UM11067

TEA19363DB1484 60 W USB-PD demo board

Rev. 1 — 14 March 2018 User manual

Document information

Information	Content
Keywords	TEA19363DB1484, TEA1936x, Universal Serial Bus (USB), power delivery, USB-PD, type-C, AC-DC controller
Abstract	This user manual describes the performance, technical data, and the connections of the TEA19363DB1484 demo board. The TEA19363DB1484 demo board operates at mains voltages from 90 V (AC) up to 264 V (AC) with an output voltage from 5 V (DC) up to 20 V (DC)

Revision history

Rev	Date	Description
v.1	20180314	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 TEA19363DB1484 demo board featuring the quasi-resonant controller TEA19361, the synchronous rectifier controller TEA1993, the USB-PD Type-C, and QC2.0/3.0 controller TEA19032B.

The TEA19363DB1484demo board is designed for delivering a maximum output power of 60 W at a maximum current of 3 A. Output voltages can be chosen from 5 V up to 20 V.

The TEA19363DB1484 provides an effective solution with a low output current ripple and high efficiency for USB-PD and Quick Charge applications.

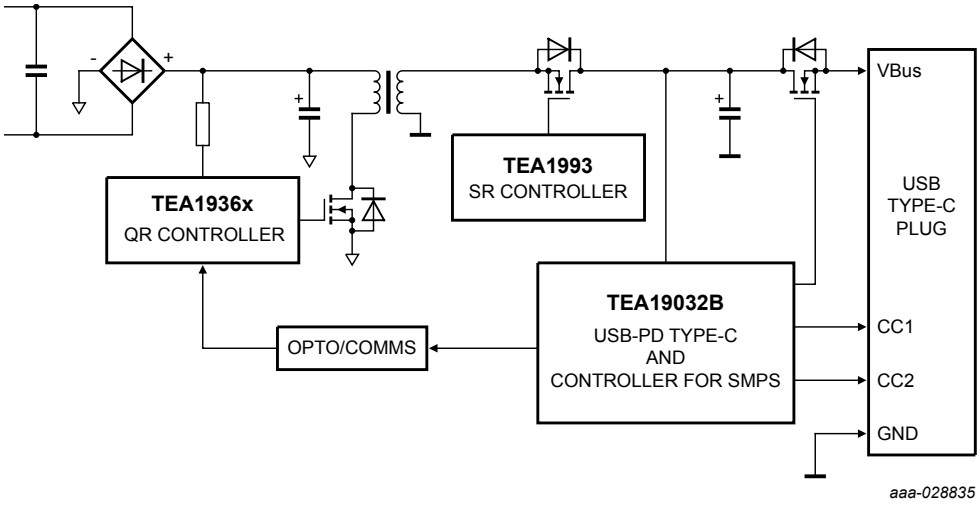


Figure 1. Principle schematic

1.1 Key features

- Protocol support for USB-PD 2.0
- Functionality user configurable end of line
- Best-in-class energy efficiency meeting all DOE & EU CoC requirements
- < 30 mW no-load power, low audible noise, low output voltage ripple
- Small size due to high near-full digital integration level and > tbd W/CI power density
- Best in class Thermal management
- Safe solution with extensive set of hardware-integrated protection features
- Complete one-stop-shop solution from NXP minimizing development time and R&D cost

1.2 Applications

Mobile chargers with Type-C cable for:

- Tablets
- Notebooks

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.

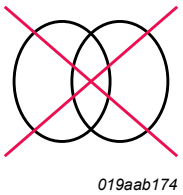
Supporting hardware (UTC) and software (TEO-II) for USB-PD are available for jump-starting application.

2 Safety warning

The 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. When the demo board is used in uncontrolled, non-laboratory environments, an isolated housing is obligatory. 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. TEA19363DB1484 specifications

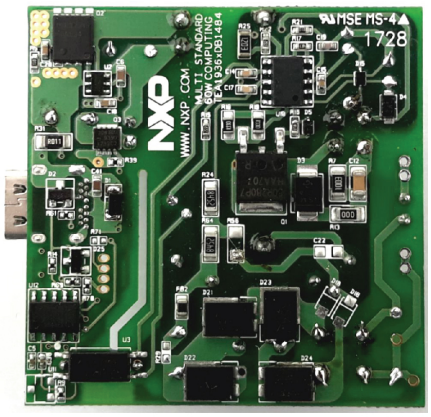
When operating at 230 V (AC)

