



TEA1998TS

GreenChip synchronous rectifier controller

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Product data sheet
COMPANY PUBLIC

1 General description

The TEA1998TS is a member of a new generation of Synchronous Rectifier (SR) controller ICs for switched mode power supplies with adaptive gate drive for maximum efficiency at any load.

The TEA1998TS is a dedicated controller IC for synchronous rectification on the secondary side of flyback converters. It incorporates the sensing stage and driver stage for driving the SR MOSFET, which is rectifying the output of the secondary transformer winding.

The TEA1998TS can generate its own supply voltage for battery charging applications with low output voltage or for applications with high-side rectification.

The TEA1998TS is fabricated in a Silicon-On-Insulator (SOI) process.

2 Features and benefits

2.1 Efficiency features

- Adaptive gate drive for maximum efficiency at any load
- Typical supply current in no-load operation below 250 μ A

2.2 Application features

- Operates in an output voltage range between 10 V and 0 V
- Drain sense pin capable of handling input voltages up to 60 V
- Self-supplying for operation with low output voltage
- Self-supplying for high-side rectification without the use of an auxiliary winding
- Operates with standard and logic level SR MOSFETs
- Supports USB BC, QuickCharge and smart charging applications
- TSOP6 package

2.3 Control features

- Adaptive gate drive for fast turn-off at the end of conduction
- UnderVoltage LockOut (UVLO) with active gate pull-down



3 Applications

The TEA1998TS is intended for flyback power supplies. In such applications, it can drive the external synchronous rectifier MOSFET, which replaces the diode for the rectification of the voltage on the secondary winding of the transformer.

It can be used in all power supplies that require a high efficiency, like:

- Chargers
- Adapters
- Flyback power supplies with very low and/or variable output voltage

4 Ordering information

Table 1. Ordering information

| Type number | Package | | |
|-------------|---------|--|---------|
| | Name | Description | Version |
| TEA1998TS | TSOP6 | plastic surface-mounted package; 6 leads | SOT457 |

5 Marking

Table 2. Marking codes

| Type number | Marking code |
|-------------|--------------|
| TEA1998TS/1 | TEA1998 |

