UM10891

GreenChip TEA1995DB1294 synchronous rectifier controller demo board

Rev. 1 — 16 July 2015 **User manual**

Document information

Info	Content
Keywords	TEA1995T, LLC converter, dual Synchronous Rectifier (SR) driver, SO8, high efficiency, power supply, TEA1995DB1294 demo board
Abstract	This user manual describes how the TEA1995DB1294 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 LFPAK MOSFETs (UM10892).

Revision history

Rev	Date	Description
v.1	20150716	first issue

Contact information

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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 the TEA1995DB1294 demo board. It provides a functional description, supported with instructions on how to connect the board to obtain the best results and performance. The TEA1995DB1294 demo board contains the secondary part of a single output LLC converter, excluding the output capacitors and the feedback control hardware. To use the TEA1995DB1294 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.

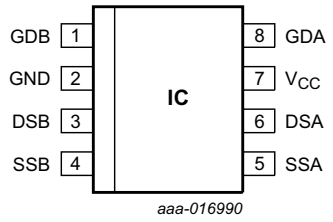


Fig 1. TEA1995T pinning configuration (SO8)

1.1 Features

- Adaptive gate drive for maximum efficiency at any load
- Supply current in no-load operation below 200 μA
- 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.

a. Isolated b. Not isolated

Fig 2. Isolation symbols

3. TEA1995DB1294 photographs

The TEA1995DB1294 demo board consists of the TEA1995T in an SO8 package and two MOSFETs in a TO-220 package with a typical R_{DSon} of 3.0 mΩ. Figure 3 shows the front side and back side of the demo board. The TEA1995DB1294 demo board is a single layer board, with plated-through vias for the V_{out} and MOSFET connections.

a. Front b. Back

Fig 3. TEA1995DB1294 demo board photographs

4. TEA1995DB1294 demo board setup

To ensure that the TEA1995DB1294 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 TEA1995DB1294 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.

