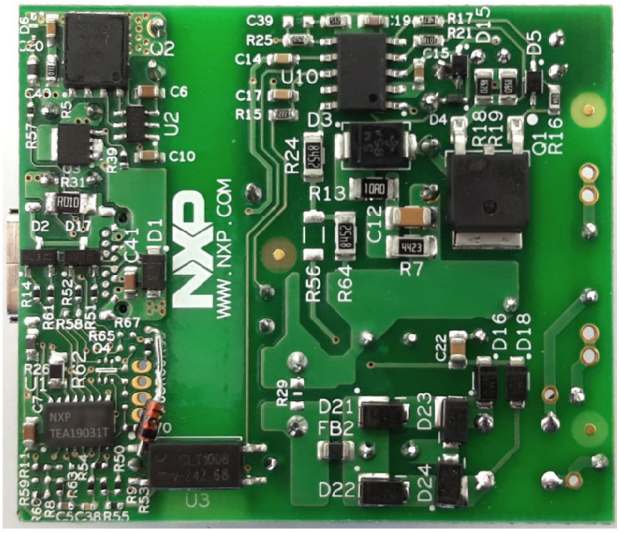
a. Top view



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b. Bottom view

Figure 4. TEA1936xDB1520

5 TEA1936xDB1520 demo board connections

The TEA1936xDB1520 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 TEA19031 PD controller IC. Section 7 lists the default settings.

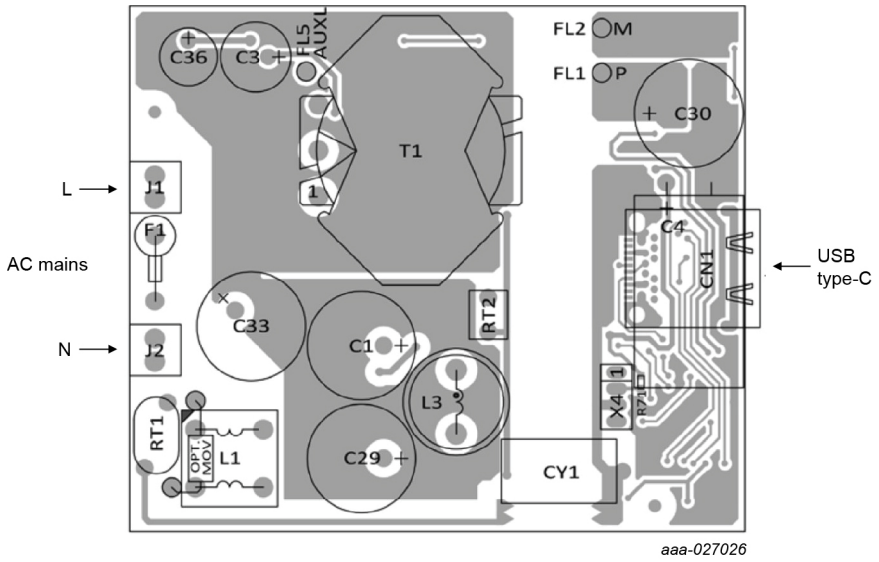


Figure 5. TEA1936xDB1520 demo board connections

6 TEA1936xDB1520 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 % (0.23 A)	88.2 %	85.9 %
25 % (0.575 A)	89.5 %	87.4 %
50 % (1.15 A)	90.1 %	88.3 %
75 % (1.725 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)

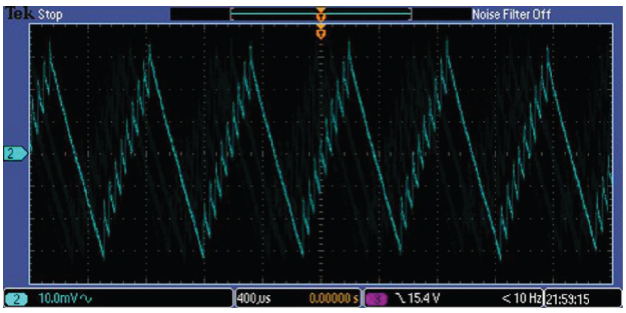
Load	Efficiency at 115 V (AC)	Efficiency at 230 V (AC)
10 % (0.23 A)	86.9 %	85.3 %
25 % (0.575 A)	90.1 %	89.0 %
50 % (1.15 A)	90.5 %	88.4 %
75 % (1.725 A)	91.9 %	92.0 %
100 % (2.3 A)	91.4 %	91.3 %
4-point average	91.0 %	90.1 %

