



UM10892

GreenChip TEA1995DB1295 synchronous rectifier controller demo board

Rev. 1 — 8 July 2015

User manual

Document information

Info	Content
Keywords	TEA1995T, LLC converter, dual Synchronous Rectifier (SR) driver, SO8, high efficiency, power supply, TEA1995DB1295 demo board
Abstract	This user manual describes how the TEA1995DB1295 demo board can be used in a resonant converter. The demo board contains a TEA1995T SR controller in an SO8 package. In addition to the TEA1995T, 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. There are two versions of the demo board available. A version containing TO-220 MOSFETs (UM10891), and a second version using LFPK MOSFETs (UM10892).



Revision history

Rev	Date	Description
v.1	20150708	first issue

Contact information

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

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 the TEA1995DB1295 demo board. It provides a functional description, supported with instructions on how to connect the board to obtain the best results and performance. The TEA1995DB1295 demo board contains the secondary part of a single output LLC converter, excluding the output capacitors and the feedback control hardware. To use the TEA1995DB1295 demo board correctly, an LLC converter board in which the demo board can replace the secondary part, is required.

The TEA1995T 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.

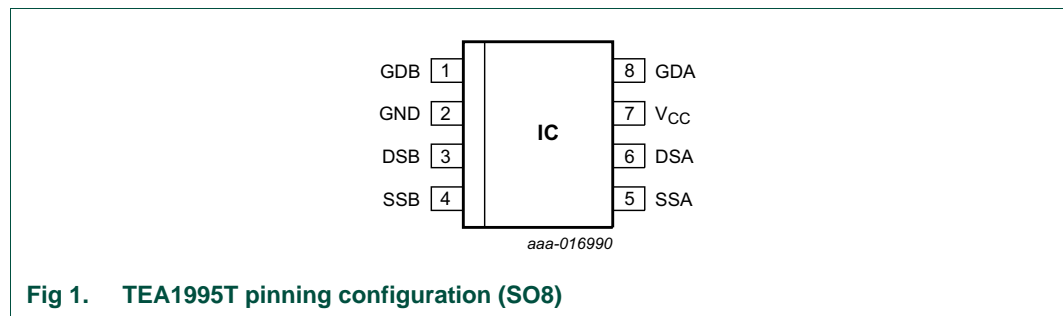


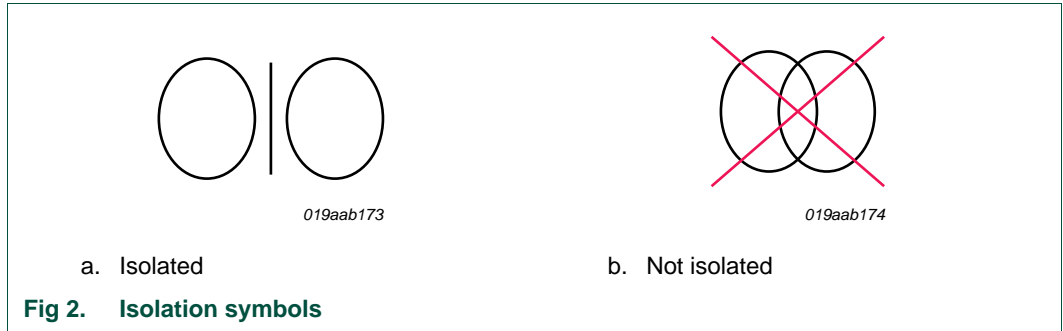
Fig 1. TEA1995T pinning configuration (SO8)

1.1 Features

- Adaptive gate drive for maximum efficiency at any load
- Supply current in no-load operation below 200 μ A
- Wide supply voltage range from 4.5 V to 38 V
- Dual synchronous rectification for LLC resonant in SO8 package
- Synchronous rectification for multi-output flyback converters
- Supports 5 V operation with logic level SR MOSFETs
- Differential inputs for sensing the drain and source voltages of each SR MOSFET
- SR control without minimum on-time
- Adaptive gate drive for fast turn-off at the end of conduction
- UnderVoltage LockOut (UVLO) with active gate pull-down