6 Block diagram

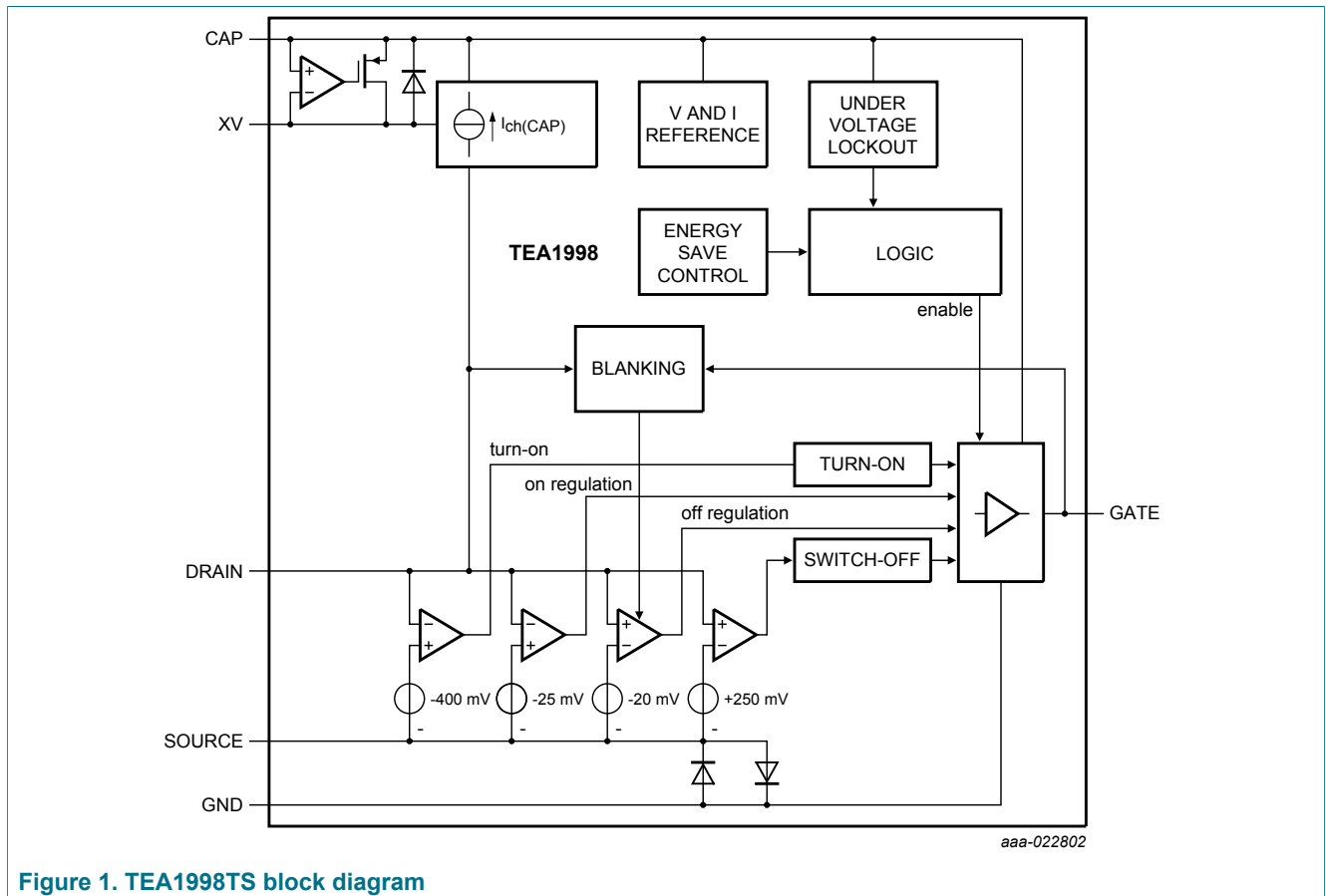


Figure 1. TEA1998TS block diagram

7 Pinning information

7.1 Pinning

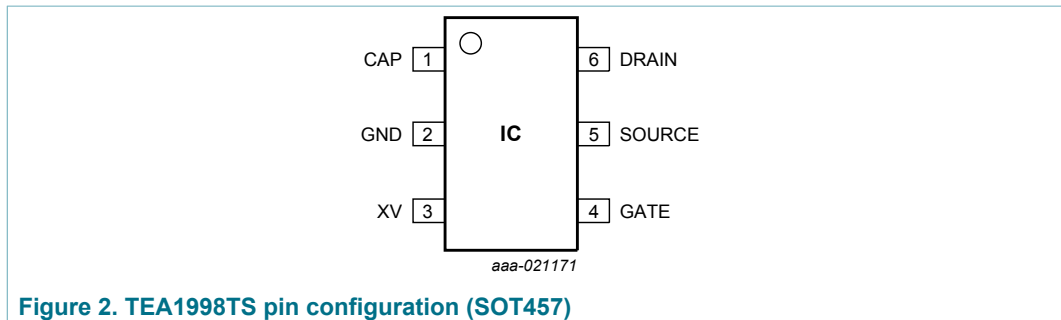


Figure 2. TEA1998TS pin configuration (SOT457)

7.2 Pin description

Table 3. Pin description

| Symbol | Pin | Description |
|--------|-----|---|
| CAP | 1 | capacitor input for internal supply voltage |
| GND | 2 | ground |
| XV | 3 | external supply input |
| GATE | 4 | gate driver output for SR MOSFET |
| SOURCE | 5 | source sense input of SR MOSFET |
| DRAIN | 6 | drain sense input of SR MOSFET |

8 Functional description

8.1 Introduction

The TEA198TS is a controller IC for Synchronous Rectification (SR) in flyback applications. It can drive the external synchronous rectifier MOSFET for the rectification of the voltage on the secondary winding of the transformer. Figure 3 shows a typical configuration.

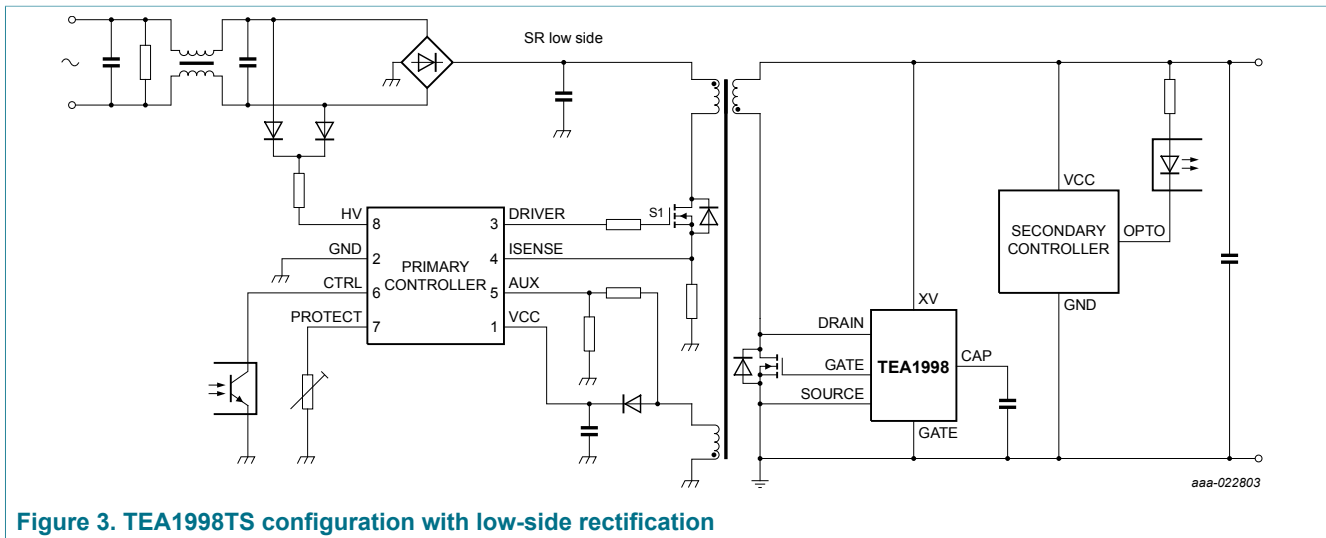


Figure 3. TEA198TS configuration with low-side rectification

8.2 Start-up and UnderVoltage LockOut (UVLO; CAP and XV pins)

The capacitor on the CAP pin supplies the TEA198TS. When the XV voltage < 4.7 V, the capacitor is charged via the DRAIN pin. When the XV voltage ≥ 4.7 V, the capacitor is charged via the XV pin and an internal regulator. The regulator reduces the voltage difference between the XV and CAP pins to a level below 100 mV.

