UM10522

TEA1721 non-isolated universal mains buck and buck/boost converter demo board

Rev. 1.1 — 19 December 2012 **User manual**

Document information

Info	Content
Keywords	TEA1721XT, non-isolated, universal mains, buck, buck/boost, AC/DC conversion, Switched Mode Power Supply (SMPS)
Abstract	This user manual describes a +12 V AC/DC buck and −12 V AC/DC non-isolated buck/boost-mode SMPS that can be used to supply up to 2.5 W into a load.

Revision history

Rev	Date	Description
v.1.1	20121219	second issue
v.1	20120308	first issue

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual describes a +12 V AC/DC buck and −12 V AC/DC non-isolated buck/boost-mode SMPS that can be used to supply up to 2.5 W into a load.

The switch mode converter operates at a maximum frequency of around 50 kHz.

Overcurrent and short-circuit protection are built in. Under no-load conditions, the power consumption of this converter is in the range of 10 mW. EMI filtering and (optional) surge voltage protection using TVS diodes is implemented in this circuit.

This application is a general purpose non-isolated SMPS.

In applications where triacs are driven in the third quadrant (such as white goods applications), the negative output voltage with respect to Neutral or Phase makes buck/boost converters particularly interesting.

The optional surge protection makes it suitable for use in environments where serious voltage transients can occur. The absolute maximum RMS mains input voltage is 280 V (AC).

1.1 Features and benefits

- Compatible with Universal Mains
- Inrush current limitation
- EMI filtering to meet EMC requirements of EN55022
- Surge input voltage protection

2. Safety Warning

The demo board is powered by AC mains voltage. Avoid touching the board when power is applied. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments.

3. Specification

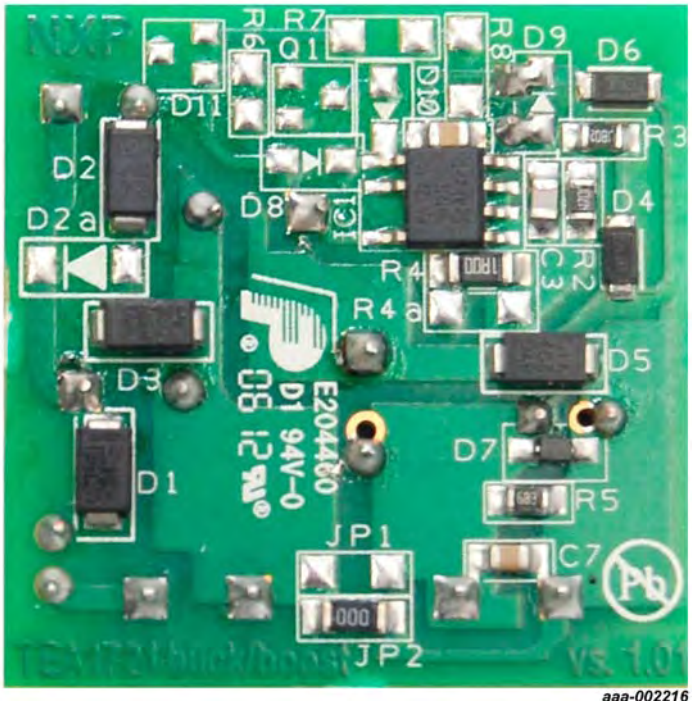
Table 1. Demo board specification

Parameter	Value	Comment
AC line input voltage	85 V (AC) to 265 V (AC)	supplied to J1.1 (phase) and J1.2 (neutral) terminals
Output voltages	buck converter mode: 12 V (DC)	supplied from connectors:
		J2.1 = 12 V
		J2.2 = 0 V[1]
	buck/boost converter mode: −12 V (DC)	supplied from connectors:
		J2.1 = 0 V
		J2.2 = −12 V[2]
Maximum output current	buck converter mode: 200 mA	-
	buck/boost converter mode: −200 mA	-
Maximum output power	2.5 W	-
Output voltage accuracy	+2 % to −5 %	-
Output voltage stability	≥ ± 1 %	in load range 10 % to 100 %
Efficiency	± 77 % at 100 % load	-
Operating temperature	−40 °C to 85 °C	-
EMC Compliance	EN 55022	-
Board dimensions	34.3 mm × 34.3 mm × 25 mm	L × B × H

[1] J2.2 is at the same potential as J1.2.

