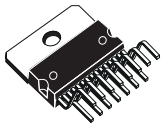
# TDA7293

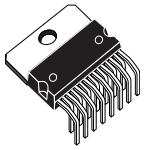
## 120-volt, 100-watt, DMOS audio amplifier with mute and standby

## Features

- Multipower BCD technology
- Very high operating voltage range (±50 V)
- DMOS power stage
- High output power (100 W into 8 Ω @ THD =10%, with $V_S$ = ±40 V)
- Muting and stand-by functions
- No switch on/off noise
- Very low distortion
- Very low noise
- Short-circuit protected (with no input signal applied)
- Thermal shutdown
- Clip detector
- Modularity (several devices can easily be connected in parallel to drive very low impedances)



Multiwatt15V



Multiwatt15H

## Description

The TDA7293 is a monolithic integrated circuit in Multiwatt15 package, intended for use as audio class AB amplifier in Hi-Fi field applications, such as home stereo, self powered loudspeakers and Topclass TV. Thanks to the wide voltage range and to the high output current capability it is able to supply the highest power into both 4-Ω and 8-Ω loads.

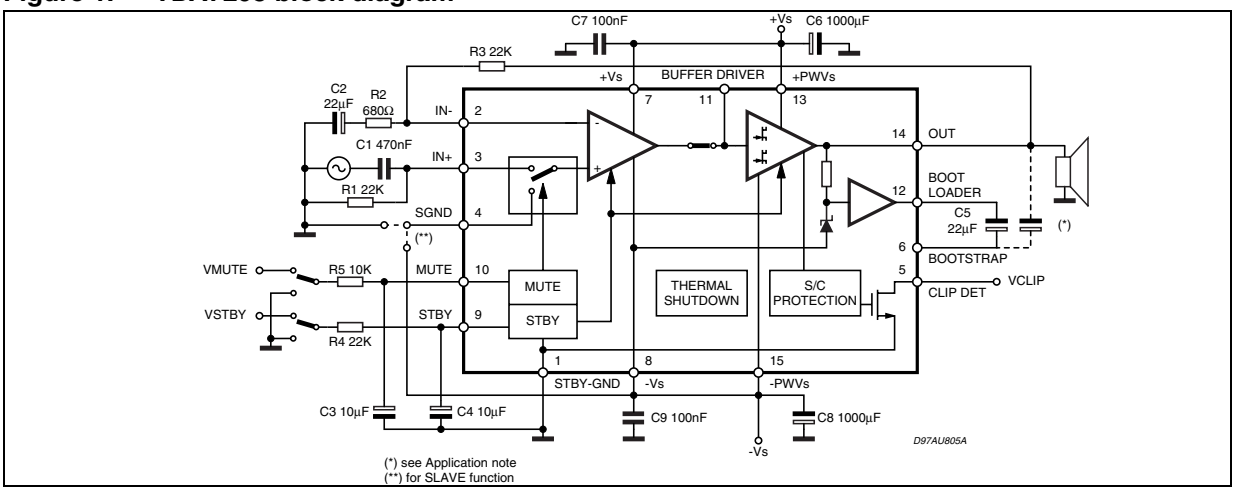
The built-in muting function with turn-on delay simplifies the remote operation avoiding on-off switching noises.

Parallel mode is possible by connecting several devices and using pin11. High output power can be delivered to very low impedance loads, so optimizing the thermal dissipation of the system

**Table 1. Device summary**

| Order code | Package |
|---|---|
| TDA7293V | Multiwatt15V |
| TDA7293HS | Multiwatt15H |

**Figure 1. TDA7293 block diagram**



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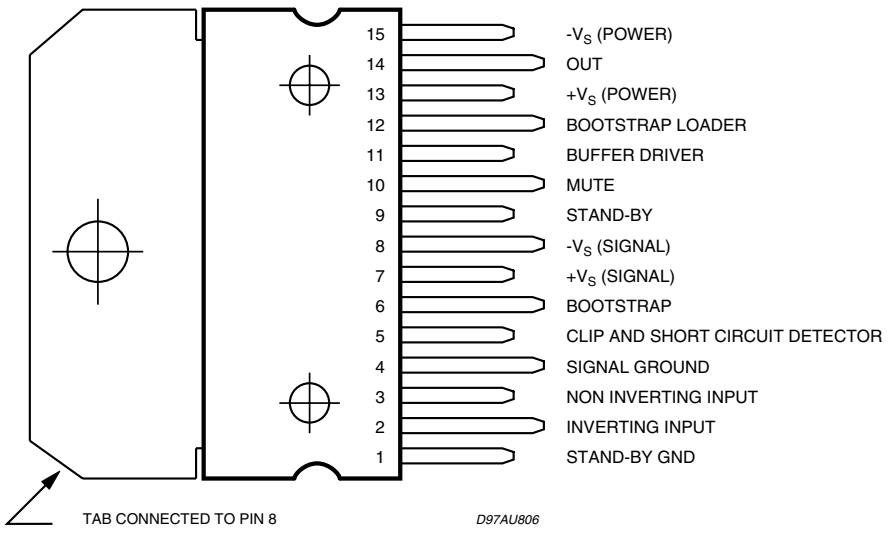
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# 1 Pin connections

**Figure 2. Pin connections**



# 2 Electrical specifications

## 2.1 Absolute maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply voltage (no signal) | ±60 | V |
| $V_1$ | $V_{STANDBY}$ GND voltage referred to $-V_S$ (pin 8) | 90 | V |
| $V_2$ | Input voltage (inverting) referred to $-V_S$ | 90 | V |
| $V_2 - V_3$ | Maximum differential inputs | ±30 | V |
| $V_3$ | Input voltage (non inverting) referred to $-V_S$ | 90 | V |
| $V_4$ | Signal GND voltage referred to $-V_S$ | 90 | V |
| $V_5$ | Clip detector voltage referred to $-V_S$ | 120 | V |
| $V_6$ | Bootstrap voltage referred to $-V_S$ | 120 | V |
| $V_9$ | Standby voltage referred to $-V_S$ | 120 | V |
| $V_{10}$ | Mute voltage referred to $-V_S$ | 120 | V |
| $V_{11}$ | Buffer voltage referred to $-V_S$ | 120 | V |
| $V_{12}$ | Bootstrap loader voltage referred to $-V_S$ | 100 | V |
| $I_O$ | Output peak current | 10 | A |
| $P_{tot}$ | Power dissipation $T_{case}$ = 70°C | 50 | W |
| $T_{op}$ | Operating ambient temperature range | 0 to 70 | °C |
| $T_{stg}$, $T_j$ | Storage and junction temperature | 150 | °C |
| $V_S$ | Supply voltage (no signal) | ±60 | V |
| $V_1$ | $V_{STANDBY}$ GND voltage referred to $-V_S$ (pin 8) | 90 | V |
| $V_{ESD_HBM}$ | ESD maximum withstanding voltage range, test condition CDF-AEC-Q100-002- ”Human body model” | ±1500 | V |

## 2.2 Thermal data

**Table 3. Thermal data**

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| $R_{thj\text{-}case}$ | Thermal resistance junction to case | - | 1 | 1.5 | °C/W |

## 2.3 Electrical characteristics

The specifications given here were obtained with the conditions $V_S$ = ±40 V, $R_L$ = 8 Ω, $R_g$ = 50 Ω, $T_{amb}$ = 25 °C, f = 1 kHz unless otherwise specified.