When the voltage on the CAP pin exceeds $V_{start(CAP)}$ (3.7 V typical), the IC leaves the UVLO state and activates the synchronous rectifier circuitry. When the voltage drops below 3.6 V (typical), the UVLO state is reentered and the SR MOSFET gate driver output is actively kept low.

8.3 Drain sense (DRAIN pin)

The drain sense pin is an input pin capable of handling input voltages up to 60 V. At positive drain sense voltages, the gate driver is in off-mode with the gate driver pulled down (pin GATE). At negative drain sense voltages, the IC enables the Synchronous Rectification (SR) by sensing the drain source differential voltage.

8.4 Synchronous rectification (DRAIN and SOURCE pins)

The IC senses the voltage difference between the drain sense (DRAIN pin) and the source sense (SOURCE pin) connections. This drain source differential voltage of the SR MOSFET is used to drive the gate of the SR MOSFET.

When this absolute voltage difference is higher than $V_{act(drv)}$, the corresponding gate driver output turns on the external SR MOSFET. When the external SR MOSFET is switched on, the absolute voltage difference between the drain and the source sense connections drops to below $V_{act(drv)}$. The regulation phase follows the turn-on phase.

In the regulation phase, the IC regulates the difference between the drain and the source sense inputs to an absolute level of 25 mV. When the absolute difference exceeds 25 mV ($V_{reg(drv)}$), the gate driver output increases the gate voltage of the external SR MOSFET until the 25 mV level is reached. The SR MOSFET does not switch off at low current. To avoid that the device switches off because of ringing, a minimum on-time of 1.4 μs ($t_{act(sr)}$ _(min)) is integrated.

When the absolute difference < 20 mV, the gate driver output decreases the gate voltage of the external SR MOSFET. The voltage waveform on the gate of the SR MOSFET follows the waveform of the current through the SR MOSFET. When the current through the SR MOSFET reaches zero, the SR MOSFET is switched off quickly.

After SR MOSFET switch-off, the drain voltage increases. When the drain voltage exceeds 250 mV, a low ohmic gate pull-down of 3 Ω keeps the gate of the SR MOSFET switched off.

8.5 Gate driver (GATE pin)

The gate driver circuit charges the gate of the external SR MOSFET during the rising part of the current. The driver circuit discharges the gate during the falling part of the current. The gate driver has a source capability of typically 0.70 A. It has a sink capability of typically 0.50 A. The source and sink capabilities allow fast turn-on and fast turn-off of the external SR MOSFET.

The maximum output voltage of the driver is limited to the voltage on the CAP pin. The maximum output voltage ranges between 4.7 V and 10 V, depending on the voltage on the CAP pin. The high output gate voltage drives all MOSFET brands to the minimum on-state resistance. In applications where the IC is supplied with 5 V, the maximum output voltage of the driver is 4.90 V and logic level SR MOSFETs can be used.

The IC is self-supplying in applications with high-side rectification or in battery charging applications with an output voltage < 4.7 V. When the XV pin is connected to ground for driving standard SR MOSFETs, the driver is regulated to 10 V. When the XV pin is connected to the converter output for driving logic-level SR MOSFETs, the driver is regulated to the voltage on the XV pin with a minimum of 4.7 V.

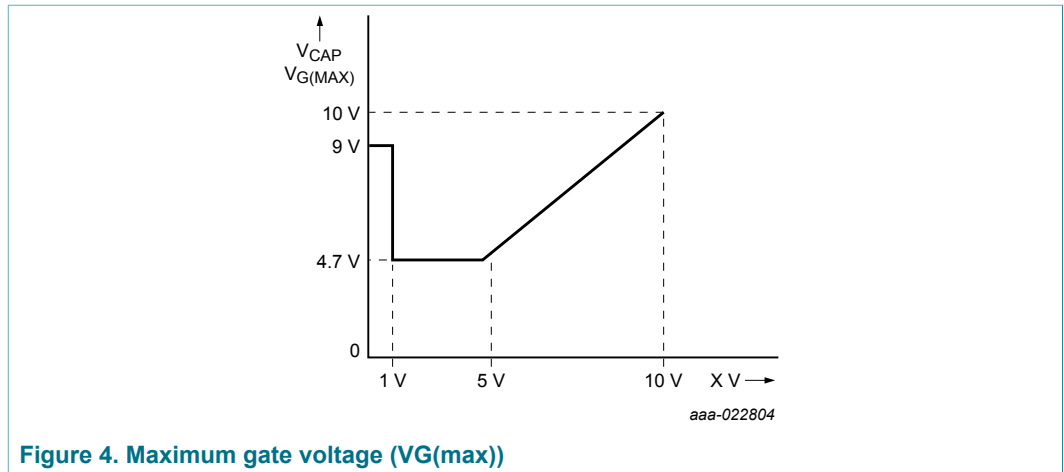


Figure 4. Maximum gate voltage ($V_{G(max)}$)

During start-up conditions ($V_{CAP} < V_{start(CAP)}$) and UVLO, the driver output voltage is actively pulled low.

