UM11296

TEA2095DB1574 synchronous rectifier controller demo board

Rev. 2 — 26 August 2020 User manual

Document information

Information	Content
Keywords	TEA2095TE, LLC converter, dual synchronous rectifier (SR) driver, SO8, HSO8, high efficiency, power supply, TEA2095DB1574 demo board
Abstract	This user manual describes how the TEA2095DB1574 demo board can be used in a resonant converter. The demo board contains a TEA2095TE SR controller in a HSO8 package. In addition to the TEA2095TE, the demo board contains two power MOSFETs. The demo board replaces the secondary side of the resonant converter, excluding the output capacitors and the feedback hardware. The demo board is equipped with LFPAK MOSFETs.

Revision history

Rev	Date	Description
v.2	20200826	Second edition
v.1	20191025	Initial version

1 Introduction

This user manual describes the TEA2095DB1574 demo board. It provides a functional description, supported with instructions on how to connect the board to obtain the best results and performance. The TEA2095DB1574 demo board contains the secondary part of a single output LLC converter, excluding the output capacitors and the feedback control hardware. To use the TEA2095DB1574 demo board correctly, an LLC converter board in which the demo board can replace the secondary part, is required.

The TEA2095TE is a dedicated controller IC for synchronous rectification on the secondary side of resonant converters. It incorporates two driver stages for driving the SR MOSFETs, which rectify the outputs of the central tap secondary transformer windings. The two gate driver stages have their own sensing inputs and operate independently.

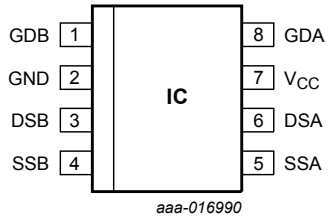


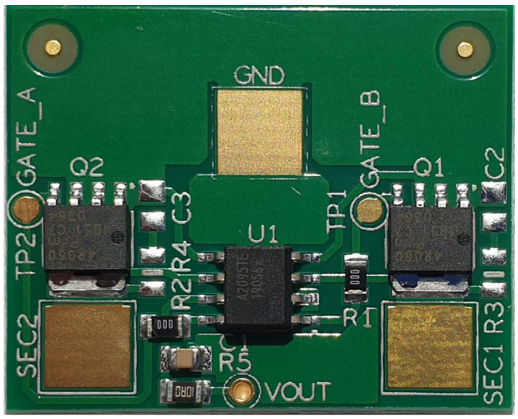
Figure 1. TEA2095TE pinning configuration (HSO8)

1.1 Features

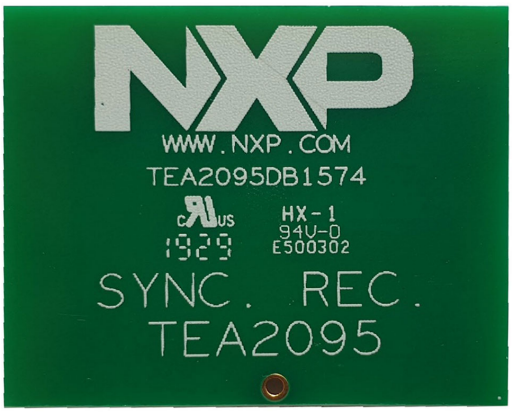
- Adaptive gate drive for maximum efficiency at any load
- Supply current in energy save operation of 90 µA
- Regulation level of −25 mV for driving low-ohmic MOSFETs
- Wide supply voltage range from 4.5 V to 30 V (limited by V_{ds} rating of MOSFETs; maximum V_{CC} TEA2095 is 38 V)
- Dual synchronous rectification for LLC resonant
- Supports 5 V operation with logic level SR MOSFETs
- Differential inputs for sensing the drain and source voltages of each SR MOSFET
- SO8 package (TEA2095T) and HSO8 package with exposed die pad (TEA2095TE)
- Discharge of the output capacitor after mains disconnect
- SR control without minimum on-time
- Adaptive gate drive for fast turn-off at the end of conduction
- Undervoltage lockout (UVLO) protection with active gate pull-down
- Interlock function to prevent simultaneous conduction of the external MOSFETs
- Supports 1 MHz switching frequency