**Table 4. Electrical characteristics**

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_S$ | Supply range | - | ±12 | - | ±50 | V |
| $I_q$ | Quiescent current | - | - | 50 | 100 | mA |
| $I_b$ | Input bias current | - | - | 0.3 | 1 | µA |
| $V_{OS}$ | Input offset voltage | - | -10 | - | 10 | mV |
| $I_{OS}$ | Input offset current | - | - | - | 0.2 | µA |
| $P_O$ | Continuous output power | d = 1%, $R_L$ = 4 Ω, $V_S$ = ±29 V | 75 | 80<br>80 | - | W |
| | | d = 10%, $R_L$ = 4Ω, $V_S$ = ±29 V | 90 | 100<br>100 | - | W |
| d | Total harmonic distortion (1) | $P_O$ = 5 W, f = 1 kHz | - | 0.005 | - | % |
| | | $P_O$ = 0.1 to 50 W, f = 20 Hz to 15 kHz | - | - | 0.1 | % |
| $I_{SC}$ | Current limiter threshold | $V_S \leq$ ±40 V | - | 6.5 | - | A |
| SR | Slew rate | - | 5 | 10 | - | V/µs |
| $G_V$ | Open loop voltage gain | - | - | 80 | - | dB |
| $G_V$ | Closed loop voltage gain (2) | - | 29 | 30 | 31 | dB |
| $e_N$ | Total input noise | A = curve | - | 1 | - | µV |
| | | f = 20 Hz to 20 kHz | - | 3 | 10 | µV |
| $R_i$ | Input resistance | - | 100 | - | - | kΩ |
| SVR | Supply voltage rejection | f = 100 Hz, $V_{ripple}$ = 0.5 V RMS | - | 75 | - | dB |
| $T_S$ | Thermal protection | Device mutes | - | 150 | - | °C |
| | | Device shuts down | - | 160 | - | °C |
| Standby function (ref. to to pin 1) | | | | | | |
| $V_{ST\ on}$ | Standby on threshold | - | - | - | 1.5 | V |
| $V_{ST\ off}$ | Standby off threshold | - | 3.5 | - | - | V |
| $ATT_{st\text{-}by}$ | Standby attenuation | - | 70 | 90 | - | dB |
| $I_{q\ st\text{-}by}$ | Quiescent current @ standby | - | - | 0.5 | 1 | mA |
| Mute function (ref. to pin 1) | | | | | | |
| $V_{Mon}$ | Mute on threshold | - | - | - | 1.5 | V |
| $V_{Moff}$ | Mute off threshold | - | 3.5 | - | - | V |
| $ATT_{mute}$ | Mute attenuatIon | - | 60 | 80 | - | dB |

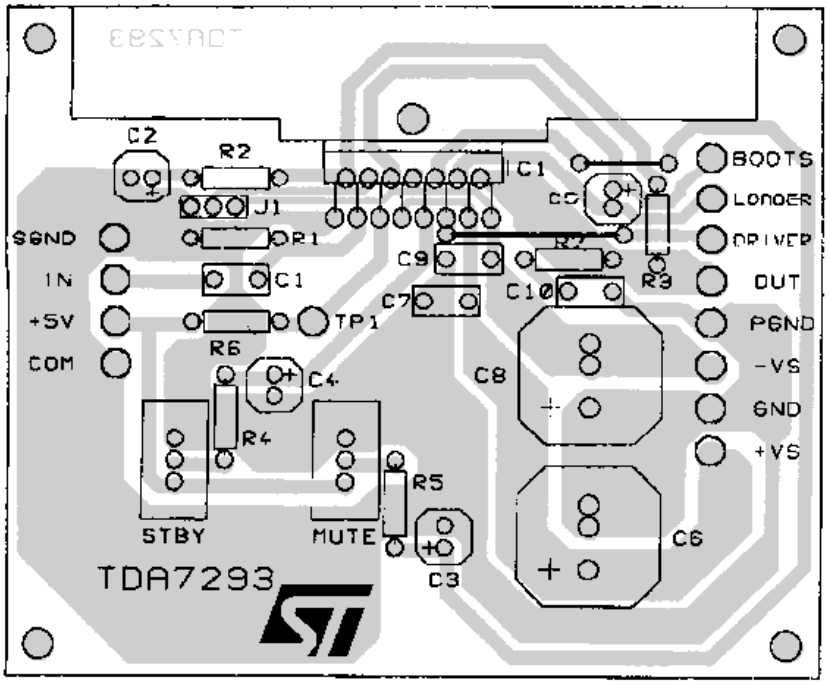
**Table 4. Electrical characteristics (continued)**

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Clip detector | | | | | | |
| Duty | Duty cycle ( pin 5) | d = 1%, $R_{PULLUP}$ = 10 kΩ to 5 V | - | 10 | - | % |
| | | d = 10%, $R_{PULLUP}$ = 10 kΩ to 5 V | 30 | 40 | 50 | % |
| $I_{CLEAK}$ | - | $P_O$ = 50 W | - | - | 3 | µA |
| Slave function pin 4 (ref. to pin 8) | | | | | | |
| $V_{Slave}$ | Slavethreshold | - | - | - | 1 | V |
| $V_{Master}$ | Master threshold | - | 3 | - | - | V |

1. Tested with optimized applications board (see fig. 3)
2. $G_{Vmin} \geq 26dB$

*Note: Pin 11 only for modular connection. Max external load 1 MΩ / 10 pF, only for test purposes*

**Figure 3. Typical application PCB and component layout**



# 3 Circuit description

In consumer electronics, an increasing demand has arisen for very high power monolithic audio amplifiers able to match, with a low cost, the performance obtained from the best discrete designs.

The task of realizing this linear integrated circuit in conventional bipolar technology is made extremely difficult by the occurence of 2nd breakdown phoenomenon. It limits the safe operating area (SOA) of the power devices, and, as a consequence, the maximum attainable output power, especially in presence of highly reactive loads.

Moreover, full exploitation of the SOA translates into a substantial increase in circuit and layout complexity due to the need of sophisticated protection circuits.

To overcome these substantial drawbacks, the use of power MOS devices, which are immune from secondary breakdown is highly desirable.

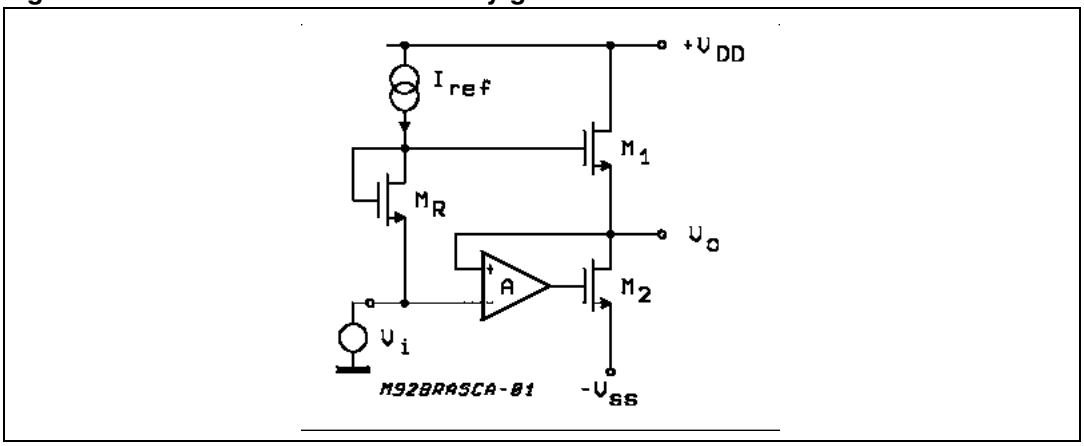
The device described has therefore been developed in a mixed bipolar-MOS high voltage technology called BCDII 100/120.

