UM10526

TEA1792TS GreenChip synchronous rectifier controller add-on board

Rev. 1 — 26 June 2012 **User manual**

Document information

Info	Content
Keywords	TEA1792TS, Synchronous Rectifier (SR) driver, high efficiency, TSOP6, flyback converter, TEA1792DB1074 add-on board
Abstract	This user manual describes how the TEA1792TS add-on board can be used in a flyback converter. The add-on board contains a TEA1792TS SR controller in TSOP-6 package. Besides the add-on board also contains a power MOSFET, as well as a charge pump circuit to generate the supply voltage for the SR controller. The add-on board replaces the rectifier diode at the secondary side of the flyback converter. It is intended for high-side applications, but with minor modifications it can also be used for low-side applications.

Revision history

Rev	Date	Description
v.1	20120626	first issue

Contact information

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1. Introduction

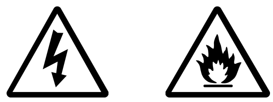
This document describes the TEA1792TS add-on board. A functional description and a set of measurements illustrate the performance of the TEA1792TS add-on board. The add-on board also contains a charge pump circuit, capable of delivering the supply voltage for the SR controller. The charge pump circuit eliminates the auxiliary transformer winding in the flyback convertor.

A flyback converter board in which the secondary part (diode) can be replaced by the add-on board is required to use the add-on board correctly.

2. Safety Warning

WARNING

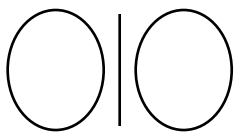
Lethal voltage and fire ignition hazard



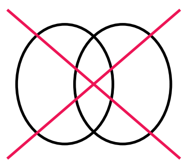
The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

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.

The complete add-on board application is AC mains voltage powered. Avoid touching the board when power is applied. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Always provide galvanic isolation of the mains phase using a variable transformer. The following symbols identify isolated and non-isolated devices.



a. Isolated.



b. Non-isolated

Fig 1. Isolated and non-isolated symbols

3. TEA1792TS SR controller

The TEA1792TS is a member of the new generation of Synchronous Rectifier (SR) controller ICs for switched mode power supplies. Its high level of integration allows the design of a cost-effective power supply with a very low number of external components. The IC provides synchronous rectification on the secondary side for discontinuous conduction mode and quasi-resonant mode flyback converters.

It is a successor to the TEA1791T synchronous rectifier controller IC. The TEA1792TS provides improved performance, a smaller package option (TSOP6) and two different selectable regulation levels.

An efficient control algorithm built into the IC determines when a MOSFET is switched on or off. After a negative voltage lower than $V_{act(drv)}$ (–220 mV typical) is sensed on the SRSENSE pin, the driver output voltage is driven HIGH. Then the external MOSFET is switched on. When $V_{SRSENSE}$ rises to $V_{reg(drv)}$ (–42 mV/–30 mV), the driver output voltage is regulated to maintain the $V_{reg(drv)}$ on the SRSENSE pin. When the SRSENSE voltage is above the $V_{deact(drv)}$ level (–12 mV typical), the driver output is pulled to ground.

After switch-on of the SR MOSFET, the input signal on the SRSENSE pin is blanked during the $t_{act(sr)(min)}$ (1.8 μs typical). This action eliminates false switch-off due to high frequency ringing at the start of the secondary stroke.

When the secondary current is reduced until the SRSENSE voltage is V_{ref}, the internal control loop maintains the $V_{reg(drv)}$ level across the MOSFET. Maintaining $V_{reg(drv)}$ in this instance is achieved when the V_{DRIVER} voltage is decreased. This reduction enables the external power switch to be switched off quickly when the current through the switch reaches zero. The zero current is detected by sensing a $V_{deact(drv)}$ (–12 mV typical) level on the SRSENSE pin.

The TEA1792TS stops performing synchronous rectification for short pulses which removes the need for a separate Standby mode to maintain high efficiency at low-loads.

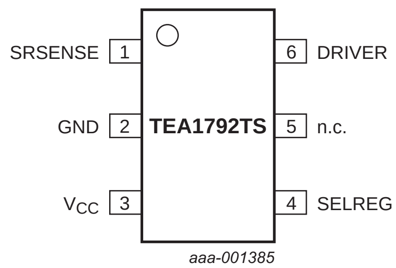


Fig 2. Pin configuration TEA1792TS (TSOP6)

4. General application of the TEA1792TS

General application diagrams of high-side and low-side rectification are given in Figure 3 and Figure 4. See Figure 2 for the relevant pin numbers.