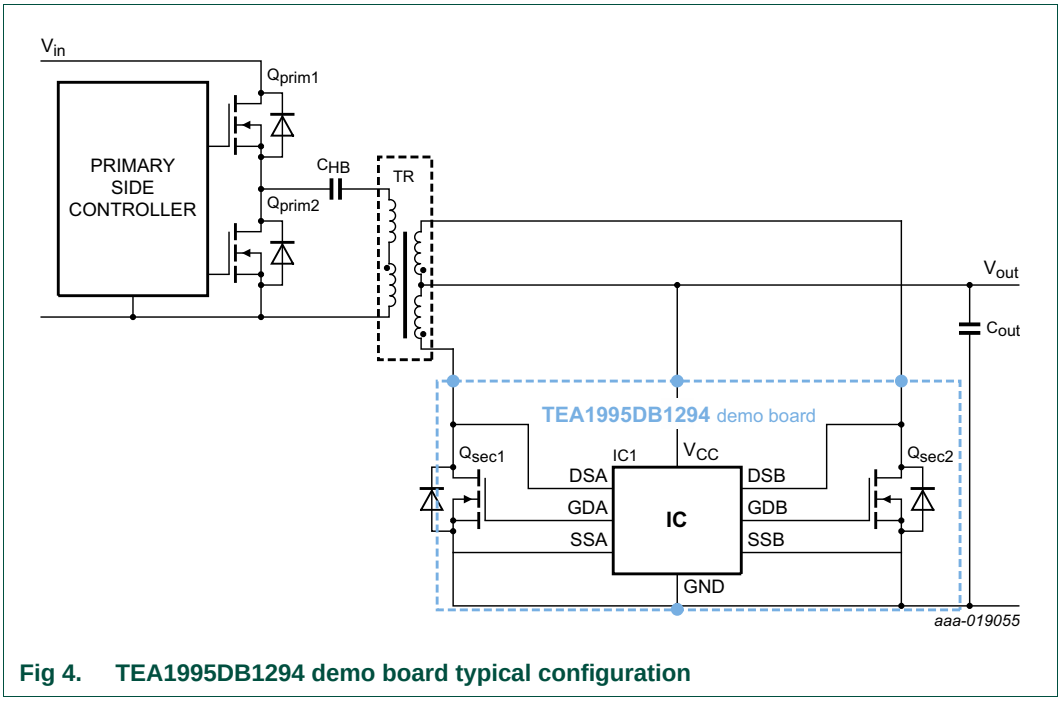


Fig 4. TEA1995DB1294 demo board typical configuration

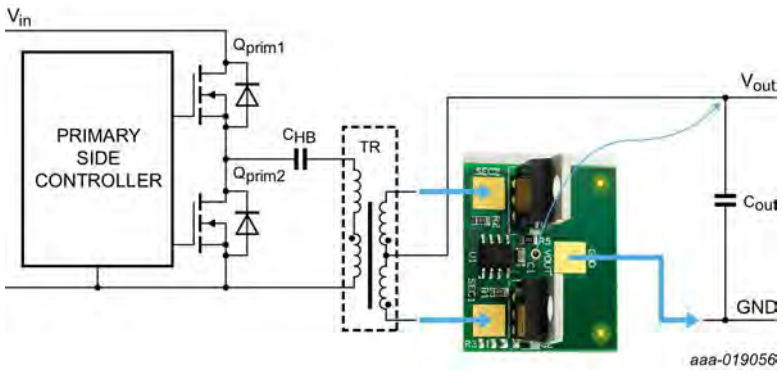


Fig 5. Placement of demo board in existing resonant converter

5. Connecting the TEA1995DB1294 demo board

Figure 6 shows an example of the TEA1995DB1294 demo board used in a typical resonant adapter.

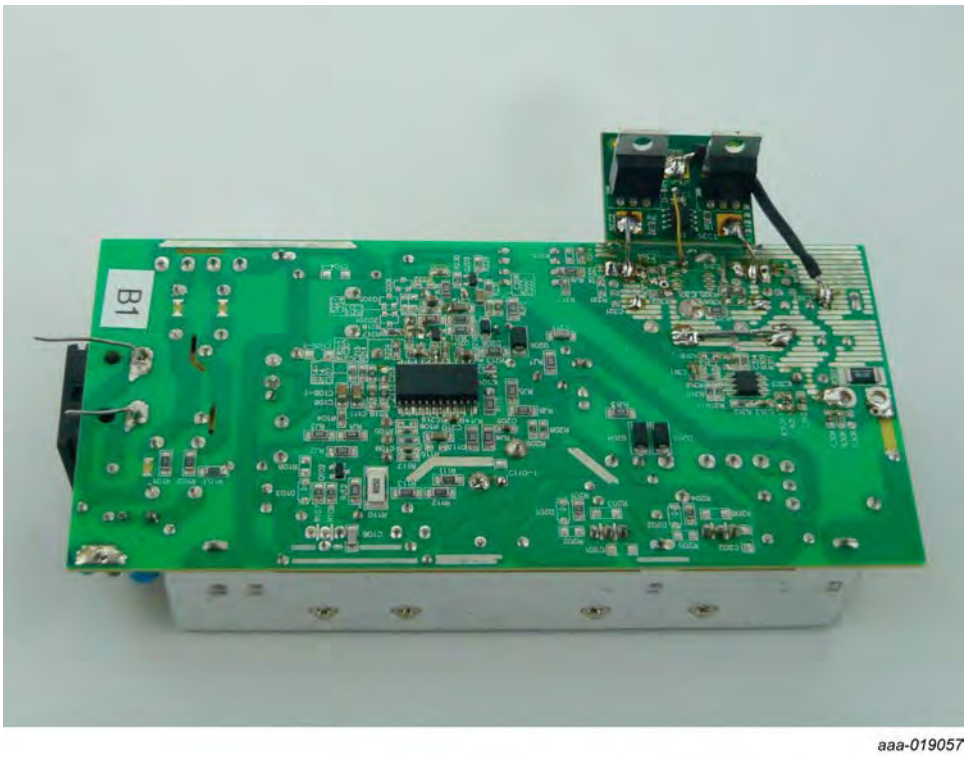


Fig 6. TEA1995DB1294 demo board connected to 150 W resonant adapter board APBADC069

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_{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. 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.