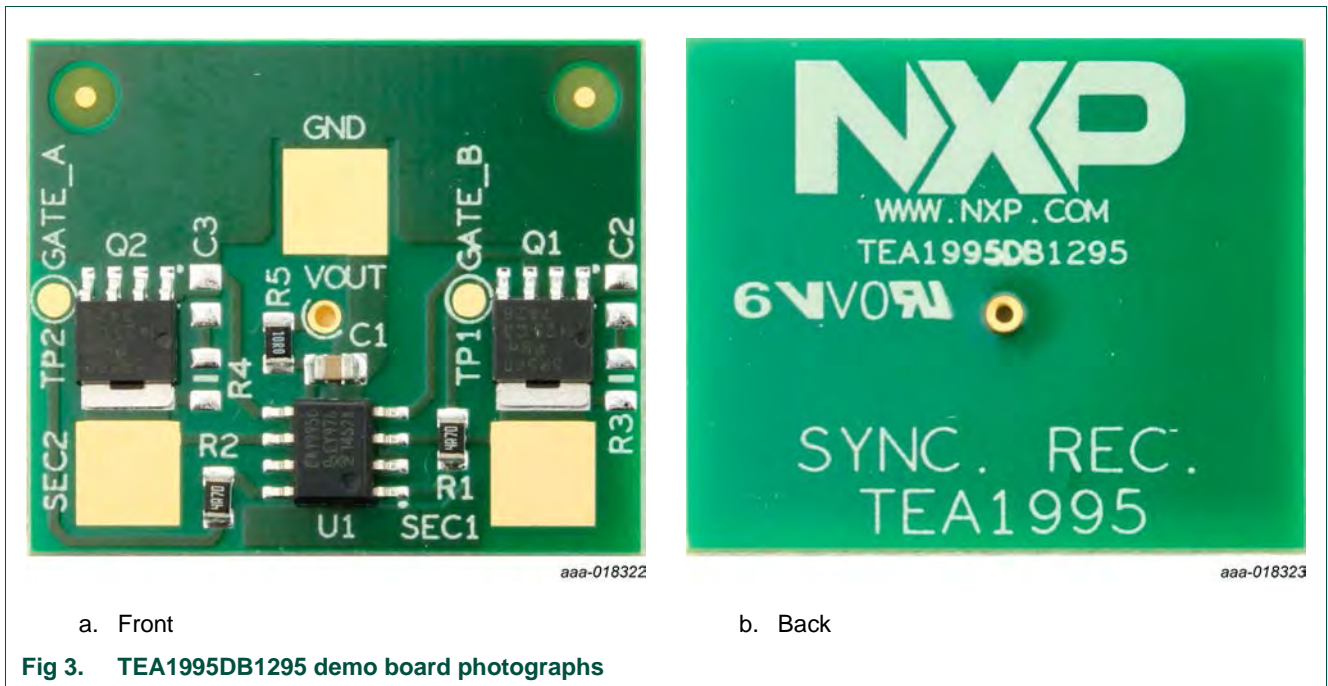
2. Safety warning

The 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. [Figure 2](#) shows the symbols that identify isolated and non-isolated devices.



3. TEA1995DB1295 photographs

The TEA1995DB1295 demo board consists of the TEA1995T in an SO8 package and two MOSFETs in an LFPACK package with a typical R_{DSon} of 5.5 m Ω . [Figure 3](#) shows the front side and back side of the demo board. The TEA1995DB1295 demo board is a single layer board, with one plated-through via for improved solderability and robustness.



4. TEA1995DB1295 demo board setup

To ensure that the TEA1995DB1295 demo board can be used in various applications, two versions are available.

- The TEA1995DB1294 demo board contains two NXP Semiconductors power MOSFETs PSMN3R0-60PS (TO-220 package), intended for low output voltage (12 V) applications with relative high output currents.
- The TEA1995DB1295 demo board contains two NXP Semiconductors power MOSFETs (PSMN5R5-60PS; LFPAK), intended for applications with a higher output voltage (19.5 V) and relatively lower output currents.

