UM11815

TEA2096DB2201 synchronous rectifier evaluation board

Rev. 1 — 19 September 2022 User manual

Document information

Information	Content
Keywords	TEA2096T, LLC converter, dual synchronous rectifier (SR) driver, SO8, high efficiency, power supply, TEA2096DB2201, evaluation board
Abstract	This user manual describes the TEA2096DB2201 evaluation board, including instructions about how to connect the board, for the best results and performance. The TEA2096DB2201 evaluation board contains the secondary side rectification part of a resonant converter, excluding the output capacitors and the feedback control hardware. To use the TEA2096DB2201 evaluation board correctly, a resonant converter board in which the evaluation board can replace the secondary rectifier part is required.

Revision history

Rev	Date	Description
v.1	20220919	Initial version

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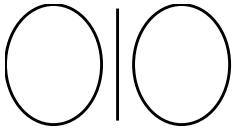
2 Safety warning

The board application is AC-mains voltage powered. 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 1 shows the symbols on how to recognize these devices.



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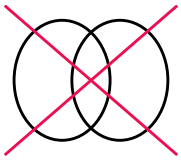
a. Isolated



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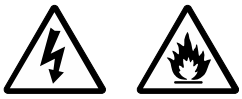
b. Not isolated

Figure 1. Isolation symbols

3 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.

The TEA2096DB2201 evaluation board is intended for engineers involved in the evaluation and the design of switch-mode power supplies (SMPS).

This user manual contains all the information required to replace the secondary-side rectification of an existing SMPS with a resonant topology with the TEA2096DB2201 evaluation board.

4 Finding kit resources and information on the NXP website

NXP Semiconductors provides online resources for this user manual and its supported devices at https://www.nxp.com.

This design example user manual can be found at: https://www.nxp.com/TEA2096DB2201.

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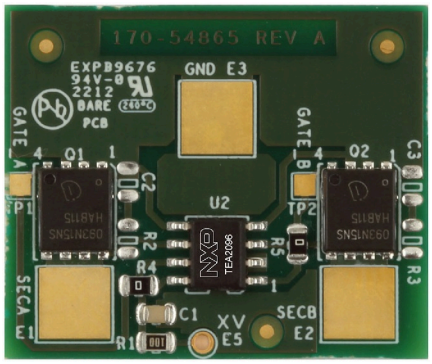
5 Getting ready

5.1 Box contents

The box contains the TEA2096DB2201 evaluation board. This evaluation board incorporates the TEA2096T in an SO-8 package and two 150 V MOSFETs in a PG-TDSON-8 package with a typical R_{DSon} of 9.3 mΩ. Figure 2 shows the top side and bottom side of the evaluation board. The TEA2096DB2201 evaluation board is a single layer board with one plated-through via for improved solderability and robustness.



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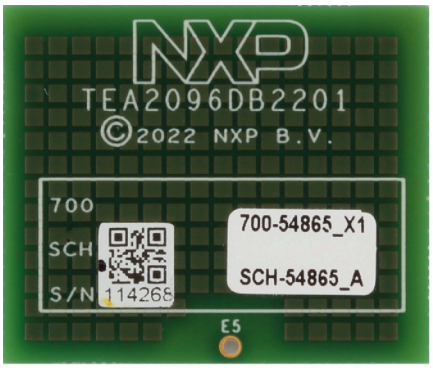
a. Top side



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a. Bottom side

Figure 2. TEA2096DB2201 evaluation board photographs

6 Getting to know the hardware

6.1 Overview

The TEA2096DB2201 evaluation board contains a TEA2096T SR controller in an SO-8 package and two 150 V MOSFETs in PD-TSON-8 package.

The TEA2096T is a dedicated controller IC for synchronous rectification on the secondary side of resonant converters. It incorporates two stages for sensing and driving the SR MOSFETs, which rectify the outputs of the central tap secondary transformer windings. The TEA2096T has a drain-source voltage rating of 200 V.

These features make the evaluation board suitable for applications with an output voltage of up to 60 V.