8.6 Source sense (SOURCE pin)

The IC is equipped with an additional source sense pin (SOURCE). This pin is used for measuring the drain-to-source voltage of the external SR MOSFET. Voltage differences on PCB tracks because of parasitic inductance in combination with large di/dt values, can cause errors. To minimize these errors, the source sense input must be connected as close as possible to the SOURCE pin of the external SR MOSFET.

9 Limiting values

Table 4. Limiting values

| Symbol | Parameter | Conditions | Min | Max | Unit | |
|-------------------------------|---------------------------------|---------------------------------|------|-------|------|---|
| Voltages | | | | | | |
| V_{XV} | voltage on pin XV | | -0.4 | +10.5 | V | |
| $V_{\text{sense(DRAIN)}}$ | sense voltage on pin DRAIN | | -0.8 | +60 | V | |
| $V_{\text{sense(SOURCE)}}$ | sense voltage on pin SOURCE | | -0.4 | +0.4 | V | |
| General | | | | | | |
| P_{tot} | total power dissipation | $T_{\text{amb}} = 90\text{ °C}$ | - | 300 | mW | |
| T_{stg} | storage temperature | | -55 | +150 | °C | |
| T_j | junction temperature | | -40 | +150 | °C | |
| ElectroStatic Discharge (ESD) | | | | | | |
| V_{ESD} | electrostatic discharge voltage | class 2 | | | | |
| | | human body model | [1] | - | 2000 | V |
| | | charged device model | | - | 500 | V |

[1] Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

10 Thermal characteristics

Table 5. Thermal characteristics

| Symbol | Parameter | Conditions | Typ | Unit |
|----------------------|---|------------------|-----|------|
| $R_{\text{th(j-a)}}$ | thermal resistance from junction to ambient | JEDEC test board | 200 | K/W |
| $R_{\text{th(j-c)}}$ | thermal resistance from junction to case | JEDEC test board | 115 | K/W |