Symbol	Parameter	Value
V_{mains}	AC mains voltage	90 V (AC) up to 264 V (AC)
$P_{out(max)}$	maximum output power	60 W
f_{mains}	mains frequency	50 Hz to 60 Hz
P_{idle}	No-load input power	< 30 mW
η	efficiency	> 92 % at $P_{out(max)}$
V_{out}	output voltage	5 V (DC) to 20 V (DC)
$I_{out(max)}$	maximum output current	3 A
$V_{O(ripple)burst}$	output voltage ripple in burst mode	100 mV_{pp} at cable end
$V_{O(ripple()ull}$	output voltage ripple at continuous switching	80 mV_{pp} at cable end
EMI_C	Conductive EMI	−3 dB
CMN	common-mode noise	< 2 V_{pp}
ESD	ElectroStatic Discharge	+5/−5 kV through air
		+8/−8 kV via contact

4 Board photographs

Figure 3. TEA19363DB1484 demo board

a. Top view



b. Bottom view

Figure 4. TEA19363DB1484

5 Board connections

The TEA19363DB1484 demo board is a universal mains supplied application. Its output is the Type-C connector. Programmable settings can be provided via the UTC using the TEO-II Graphical User Interface software.

Section 7 shows the default settings.

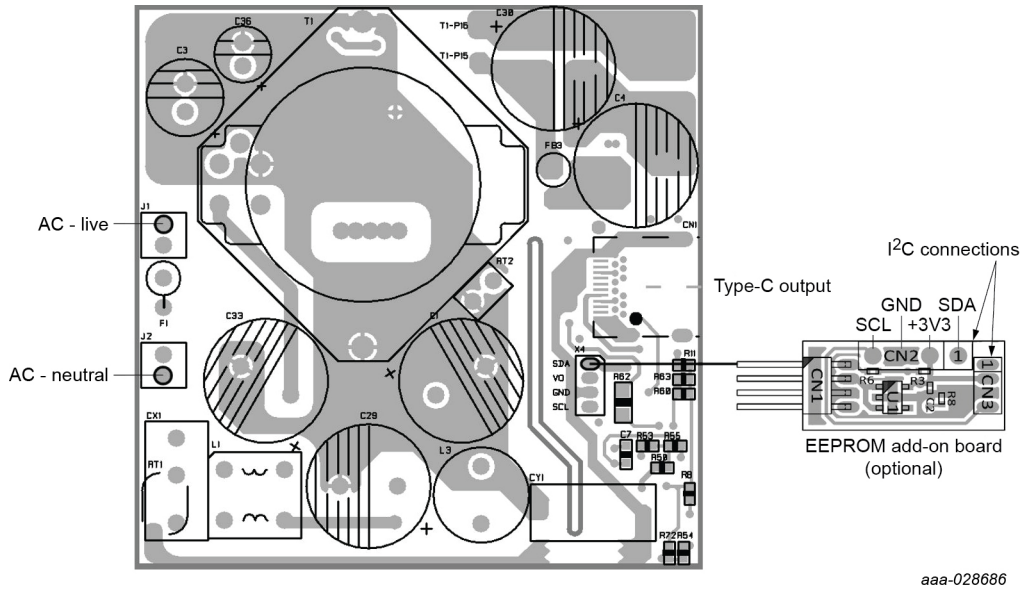


Figure 5. TEA19363DB1484 demo board connections

6 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)	86.7	85.4
25 % (0.75 A)	88.4	88.2
50 % (1.5 A)	88.5	87.4
75 % (2.25 A)	88.8	87.2
100 % (3 A)	89.8	88.4
4-point average	88.9	87.8

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

Load	Efficiency at 115 V (AC) (%)	Efficiency at 230 V (AC) (%)
10 % (0.3 A)	87.8	88.5
25 % (0.75 A)	89.2	88.1
50 % (1.5 A)	91.0	89.2
75 % (2.25 A)	91.4	89.6
100 % (3 A)	92.0	91.2
4-point average	90.9	89.5

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

Load	Efficiency at 115 V (AC) (%)	Efficiency at 230 V (AC) (%)
10 % (0.3 A)	87.4	86.5
25 % (0.75 A)	88.6	88.0
50 % (1.5 A)	90.2	89.8
75 % (2.25 A)	91.7	90.6
100 % (3 A)	92.2	91.5
4-point average	90.7	90.0

Table 5. Efficiency at 15 V output (PCB end)

Load	Efficiency at 115 V (AC) (%)	Efficiency at 230 V (AC) (%)
10 % (0.3 A)	87.5	87.3
25 % (0.75 A)	89.2	88.4
50 % (1.5 A)	91.0	90.2
75 % (2.25 A)	92.6	91.4
100 % (3 A)	92.5	92.2
4-point average	91.3	90.5

Table 6. Efficiency at 20 V output (PCB end)