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

Figure 4 and Figure 5 show the connection of the TEA1995DB1295 demo board to the secondary side of an LLC controller board. The demo board has 4 connections. Connect the 2 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 is only required to supply the TEA1995T.

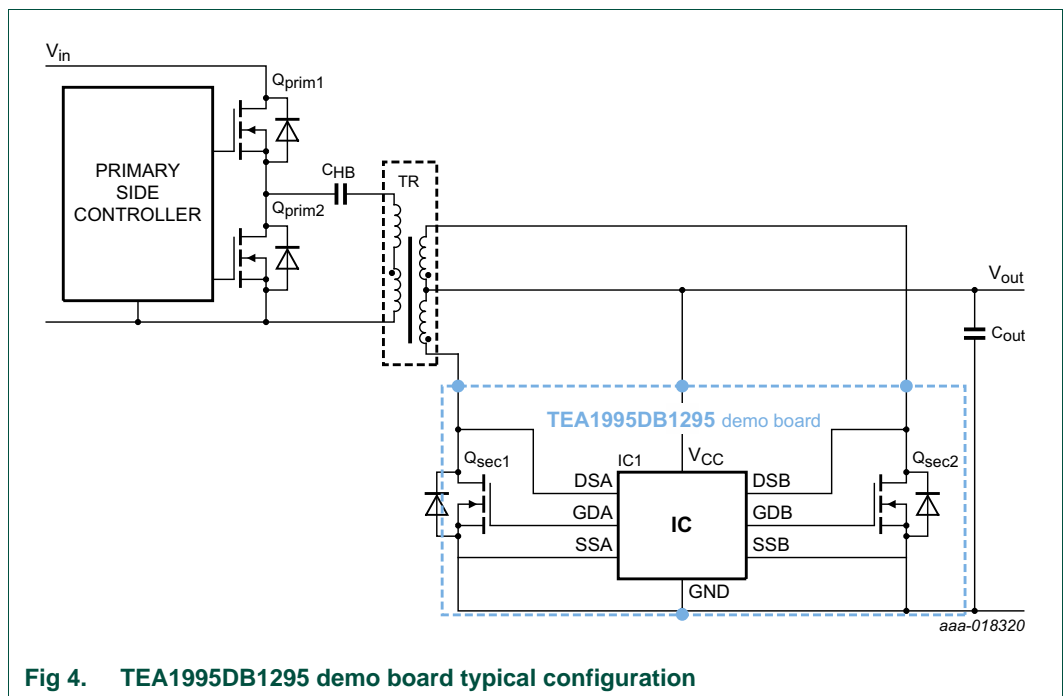


Fig 4. TEA1995DB1295 demo board typical configuration

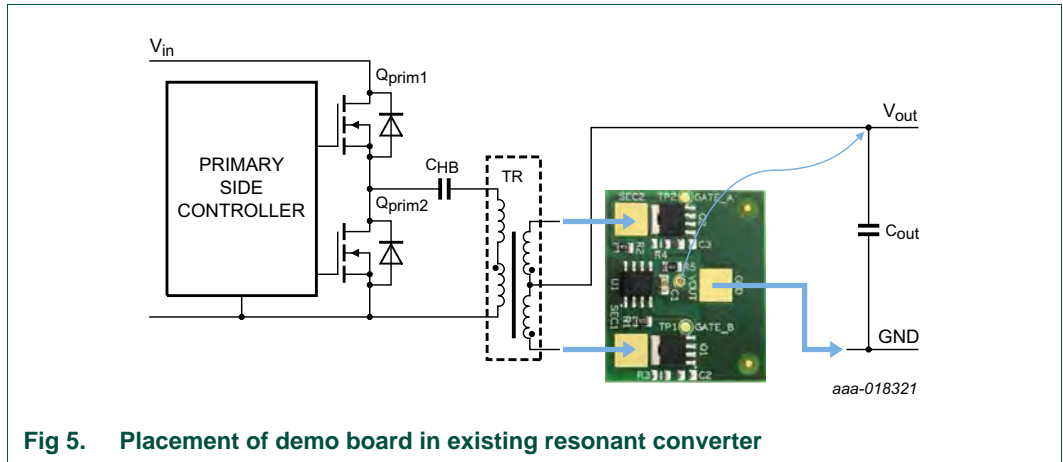


Fig 5. Placement of demo board in existing resonant converter

5. Connecting the TEA1995DB1295 demo board

Figure 6 shows an example of the TEA1995DB1295 demo board used in a typical resonant adapter.