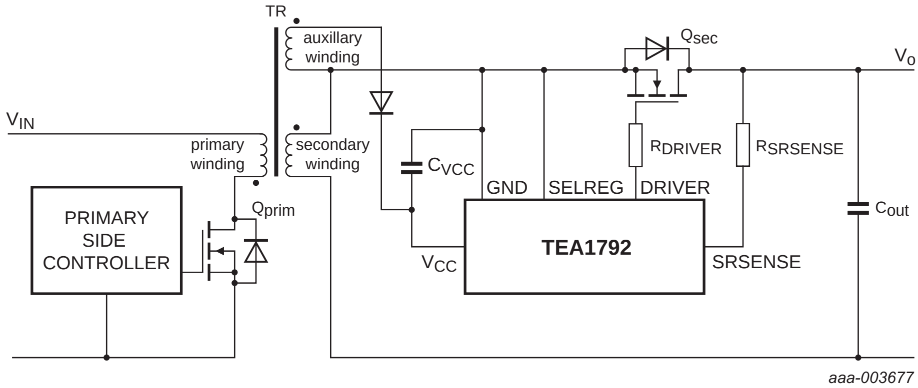


Fig 3. Application diagram for high-side rectification

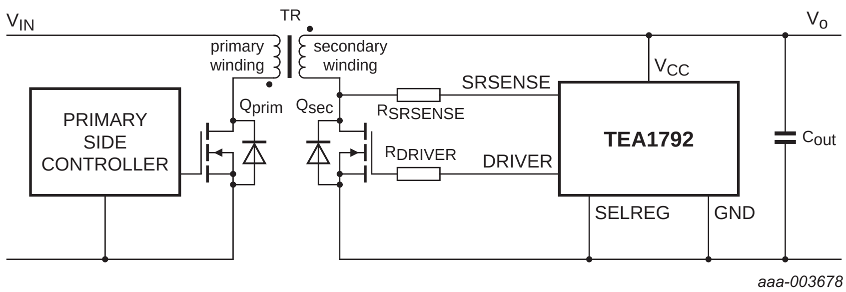


Fig 4. Application diagram for low-side rectification

In high-side rectification (Figure 3), the supply voltage for the TEA1792TS is normally derived from an auxiliary winding on the transformer secondary side.

In low-side rectification (Figure 4), the output voltage V_{OUT} is used in most cases as the TEA1792TS supply.

High-side rectification is the preferred application for the best EMI performance.

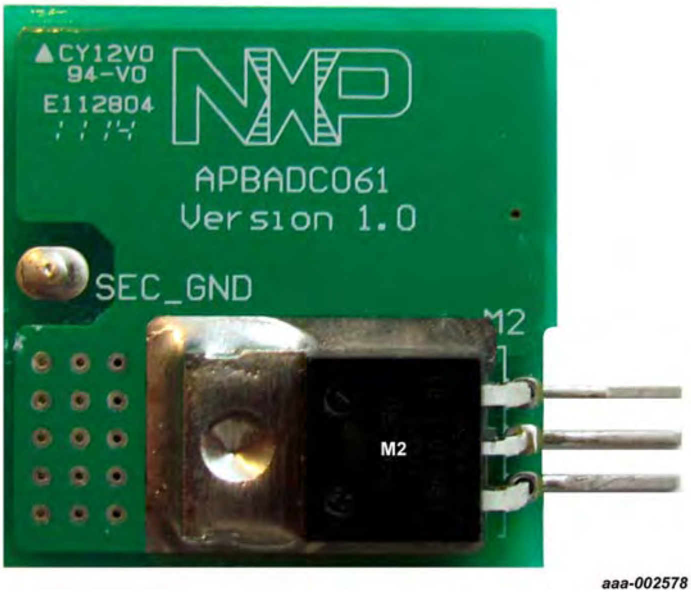
4.1 Add-on board set-up

The add-on board is designed for incorporation into existing flyback power supplies by replacing the secondary rectifier diode. Although the add-on board was designed for high-side rectifier applications, it is also possible to replace the rectifier diode in low-side applications.