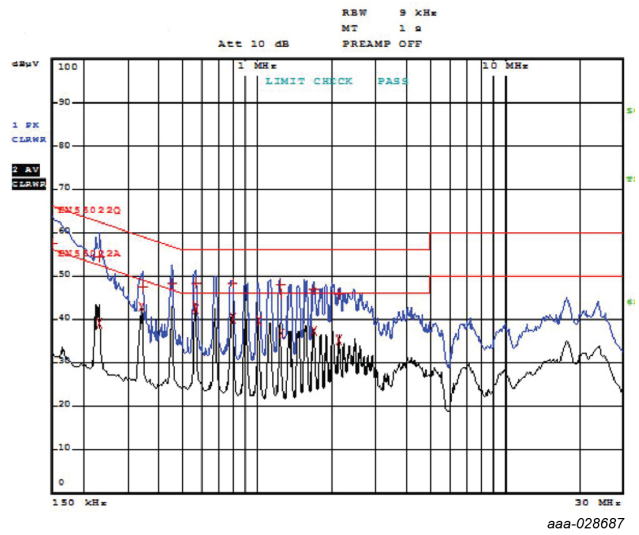
Load	Efficiency at 115 V (AC) (%)	Efficiency at 230 V (AC) (%)
10 % (0.3 A)	86.4	86.0
25 % (0.75 A)	89.1	88.9
50 % (1.5 A)	91.4	90.9
75 % (2.25 A)	92.5	91.7
100 % (3 A)	92.4	93.2
4-point average	91.3	91.2

6.2 No-load power consumption

Table 7. No-load consumption at 5 V output

Input voltage (V (AC))	Input frequency (Hz)	No-load power (mW)
90	60	23.1
115	60	23.7
150	60	24.2
180	50	25.1
200	50	24.7
230	50	27.3
264	50	31.9

6.3 ElectroMagnetic Interference (EMI)



Positive earth is connected to secondary ground

Figure 6. Connected EMI at full load 230 V (AC)/50 Hz

EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
1	Quasi Peak	150 kHz	57.69	N	-8.30
1	Quasi Peak	230 kHz	54.37	L1	-8.07
2	Average	230 kHz	39.11	L1	-13.34
2	Average	338 kHz	42.87	L1	-6.37
1	Quasi Peak	342 kHz	47.61	L1	-11.53
1	Quasi Peak	450 kHz	48.38	L1	-8.49
2	Average	562 kHz	43.23	L1	-2.76
1	Quasi Peak	566 kHz	48.42	L1	-7.57
2	Average	566 kHz	42.48	L1	-3.51
1	Quasi Peak	794 kHz	48.33	L1	-7.66
2	Average	794 kHz	40.33	L1	-5.66
2	Average	1.014 MHz	39.73	L1	-6.26
1	Quasi Peak	1.242 MHz	48.05	L1	-7.94
2	Average	1.25 MHz	36.88	L1	-9.11
1	Quasi Peak	1.254 MHz	46.17	L1	-9.82
1	Quasi Peak	1.698 MHz	46.96	L1	-9.03
2	Average	1.698 MHz	37.28	L1	-8.71
1	Quasi Peak	2.15 MHz	45.68	L1	-10.31
2	Average	2.15 MHz	35.42	L1	-10.57

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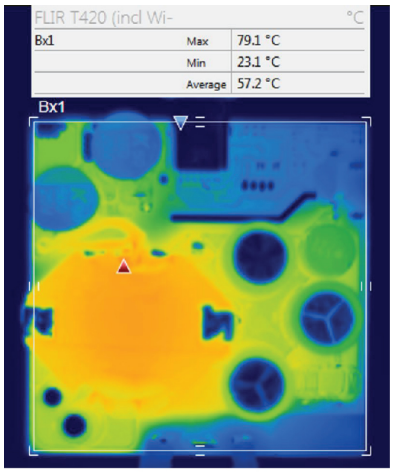
Positive earth is connected to secondary ground

Figure 7. Conducted EMI peak list at full load 230 V (AC)/50 Hz

6.4 Thermal



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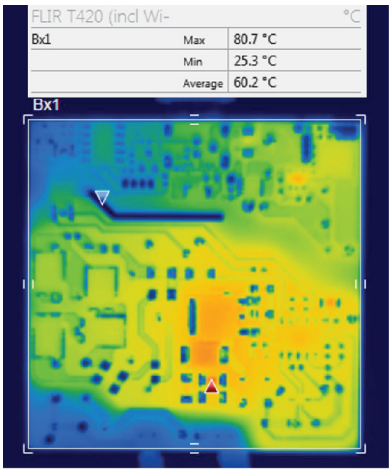
a. Top side



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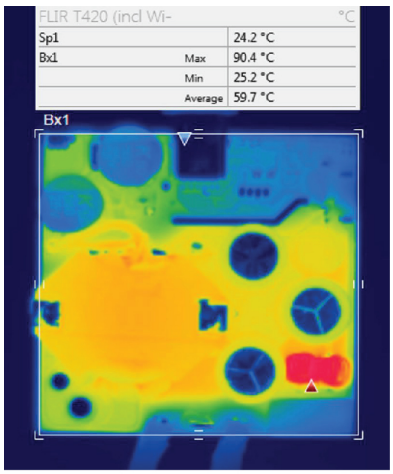
b. Bottom side