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



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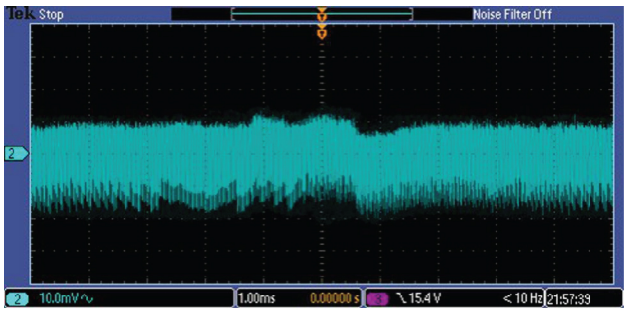
a. 115 V (AC); at 50 % burst; ~65 mV_{pp}.



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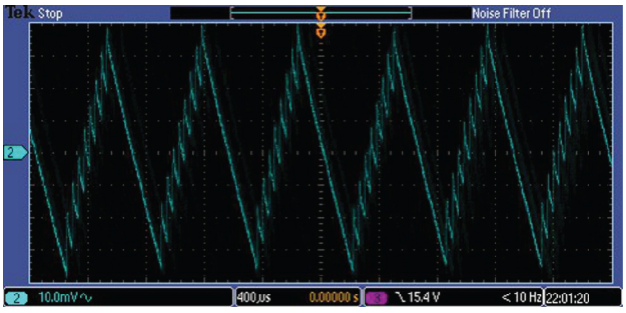
b. 115 V (AC); at 3 A load; ~35 mV_{pp}.



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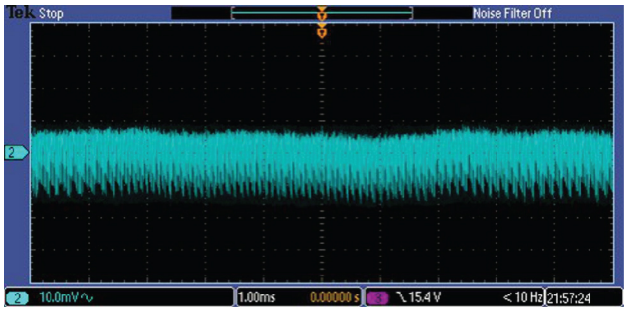
c. 230 V (AC); at 50 % burst; ~75 mV_{pp}.



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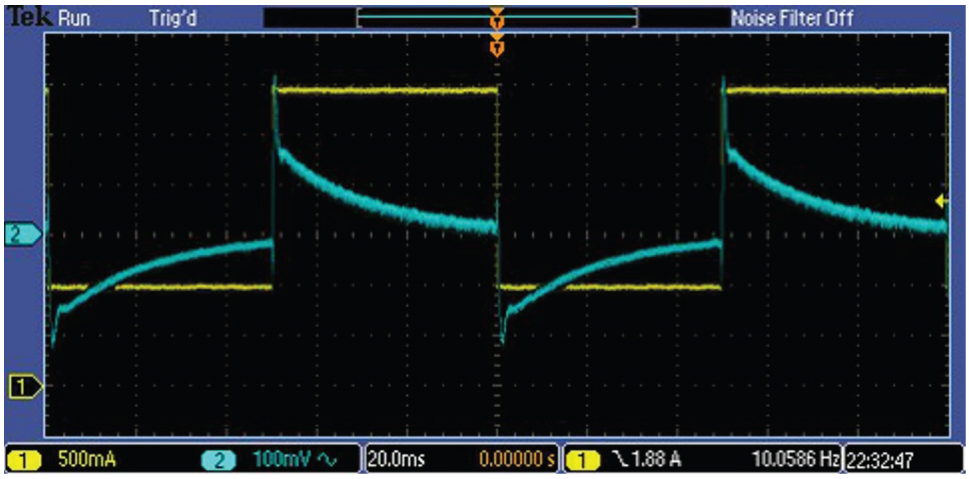
d. 230 V (AC); at 3 A load; ~25 mV_{pp}.