6.2 Features

- Dual synchronous rectification for resonant converters
- Easy replacement of secondary-side rectifiers of an existing resonant converter
- Differential inputs for sensing the drain and source voltages of each SR MOSFET independently
- Adaptive gate drive for fast turn-off at the end of conduction and maximum efficiency at any load
- Regulation level of −25 mV for driving low-ohmic MOSFETs
- SR control without minimum on-time
- Supports 1 MHz switching frequency
- Interlock function to prevent simultaneous conduction of the external MOSFETs
- Wide supply voltage range from 4.75 V to 38 V
- Supports 5 V supply operation with logic level SR MOSFETs
- Supply current in energy save operation of 80 µA
- Undervoltage lockout (UVLO) protection with active gate pull-down

6.3 Block diagram

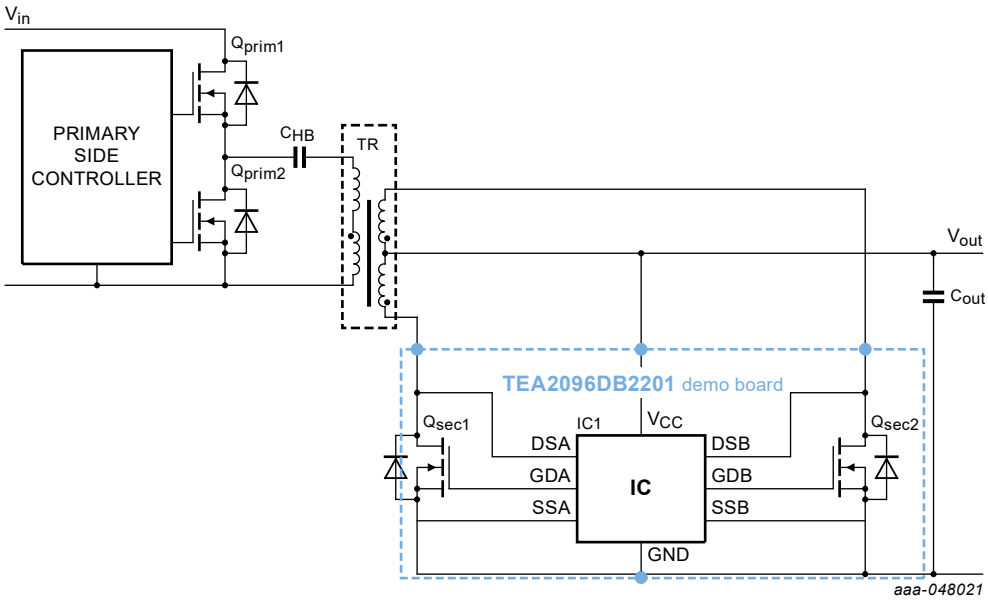

Figure 3. block diagram

6.4 Board description

The board consists of the TEA2096T SR and two SR MOSFETs. The TEA2096T acts as a dual controlled amplifier. For each side, the input is the voltage difference between drain and source. The corresponding gate driver signal is the output.

To ensure that the layout design for a single-sided board is easy, resistors R4 and R5 are added. Keep the resistor value 0 Ω for the fastest turn-off time. Capacitor C1 is a decoupling capacitor for the VCC pin of the TEA2096T. Connect it close to the IC. In combination with resistor R5, it acts as a simple RC filter.

Provisions are made for snubbers resistor R2/capacitor C2 and resistor R3/capacitor C3. The components are not mounted. However, if high-voltage spikes are present on the drain-source connections of the MOSFETs, they can be added.

6.5 Operational behavior

6.5.1 Turn-on

When the drain-source voltage drops to below the turn-on threshold (−400 mV), the MOSFETs are turned on. The corresponding gate driver output turns on the external SR MOSFET. The gate of this MOSFET is rapidly charged to a level that exceeds its threshold level. After the turn-on phase, the regulation phase starts. There is no minimum on-time.

6.5.2 Regulation mode and turn-off

During regulation mode, the IC regulates the voltage difference between the drain and the source sense inputs to an absolute level of 25 mV. The corresponding gate driver output level is adjusted accordingly. In this mode, the gate driver voltage follows the

waveform of the current through the external MOSFET. When the current drops to lower values, the corresponding gate driver output is discharged to a value just above the gate threshold voltage of the external MOSFET. When the current reaches zero, the discharge enables a quick turn-off of the external MOSFET.

Especially at continuous conduction mode (CCM) conditions, choose a MOSFET with a sufficiently low R_{DSon} value. It enables the discharge of the gate driver output to just above the gate-source threshold level of the external MOSFET. When the current drops to zero, this discharge makes a rapid switch-off possible.

Rapid switch-off is very important for CCM conditions. It minimizes the reverse current and the related voltage overshoot on the drain terminal of the external MOSFET.

When the drain voltage exceeds 150 mV, the driver output voltage is actively pulled low.