11 Characteristics

Table 6. Characteristics

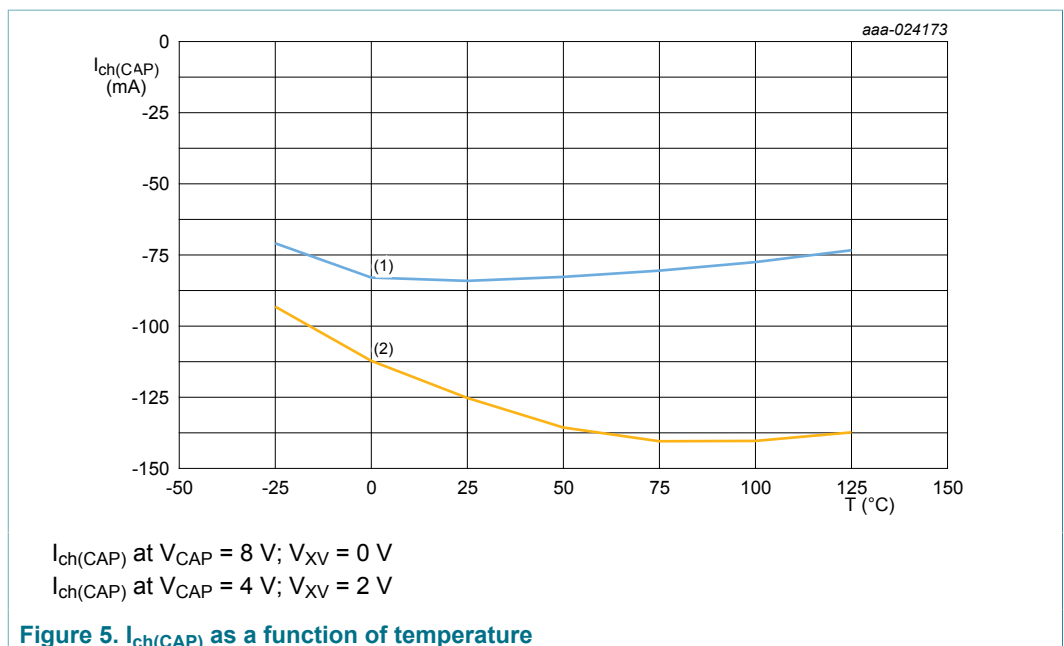
$-25\text{ }^{\circ}\text{C} < T_j < +125\text{ }^{\circ}\text{C}$; $V_{XV} = 5\text{ V}$; $C_{CAP} = 1\text{ }\mu\text{F}$; $C_{GATE} = 10\text{ nF}$ (capacitor between the GATE and the GND pins); all voltages are measured with respect to ground (pin 2); currents are positive when flowing into the IC; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|--------------------------------|--|------|------|------|---------------|
| Supply voltage management (XV and CAP pins) | | | | | | |
| $V_{\text{start(CAP)}}$ | start voltage on pin CAP | $V_{XV} = 0\text{ V}$ | 3.5 | 3.7 | 3.9 | V |
| $V_{\text{stop(CAP)}}$ | stop voltage on pin CAP | $V_{XV} = 0\text{ V}$ | 3.4 | 3.6 | 3.8 | V |
| $I_{\text{ch(CAP)}}$ | charge current on pin CAP | power save operation | | | | |
| | | $V_{XV} = 0\text{ V}$; $V_{CAP} = 8\text{ V}$; $V_{DRAIN} = 12\text{ V}$; $T_j = 25\text{ }^{\circ}\text{C}$ | -95 | -80 | -70 | mA |
| | | $V_{XV} = 2\text{ V}$; $V_{CAP} = 4\text{ V}$; $V_{DRAIN} = 12\text{ V}$; $T_j = 25\text{ }^{\circ}\text{C}$ | -150 | -125 | -100 | mA |
| $V_{I(\text{CAP})}$ | input voltage on pin CAP | $V_{XV} = 0\text{ V}$; $V_{DRAIN} = 12\text{ V}$ | 9.0 | 9.8 | 10.5 | V |
| | | $V_{XV} = 2\text{ V}$; $V_{DRAIN} = 12\text{ V}$ | 4.45 | 4.60 | 4.75 | V |
| | | $V_{XV} = 5\text{ V}$ | 4.8 | 4.9 | 5.0 | V |
| | | $V_{XV} = 10\text{ V}$ | 9.8 | 9.9 | 10.0 | V |
| $I_{I(XV)}$ | input current on pin XV | power save operation; $V_{XV} = 5\text{ V}$ | 190 | 210 | 240 | μA |
| | | normal operation; without gate charge; $V_{XV} = 5\text{ V}$; $T_j = 25\text{ }^{\circ}\text{C}$ | 1.0 | 1.2 | 1.4 | mA |
| $t_{\text{act(pwrsave)}}$ | power-save activation time | | 70 | 100 | 130 | μs |
| Synchronous rectification sense input (DRAIN and SOURCE pins) | | | | | | |
| $V_{\text{act(drv)}}$ | driver activation voltage | $V_{\text{SOURCE}} = 0\text{ V}$ | - | -400 | - | mV |
| $V_{\text{reg(drv)}}$ | driver regulation voltage | $V_{\text{SOURCE}} = 0\text{ V}$; $T_j = 25\text{ }^{\circ}\text{C}$ | -30 | -25 | -20 | mV |
| V_{swoff} | switch-off voltage | $V_{\text{SOURCE}} = 0\text{ V}$ | 180 | 250 | 320 | mV |
| $t_{\text{d(act)(drv)}}$ | driver activation delay time | $V_{\text{SOURCE}} = 0\text{ V}$; normal operation; time for step-on V_{DRAIN} (2 V to -0.5 V) to rising of V_{GATE} at 10 % of end value | - | 40 | - | ns |
| $t_{\text{d(deact)(drv)}}$ | driver deactivation delay time | $V_{\text{SOURCE}} = 0\text{ V}$; normal operation; time for step-on V_{DRAIN} (-50 mV to 2 V) to falling of V_{GATE} at 90 % of begin value | - | 40 | - | ns |