Figure 8. Thermal performance; V_{in} = 230 V (AC); P_{out} = 60 W



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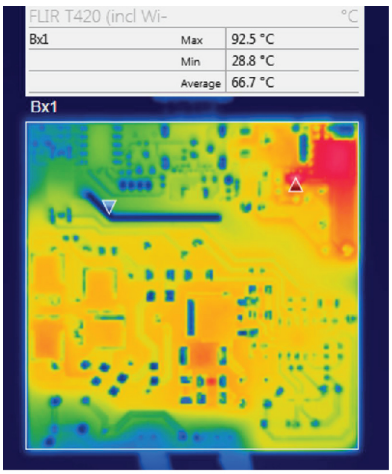
a. Top side



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b. Bottom side

Figure 9. Thermal performance; V_{in} = 115 V (AC); P_{out} = 60 W

Note: *Typical temperature distribution at T_{amb} = 25 °C; PCB in free air, natural convection, and radiation only. For the TEA19363DB1484 demo board, the voltage levels must not exceed 20 V also. Current limit levels must not exceed 3.25 A. Power limit levels must not exceed 65 W.*

7 PDO settings

The output voltages and currents for the efficiency measurement were set as shown in Table 8.

Table 8. PDO settings

Default values for demo board TEA19363DB1484

PDO (#)	V_{out} (V)	I_{out} (A)
1	5	3
2	9	3
3	12	3
4	15	3
5	20	3

PDO settings can be changed by reprogramming the MTP settings of the TEA19032B via UTC using the TEO-II software (see the TEA190x Evaluation Overdrive (TEO) user manual).

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). Also, for the TEA19363DB1484 demo board, the voltage levels must not exceed 20 V. Current limit levels must not exceed 3.25 A. Power limit levels must not exceed 65 W.*

8 Schematic

The schematic of the TEA19363DB1484 incorporates the quasi-resonant controller TEA19361, the synchronous rectifier controller TEA1993, and the USB-PD/QC controller TEA19032B.

In this application, a TEA19361 could be used because a 100 nF X-capacitor was adequate for differential mode EMI filtering. When a larger X-capacitor is needed, an active X-capacitor discharge is required. To support computing applications that typically have an X-capacitor with a higher value than 100 nF, the TEA19363 must be used instead of the TEA19361 because it incorporates an active X-capacitor discharge function.