Fig 6. TEA1995DB1295 demo board connected to 150 W resonant adapter board APBADC069

6. Operation

6.1 Turn-on

The MOSFETs are turned on when the drain-source voltage drops to below the turn-on threshold (-400 mV). 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.

6.2 Regulation mode and turn-off

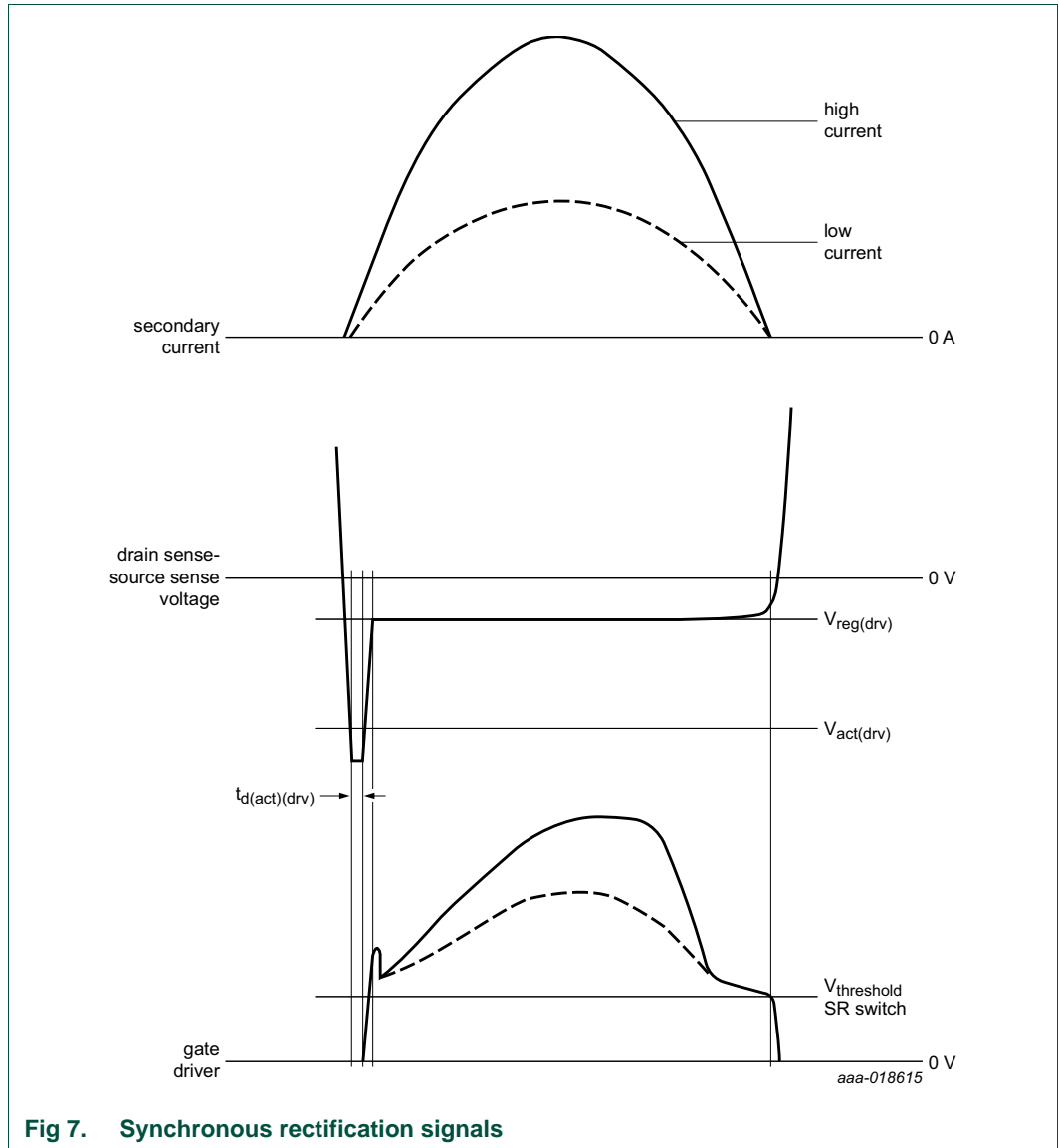
During regulation mode, the IC regulates the voltage difference between the drain and the source sense inputs to an absolute level of 55 mV. The corresponding gate driver output level is adjusted accordingly. In this mode, the gate driver voltage follows the waveform of the current through the external 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. The discharge enables a quick turn-off of the external MOSFET when the current reaches zero.