## 3.1 Output Stage

The main design task in developping a power operational amplifier, independently of the technology used, is that of realization of the output stage.

The solution shown as a principle shematic by Fig6 represents the DMOS unity - gain output buffer of the TDA7293.

**Figure 4. Schematic of a DMOS unity-gain buffer**




This large-signal, high-power buffer must be capable of handling extremely high current and voltage levels while maintaining acceptably low harmonic distortion and good behaviour over frequency response; moreover, an accurate control of quiescent current is required.

A local linearizing feedback, provided by differential amplifier A, is used to fullfil the above requirements, allowing a simple and effective quiescent current setting. Proper biasing of the power output transistors alone is however not enough to guarantee the absence of crossover distortion.

While a linearization of the DC transfer characteristic of the stage is obtained, the dynamic behaviour of the system must be taken into account.

A significant aid in keeping the distortion contributed by the final stage as low as possible is provided by the compensation scheme, which exploits the direct connection of the Miller capacitor at the amplifier's output to introduce a local AC feedback path enclosing the output stage itself.

## 3.2 Protection

In designing a power IC, particular attention must be reserved to the circuits devoted to protection of the device from short circuit or overload conditions. Due to the absence of the 2nd breakdown phenomenon, the SOA of the power DMOS transistors is delimited only by a maximum dissipation curve dependent on the duration of the applied stimulus.

In order to fully exploit the capabilities of the power transistors, the protection scheme implemented in this device combines a conventional SOA protection circuit with a novel local temperature sensing technique which " dynamically" controls the maximum dissipation.

In addition to the overload protection described above, the device features a thermal shutdown circuit which initially puts the device into a muting state (@ $T\varphi$ = 150 °C) and then into stand-by (@ $T_j$ = 160 °C).

Full protection against electrostatic discharges on very pin is included.

## 3.3 Other Features

The device is provided with both standby and mute functions, independently driven by two CMOS logic compatible input pins.

The circuits dedicated to the switching on and off of the amplifier have been carefully optimized to avoid any kind of uncontrolled audible transient at the output.

The sequence that we recommend during the on/off transients is shown in Figure 8. The application of figure 9 shows the possibility of sing only one command for both st-by and mute functions. On both the pins, the maximum applicable range corresponds to the operating supply voltage.

**Figure 5. Suggested turn-on/off sequence**

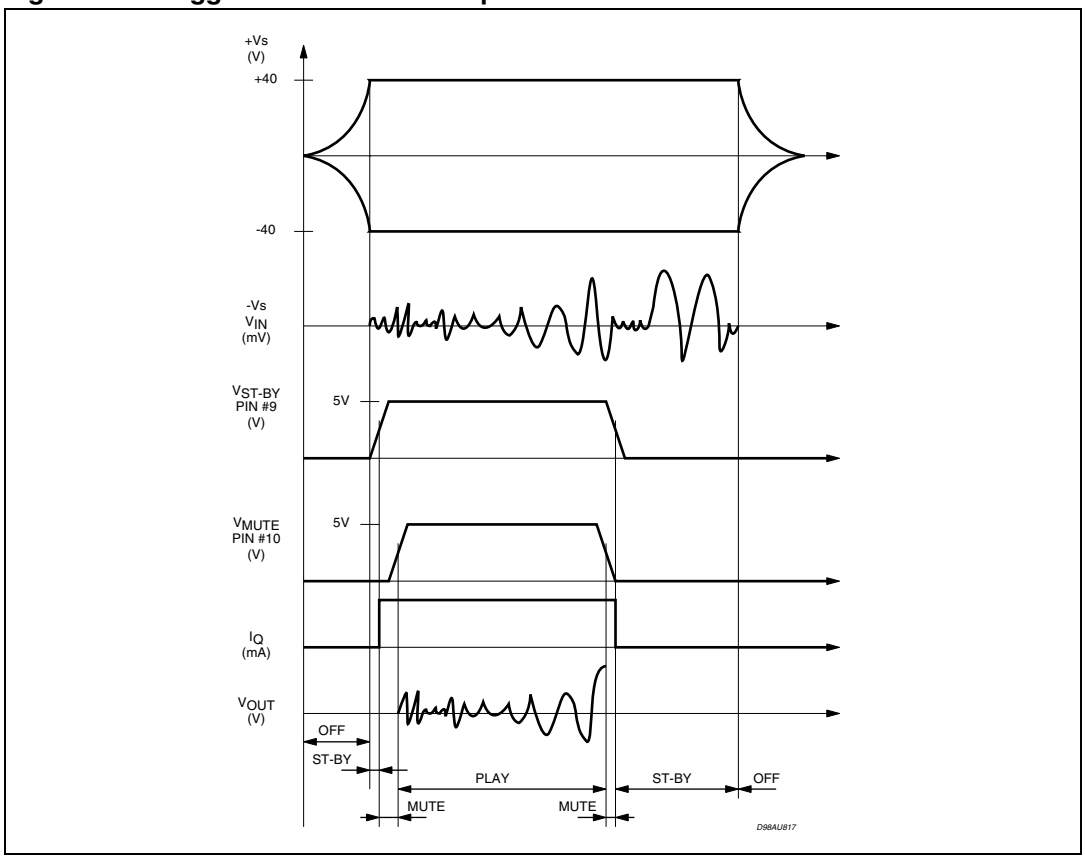
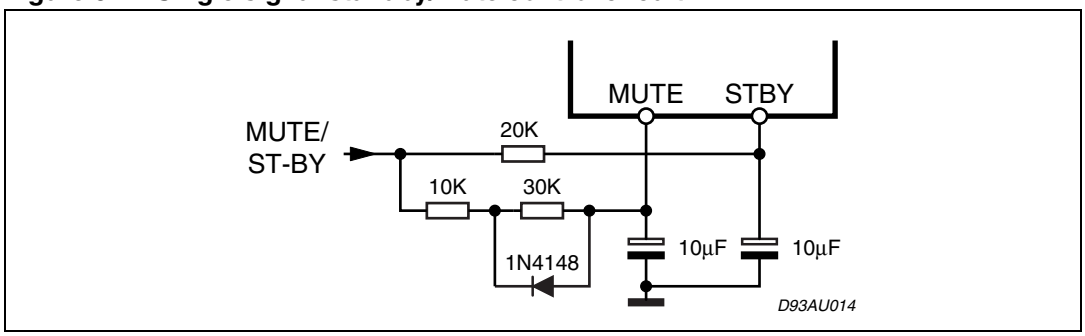



**Figure 6. Single signal standby/mute control circuit**



# 4 Applications information

## 4.1 Applications suggestions

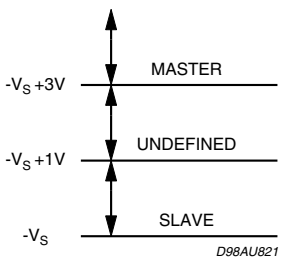
The recommended values of the external components are those shown on the application circuit of *Figure 1 on page 1*. Different values can, however, be used and the following table could be useful when choosing alternative values.