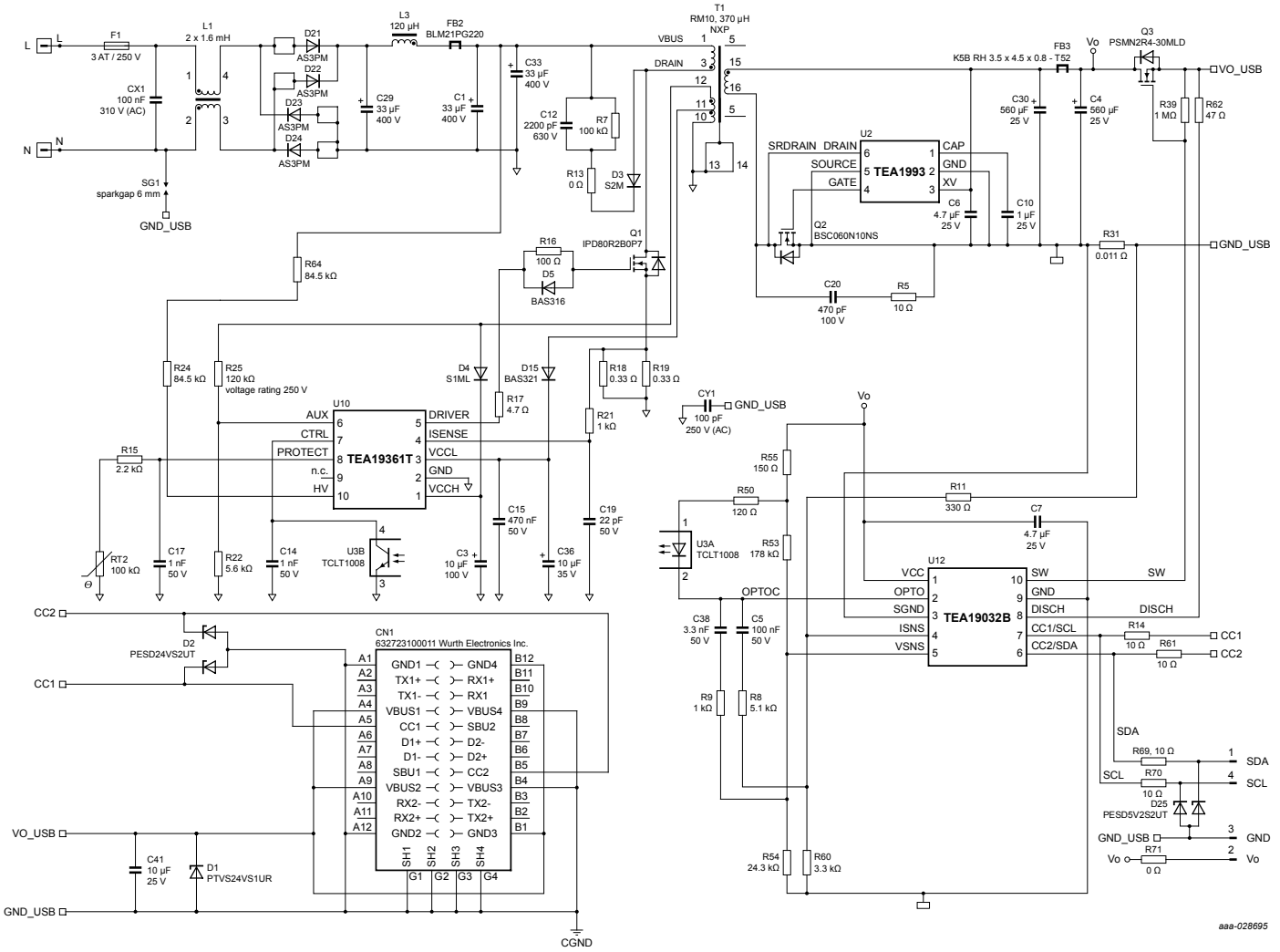


Figure 10. Schematic of the TEA19363DB1484 demo board

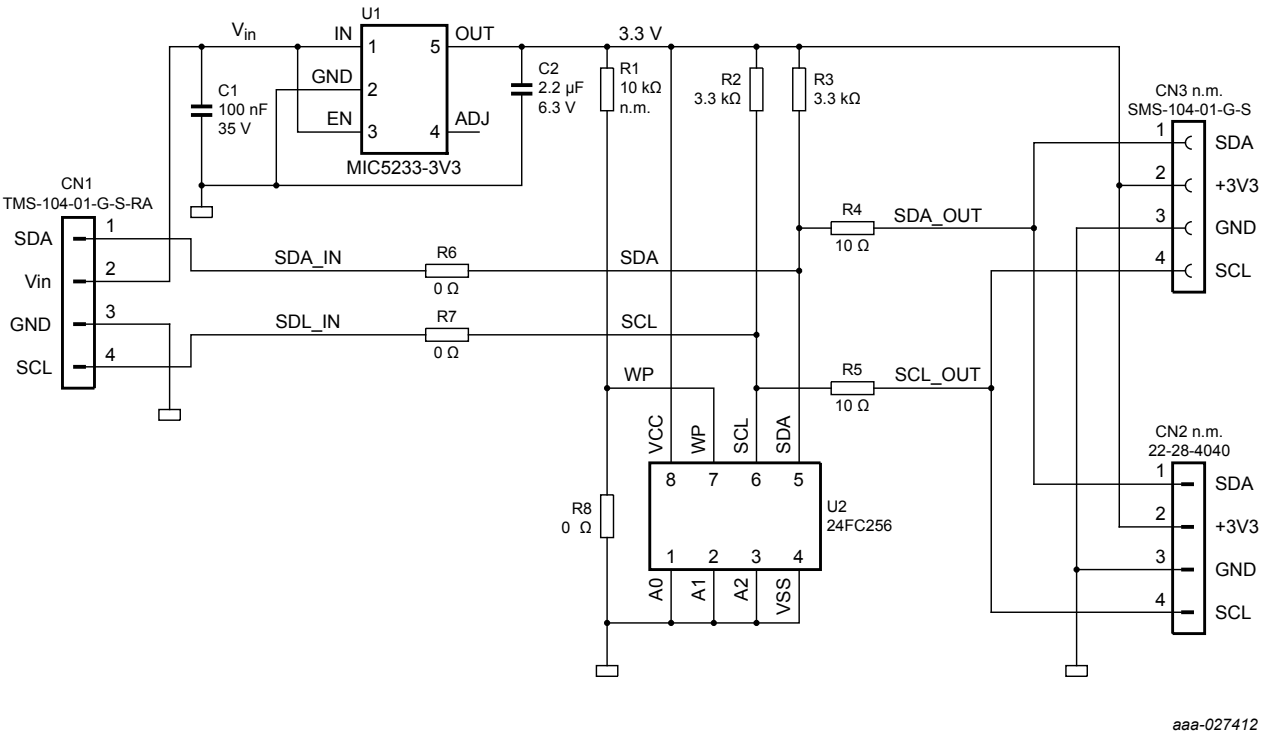


Figure 11. Optional EEPROM demo board EEPROM_DB1418 with I2C connections

9 Bill Of Materials (BOM)

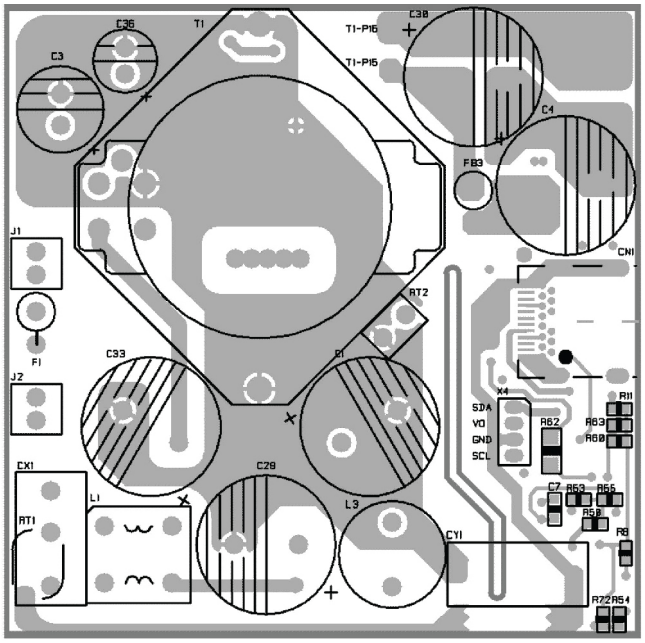
Reference	Description and values	Part Number	Manufacturer
C1	capacitor; 33 µF; 20 %; 400 V; ALU; D10xL20mm	EKM336M2GG20RR	SAMXON
C3	capacitor; 10 µF; 20 %; 100 V; ALU; THT	100YXJ10M5X11	Rubycon
C4	capacitor; 560 µF; 20 %; 25 V; ALU; THT	A750MS567M1EAAE015	KEMET
C5	capacitor; 100 nF; 10 %; 50 V; X7R; 0402	C1005X7R1H104K050BB	TDK
C6; C7	capacitor; 4.7 µF; 10 %; 25 V; X5R; 0603	C1608X5R1E475K080AC	TDK
C10	capacitor; 1 µF; 10 %; 25 V; X7R; 0603	-	-
C12	capacitor; 2.2 nF; 10 %; 630 V; X7R; 1206	C1206C222KBRAC	KEMET
C14; C17	capacitor; 1 nF; 10 %; 50 V; X7R; 0603	-	-
C15	capacitor; 470 nF; 10 %; 50 V; X7R; 0603	C1608X7R1H474K	TDK
C19	capacitor; 22 pF; 5 %; 50 V; C0G; 0603	-	-
C20	capacitor; 470 pF; 10 %; 100 V; X7R; 0603	-	-
C29; C33	capacitor; 33 µF; 20 %; 400 V; ALU; D10xL20mm	EKM336M2GG20RR	SAMXON
C30	capacitor; 560 µF; 20 %; 25 V; ALU; THT	A750MS567M1EAAE015	KEMET