6.5.3 Synchronous rectification waveforms

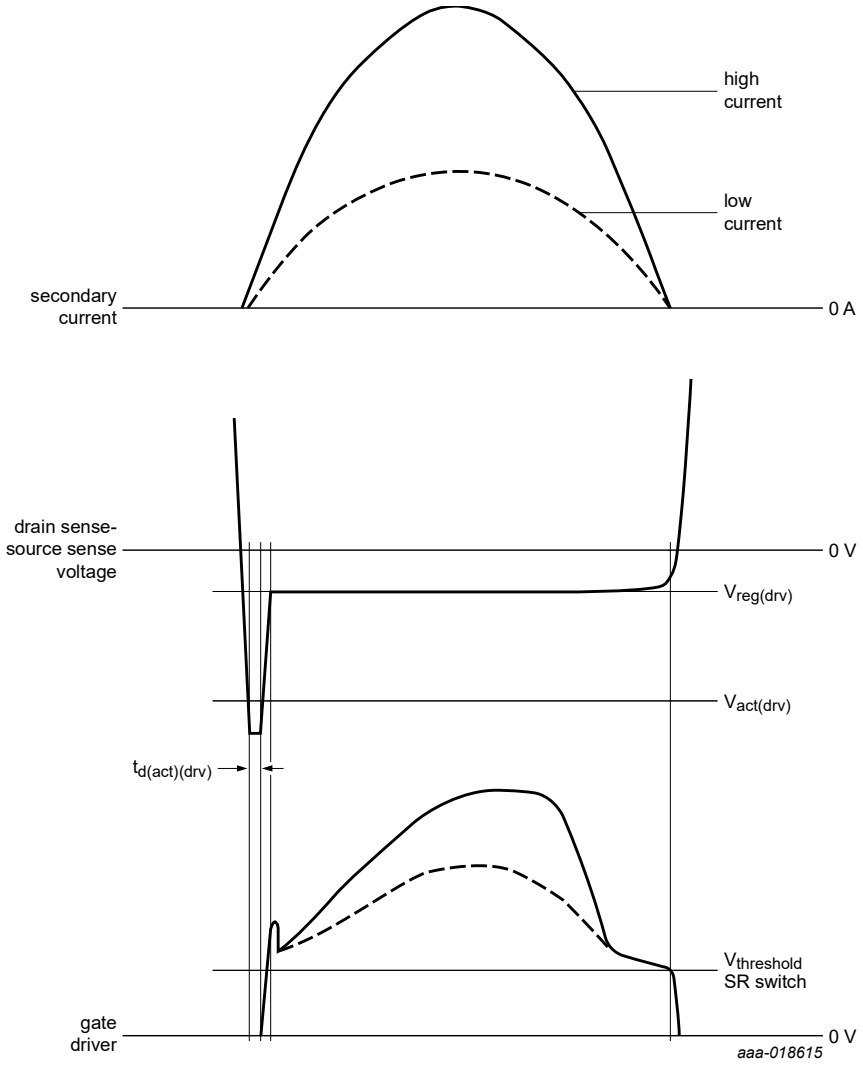

Figure 4. Synchronous rectification signals with the TEA2096T

6.5.4 Interlock function

The TEA2096T incorporates an interlock function. The interlock function avoids the turn-on of both gate driver outputs at the same time.

After one gate driver output is turned off, the IC waits maximum 200 ns ($t_{d(interlock)}$) before turning on the other gate driver output.

7 Connecting the hardware

Figure 5 shows an example of the TEA2096DB2201 evaluation board used in a typical resonant adapter.