**Table 5. Choosing alternative component values**

| Component | Suggested value | Purpose | Larger than suggested | Smaller than suggested |
|---|---|---|---|---|
| R1 (1) | 22 kΩ | Input resistance | Increase input impedance | Decrease input impedance |
| R2 | 680 Ω | Closed loop gain, set to 30 dB (2) | Decrease of gain | Increase of gain |
| R3 (1) | 22 kΩ | | Increase of gain | Decrease of gain |
| R4 | 22 kΩ | Standby time constant | Larger Standby on/off time | Smaller standby ON/OFF time; pop noise |
| R5 | 10 kΩ | Mute time constant | Larger mute on/off time | Smaller mute on/off time |
| C1 | 0.47 µF | Input DC decoupling | - | Higher low-frequency cutoff |
| C2 | 22 µF | Feedback DC decoupling | - | Higher low-frequency cutoff |
| C3 | 10 µF | Mute time constant | Larger mute on/off time | Smaller mute on/off time |
| C4 | 10 µF | Standby time constant | Larger standby on/off time | Smaller standby on/off time; pop noise |
| C5 | 22 µF (3) x N | Bootstrapping | - | Signal degradation at low frequency |
| C6, C8 | 1000 µF | Supply voltage bypass | - | - |
| C7, C9 | 0.1 µF | Supply voltage bypass | - | Danger of oscillation |

1. R1 = R3 for pop optimization
2. Closed loop gain has to be ³ 26dB
3. Multiply this value by the number, N, of modular parts connected

**Figure 7. Slave function: pin 4 (Ref to pin 8)**




*Note: If in the application the speakers are connected via long wires, it is a good rule to add, between the output and GND, a boucherot cell in order to avoid dangerous spurious oscillations if the speakers terminal are shorted.*
*The suggested boucherot resistor is 3.9Ω/2W and the capacitor is 1µF.*

## 4.2 High efficiency

Constraints of implementing high power solutions are the power dissipation and the size of the power supply. These are both due to the low efficiency of conventional AB class amplifier approaches.

The circuit below in *Figure 8* is a high efficiency amplifier which can be adopted for both hi-fi and car-radio applications. The TDA7293 is a monolithic MOS power amplifier which can be operated with a 100-V supply (120 V with no signal applied) while delivering output currents up to ±6.5 A. This allows the use of this device as a very high-power amplifier (up to 180 W peak power with THD = 10% and $R_L$ = 4 Ω); the only drawback is the power dissipation, hardly manageable in the above power range.

The typical junction-to-case thermal resistance of the TDA7293 is 1 °C/W (max = 1.5 °C/W). In worst case conditions, to avoid the chip temperature exceeding 150 °C the thermal resistance of the heatsink must be 0.038 °C/W (at a maximum ambient temperature of 50 °C).

As the above value is pratically unreachable, a high efficiency system is needed in those cases where the continuous average output power is higher than 50 to 60 W.

The TDA7293 was designed to work also in a higher efficiency way. For this reason there are four power supply pins: two intended for the signal part and two for the power part. T1 and T2 are two power transistors that only operate when the output power reaches a certain threshold (for example, 20 W).

If the output power increases, these transistors are switched on during the portion of the signal where more output voltage swing is needed, thus "bootstrapping" the power supply pins (13 and 15). The current generators formed by T4, T7, zener diodes Z1, Z2 and resistors R7, R8 define the minimum drop across the power MOS transistors of the TDA7293. L1, L2, L3 and the snubbers C9, R1 and C10, R2 stabilize the loops formed by the "bootstrap" circuits and the output stage of the TDA7293.

By considering again a maximum average output power (music signal) of 20 W, in case of the high efficiency application, the thermal resistance value needed from the heatsink is 2.2 °C/W (with $V_S$ = ±50 V and $R_L$ = 8 Ω). All components (TDA7293 and power transistors T1 and T2) can be placed on a 1.5 °C/W heatsink, with the power darlingtons electrically insulated from the heatsink.

Since the total power dissipation is less than that of a usual class AB amplifier, additional cost savings can be obtained while optimizing the power supply, even with a large heatsink.

## 4.3 Bridge application

Another application suggestion is the bridge configuration, where two TDA7293 are used.

In this application, the value of the load must not be lower than 8 Ω for dissipation and current capability reasons.

A suitable field of application includes hi-fi/TV subwoofer realizations. The main advantages offered by this solution are:

- High power performance with limited supply voltage level.
- Considerably higher output power even with high load values, such as 16 Ω.

With $R_L$ = 8 Ω and $V_S$ = ±25 V, the maximum output power obtainable is 150 W, whilst with $R_L$ = 16 Ω and $V_S$ = ±40 V, the maximum Pout is 200 W.

## 4.4 Modular application (ref. figure 12)

The modular application is where several devices operate in parallel.

The modular application allows very high power be delivered to very low-impedance loads. In this type of application one device acts as a master and the others as slaves.

The slave power stages are driven by the master device and work in parallel together while the input and the gain stages of the slave devices are disabled. The figure below shows the connections required to configure two devices to work together.

- The master chip connections are the same as the normal single ones.
- The outputs can be connected together **without the need of any ballast resistor**.
- The slave SGND pin must be tied to the negative supply.
- The slave STANDBY and MUTE pins must be connected to the master STANDBY and MUTE pins.
- The bootstrap lines must be connected together and the bootstrap capacitor must be increased: for N devices the bootstrap capacitor must be 22 µF times N.
- The slave IN pin must be connected to the negative supply.

## 4.5 Bootstrap capacitor

For compatibility purpose with the previous devices of the family, the bootstrap capacitor can be connected either between the bootstrap pin (6) and the output pin (14) or between the bootstrap pin (6) and the bootstrap loader pin (12).

When the bootstrap is connected between pins 6 and 14 the maximum supply voltage in the presence of an output signal is limited to 100 V, due the bootstrap capacitor overvoltage.

When the bootstrap is connected between pins 6 and 12 the maximum supply voltage extends to the full voltage that the technology can stand, in this case 120 V.

This is accomplished by the clamp introduced at the bootstrap loader pin (12). This pin follows the output voltage up to 100 V and remains clamped at 100 V for higher output voltages.

This feature lets the output voltage swing up to a gate-source voltage from the positive supply ($V_S$ -3 to 6 V).