C36	capacitor; 10 µF; 20 %; 35 V; ALU; THT	UVR1V100MDD6TP	Nichicon
C38	capacitor; 3.3 nF; 10 %; 50 V; X7R; 0402	-	-
C40	capacitor; 100 nF; 10 %; 50 V; X7R; 0603	-	-
C41	capacitor; 10 µF; 10 %; 25 V; X5R; 0603	C1608X5R1E106M080AC	TDK
CN1	USB 3.1 type-C receptacle THT/SM	632723100011	Würth Elektronik
CX1	capacitor; 100 nF; 20 %; 630 V; PP; X2	BFC233920104	Vishay
CY1	capacitor; 220 pF; 10 %; 250 V (AC); B; THT; X1/Y2	DE2B3KY221KA2BM01F	Murata
D1	diode; TVS; unidirectional; 24 V; 400 W	PTVS24VS1UR	NXP Semiconductors
D2	diode; ESD protection; 24 V; 3 A	PESD24VS2UT	NXP Semiconductors
D3	diode; 1 kV; 2 A	S2M	Fairchild
D4	diode; 1 kV; 1 A	S1ML	Taiwan Semiconductor
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; 3 A	AS3PM-M3/86A	Vishay
D25	diode; ESD protection; 30 kV; 3 A	PESD5V2S2UT	NXP Semiconductors
F1	fuse, PCB; leaded; slow blow; 3 A; 250 V (AC); axial-leaded	MCPMP3A250V	Multicomp
FB2	fbead; 0.009 Ω; 6 A; 0805	BLM21PG220SH1D	Murata
FB3	fbead; K5B RH 3.5 × 4.5 × 0.8	K5B RH 3.5 x 4.5 x 0.8 - T52	King Core Electronics Inc.
L1	inductor CM; 2 × 1.6 mH; bifilar windings	T10x6x4 T38 Epcos	NXP Semiconductors
L3	inductor; 120 µH; 850 mA; 0.22 Ω	744772121	Würth Elektronik