[2] J2.1 is at the same potential as J1.2.

a. Front view.



b. Back view

Fig 1. Photographs of the board

4. Demo board connections

Remark: Mount the board in a shielded or isolated box for demonstration purposes.

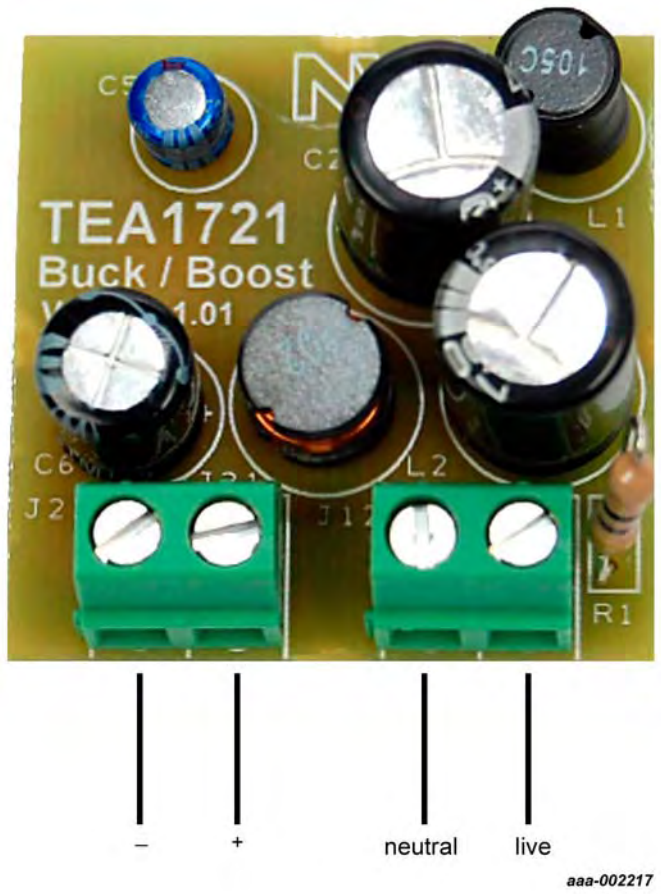


Fig 2. TEA1721XT Demo board connections

5. Operation and performance

Basic operation of the IC is described in the *TEA1721 data sheets*.

5.1 No-load power consumption

Table 2. Typical no-load power consumption

Power supply	Energy Star 2.0 requirement	No-load power consumption
115 V (AC)/60 Hz	<300 mW	± 5 mW
230 V (AC)/50 Hz	<300 mW	± 8 mW

The typical no-load power consumption of the TEA1721 universal mains buck/boost converter exceeds the Energy Star 2.0 level V requirement by approximately two orders of magnitude.

5.2 Efficiency

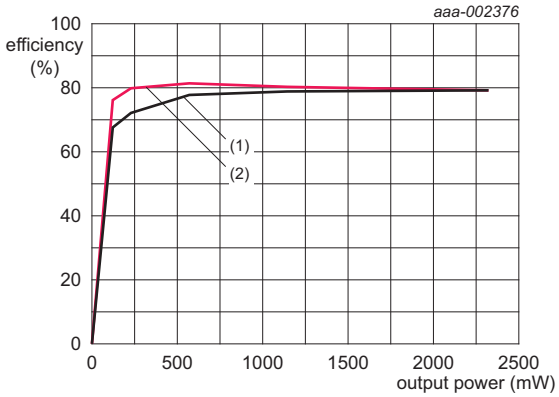
Table 3. Buck mode typical efficiency data

Parameter	Energy Star 2.0 level V (%)	Efficiency (%)				
		average	25 % load	50 % load	75 % load	100 % load
115 V (AC)/60 Hz	67.9	80	81.2	80.4	79.3	79.1
230 V (AC)/50 Hz	67.9	78.7	77.6	78.9	79	79.1

Table 4. Buck/boost mode typical efficiency data

Parameter	Energy Star 2.0 level V (%)	Efficiency (%)				
		average	25 % load	50 % load	75 % load	100 % load
115 V (AC)/60 Hz	67.9	78.2	79.5	78.7	77.6	76.8
230 V (AC)/50 Hz	67.9	77.3	76.7	78	77.1	77.5