**Figure 8. High-efficiency applications circuit**

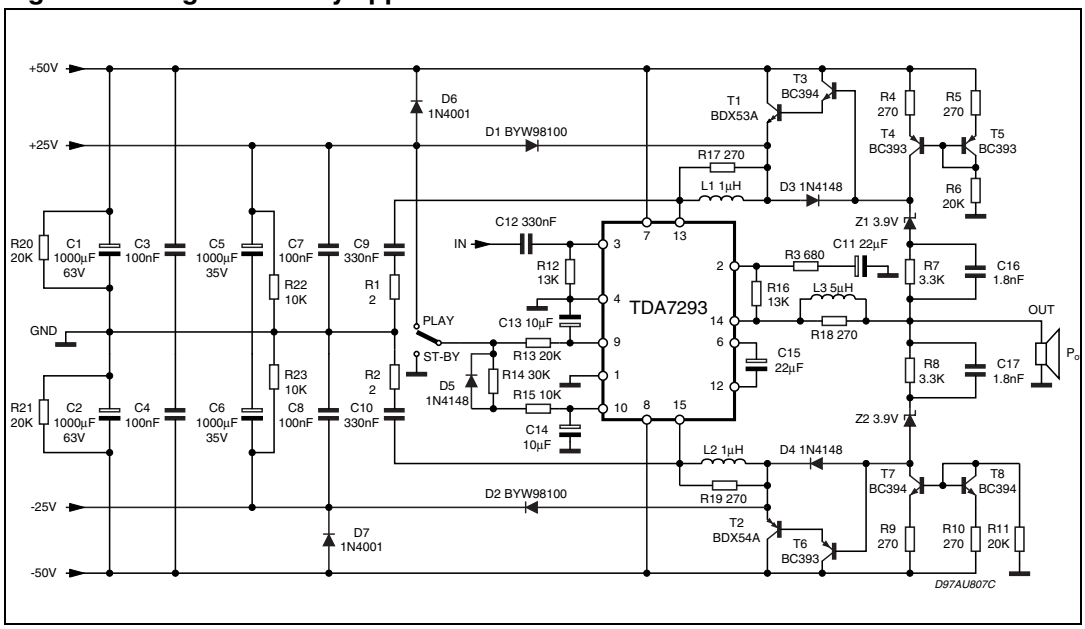



**Figure 9. PCB and component layout of fig. 8**

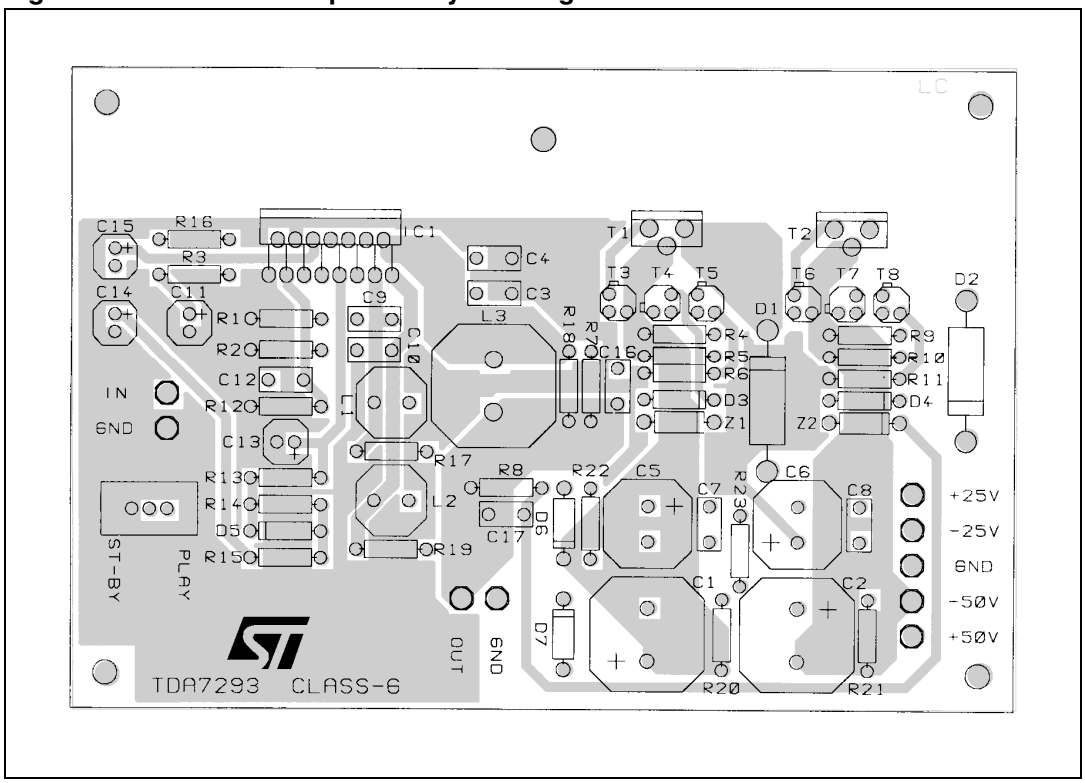


**Figure 10. PCB - solder side of the Fig 9**

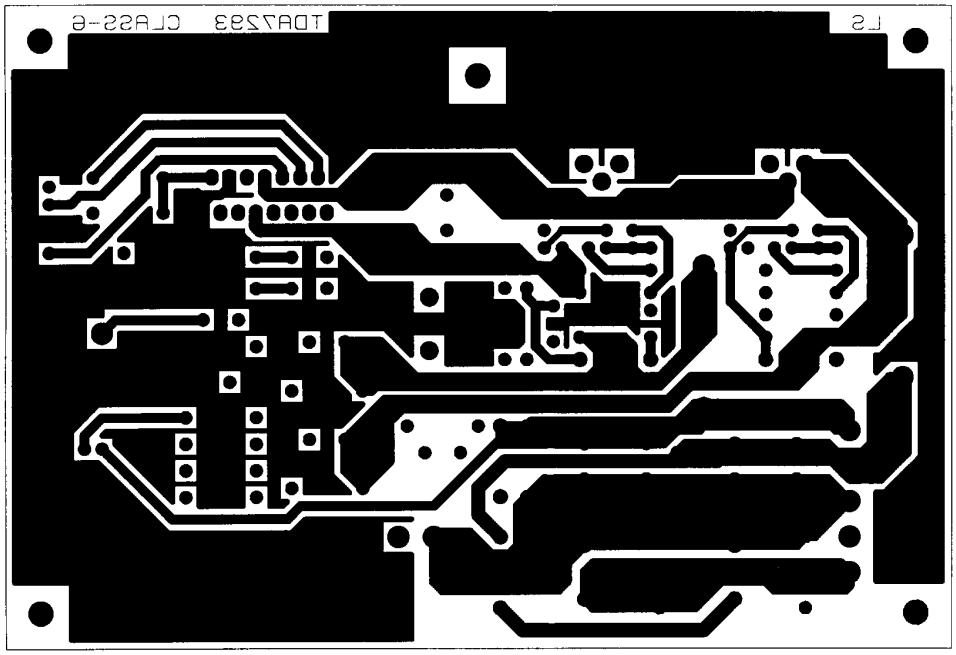


**Figure 11. Modular application circuit**

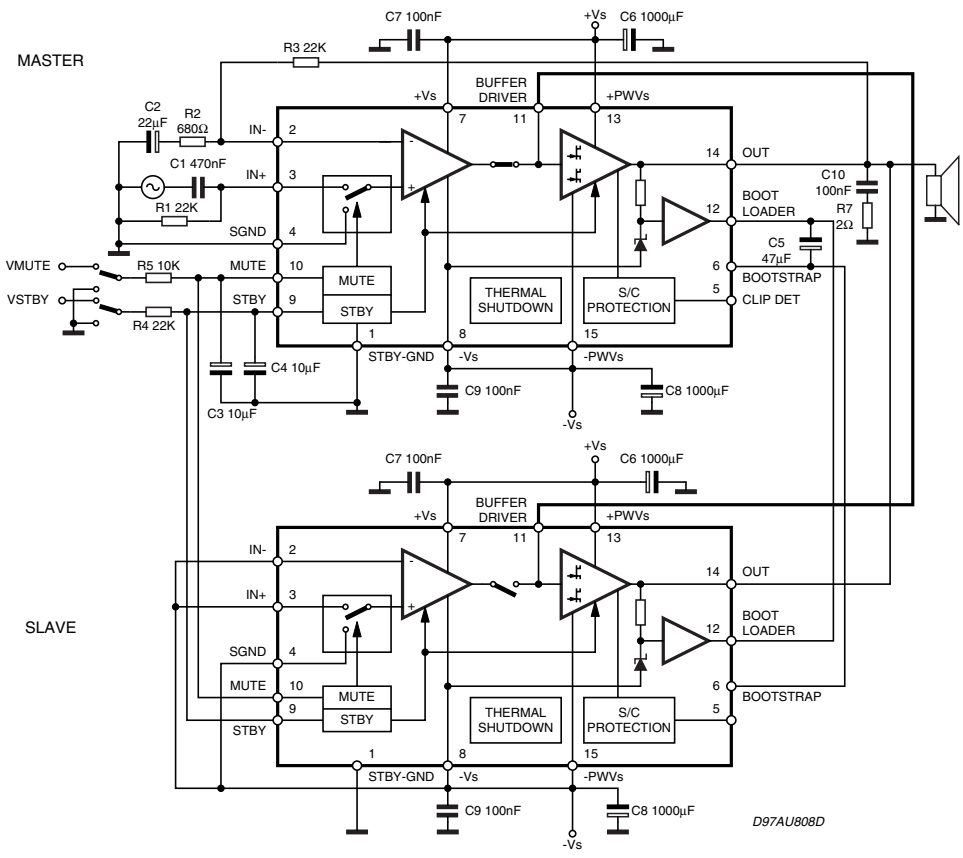


**Figure 12. Modular application PCB and component layout (component side)**

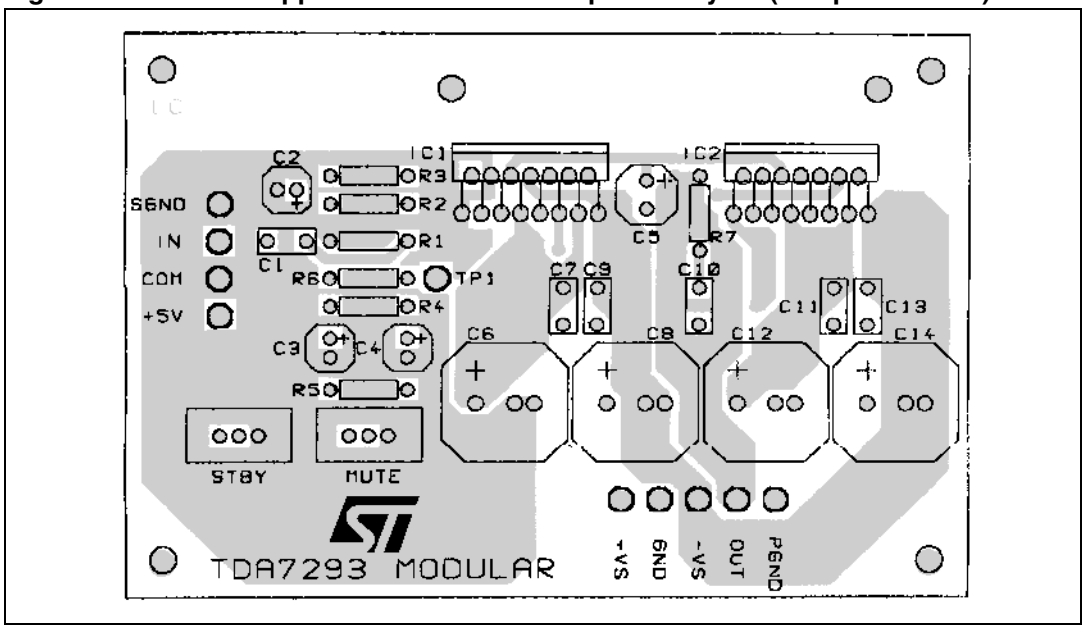



**Figure 13. Modular application PCB and component layout (solder side)**

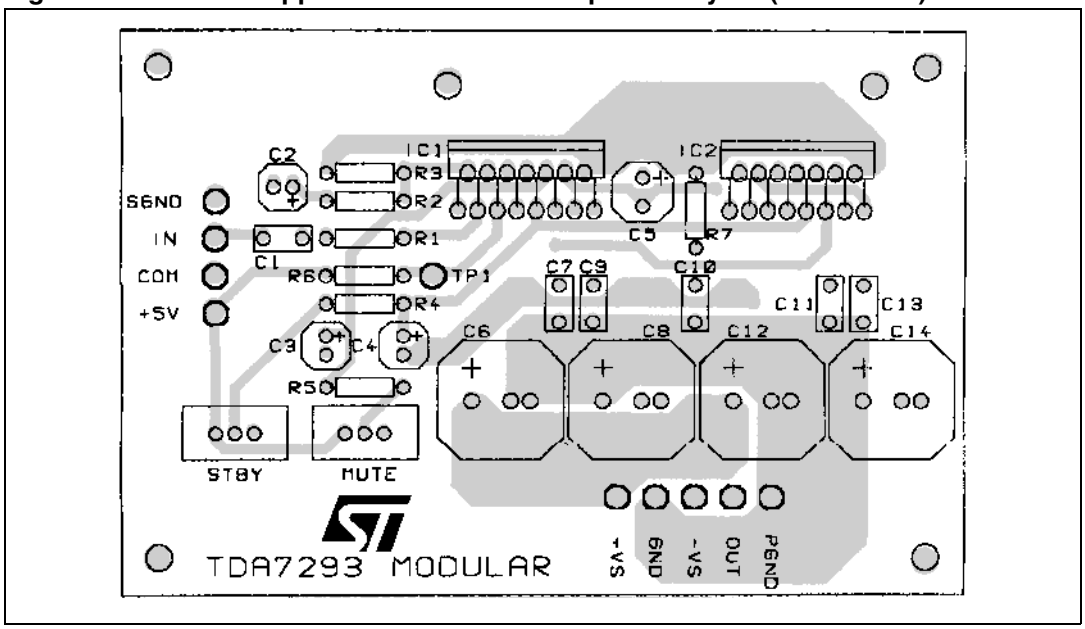


**Figure 14. Distortion vs output power**

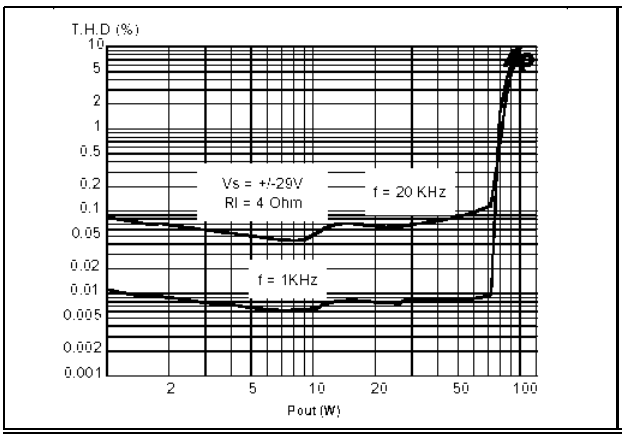



**Figure 15. Distortion vs output power**

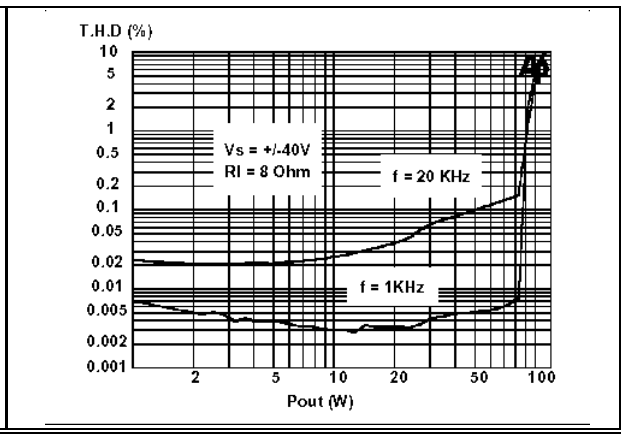