Especially at Continuous Conduction Mode (CCM) conditions, it is important to choose a MOSFET with a sufficiently low $R_{DS(on)}$ 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. The 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.

6.3 Operational behavior

Figure 7 shows the corresponding SR waveforms.



7. Schematic

Figure 8 shows the schematic diagram of the TEA1995DB1295 demo board. Basically, the board consists of the TEA1995T SR and two SR MOSFETs. The TEA1995T 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.

Resistors R1 and R2 are added to ensure easy layout design for a single-sided board. The resistor values must be in the range of 0 Ω to 10 Ω. Use the lowest value for the fastest turn-off time. Capacitor C1 is a decoupling capacitor for the V_{CC} of the TEA1995T. Connect it close to the IC. In combination with resistor R5, it acts as a simple RC filter.

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.

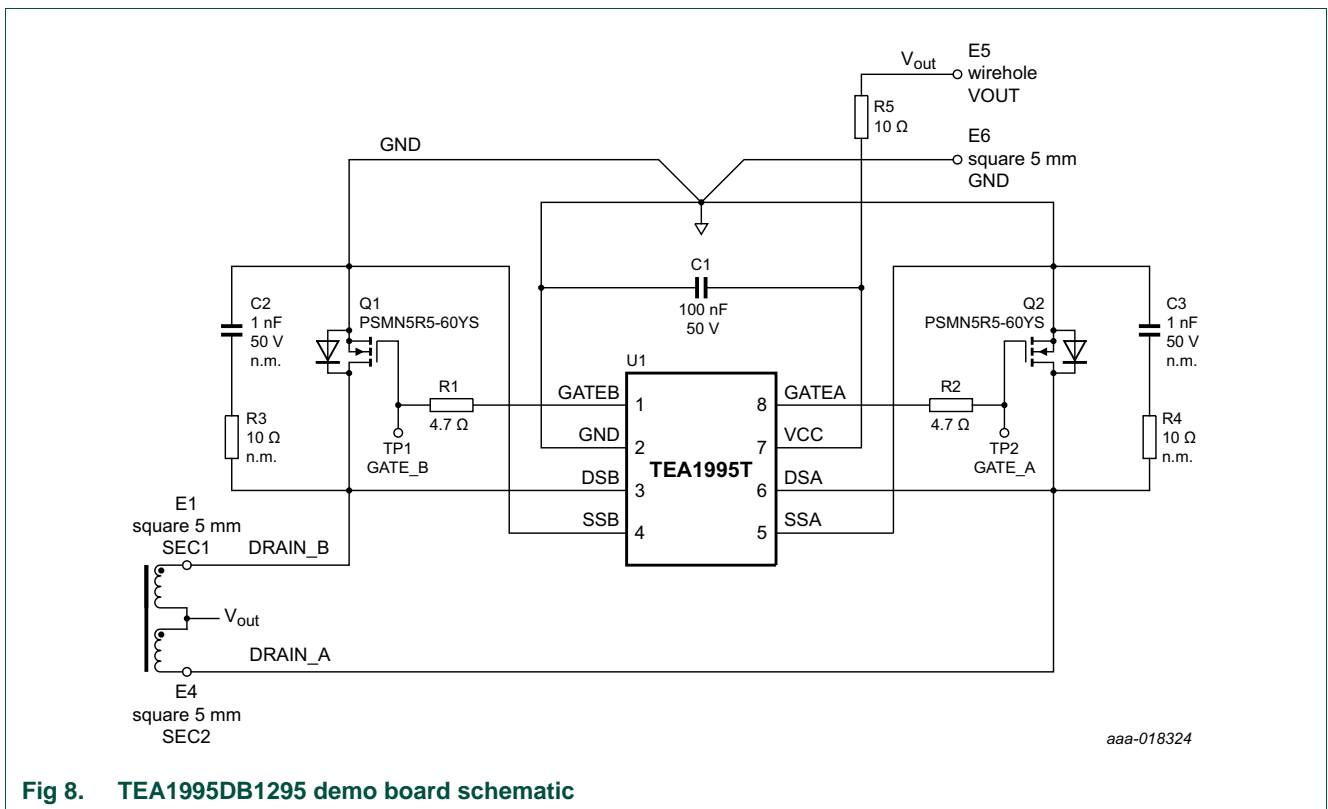


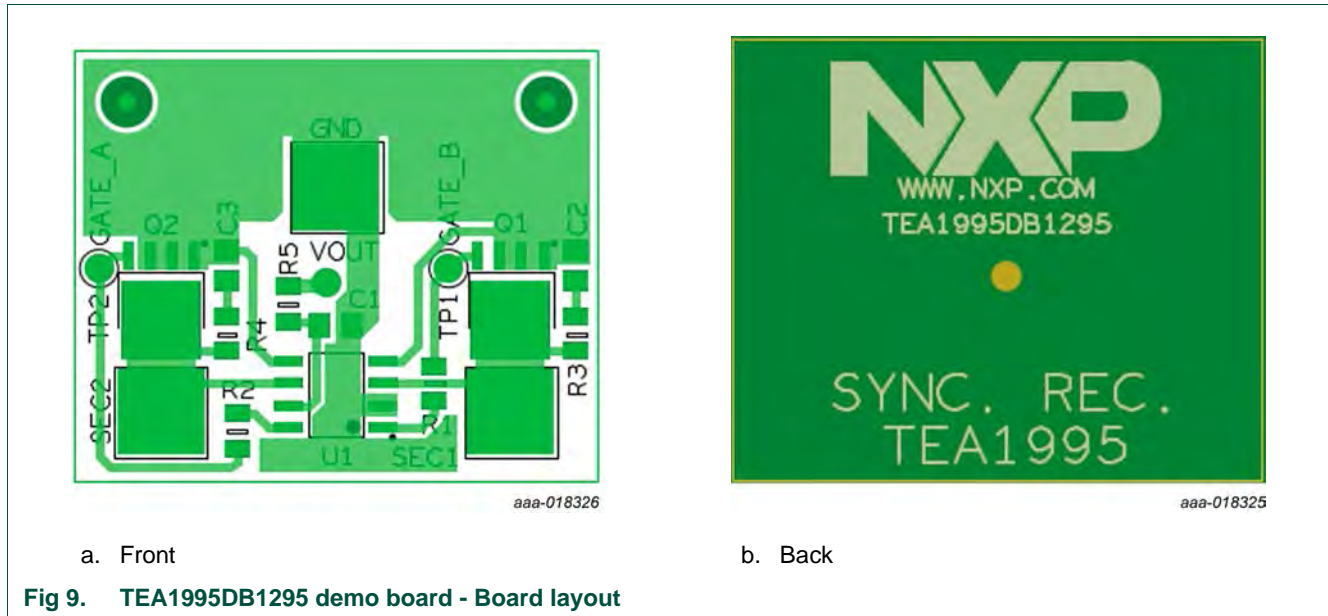
Fig 8. TEA1995DB1295 demo board schematic