The add-on board consists of:

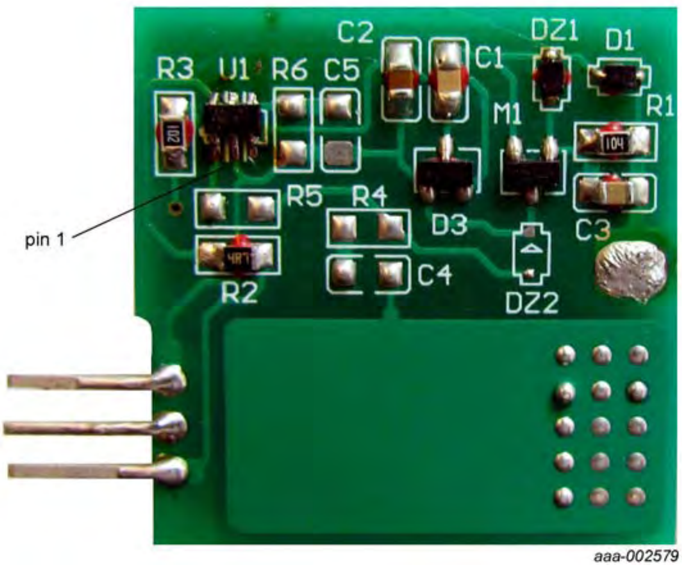
- the TEA1792TS in TSOP-6 package
- a MOSFET with a typical R_{ON} of 7 mΩ
- a charge pump circuit capable of delivering the SR controller supply voltage

Figure 5 shows the top and bottom views of the add-on board. Only the MOSFET is soldered to the front side of the add-on board. The MOSFET DRAIN (middle pin) is soldered to the large copper plane. The plane is connected via 15 interconnects to the back side of the add-on board. All the other SMD components are mounted on the back side.



M2 = PSMN7R0-100PS (see Table 5).

a. Top view.



U1 = TEA1792TS (see Table 5).

b. Bottom view.

Fig 5. TEA1792DB1074 add-on board photographs

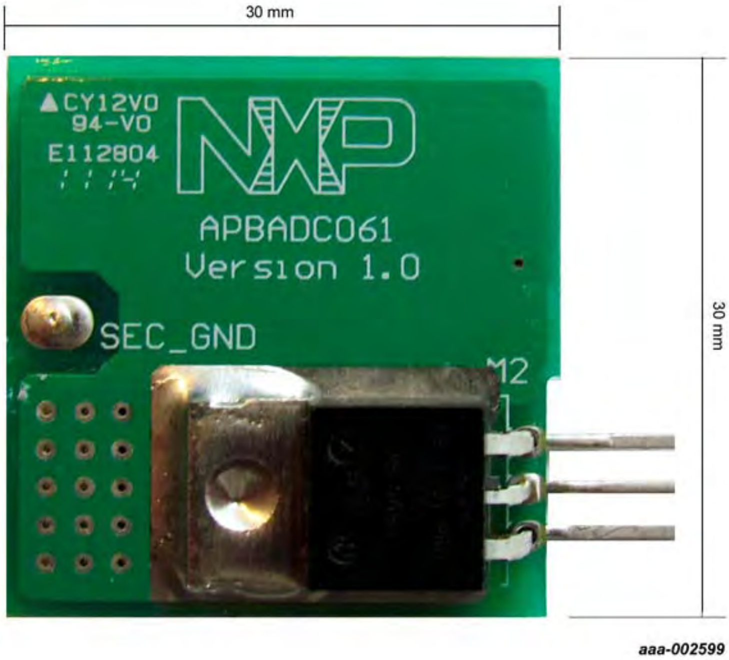
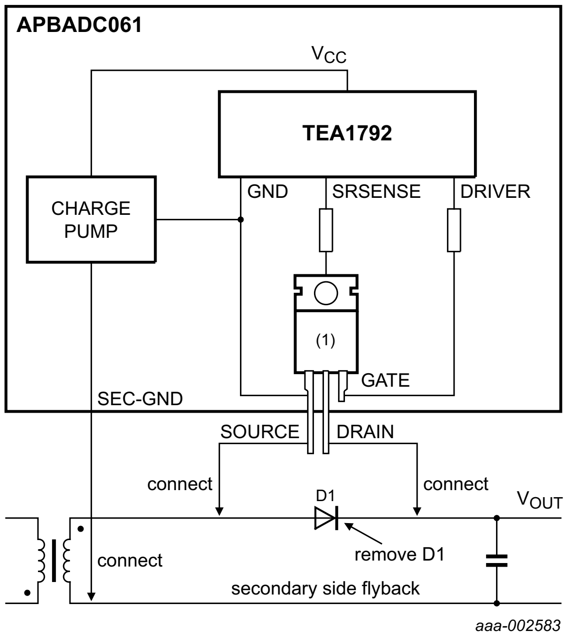