**Figure 16. Distortion vs frequency**

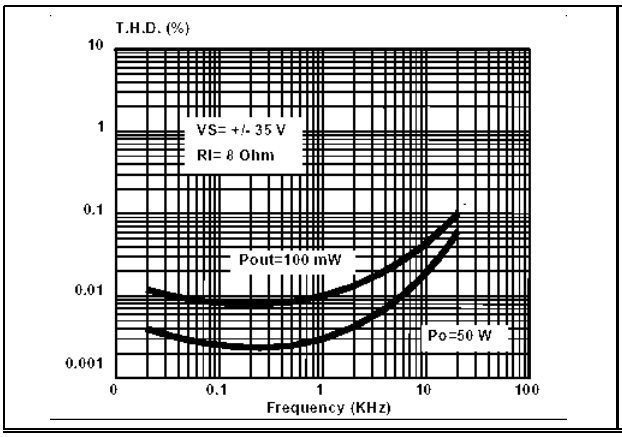



**Figure 17. Modular application derating rload vs voltage supply (ref. fig. 12)**

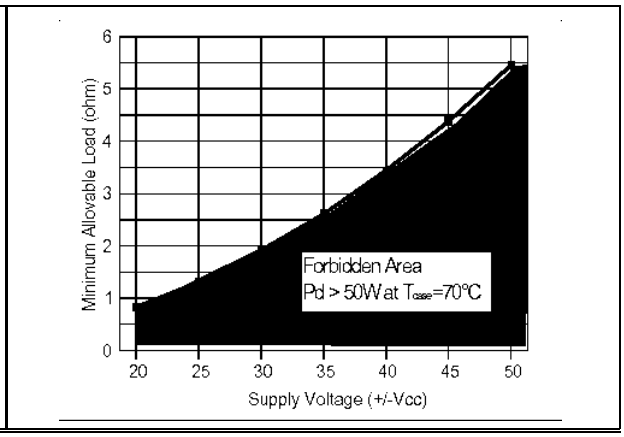



**Figure 18. Modular application Pd vs voltage supply (ref. fig. 12)**

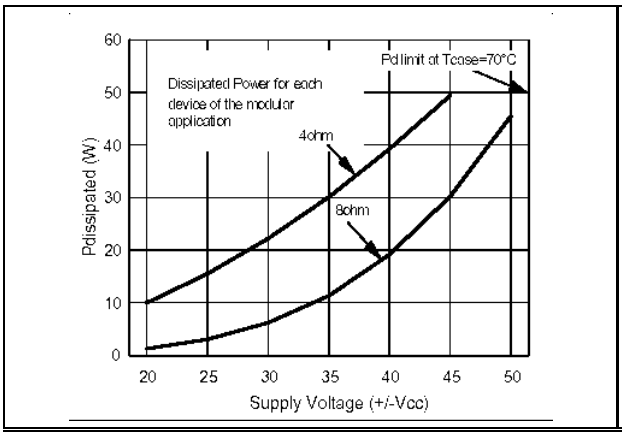
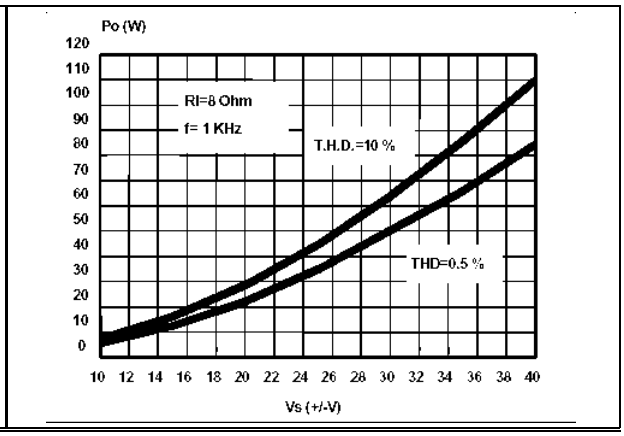



**Figure 19. Output power vs. supply voltage**



# 5 Package mechanical data

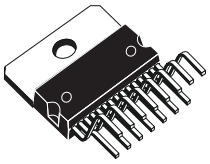
The TDA7293 comes with a choice of two 15-pin packages, Multiwatt15V and Multiwatt15H. The package sizes and outline drawings are given below.

## 5.1 Vertically-mounted package

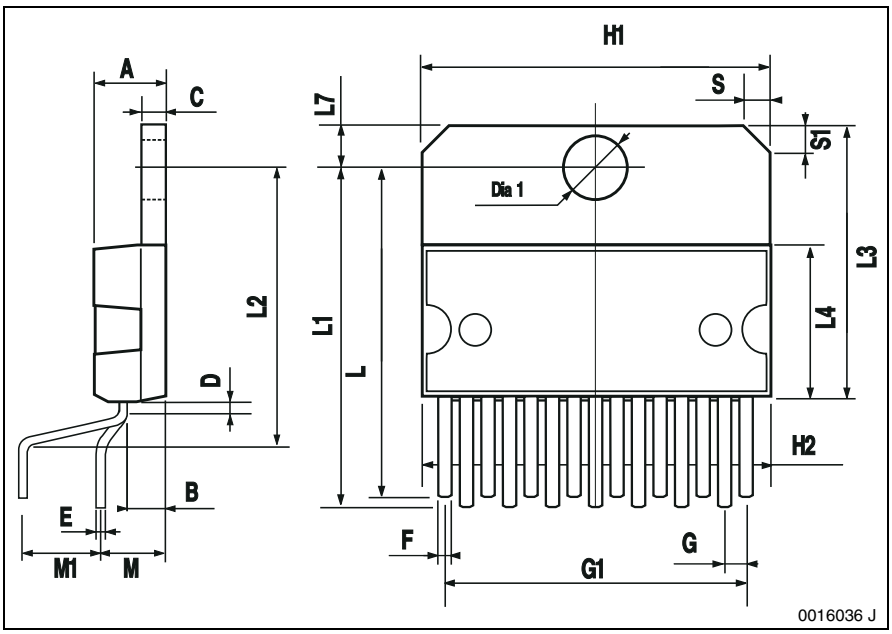
**Figure 20. Multiwatt15V package**

| DIM. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A5 | | | | | | 0.197 |
| B | | | 2.65 | | | 0.104 |