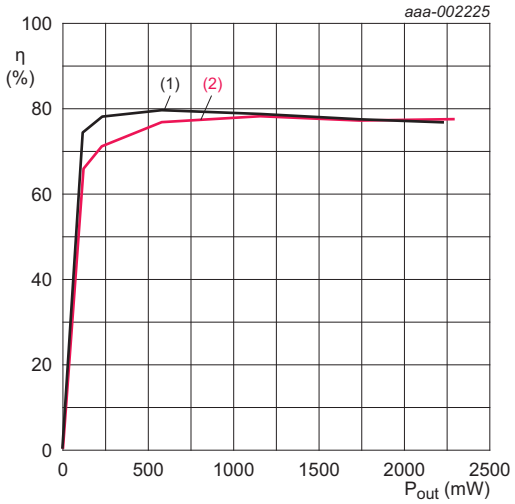
The typical efficiency of the TEA1721 universal mains buck/boost converter exceeds the Energy Star 2.0 level V requirement by approximately 10 % on average.



(1) 230 V (AC).

(2) 115 V (AC).

Fig 3. Buck mode: typical efficiency as a function of load



(1) 115 V (AC).

(2) 230 V (AC).

Fig 4. Buck/boost mode: Typical efficiency as a function of load

5.3 Output voltage stability

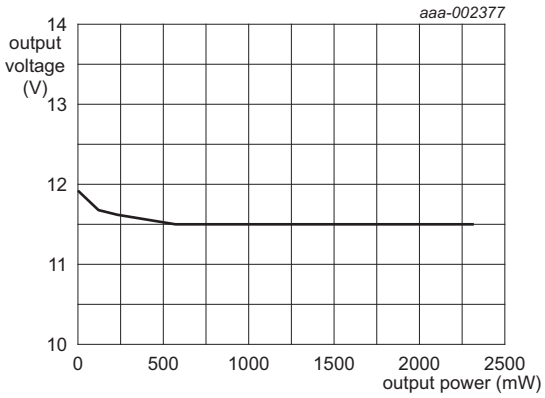
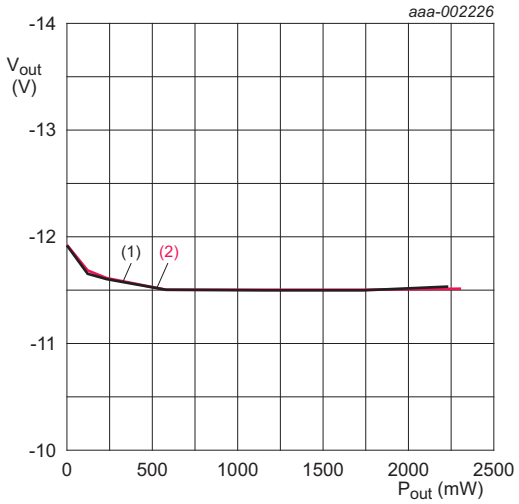


Fig 5. Buck mode: typical output voltage stability as a function of load



(1) 115 V (AC).

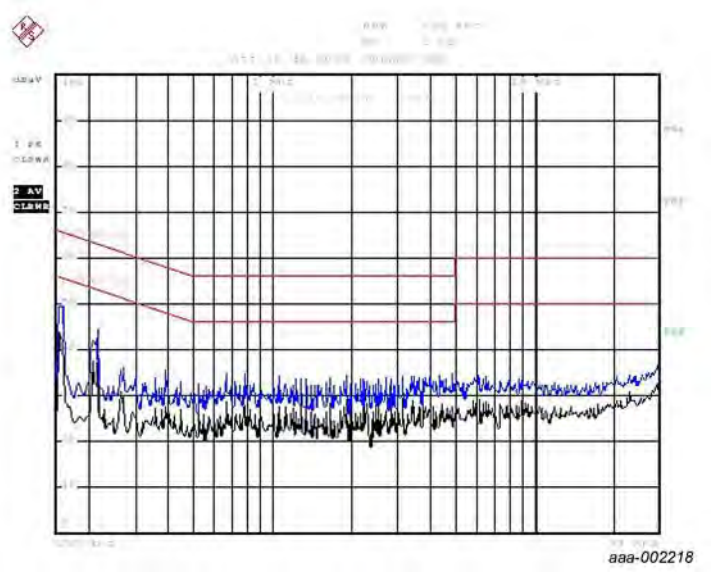
(2) 230 V (AC).