Fig 6. Add-on board dimensions

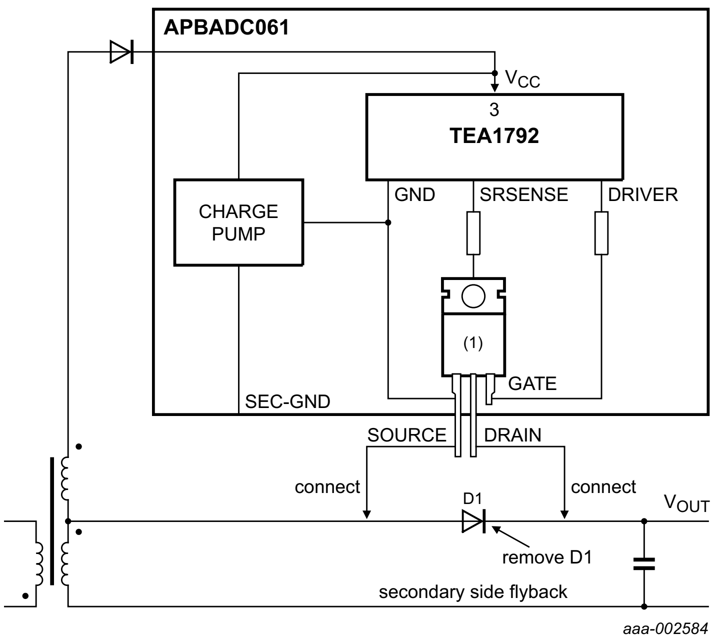
4.2 Connecting the TEA1792DB1074 add-on board

The add-on board replaces the existing rectifier diode at the secondary side of the flyback supply in high-side and low-side applications.

In Figure 7, the internal and external supply options for high-side applications are shown. Figure 8 shows the possibilities for low-side applications.



a. Internal charge pump supply



(1) PSMN7R0-100PS (see Table 5).

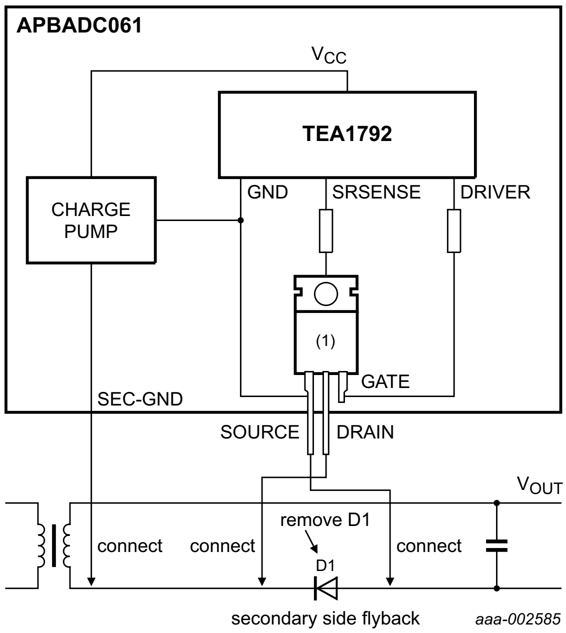
b. External auxiliary supply

Fig 7. TEA1792DB1074 add-on board high-side connections

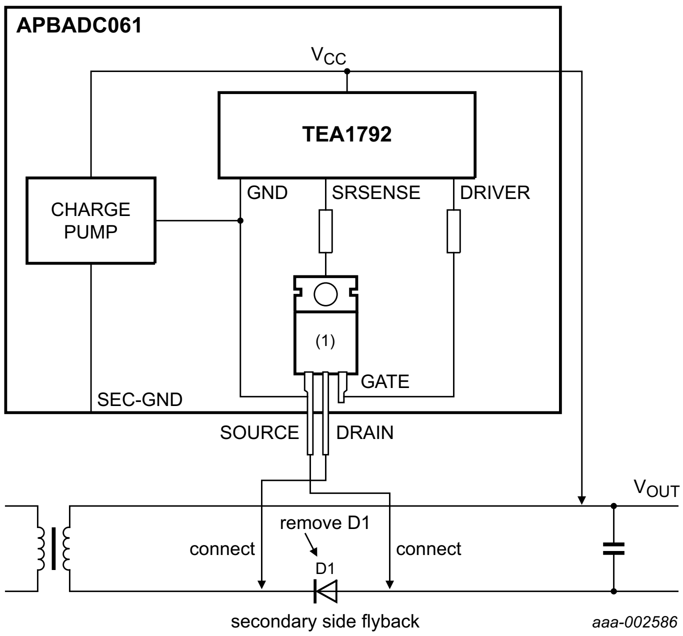
Figure 7(a) shows the connections to be made when the internal charge pump supply is used. This charge pump generates a V_{CC} supply with a value of V_{OUT} –2 V. The TEA1792TS supply must be between 8.5 V and 38 V (see Ref. 1). The V_{OUT} voltage must be between 10.5 V to 40 V. A flyback adapter output voltage is normally within this range.