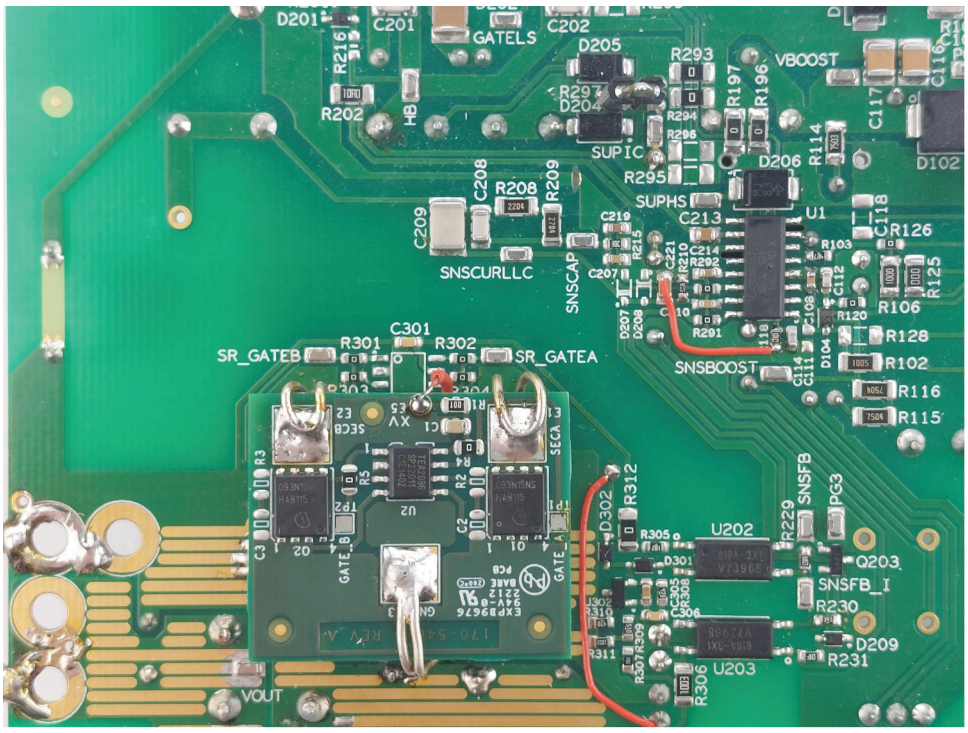

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Figure 5. TEA2096DB2201 evaluation board connected to 240 W resonant adapter board

Figure 3 and Figure 6 show the connection of the TEA2096DB2201 evaluation board to the secondary side of an LLC controller board. The evaluation board has four connections.

Connect the pads SECA and SECB to the secondary outputs of the transformer. Connect the GND pad to the power ground of the main board. Use thick wires for the SECA, SECB, and GND connections, because the currents in these tracks can be high.

For output voltages up to 38 V, the XV connection can be connected to the V_{out} of the main board. For output voltages of more than 38 V, a series regulator is required to reduce the supply voltage of the TEA2096T to below 38 V. When a series regulator is used, a trade-off can be made between the dissipation in the regulator and the dissipation in the TEA2096T.