8. Bill Of Materials (BOM)

Table 1. TEA1995DB1295 bill of materials

Reference	Description and values	Part number	Manufacturer
C1	capacitor; 100 nF; 50 V; 0805	-	-
C2	capacitor; not mounted; 1 nF; 0805	-	-
C3	capacitor; not mounted; 1 nF; 0805	-	-
Q1; Q2	MOSFET; $R_{on} = 5.5 \text{ m}\Omega$; LFPAK	PSMN5R5-60YS	NXP Semiconductors
R1	resistor; 4.7 Ω ; 0805	-	-
R2	resistor; 4.7 Ω ; 0805	-	-
R3	resistor; 10 Ω ; 0805	-	-
R4	resistor; not mounted; 10 Ω ; 0805	-	-
R5	resistor; not mounted; 10 Ω ; 0805	-	-
U1	IC; TEA1995T; SO8	-	NXP Semiconductors

9. TEA1995DB1295 board layout



Some 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 from the DSA/B pin to MOSFET drain to MOSFET source to the SSA/B pin as small as possible. Make sure that this loop overlaps the power drain track or power source track as minimal as possible and the 2 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. If possible, use a small ground plane underneath the IC, which is good for 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.

10. NXP Semiconductors Power MOSFETs

[Table 2](#) gives a selection of NXP Semiconductors MOSFETs that are suited to be used for SR applications. The complete Power MOSFET selection guide can be found at: www.nxp.com/products/mosfets.

Table 2. Extract from NXP Semiconductors Power MOSFETs Selection Guide

Type number	Package name	V _{DS(max)} (V)	R _{DS(on)(max)} at V _{GS} = 10 V (mΩ)	I _{D(max)} (A)	Q _{GD} (typical) (nC)	Q _{G(tot)} (typical) (nC)
PSMN1R0-40YLD	LFPAK56	40	1.1	100	17	59
PSMN1R4-40YLD	LFPAK56	40	1.4	100	13	45
PSMN1R5-40ES	I2PAK	40	1.6	120	32	136
PSMN1R5-40PS	TO-220AB	40	1.6	150	32	136
PSMN1R6-40YLC	LFPAK56	40	1.55	100	15.3	59
PSMN1R8-40YLC	LFPAK56	40	1.8	100	10.9	45
PSMN1R9-40PL	TO-220AB	40	1.7	150	40.9	230
PSMN2R1-40PL	TO-220AB	40	2.2	150	29.6	168.9
PSMN2R2-40PS	TO-220AB	40	2.1	100	25	110
PSMN2R6-40YS	LFPAK56	40	2.8	100	14	63
PSMN2R8-40PS	TO-220AB	40	2.8	100	17	71
PSMN3R3-40YS	LFPAK56	40	3.3	100	11.2	49
PSMN4R0-40YS	LFPAK56	40	4.2	100	7	38
PSMN4R5-40PS	TO-220AB	40	4.6	100	8.8	35
PSMN5R8-40YS	LFPAK56	40	5.7	90	7.8	28.8
PSMN8R0-40PS	TO-220AB	40	7.6	77	3.8	17
PSMN8R3-40YS	LFPAK56	40	8.6	70	4.5	20
PSMN2R0-60ES	I2PAK	60	2.2	120	32	137
PSMN2R0-60PS	TO-220AB	60	2.2	120	32	137
PSMN2R5-60PL	TO-220AB	60	2.6	150	41.2	223
PSMN2R6-60PS	TO-220AB	60	2.6	150	43.7	140
PSMN3R0-60ES	I2PAK	60	3	100	28	130
PSMN3R0-60PS	TO-220AB	60	3	100	28	130
PSMN3R3-60PL	TO-220AB	60	3.4	130	31	175
PSMN3R9-60PS	TO-220AB	60	3.9	130	33	103
PSMN4R2-60PL	TO-220AB	60	3.9	130	27	151
PSMN4R6-60PS	TO-220AB	60	4.6	100	14.8	70.8
PSMN5R5-60YS	LFPAK56	60	5.2	100	11.2	56
PSMN7R0-60YS	LFPAK56	60	6.4	89	9.6	45
PSMN7R6-60PS	TO-220AB	60	7.8	92	10.6	38.7
PSMN8R5-60YS	LFPAK56	60	8	76	7.7	39
PSMN3R3-80ES	I2PAK	80	3.3	120	27	139
PSMN3R3-80PS	TO-220AB	80	3.3	120	27	139
PSMN3R5-80ES	I2PAK	80	3.5	120	27	139