When there is an auxiliary voltage available in the flyback adapter application, it can be used to supply the TEA1792TS V_{CC}. See Figure 7(b).

In both situations, the MOSFET SOURCE and DRAIN leads are inserted and soldered at the removed diode D1 anode and cathode connections.



a. Internal charge pump supply.



(1) PSMN7R0-100PS (see Table 5).

b. V_{OUT} supply.

Fig 8. TEA1792DB1074 add-on board low-side connections

In low-side applications, the board is easily connected. Using either the internal charge pump supply or with V_{OUT} as the supply. The required connections are shown in Figure 8.

Figure 9 shows an example of the add-on board TEA1792DB1074 used in a typical 90 W flyback adapter.

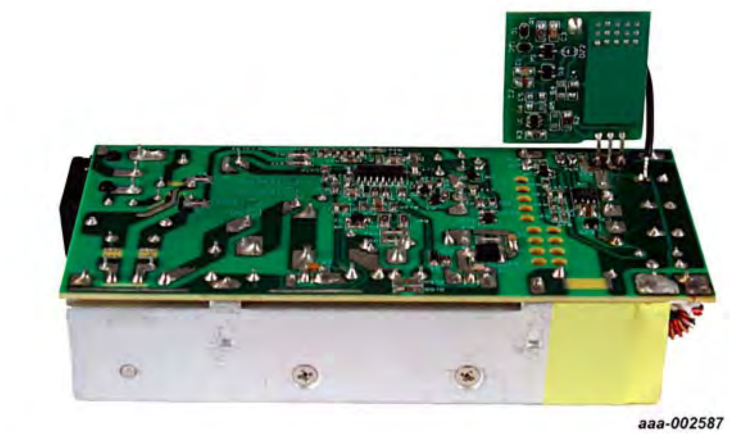


Fig 9. Example of add-on board TEA1792DB1074 connected to the APBADC031 TEA1752 90 W flyback adapter

5. Measurements

5.1 Introduction

The performance has been measured on mainboard TEA1752 90 W flyback and PFC (see Ref. 3) with the add-on module TEA1792DB1074 connected for the high-side SR.

5.1.1 Test equipment and conditions

The following test equipment is used:

- AC source: Agilent 6812B
- Power meter: Yokogawa WT210 with harmonics option
- DC electronic load: Chroma, Model 63103
- Digital oscilloscope: Yokogawa DL1640L
- Current probe Yokogawa 701933 30 A; 50 MHz
- 100 MHz, high-voltage differential probe: Yokogawa 700924
- 500 MHz, low voltage differential probe: Yokogawa 701920
- Multimeter: Keithley 2000
- ElectroMagnetic Compatibility (EMC) receiver: Rohde & Schwarz ESPI-3 + Line Impedance Standardization Network (LISN) ENV216

The board was tested under the following conditions:

- Adapter on the lab-table with heat sinks facing downwards
- The adapter has no casing
- Ambient temperature between 20 °C and 25 °C
- Measurements were made after stabilization of temperature according to "test method for calculating the efficiency of single-voltage external AC-to-DC and AC-to-AC power supplies" of ENERGY STAR

5.2 Efficiency

Test conditions:

The adapter is set to maximum load and preheated until temperature stabilization is achieved. Temperature stabilization is established for every load step before recording any measurements.

Remark: The output voltage is measured at the end of the output cable (2×20 mΩ).

The arithmetic average of the four efficiency measurements must be ≥ 87 % for adapters, to comply with ENERGY STAR EPS2.0.

Universal mains adapters must pass the criteria at both 115 V; 60 Hz and 230 V; 50 Hz. To meet this criteria, the PFC must be off at 25 % load and preferably on at 50 % load. The performance was measured with and without SR (so diode ISO MOSFET).