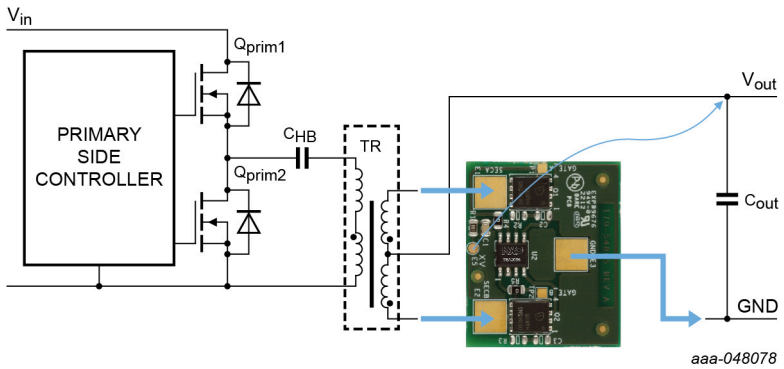


Figure 6. Placement of evaluation board in existing resonant converter

8 Schematic, board layout and bill of materials

8.1 Schematic

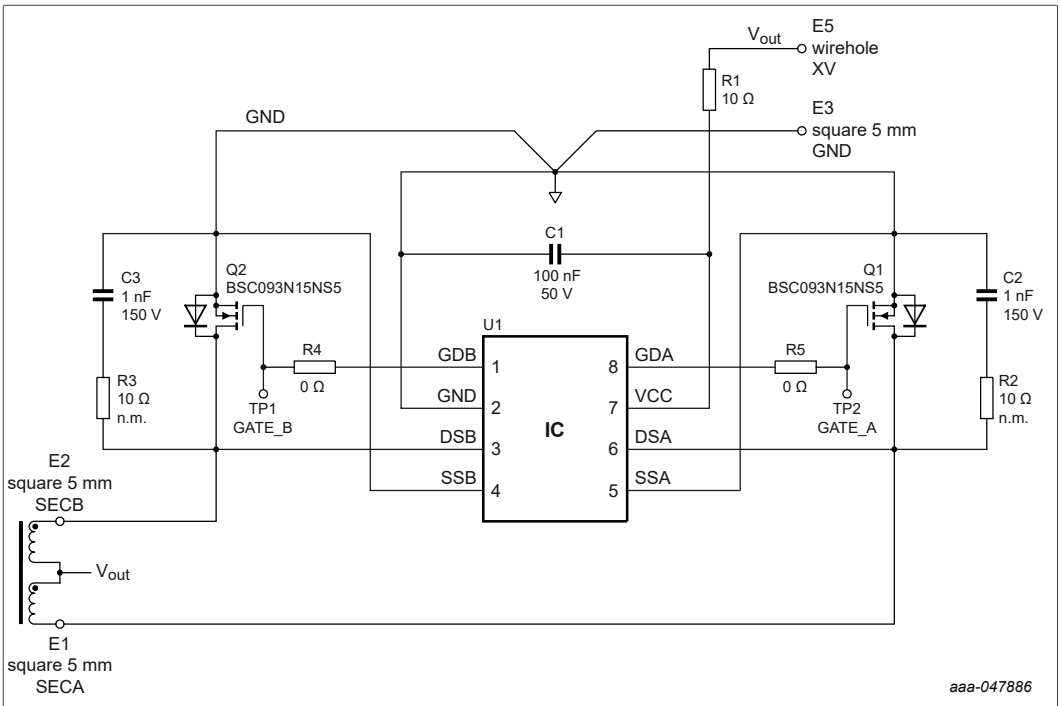


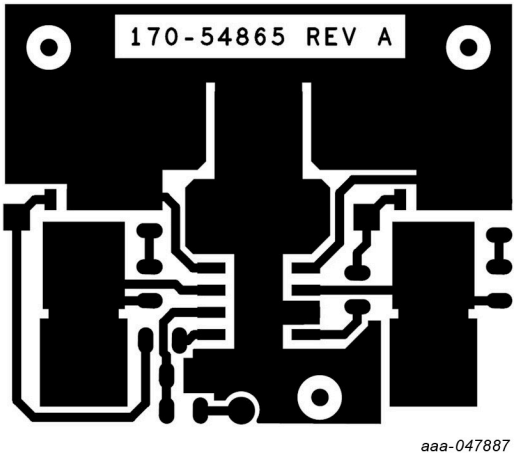
Figure 7. Schematic TEA2096DB2201

8.2 Bill of materials

Table 1. TEA2096DB2201 bill of materials (BOM)

Reference	Description and values	Part number	Manufacturer
C1	capacitor; 100 nF; 50 V; 0805	-	-
C2; C3	capacitor; not mounted; 1 nF; 150 V; 0805	-	-
Q1; Q2	MOSFET; 150 V; 9.3 mΩ; PG-TDSON-8	BSC093N15NS5ATMA1	Infineon
R4; R5	resistor; 0 Ω; 0805	-	-
R2; R3	resistor; not mounted; 10 Ω; 0805	-	-
R1	resistor; 10 Ω; 0805	-	-
U12	IC; TEA2096T	-	NXP Semiconductors

8.3 Board layout



a. Top copper b. Top silkscreen

Figure 8. TEA2096DB2201 evaluation board layout

Below are several important guidelines for a good layout:

- Keep the trace from the DSA/B pin to the MOSFET drain pin as short as possible.
- Keep the trace from the SSA/B pin to MOSFET source pin as short as possible.
- Keep the area of the loop DSA/B pin-MOSFET drain-MOSFET source-SSA/B pin as small as possible. Make sure that this loop overlaps the power drain track or power source track as little as possible. And ensure that the two loops do not cross each other.
- Keep tracks from GATE pins to gate of MOSFETs as short as possible.
- Decouple pins V_{CC} and GND as close to the IC as possible with a small (100 nF) capacitor.
- Use separate clean tracks for the V_{CC} pin and GND.
- Use a GND plane underneath the IC connected to the GND pin. It results in a better heat dispersion.
- Keep the ground and source sense tracks separated. Use separate tracks for each source sense connection and connect the IC ground to the ground plane on the PCB.

9 Abbreviations

Table 2. Abbreviations

Acronym	Description
CCM	continuous conduction mode
MOSFET	metal-oxide semiconductor field-effect transistor
SMPS	switch-mode power supplies
SR	synchronous rectifier
UVLO	undervoltage lockout

10 References

[1] **TEA2096T data sheet** — Dual synchronous rectifier controller; 2022, NXP Semiconductors

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