2 TEA2095DB1574 photographs

The TEA2095DB1574 demo board consists of the TEA2095TE in an HSO8 package with exposed die pad and two MOSFETs in an LFPAK package with a typical R_{DSon} of 4.0 mΩ. Figure 2 shows the front side and back side of the demo board. The TEA2095DB1574 demo board is a single layer board, with one plated-through via for improved solderability and robustness.



a. Front



b. Back

Figure 2. TEA2095DB1574 demo board

3 TEA2095DB1574 demo board setup

The TEA2095DB1574 demo board contains two 4.0 mΩ MOSFETs in LFPAK with a drain-source voltage rating of 60 V. These features make the board suitable for applications with an output voltage of up to 19.5 V.

The TEA2095DB1574 demo board can be incorporated into an existing resonant power supply.

Figure 3 and Figure 4 show the connection of the TEA2095DB1574 demo board to the secondary side of an LLC controller board. The demo board has four connections. Connect the two drain lines to the secondary outputs of the transformer. Connect the GND connection to the power ground of the main board. And connect the V_{CC} connection to the V_{out} terminal of the main board. Use thick wires for the drain and GND connections, as the currents in these tracks can be high. The V_{CC} can be connected to the V_{out} with a small wire. This wire only supplies the TEA2095TE.

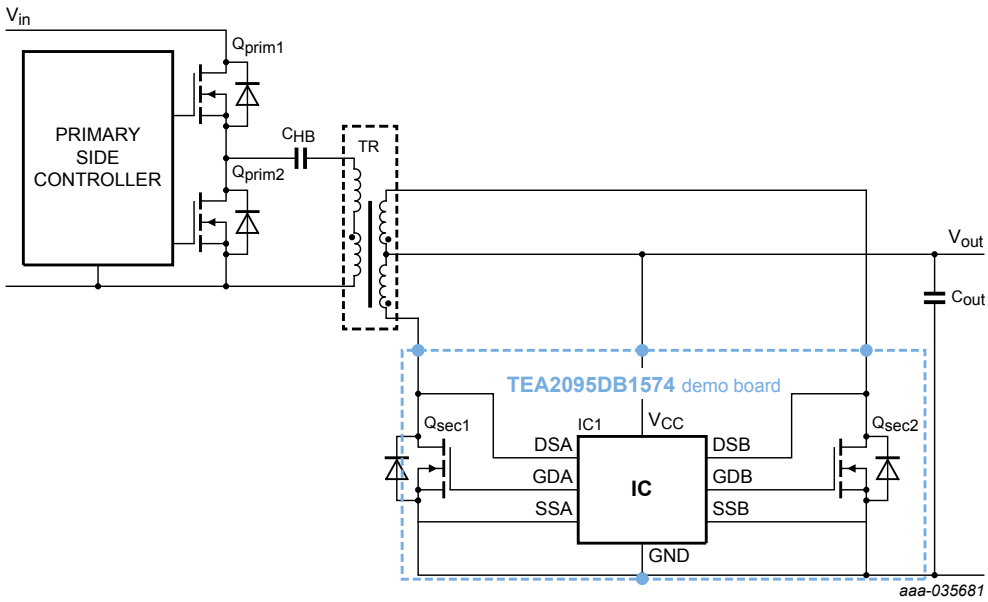


Figure 3. TEA2095DB1574 demo board typical configuration

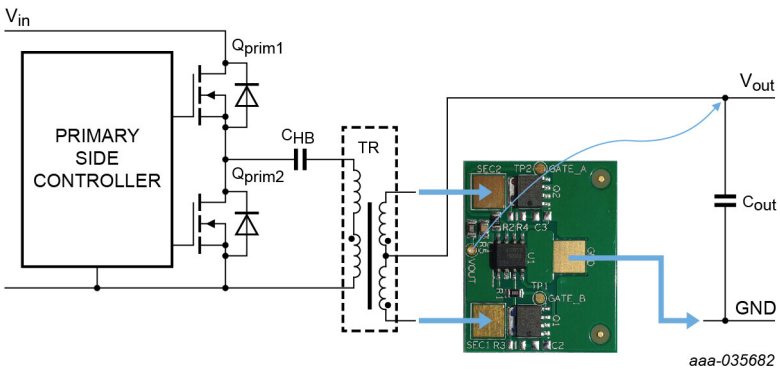


Figure 4. Placement of demo board in existing resonant converter

4 Connecting the TEA2095DB1574 demo board

Figure 5 shows an example of the TEA2095DB1574 demo board used in a typical resonant adapter.