| C | | | 1.6 | | | 0.063 |
| D | | 1 | | | 0.039 | |
| E | 0.49 | | 0.55 | 0.019 | | 0.022 |
| F | 0.66 | | 0.75 | 0.026 | | 0.030 |
| G | 1.02 | 1.27 | 1.52 | 0.040 | 0.050 | 0.060 |
| G1 | 17.53 | 17.78 | 18.03 | 0.690 | 0.700 | 0.710 |
| H1 | 19.6 | | | 0.772 | | |
| H2 | | | 20.2 | | | 0.795 |
| L | 21.9 | 22.2 | 22.5 | 0.862 | 0.874 | 0.886 |
| L1 | 21.7 | 22.1 | 22.5 | 0.854 | 0.87 | 0.886 |
| L2 | 17.65 | | 18.1 | 0.695 | | 0.713 |
| L3 | 17.25 | 17.5 | 17.75 | 0.679 | 0.689 | 0.699 |
| L4 | 10.3 | 10.7 | 10.9 | 0.406 | 0.421 | 0.429 |
| L7 | 2.65 | | 2.9 | 0.104 | | 0.114 |
| M | 4.25 | 4.55 | 4.85 | 0.167 | 0.179 | 0.191 |
| M1 | 4.73 | 5.08 | 5.43 | 0.186 | 0.200 | 0.214 |
| S | 1.9 | | 2.6 | 0.075 | | 0.102 |
| S1 | 1.9 | | 2.6 | 0.075 | | 0.102 |
| Dia1 | 3.65 | | 3.85 | 0.144 | | 0.152 |