Figure 6. Output voltage ripple - 5 V

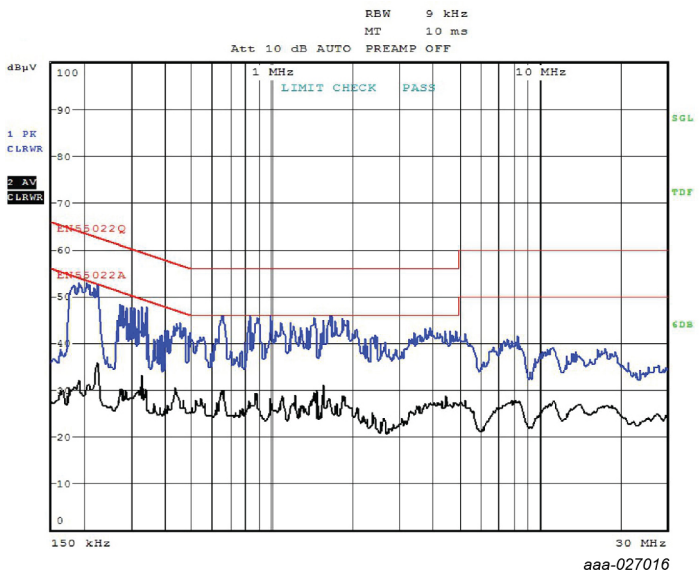
6.4 Load step behavior



Voltage overshoot ≈ 350 mV; voltage undershoot ≈ 350 mV.

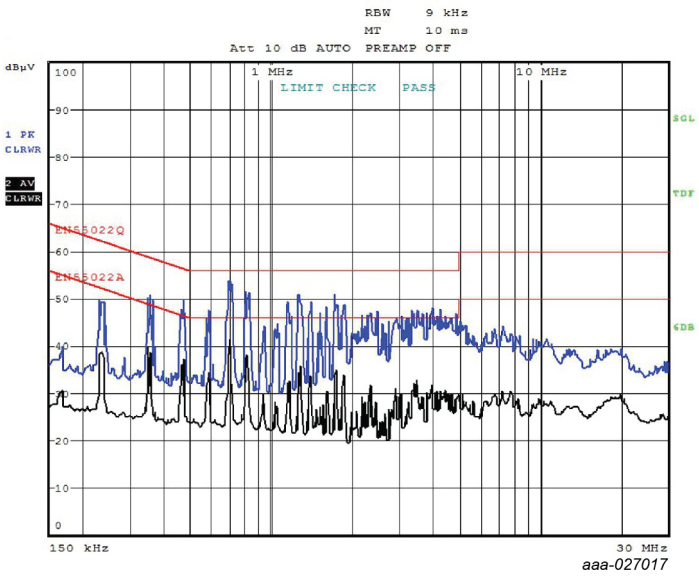
Figure 7. Load step behavior at 5 V output, load alternating between 1 A and 3 A

6.5 ElectroMagnetic Interference (EMI)



Protective earth not connected to secondary ground.