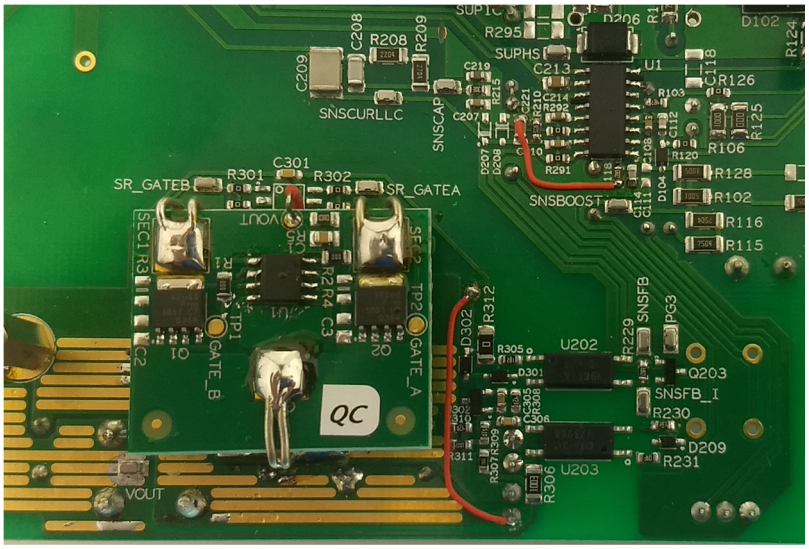


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Figure 5. TEA2095DB1574 demo board connected to 240 W resonant adapter board

5 Operation

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.

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-source threshold level 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, it is important to 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.

5.3 Operational behavior

Figure 6 shows the corresponding SR waveforms.