Reference	Description and values	Part Number	Manufacturer
Q1	MOSFET-N; 800 V; 0.28 Ω; 17 A	IPD80R280P7ATMA1	Infineon
Q2	MOSFET-N; 100 V; 90 A; 0.006 Ω; TDSON	BSC060N10NS3GATMA1	Infineon
Q3	MOSFET-N; 30 V; 2.4 mΩ; 70 A	PSMN2R4-30MLD	NXP Semiconductors
R5	resistor; 10 Ω; 1 %; 63 mW; 0603	-	-
R7	resistor; 100 kΩ; 1 %; 660 mW; 1206	ERJP08F1003V	Panasonic
R8	resistor; 5.1 kΩ; 1 %; 63 mW; 0402	-	-
R9; R21	resistor; 1 kΩ; 1 %; 63 mW; 0402	-	-
R11	resistor; 330 Ω; 1 %; 63 mW; 0402	-	-
R13	resistor; jumper; 0 Ω; 250 mW; 1206	-	-
R14	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; R19	resistor; 0.33 Ω; 1 %; 250 mW; 0805	ERJS6QFR33V	Panasonic
R22	resistor; 5.6 kΩ; 1 %; 63 mW; 0603	-	-
R24	resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206	ERJP08F8452V	Panasonic
R25	resistor; 120 kΩ; 1 %; 660 mW; 500 V; 1206	ERJP08F1203V	Panasonic
R31	resistor; 0.011 Ω; 1 %; 1 W; 1206	ERJ8CWFR011V	Panasonic
R39	resistor; 1 MΩ; 1 %; 63 mW; 0402	CRCW04021M00FKED	Vishay
R50	resistor; 120 Ω; 1 %; 100 mW; 0402	ERJ2RKF1200X	Panasonic
R53	resistor; 178 kΩ; 1 %; 63 mW; 0402	-	-
R54	resistor; 24.3 kΩ; 1 %; 63 mW; 0402	-	-
R55	resistor; 150 Ω; 1 %; 100 mW; 0402	ERJ2RKF1500X	Panasonic
R60	resistor; 3.3 kΩ; 1 %; 63 mW; 0603	-	-
R61	resistor; 10 Ω; 1 %; 100 mW; 0402	ERJ2RKF10R0X	Panasonic
R62	resistor; 100 Ω; 1 %; 500 mW; 0805	ERJP6WF1000V	Panasonic
R64	resistor; 84.5 kΩ; 1 %; 660 mW; 500 V; 1206	ERJP08F8452V	Panasonic
R69; R70	resistor; 10 Ω; 1 %; 100 mW; 0402	ERJ2RKF10R0X	Panasonic
R71	resistor; jumper; 0 Ω; 100 mW; 0402	ERJ2GE0R00X	Panasonic
RT2	resistor; NTC; 100 kΩ; 5 %; 100 mW; 4190 K	NTCLE100E3104JB0	Vishay
T1	transformer; RM10; 370 µH	RM10	NXP Semiconductors
U2	synchronous rectifier controller; TEA1993	TEA1993	NXP Semiconductors
U10	SMTP controller; TEA19361	TEA19361	NXP Semiconductors
U12	TEA19032B; USB-PD controller; SO10	TEA19032B	NXP Semiconductors
U3	optocoupler; NPN; 70 V; 50 mA	TCLT1008	Vishay

Table 9. Bill of materials EEPROM_DB1418

Reference	Description and values	Part Number	Manufacturer
C1	capacitor; 100 nF; 10 %; 35 V; X7R; 0402	-	-
C2	capacitor; 2.2 µF; 20 %; 6. 3 V; X5R; 0402	GRM155R60J225ME15D	Murata
CN1	header; right angle; 1 × 4-way; 1.27 mm	TMS-104-01-G-S-RA	Samtec
CN2	header; straight; not mounted; 1 × 4-way; 2.54 mm	22-28-4040	Molex
CN3	receptacle; straight; not mounted; 1 × 4-way; 1.27 mm	SMS-104-01-G-S	Samtec
R1	resistor; not mounted; 10 kΩ; 1 %; 63 mW; 0402	CRCW040210K0FKED	Vishay
R2; R3	resistor; 3.3 kΩ; 1 %; 63 mW; 0402	CRCW04023K30FKED	Vishay
R4; R5	resistor; 10 Ω; 1 %; 200 mW; 0402	ERJ-PA2F10R0X	Panasonic
R6; R7; R8	resistor; jumper; 0 Ω; 63 mW; 0402	CRCW04020000Z0ED	Vishay
U1	LDO; 3.3 V	MIC5233-3.3YM5 TR	MICREL
U2	EEPROM; 256 K; I^2C; CMOS	24FC256-I/SN	Microchip