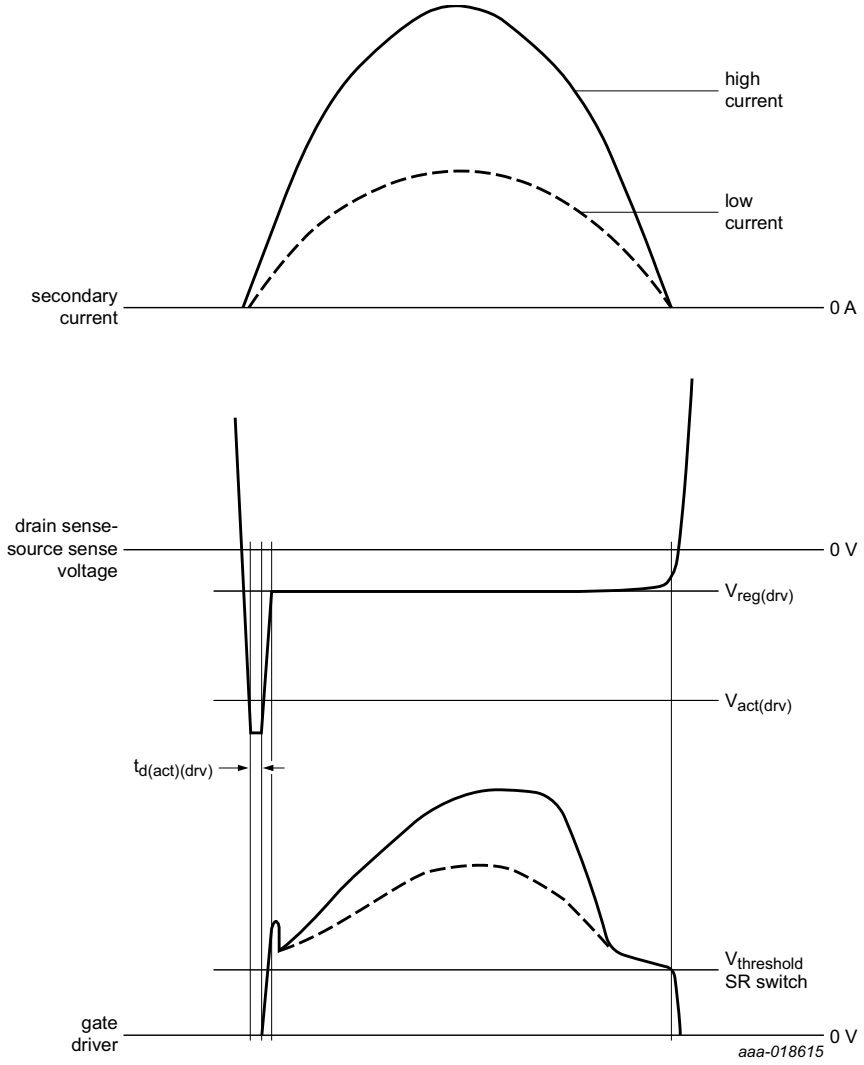


Fig 7. Synchronous rectification signals

7. Schematic

Figure 8 shows the schematic diagram of the TEA1995DB1294 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.