Table 1. TEA1792TS efficiency at 115 V; 60 Hz

Load (%)	P_{IN} (W)	V_{OUT} (V)	I_o (A)	η (%)
25	24.78	19.335	1.165	90.90
50	49.09	19.304	2.3103	90.85
75	73.57	19.273	3.4722	90.96
100	98.57	19.25	4.6281	90.38

Table 2. TEA1792TS efficiency at 230 V; 50 Hz

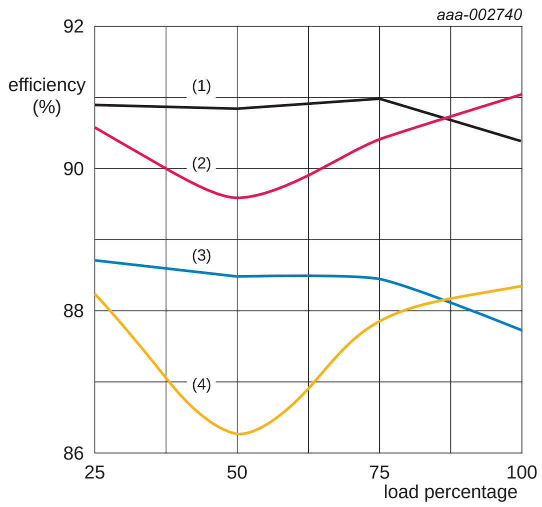
Load (%)	P_{IN} (W)	V_{OUT} (V)	I_o (A)	η (%)
25	24.88	19.343	1.165	90.57
50	49.77	19.304	2.3103	89.61
75	74.11	19.296	3.4722	90.41
100	98.02	19.281	4.6281	91.04

Table 3. Efficiency using STPS20M100S Schottky diode at 115 V; 60 Hz

Load (%)	P_{IN} (W)	V_{OUT} (V)	I_o (A)	η (%)
25	25.29	19.288	1.1634	88.73
50	50.24	19.257	2.3091	88.50
75	75.52	19.242	3.4709	88.44
100	101.33	19.218	4.6262	87.74

Table 4. Efficiency using STPS20M100S Schottky diode at 230 V; 50 Hz

Load (%)	P_{IN} (W)	V_{OUT} (V)	I_o (A)	η (%)
25	25.43	19.288	1.1634	88.24
50	51.56	19.265	2.3091	86.27
75	76.01	19.242	3.4709	87.87
100	100.63	19.218	4.6281	88.35



(1) TEA1792TS SR at 115 V; 60 Hz

(2) TEA1792TS SR at 230 V; 50 Hz

(3) STPS20M100S Schottky diode at 115 V; 60 Hz

(4) STPS20M100S Schottky diode at 230 V; 50 Hz

Fig 10. Efficiency as a function of percentage load

5.3 Operational Behavior

Figure 11[a] and Figure 11[b] show oscilloscope traces with the typical waveforms. The waveforms were measured when the TEA1792DB1074 SR demo board was connected to the 90 W TEA1752 adapter board as a high-side application. The two waveforms represent the gate drive voltage (purple) TEA1792TS SR controller DRIVER pin and the secondary output current (green). The output current was measured using a voltage probe directly connected over a 100 mΩ resistor in series with the secondary side ground track.

Figure 11[a] shows the waveforms for a 4 A load with the SELREG pin open. This configuration sets the regulation level at –30 mV.

Figure 11[b] shows the waveforms for a 4 A load with the SELREG pin connected to ground. This configuration sets the regulation level to –42 mV)

a. 4 A load, SELREG pin open, regulation level −30 mV.

(1) Purple: gate drive current.

(2) Green: secondary output current.

b. 4 A load, SELREG pin connected to ground, regulation level −42 mV.

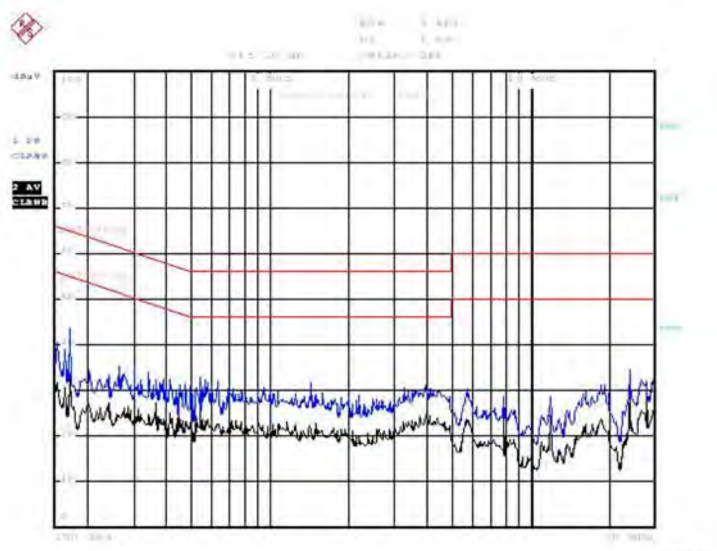
Fig 11. TEA1792DB1074 SR and 90 W TEA1752 as a high-side application