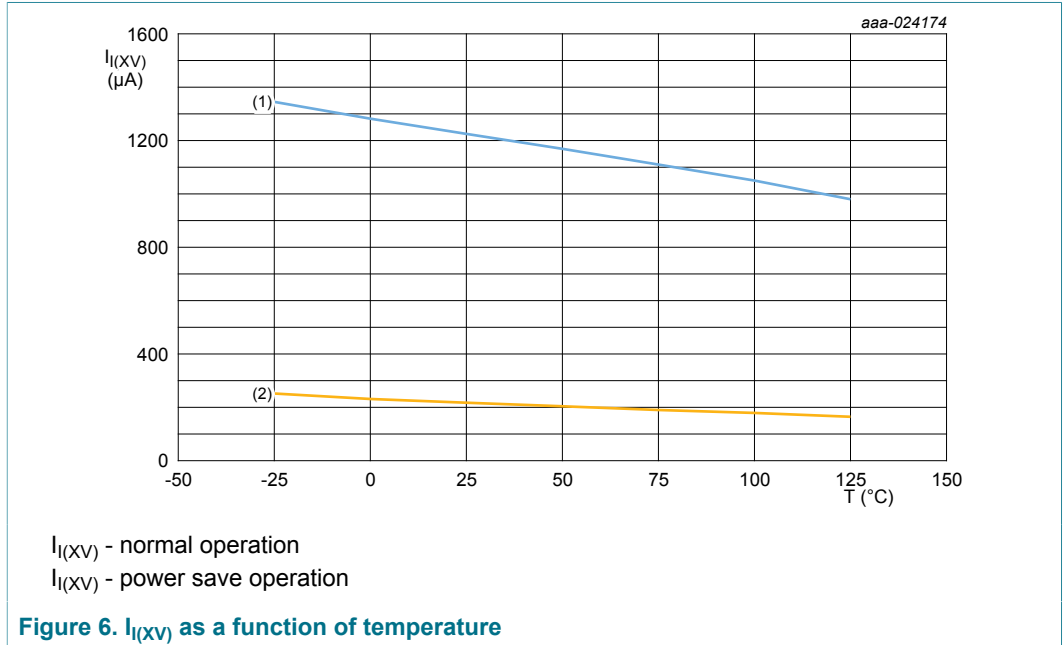
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------|---|--|------|-------|------|----------|
| $t_{act(sr)(min)}$ | minimum synchronous rectification active time | | 1.2 | 1.4 | 1.7 | ns |
| Gate driver (GATE pin) | | | | | | |
| I_{source} | source current | peak current; $V_{XV} = 5\text{ V}$; $V_{ds} = -0.5\text{ V}$; $V_G = 0\text{ V}$ | - | -0.70 | - | A |
| I_{sink} | sink current | regulation current; $V_{XV} = 5\text{ V}$; $V_{ds} = 0\text{ V}$; $V_G = 3\text{ V}$ | - | 100 | - | mA |
| | | peak current; $V_{XV} = 5\text{ V}$; $V_{ds} = 0.5\text{ V}$; $V_G = 4\text{ V}$ | - | 0.50 | - | A |
| $R_{pd(G)}$ | gate pull-down resistance | $V_{DRAIN} = 0.5\text{ V}$; $I_{GATE} = 100\text{ mA}$; $V_{XV} = 5\text{ V}$; $T_j = 25\text{ }^\circ\text{C}$ | 2.6 | 3.2 | 4.0 | Ω |
| $V_{G(max)}$ | maximum gate voltage | $V_{XV} = 0\text{ V}$ | 9.0 | 9.8 | 10.5 | V |
| | | $V_{XV} = 2\text{ V}$ | 4.45 | 4.60 | 4.75 | V |
| | | $V_{XV} = 5\text{ V}$ | 4.8 | 4.9 | 5.0 | V |
| | | $V_{XV} = 10\text{ V}$ | 9.8 | 9.9 | 10.0 | V |

11.1 Temperature curves

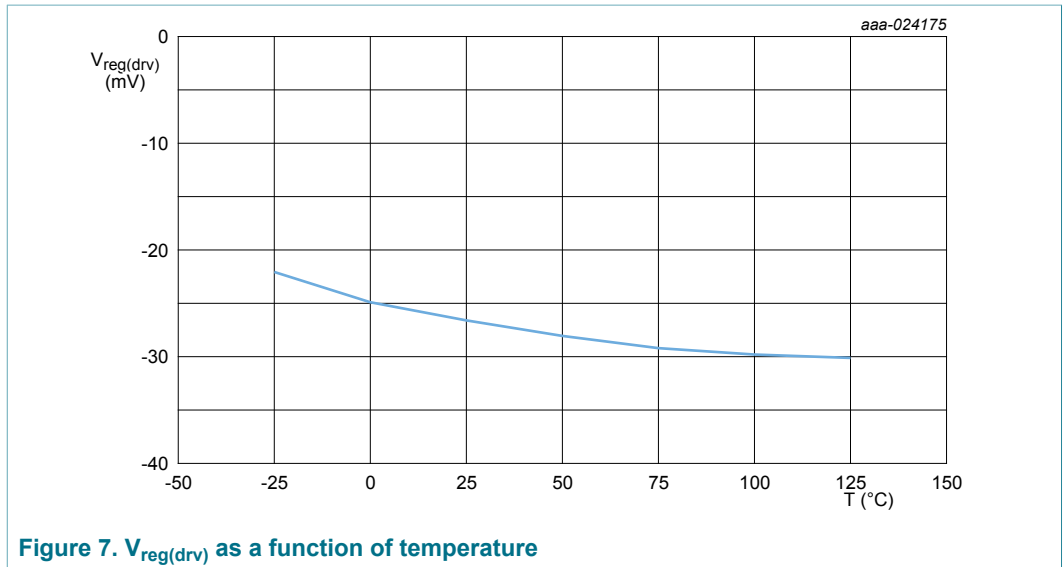
11.1.1 Charge current (CAP pin)