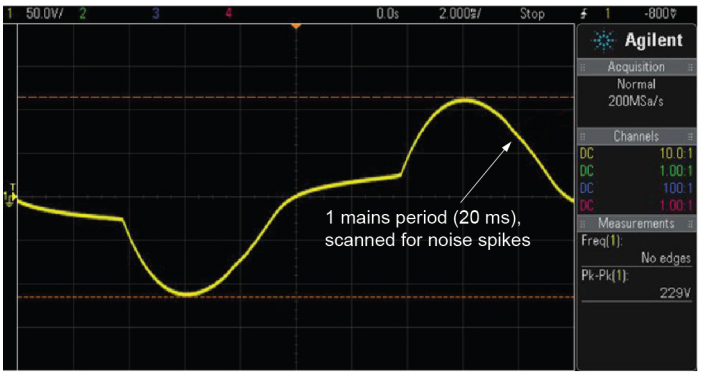
Figure 8. Conducted EMI at full load 115 V (AC)/60 Hz; pass with > 10 dB margin



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



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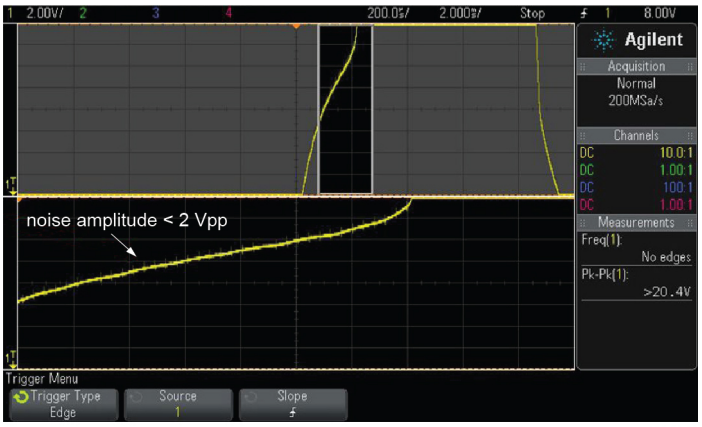
a. Scan for noise spikes



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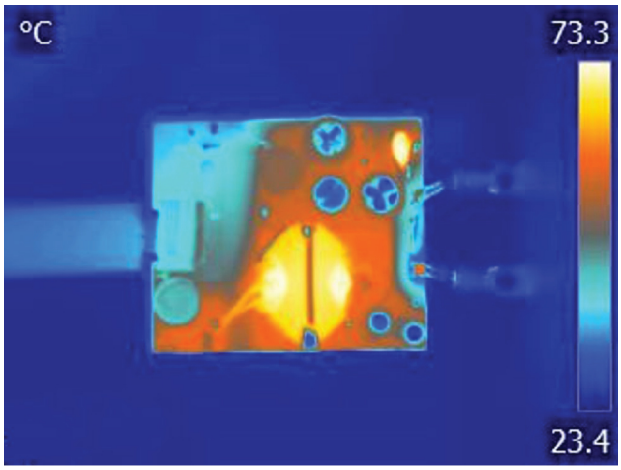
b. Noise amplitude

Figure 10. Common mode cf. IEC62684 < 2 V_{pp}; pass IEC62684 requirements

6.7 Thermal



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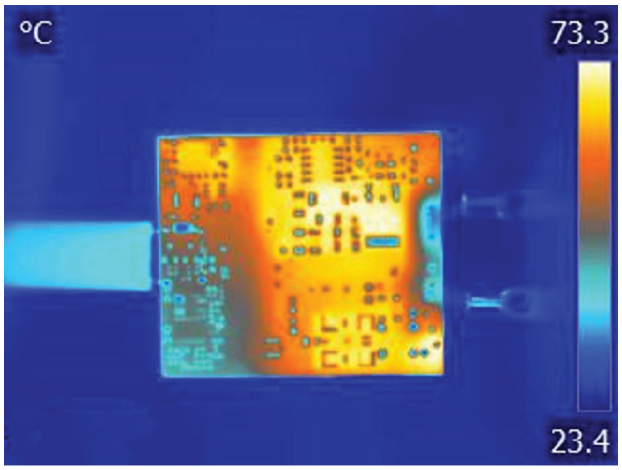
a. Top side