Fig 6. Buck/boost mode: Typical output voltage stability as a function of load

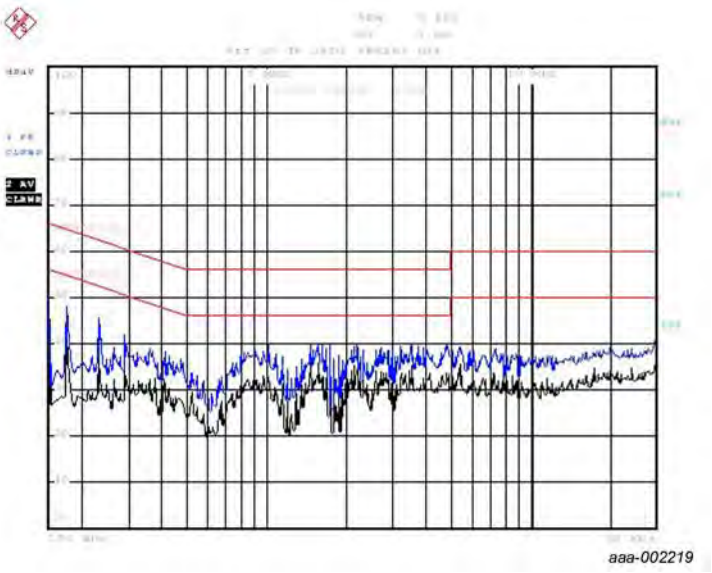
6. Test results

6.1 ElectroMagnetic Interference

The TEA1721 buck and buck/boost mode converter application meets the requirements of EN55022. There is a margin of at least 10 dB with respect to the formal limits.



a. EMI at 115 V (AC) input voltage and 2 W output at 80 % load.



b. 230 V (AC) input voltage and 2 W output at 80 % load.