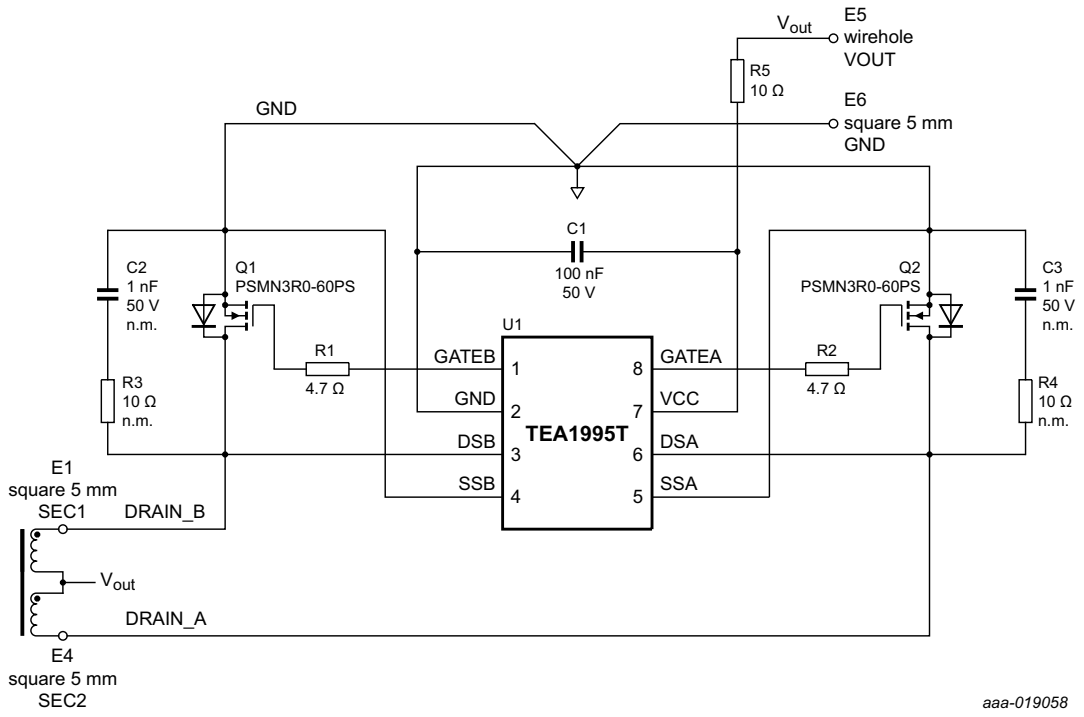


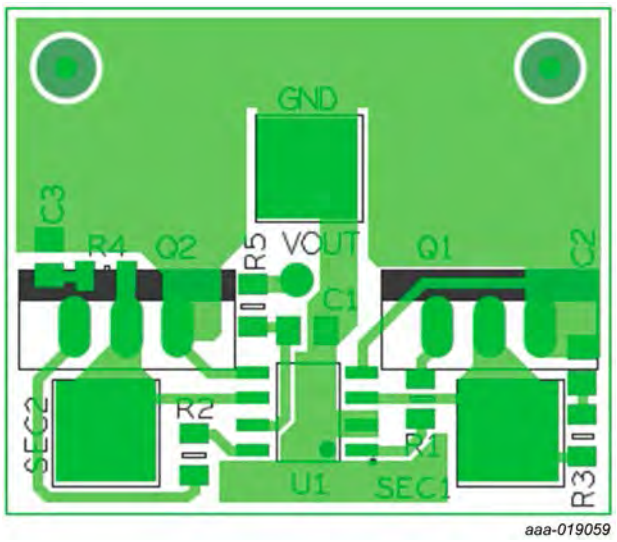
Fig 8. TEA1995DB1294 demo board schematic

8. Bill Of Materials (BOM)

Table 1. TEA1995DB1294 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} = 3.0 mΩ; TO-220	PSMN3R0-60PS	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. TEA1995DB1294 board layout



a. Front

b. Back

Fig 9. TEA1995DB1294 demo board - 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)	$R_{DSon(max)}$ at VGS = 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 VGS = 10 V (mΩ)	$I_{D(max)}$ (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*

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