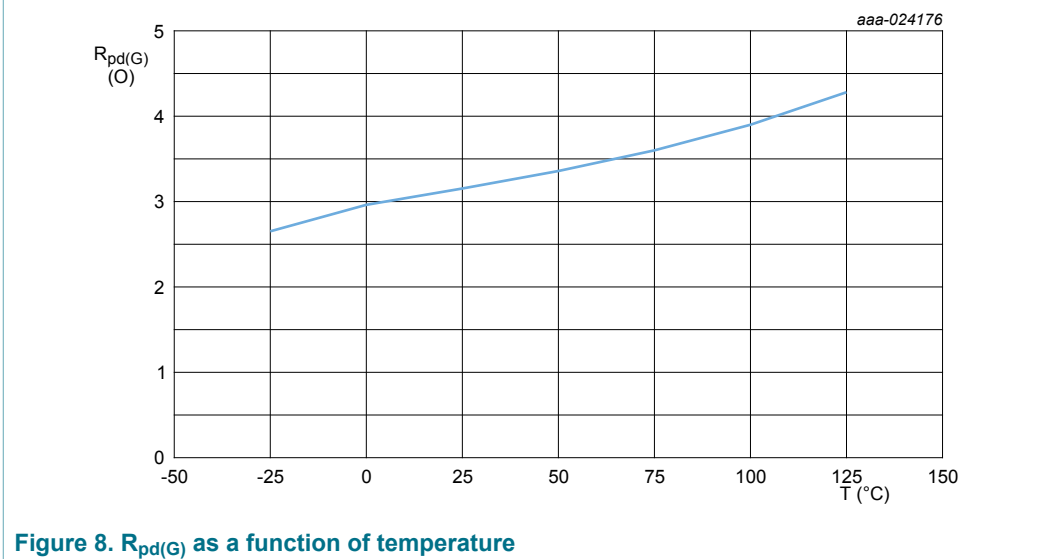
11.1.2 Operating current (XV pin)



11.1.3 Driver regulation voltage



11.1.4 Gate pull-down resistance



12 Application information

A flyback switched mode power supply with the TEA1998TS consists of a primary side controller with a primary switch, a transformer, and an output stage. To obtain low conduction loss rectification, an SR MOSFET is used in the output stage. The SR MOSFET can be placed low-side (see [Figure 3](#)) or can be placed high-side (see [Figure 9](#)). In the high-side application, the TEA1998TS is self-supplying. The capacitor on the CAP pin supplies the TEA1998TS. When the drain voltage is positive, it is charged via the DRAIN pin.

The gate drive voltage for the synchronous rectifier switch is derived from the voltage difference between the corresponding drain sense and source sense pins.

Special attention must be paid to the connection of the drain sense and source sense pins. The voltages measured on these pins are used for the gate drive voltage. Wrong measurement results in a less efficient gate drive because a gate voltage that is either too low or too high. The connections to these pins must not interfere with the power wiring.

The power wiring conducts currents with high di/dt values. It can easily cause measurement errors resulting from induced voltages due to parasitic inductances. The separate source sense pins make it possible to sense the source voltage of the external MOSFETs directly, without having to use the current carrying power ground tracks.