Fig 7. Typical EMI patterns measured at 2 W load

7. Demo board schematic

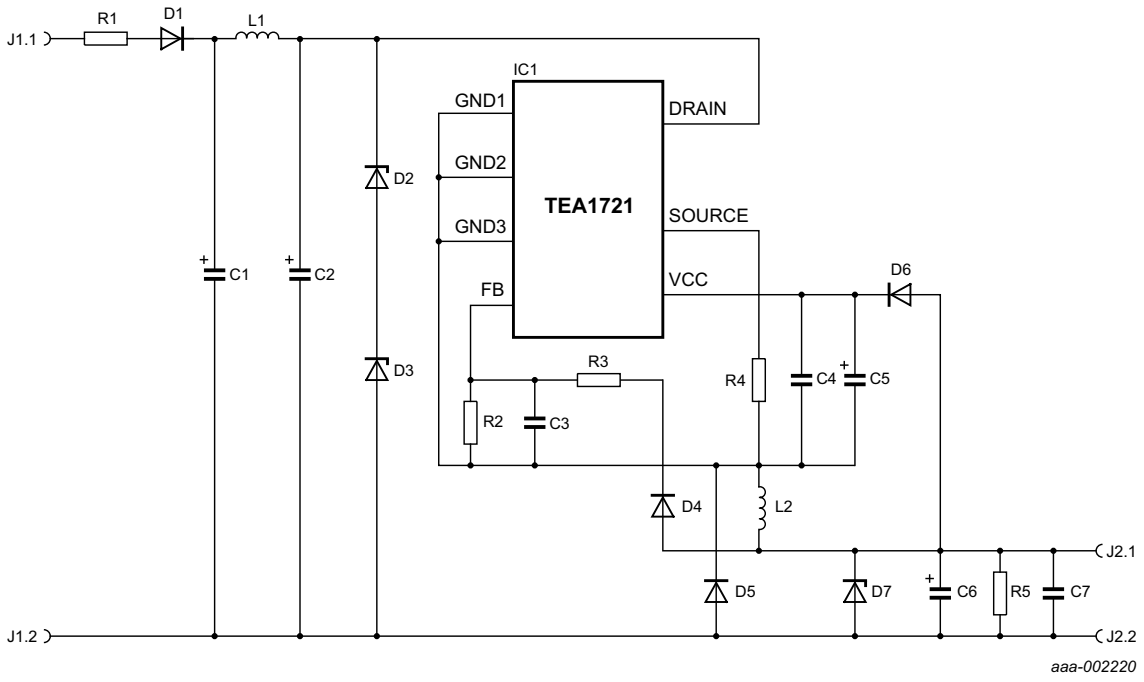


Fig 8. TEA1721 buck converter SMPS circuit diagram

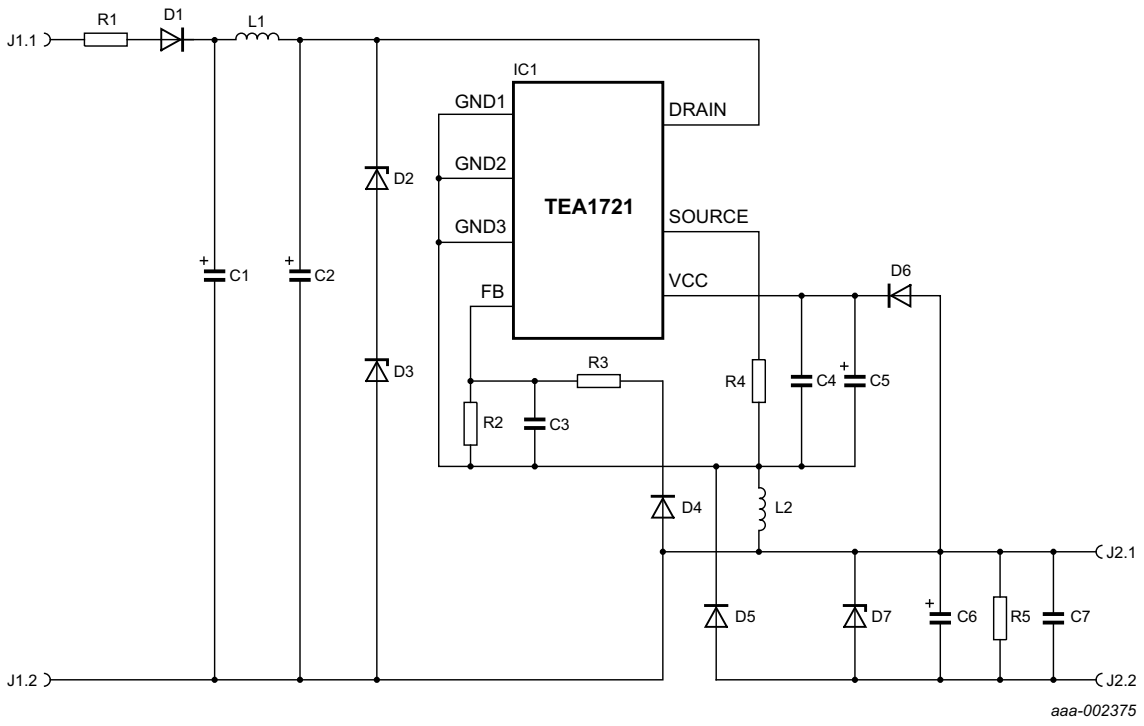


Fig 9. TEA1721 buck/boost converter SMPS circuit diagram

8. PCB components

Table 5. Demo board components

Reference	Description and value	Part number	Manufacturer
C1	electrolytic capacitor; 4.7 μF; 400 V	-	-
C2	electrolytic capacitor; 4.7 μF; 400 V	-	-
C3	capacitor; 10 pF; 25 V	-	-
C4	capacitor; 100 nF; 50 V	-	-
C5	electrolytic capacitor; 10 μF; 35 V	-	-
C6	electrolytic capacitor; 470 μF; 16 V	-	-
C7	capacitor; 100 nF; 50 V	-	-
D1	diode; S1M; SMA	-	-
D2	diode; BZG03-C200; optional see text; SMA	BZG03-C200	-
D3	diode; BZG03-C200; optional see text; SMA	BZG03-C200	-
D4	diode; ES1JL; SMF	-	-
D5	diode; BYG20J; SMA	BYG20J	-
D6	diode; ES1JL; SMF	-	-
D7	diode; BZX384-B12; SOD323	BZX384-B12	NXP Semiconductors
IC1	TEA1721; SO7	-	NXP Semiconductors
JP1	jumper; 0 Ω; must be installed for buck/boost mode operation	-	-
JP2	jumper; 0 Ω installed; must be installed for buck mode only operation	-	-
L1	1 mH; 80 mA	-	-
L2	1 mH; 250 mA (RMS); I_{sat} = 500 mA	-	-
R1	carbon resistor; 47 Ω	-	-
R2	resistor; 4.7 kΩ; 1 %	-	-
R3	resistor; 18 kΩ; 1 %[1]	-	-
R4	resistor; 1 Ω; 0.25 W	-	-
R5	resistor; 68 kΩ	-	-