5.4 Conducted EMI Tests

Test conditions:

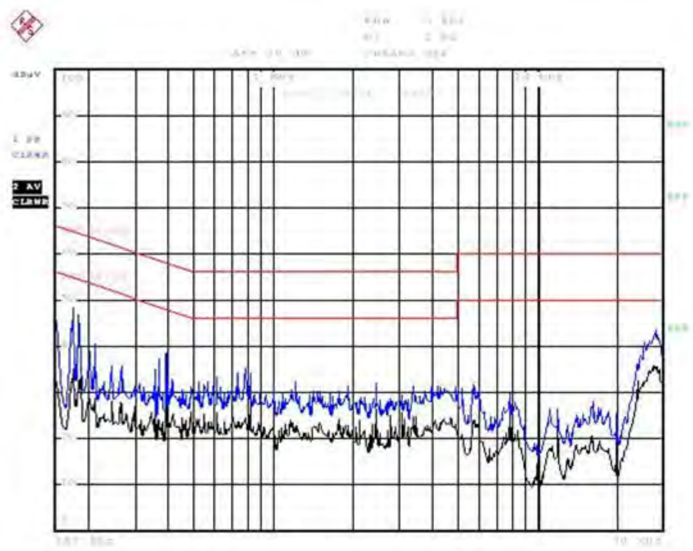
- The adapter is subjected to maximum load
- The ground connection of the output cable is connected to EMC ground
- The gate-drive resistor (R2)value = 0 Ω

Pass criteria: CISPR22 Class-B



Remark: The conducted EMI measurement result for 115 V neutral is comparable to the 115 V line.

Fig 12. Conducted EMI at 115 V (AC) line



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Remark: The conducted EMI measurement result for 230 V neutral is comparable to the 230 V line.

Fig 13. Conducted EMI at 230 V (AC) line

6. Schematic and Bill Of Materials (BOM)

The components used are shown in Figure 14.

Table 5 describes the components required for the add-on board application.