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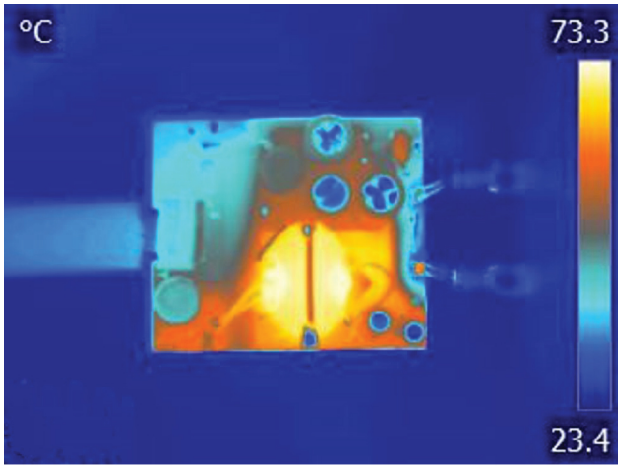
b. Bottom side

Figure 11. Thermal performance; V_{in} = 115 V (AC); P_{out} = 27 W



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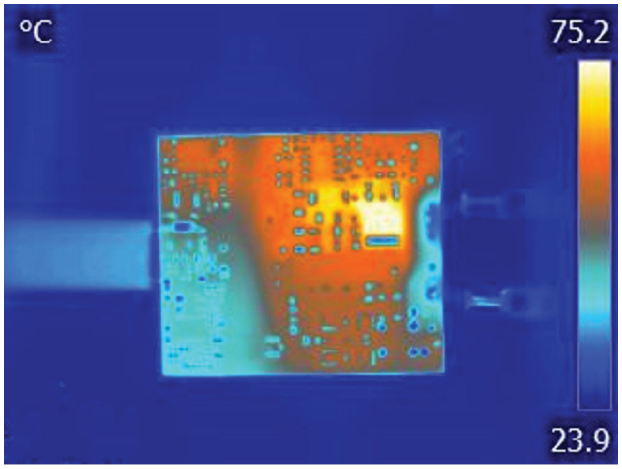
a. Top side



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b. Bottom side

Figure 12. Thermal performance; V_{in} = 230 V (AC); P_{out} = 27 W

Note: *Typical temperature distribution at T_{amb} = 25 °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 TEA1936xDB1520

PDO (#)	V_{out} (V)	I_{out} (A)
0	5	3
1	9	3
2	12	2.3

PDO settings can be changed by reprogramming the MTP settings of the TEA19031 via the USB type-C connector using the TEO II software. However, for theTEA1936xDB1520 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(PDO,i + 1) > V(PDO,i) and also P(PDO,i + 1) > P(PDO,i).*