Table 2. Extract from NXP Semiconductors Power MOSFETs Selection Guide

Type number	Package name	$V_{DS(max)}$ (V)	$R_{DSon(max)}$ at $V_{GS} = 10\text{ V}$ (m Ω)	$I_{D(max)}$ (A)	Q_{GD} (typical) (nC)	$Q_{G(tot)}$ (typical) (nC)
PSMN3R5-80PS	TO-220AB	80	3.5	120	27	139
PSMN4R3-80ES	I2PAK	80	4.3	120	28	111
PSMN4R3-80PS	TO-220AB	80	4.3	120	28.4	111
PSMN4R4-80PS	TO-220AB	80	4.1	100	25	112
PSMN5R0-80PS	TO-220AB	80	4.7	100	21	87
PSMN6R5-80PS	TO-220AB	80	6.9	100	16	71
PSMN8R2-80YS	LFPAK56	80	8.5	82	12	55
PSMN8R7-80PS	TO-220AB	80	8.7	90	11	52
PSMN4R3-100ES	I2PAK	100	4.3	120	49	170
PSMN4R3-100PS	TO-220AB	100	4.3	120	49	170
PSMN5R0-100ES	I2PAK	100	5	120	49	170
PSMN5R0-100PS	TO-220AB	100	5	120	49	170
PSMN5R6-100PS	TO-220AB	100	5.6	100	43	141
PSMN7R0-100ES	I2PAK	100	6.8	100	36	125
PSMN7R0-100PS	TO-220AB	100	6.8	100	36	125
PSMN8R5-100ES	I2PAK	100	8.5	100	33	111
PSMN8R5-100PS	TO-220AB	100	8.5	100	33	111
PSMN6R3-120ES	I2PAK	120	6.7	70	61.9	207.1
PSMN6R3-120PS	TO-220AB	120	6.7	70	61.9	207.1
PSMN7R8-120ES	I2PAK	120	7.9	70	50.5	167
PSMN7R8-120PS	TO-220AB	120	7.9	70	50.5	167

11. Abbreviations

Table 3. Abbreviations

Acronym	Description
CCM	Continuous Conduction Mode
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
SR	Synchronous Rectifier
UVLO	UnderVoltage LockOut

12. References

- [1] TEA1995T data sheet — *GreenChip dual synchronous rectifier controller*

13. Legal information

13.1 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

13.2 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the *Terms and conditions of commercial sale* of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product

design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Evaluation products — This product is provided on an "as is" and "with all faults" basis for evaluation purposes only. NXP Semiconductors, its affiliates and their suppliers expressly disclaim all warranties, whether express, implied or statutory, including but not limited to the implied warranties of non-infringement, merchantability and fitness for a particular purpose. The entire risk as to the quality, or arising out of the use or performance, of this product remains with customer.

In no event shall NXP Semiconductors, its affiliates or their suppliers be liable to customer for any special, indirect, consequential, punitive or incidental damages (including without limitation damages for loss of business, business interruption, loss of use, loss of data or information, and the like) arising out of the use of or inability to use the product, whether or not based on tort (including negligence), strict liability, breach of contract, breach of warranty or any other theory, even if advised of the possibility of such damages.

Notwithstanding any damages that customer might incur for any reason whatsoever (including without limitation, all damages referenced above and all direct or general damages), the entire liability of NXP Semiconductors, its affiliates and their suppliers and customer's exclusive remedy for all of the foregoing shall be limited to actual damages incurred by customer based on reasonable reliance up to the greater of the amount actually paid by customer for the product or five dollars (US\$5.00). The foregoing limitations, exclusions and disclaimers shall apply to the maximum extent permitted by applicable law, even if any remedy fails of its essential purpose.

Translations — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

13.3 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

GreenChip — is a trademark of NXP Semiconductors N.V.