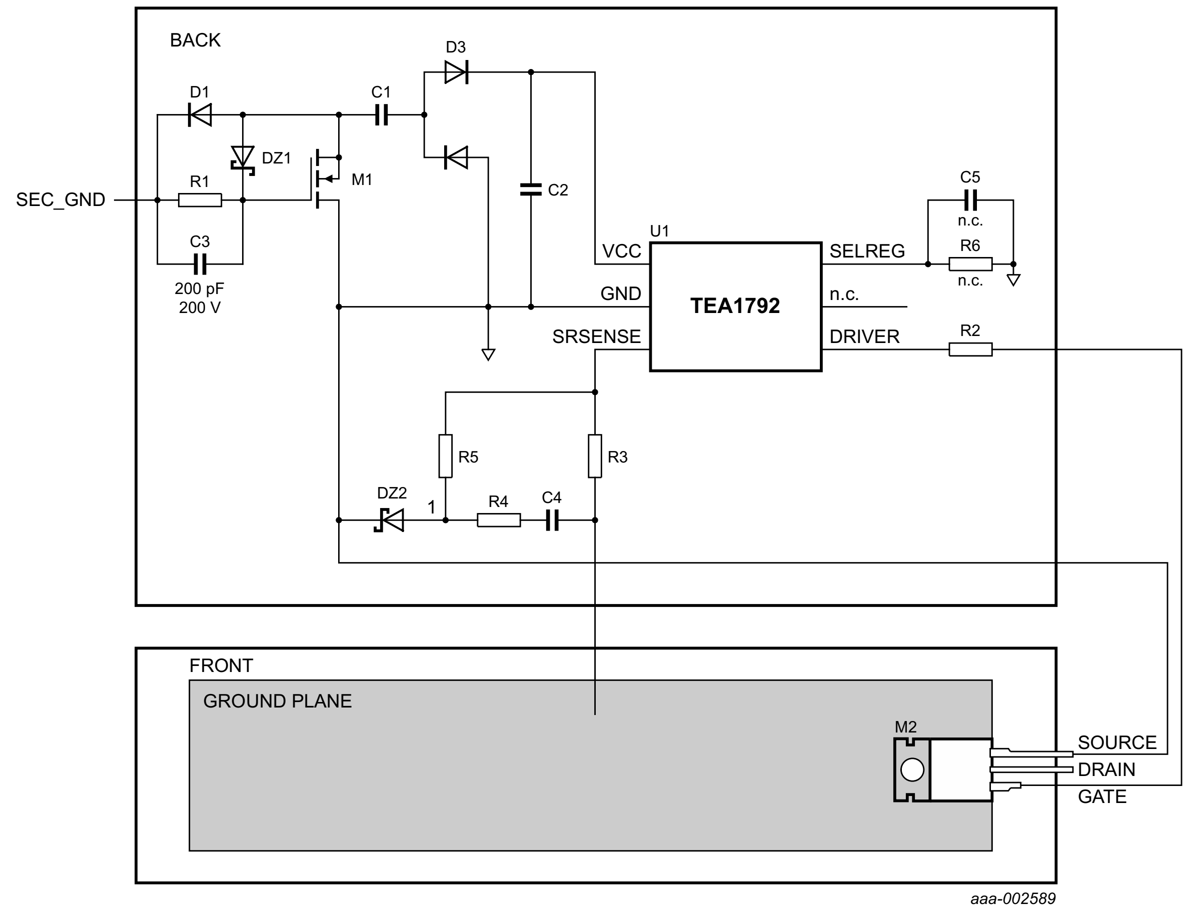

Fig 14. Schematic diagram SR add-on board TEA1792DB1074

Table 5. Bill of materials

Reference	Component	Package	Remark
R1	100 kΩ	0805	-
R2	4.7 Ω	0805	-
R3	1 kΩ	0805	-
R4	not mounted	0805	-
R5	not mounted	0805	-
R6	not mounted	0805	-
C1	47 nF; 50 V	0805	-
C2	1 μF; 50 V	0805	-
C3	200 pF; 200 V	0805	-
C4	not mounted	0805	-
C5	not mounted	0805	-
D1	BAS321	SOD523	-
D3	BAV99	SOT23	-
DZ1	BZX84J-C15	SOD323F	-
DZ2	not mounted	SOD323F	-
M1	2N7002	SOT23	-
M2	MOSFET; PSMN7R0-100P	TO220AB	R_{on} 7 mΩ
U1	TEA1792TS	TSOP6	-

Components C2, R2, R3, R6, C5 and M2 are needed for the TEA1792TS standard application. Components R1, C1, C3, DZ1, D1, D3 and M1 combine to the charge pump circuit. The charge pump circuit that generates the supply voltage for the TEA1792TS.

Mount optional components R4, R5, C4 and DZ2 when false MOSFET switch-off occurs. False MOSFET switch-off occurs when:

- large ringing is present on the transformer secondary side or
- a MOSFET with a very low R_{dson} is used

See Ref. 2 for more detailed information.

7. PCB layout

Figure 15 shows the layout of the PCB.

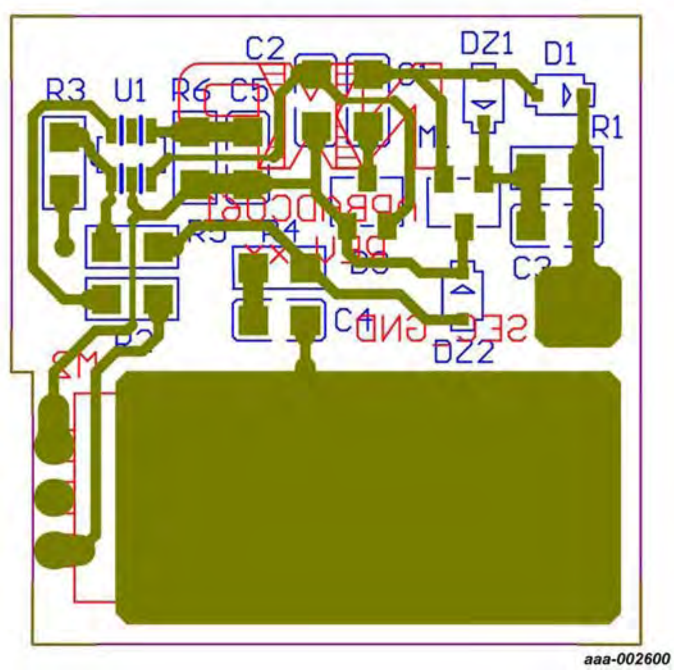

Fig 15. PCB layout

8. References

[1] **TEA1792TS —** Data sheet: GreenChip synchronous rectifier controller.

[2] **AN11149 —** Application note: GreenChip TEA1792 synchronous rectifier controller.

[3] **UM10403 —** User Manual: 90 W notebook adapter with TEA1752T and TEA1791T.

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