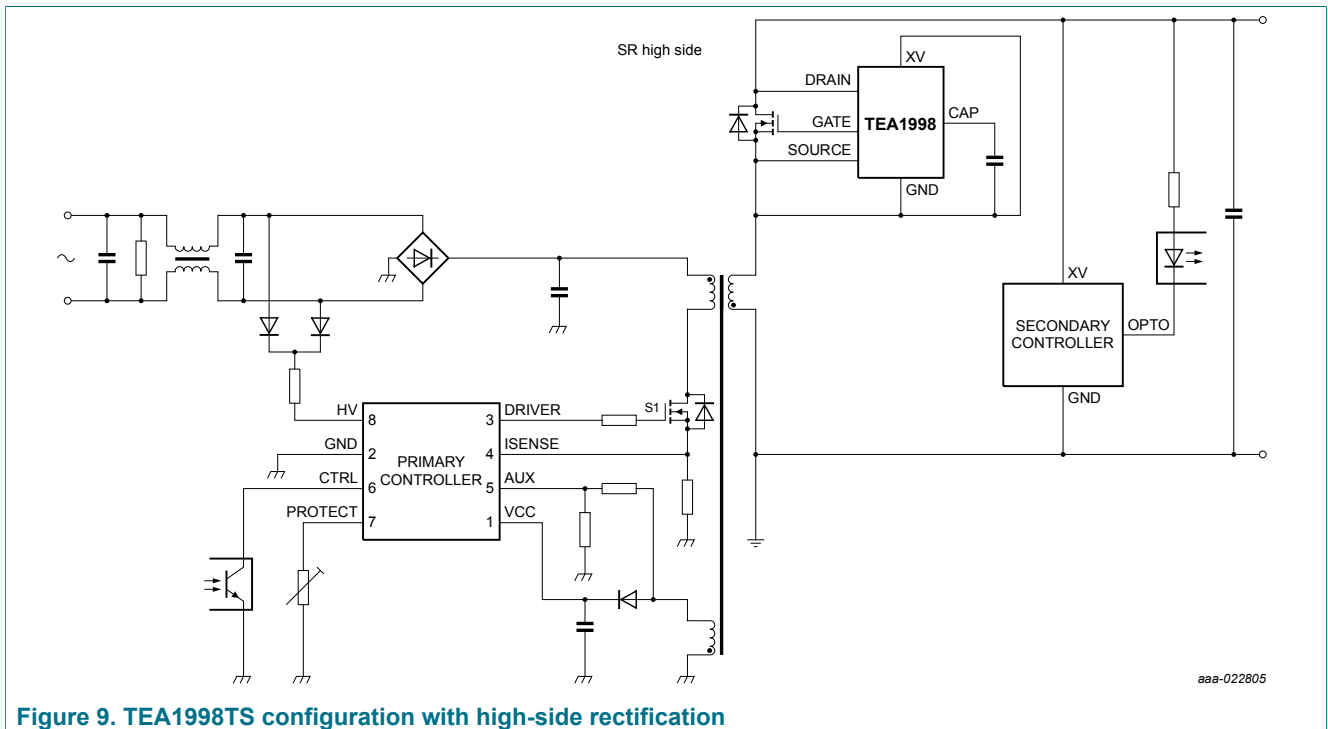


Figure 9. TEA1998TS configuration with high-side rectification

13 Package outline

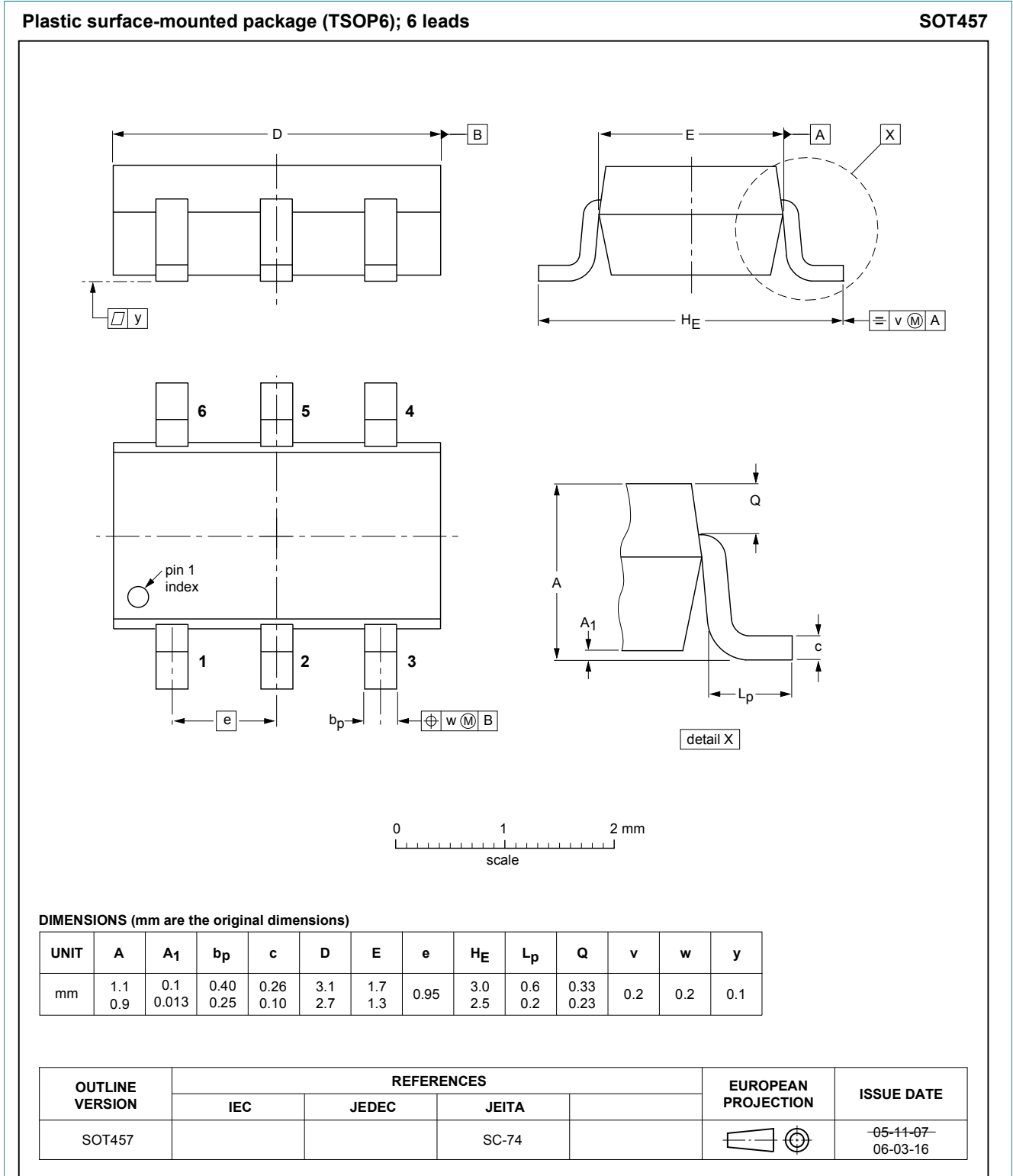


Figure 10. Package outline SOT457 (TSOP6)

14 Revision history

Table 7. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|-------------|--------------|--------------------|---------------|------------|
| TEA1998TS | 20170216 | Product data sheet | - | - |

15 Legal information

15.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
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| Product [short] data sheet | Production | This document contains the product specification. |

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