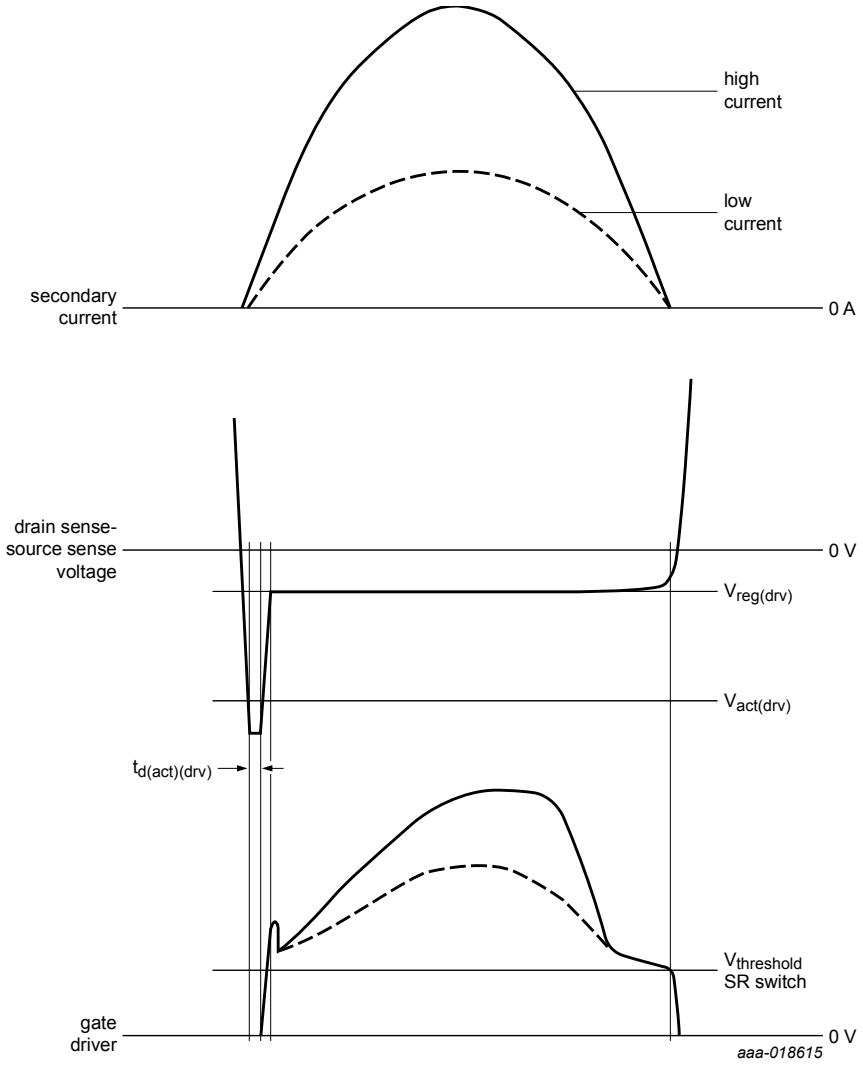


Figure 6. Synchronous rectification signals

5.4 Interlock function

The TEA2095TE 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.

5.5 Discharge function

Disconnecting a power supply from the mains voltage leads to zero output voltage and the power indicator turn-off. The TEA2095TE contains a discharge function that automatically discharges the output capacitor after a mains disconnect.

The detection of the mains disconnect happens by monitoring the activity of the synchronous rectification and applying a 1.4 s threshold for discriminating between no-load operation and power disconnect.

The discharge function creates a rapid discharge with a constant power dissipation of 0.4 W. Figure 6 shows the secondary current, the drain sense voltage, the gate driver voltage, and the supply current.

The TEA2095T enters the energy save mode 110 µs after the last SR cycle. The supply current changes to a very low level (90 µA) for low no-load power. After 1.4 seconds without SR activity, the TEA2095T makes a transition to the discharge mode and draws a current of 0.4 W divided by the VCC voltage.

For a VCC voltage below UVLO, the discharge current reduces gradually to a level of 8 mA at a VCC voltage of 1 V.

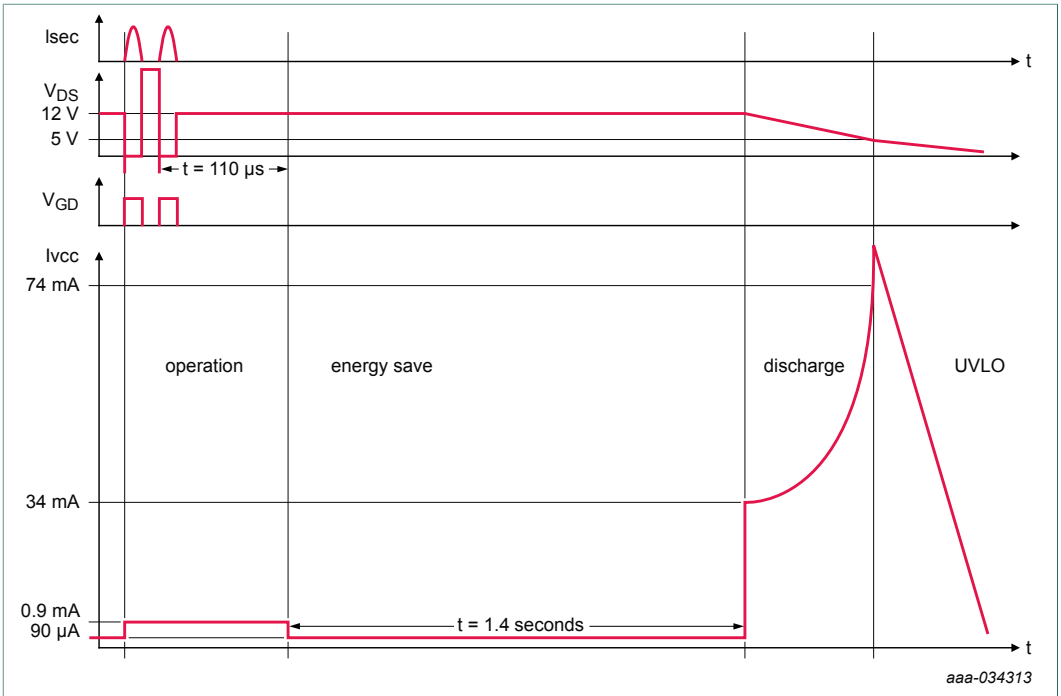


Figure 7. Discharge function signals (not to scale)

Note: *When the supply voltage of the TEA2095TE is below UVLO, the discharge function is always active.*

During start-up, when the supply voltage increases, the TEA2095TE draws a current up to 74 mA until the VCC voltage reaches its start level and the discharge function is switched off.