8 Schematic

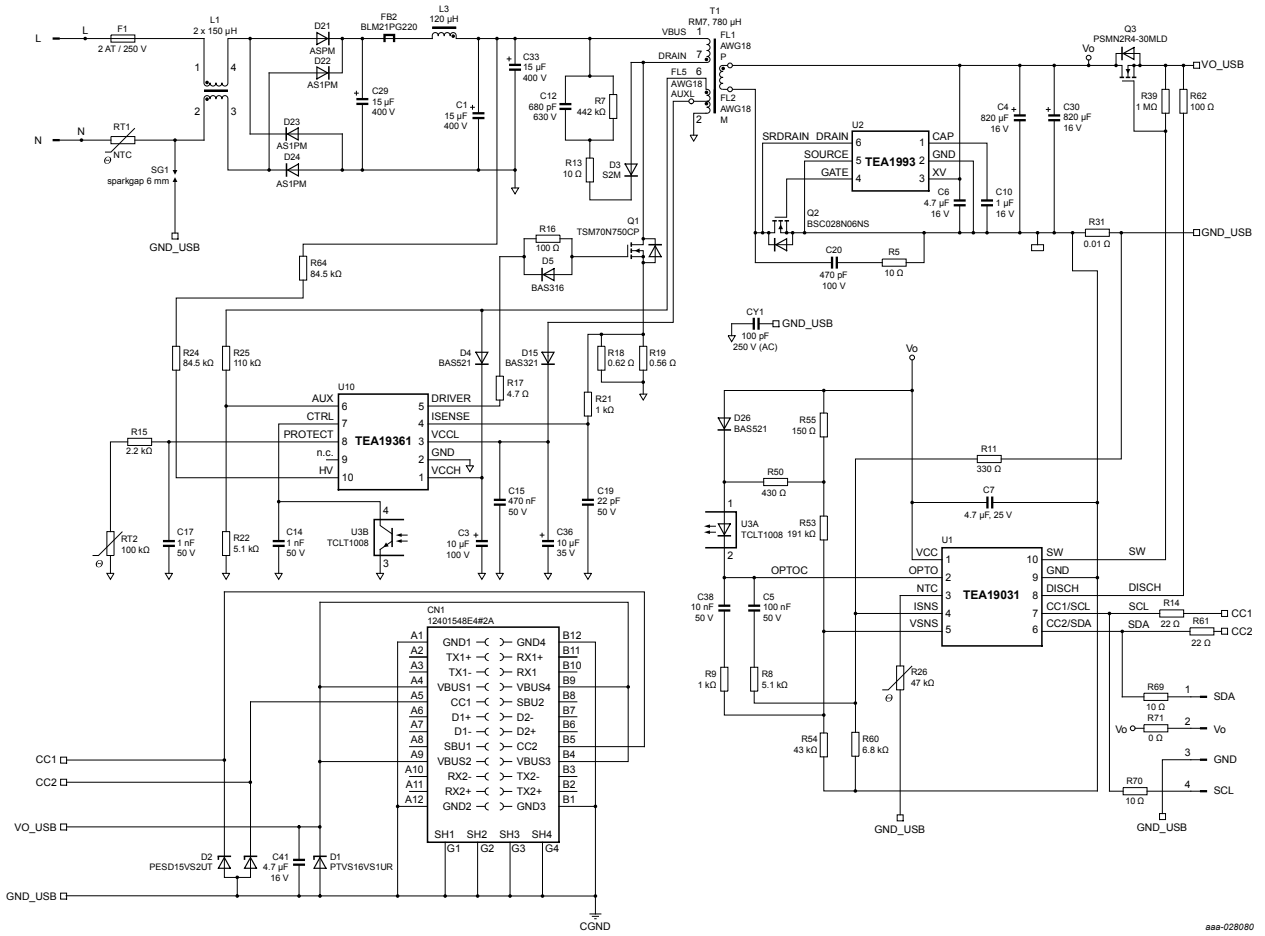


Figure 13. TEA1936xDB1520 schematic diagram

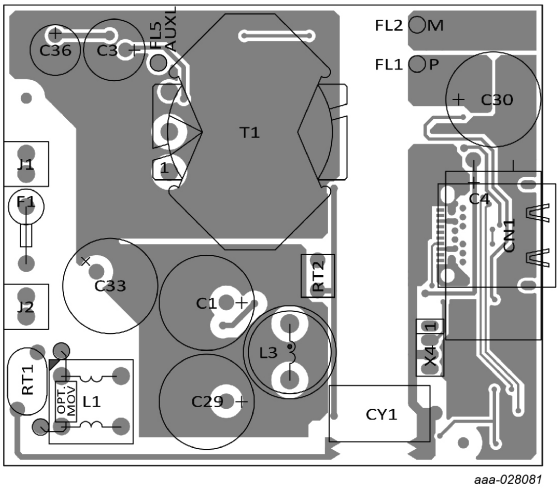
9 Bill Of Materials (BOM)