10 Layout



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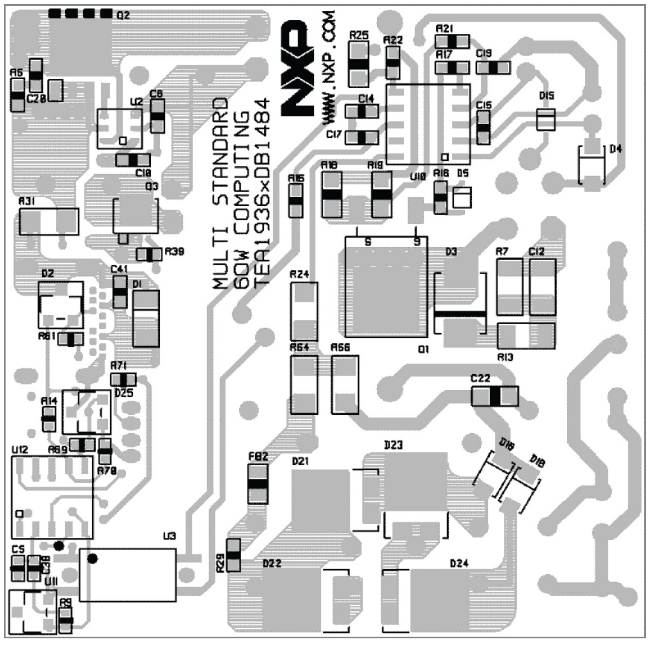
a. Top view of layout and silkscreen



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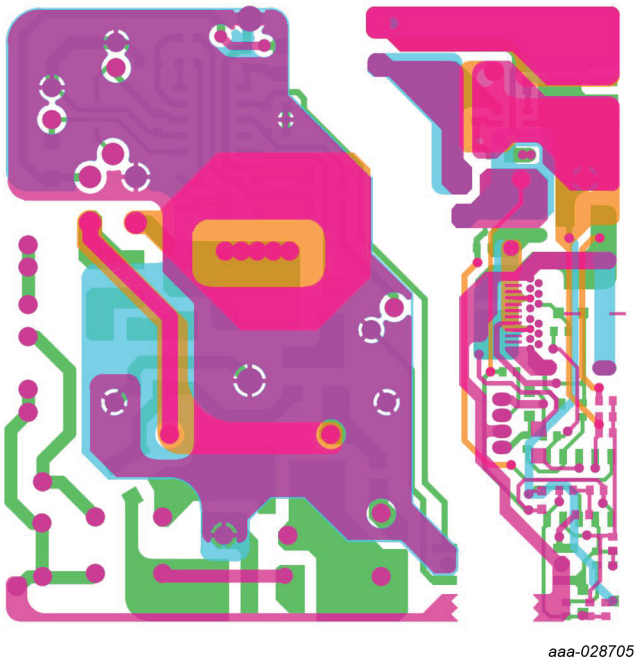
b. Bottom view of layout and silkscreen

Figure 12. TEA19363DB1484 demo board layout

To improve heat distribution and transfer across the PCB, the TEA19363DB1484 demo board is a four-layer PCB. Figure 13 shows the layers.



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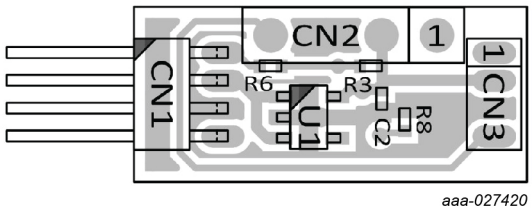
Purple: Top layer
Orange: Interconnect layer
Cyan: Interconnect layer
Green: Bottom layer

Figure 13. TEA19363DB1484 layout - all four layers



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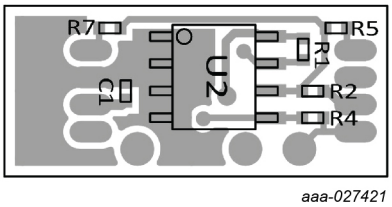
a. Top view layout and assembly



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b. Bottom view layout and assembly

Figure 14. EEPROM_DB1418 demo board layout

11 Abbreviations

Table 10. Abbreviations

Acronym	Description
MTP	Multiple Times Programmable
PD	Power Delivery
PDO	Power Data Object
TEO	TEA1905 Evaluation Overdrive
USB	Universal Serial Bus
UTC	Universal Type-C Controller

12 Legal information

12.1 Definitions

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