When using a series resistor in the V_{CC} track, ensure that the output voltage is high enough to pull V_{CC} to above V_{start} despite the voltage drop over the series resistor because of the discharge current.

When a series resistor in the V_{CC} track is used, the start-up behavior of V_{CC} is given (see Figure 8). Without series resistor, the difference between V_{out} and V_{CC} is zero.

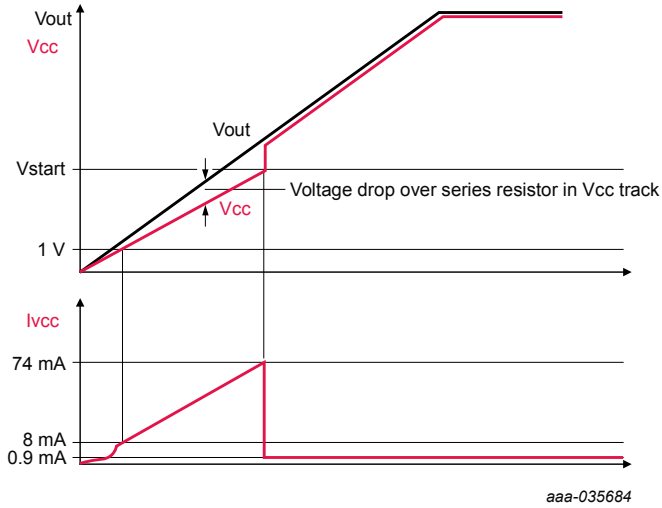


Figure 8. Discharge behavior during start-up

6 Schematic

Figure 9 shows the schematic diagram of the TEA2095DB1574 demo board. Basically, the board consists of the TEA2095TE SR and two SR MOSFETs. The TEA2095TE 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 layout design for a single-sided board is easy, resistors R1 and R2 are added. Keep the resistor value 0 Ω for the fastest turn-off time. Capacitor C1 is a decoupling capacitor for the V_{CC} of the TEA2095TE. Connect it close to the IC. In combination with resistor R5, it acts as a simple RC filter.

To prevent that V_{CC} increases to exceed the V_{start} level at start-up because of the discharge current through resistor R5, reduce the value of resistor R5 to 0 Ω when using the board for a very low output (for example, 5 V).

Provisions are made for snubbers resistor R3/capacitor C2 and resistor R4/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.