Table 7. TEA1936xDB1520 BOM

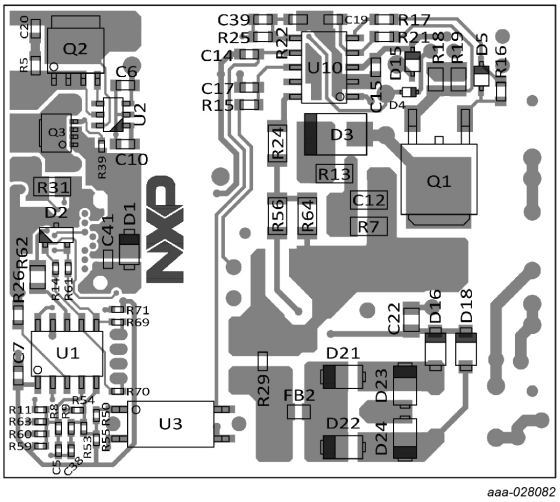
Reference	Description and values	Part number	Manufacturer
C1	capacitor; 15 µF; 20 %; 400 V; ALU; THT	EKM156M2GF16RR	Samxon
C3	capacitor; 10 µF; 20 %; 100 V; ALU; THT	100YXJ10M5X11	Rubycon
C4	capacitor; 820 µF; 20 %; 16 V; ALU; THT	827AVG016MFBJ	Illinois Capacitors
C5	capacitor; 100 nF; 10 %; 50 V; X7R; 0402	C1005X7R1H104K050BB	TDK
C6; C7	capacitor; 4.7 µF; 10 %; 16 V; X5R; 0603	C1608X5R1C475K080AC	TDK
C10	capacitor; 1 µF; 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 µF; 20 %; 400 V; ALU; THT	EKM156M2GF16RR	Samxon
C30	capacitor; 820 µF; 20 %; 16 V; ALU; THT	827AVG016MFBJ	Illinois Capacitors
C36	capacitor; 10 µf; 20 %; 35 V; ALU; THT	UVR1V100MDD6TP	Nichicon
C38	capacitor; 10 nF; 10 %; 50 V; X7R; 0402	-	-
C41	capacitor; 4.7 µF; 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	NXP Semiconductors
D2	diode; ESD protection; 30 kV; 3 A	PESD15VS2UT	NXP Semiconductors
D3	diode; 1 kV; 2 A	S2M	Fairchild
D4; D26	diode; 300 V; 250 mA	BAS521	NXP Semiconductors
D5	diode; 100 V; 250 mA	BAS316	NXP Semiconductors
D15	diode; 200 V; 250 mA	BAS321	NXP Semiconductors
D21; D22; 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 O; 6 A; 0805	BLM21PG220SH1D	Murata
L1	Inductor CM; EE7.0; Cu = 0.27 mm; 18T:18T	-	NXP Semiconductors
L3	Inductor; 120 µH	TEA1936xDB1520(L3)/74477212[1]	NXP Semiconductors/ Würth Elektronik
Q1	MOSFET-N; 700 V; 0.75 Ω; 6 A	TSM70N750CP	Taiwan Semiconductor
Q2	MOSFET-N; 60 V; 100 A; TDSON	BSC028N06NS	Infineon
Q3	MOSFET-N; 30 V; 2.4 mΩ; 70 A	PSMN2R4-30MLD	NXP Semiconductors

Reference	Description and values	Part number	Manufacturer
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; R61	resistor; 22 Ω; 1 %; 100 mW; 0402	-	-
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; R64	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; 0.01 Ω; 1 %; 1 W; 1206	ERJ8CWFR010V	Panasonic
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
R57	resistor; 10 kΩ; 1 %; 63 mW; 0402	-	-
R60	resistor; 6.8 kΩ; 1 %; 63 mW; 0402	-	-
R62	resistor; 100 Ω; 1 %; 500 mW; 0805	ERJP6WF1000V	Panasonic
R71	resistor; jumper; 0 Ω; 100 mW; 0402	ERJ2GE0R00X	Panasonic
RT1	resistor; 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; 780 µH	RM7	NXP Semiconductors
U1	USB-PD controller; TEA19031	TEA19031 (SO10)	NXP Semiconductors
U2	synchronous rectifier controller; TEA1993	TEA1993 (TSOP6)	NXP Semiconductors
U10	SMTP controller; TEA19361	TEA19361 (SO10)	NXP Semiconductors
U3	optocoupler; NPN; 70 V; 50 mA	TCLT1008	Vishay

10 Layout



a. Top view layout and assembly



b. Bottom view layout and assembly

Figure 14. TEA1936xDB1520 demo board 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

13 Legal information

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