**OUTLINE AND MECHANICAL DATA**



**Multiwatt15 (Vertical)**



## 5.2 Horizontally-mounted package

**Figure 21. Multiwatt15H outline**

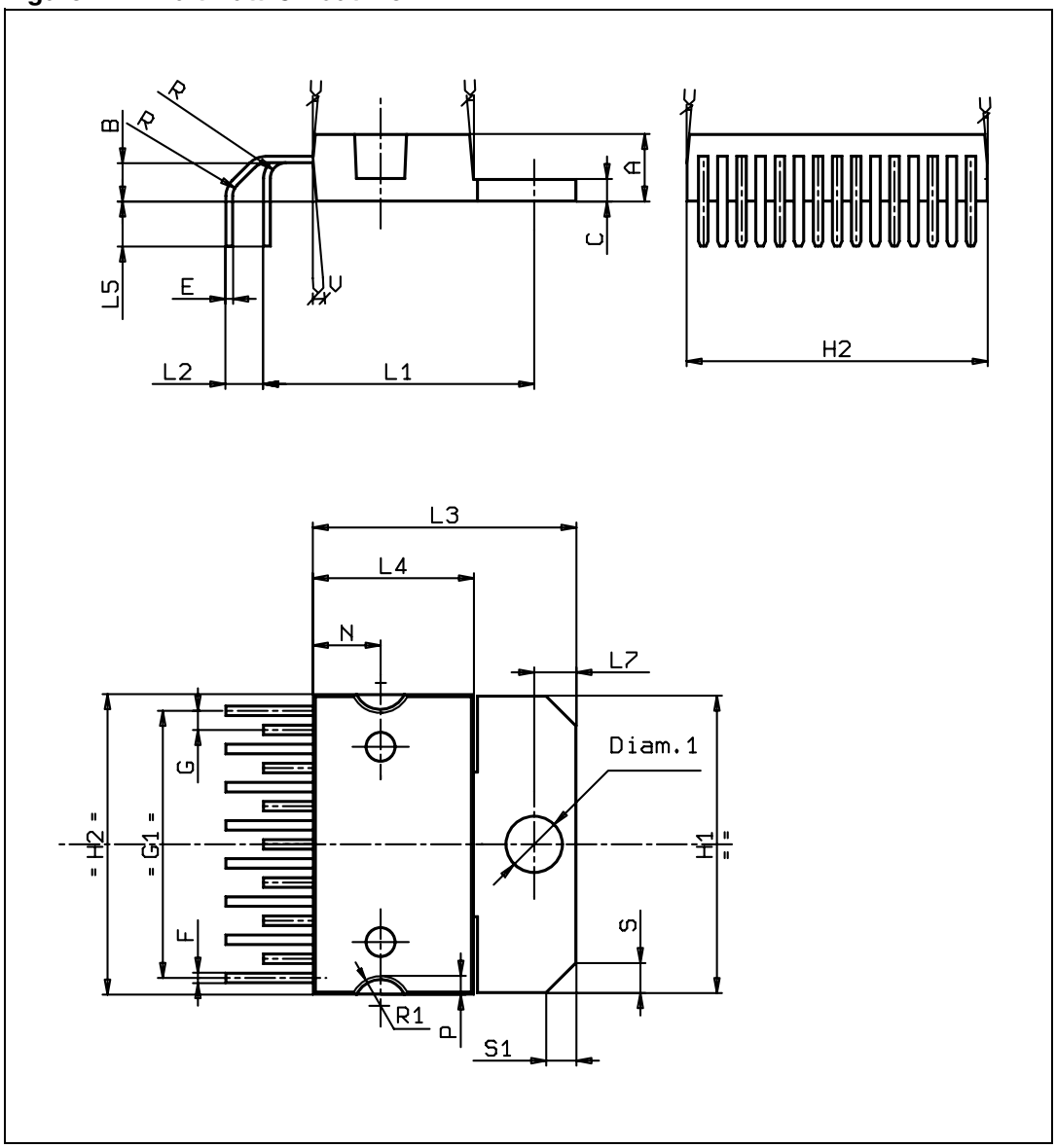


**Table 6. Multiwatt15H dimensions**

| Ref | Dimension in mm | | | Dimension in inch | | | Notes |
|---|---|---|---|---|---|---|---|
| | Min | Typ | Max | Min | Typ | Max | |
| A | - | - | 5.00 | - | - | 0.197 | - |
| B | - | - | 2.65 | - | - | 0.104 | - |
| C | - | - | 1.60 | - | - | 0.063 | - |
| E | 0.49 | - | 0.55 | 0.019 | - | 0.022 | - |
| F | 0.66 | - | 0.75 | 0.026 | - | 0.030 | - |
| G | 1.02 | 1.27 | 1.52 | 0.040 | 0.050 | 0.060 | - |
| G1 | 17.53 | 17.78 | 18.03 | 0.690 | 0.700 | 0.710 | - |
| H1 | 19.60 | - | 20.20 | 0.772 | - | 0.795 | - |
| H2 | 19.60 | - | 20.20 | 0.772 | - | 0.795 | - |
| L1 | 17.80 | 18.00 | 18.20 | 0.701 | 0.709 | 0.717 | - |
| L2 | 2.30 | 2.50 | 2.80 | 0.091 | 0.098 | 0.110 | - |
| L3 | 17.25 | 17.50 | 17.75 | 0.679 | 0.689 | 0.699 | - |
| L4 | 10.30 | 10.70 | 10.90 | 0.406 | 0.421 | 0.429 | - |
| L5 | 2.70 | 3.00 | 3.30 | 0.106 | 0.118 | 0.130 | - |
| L7 | 2.65 | - | 2.90 | 0.104 | - | 0.114 | - |
| N | - | - | - | - | - | - | - |
| P | - | - | - | - | - | - | - |
| R | - | 1.50 | - | - | 0.059 | - | - |
| R1 | - | - | - | - | - | - | - |
| S | 1.90 | - | 2.60 | 0.075 | - | 0.102 | - |
| S1 | 1.90 | - | 2.60 | 0.075 | - | 0.102 | - |
| V | - | - | - | - | - | - | - |
| Diam.1 | 3.65 | - | 3.85 | 0.144 | - | 0.152 | - |

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# 6 Revision history

Table 7. Document revision history

| Date | Revision | Changes |
|---|---|---|
| Jan-2004 | 7 | First Issue in EDOCS |
| Aug-2004 | 7.1 | Stylesheet update. No content change |
| 24-Sep-2010 | 8 | Updated package dimensions for Multiwatt15H in *Table 6 on page 19*<br>Updated presentation throughout document. |

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