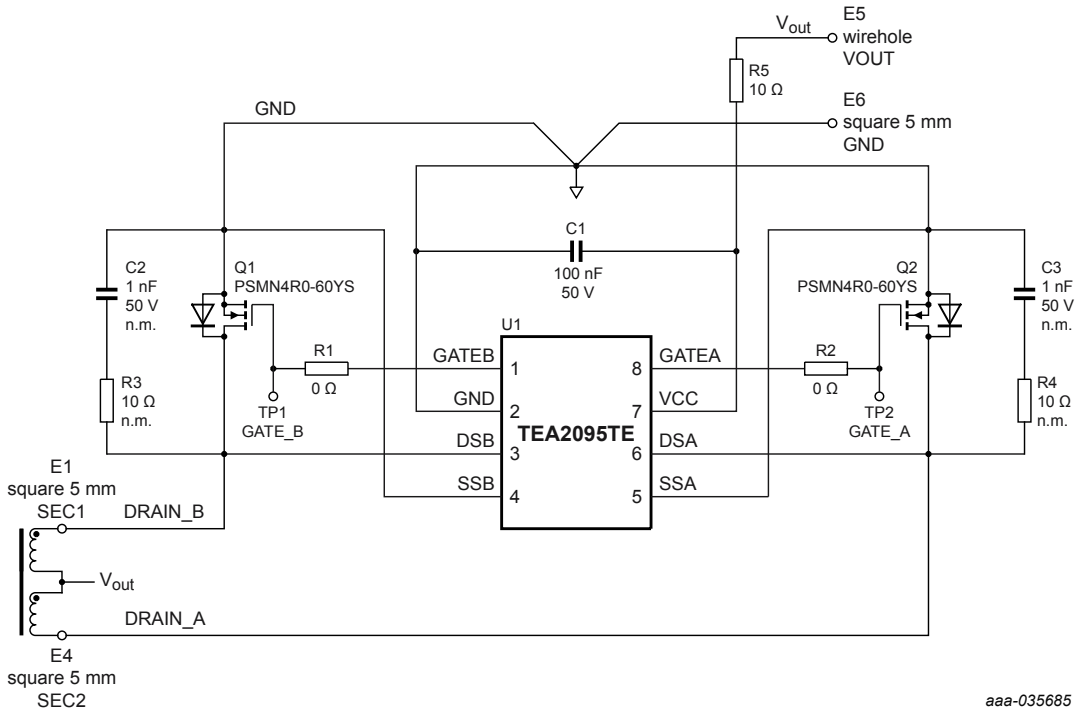


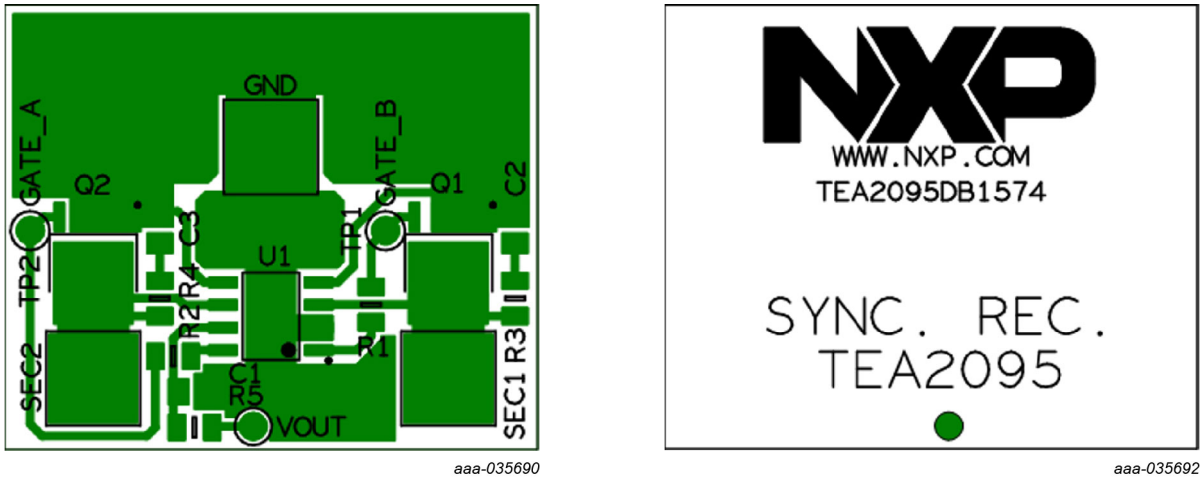
Figure 9. TEA2095DB1574 demo board schematic

7 Bill of materials (BOM)

Table 1. TEA2095DB1574 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; 0805	-	-
Q1; Q2	MOSFET; R_{on} = 4.0 mΩ; LFPAK	PSMN4R0-60YS	Nexperia
R1; R2	resistor; 0 Ω; 0805	-	-
R3; R4	resistor; not mounted; 10 Ω; 0805	-	-
R5	resistor; 10 Ω; 0805	-	-
U1	IC; TEA2095TE	HSO8	NXP Semiconductors

8 TEA2095DB1574 board layout



a. Front

b. Back

Figure 10. TEA2095DB1574 demo board layout

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 GD 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 beneath the IC with a suitable pad for HSO8. Make the area of the total GND plane as large as possible for better heat dispersion.
  For the SO8 package, use a GND plane underneath the IC connected to the GND pin as well. 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
SR	synchronous rectifier
UVLO	undervoltage lockout

10 References

[1] **TEA2095TE data sheet** — Dual synchronous rectifier controller; 2019, NXP Semiconductors

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