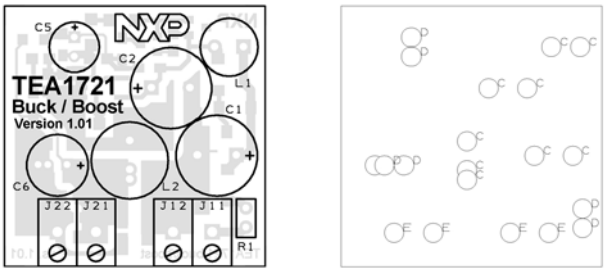
[1] To set the output voltage with greater accuracy, fine-tuning is required.

9. Implementation guidelines

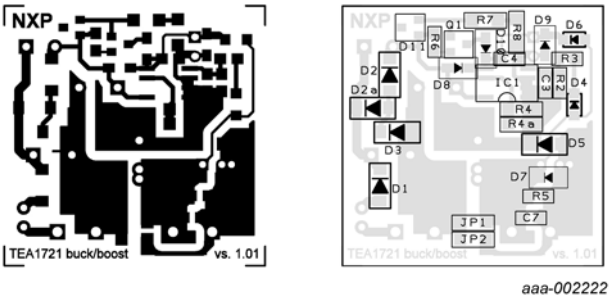
- The output voltage is adjusted using resistors R2 and R3. In Buck mode, the converter can be used to generate an output voltage between +12 V (DC) and +32 V (DC). In buck/boost mode, the output voltage is between −12 V (DC) and −32 V (DC).
- The maximum output power and output current levels are adjusted using resistor R4. The maximum current allowed in the TEA1721 IC switching MOSFET is 700 mA. Take care that under no circumstance, the peak current in inductor L2 exceeds 700 mA.
- Resistor R1 limits the inrush current. The resistor must be a carbon resistor because metal film resistors can act as a fuse in this position. If no inrush current limiting is required, the resistor can be replaced with a short-circuit.
- EMI filtering is implemented using a single differential stage (C1-L1-C2). Mount additional film capacitors in parallel with C1 and C2 for improved HF noise suppression.
- Surge voltage protection is implemented using TVS diodes D2 and D3. The surge protection limits the DC bus voltage to 400 V maximum. The TVS diodes choice determines the maximum allowable surge pulse energy. The surge protection feature is optional. When not needed diodes D2 and D3 can be eliminated
- To cope with negative voltage surge pulses, diode D1 must be capable of handling a certain amount of avalanche surge energy. The presence of resistor R1 helps to limit any avalanche surge current in diode D1.
- Capacitors C4 and C5 can be replaced with a single (SMD) 2.2 μF ceramic capacitor with the appropriate voltage rating. Though more expensive, it needs less board space.
- Resistor R5 forms a small pre-load for the converter. When the output voltages are adjusted, also adjust the pre-load resistors to ensure that they consume roughly the same amount of power. Depending on the connected load, the pre-load resistor can be eliminated.
- Zener diode D7 is an elementary output OverVoltage Protection (OVP). When OVP is not needed, eliminate the diode.
- Capacitor C7 is used to obtain additional (HF) voltage stability and noise suppression. Eliminate the capacitor when the feature is not needed.

10. Board layout

The 34.3 mm × 34.3 mm evaluation PCB accommodates either a TEA1721 buck or buck/boost mode application implementation. This board can be used for the particular application shown in the circuit diagram and the associated component list.



a. Top silk screen plus top component placement and drill pattern



b. Bottom copper and bottom silk screen plus component placement

Fig 10. PCB layout

The bottom silk screen is normally not used in PCB production. Merged with the bottom copper, it is shown here as a component placement reference only. Populate all component positions in this application. See Table 5 for a list of components.

Table 6. Drill tool table

Drill tool code	Drill diameter
C	1 mm
D	0.9 mm
E	1.3 mm

11. References

[1] **TEA1721XT -** Ultra-low standby SMPS controller with integrated power switch

[2] **AN11060 -** TEA172X 5 W to 11 W power supply/USB charger

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Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А