

## 70V - 60W DMOS AUDIO AMPLIFIER WITH MUTE/ST-BY

### 1 FEATURES

- MULTIPOWER BCD TECHNOLOGY
- VERY HIGH OPERATING VOLTAGE RANGE ( $\pm 35V$ )
- DMOS POWER STAGE
- HIGH OUTPUT POWER (UP TO 60W MUSIC POWER)
- MUTING/STAND-BY FUNCTIONS
- NO SWITCH ON/OFF NOISE
- NO BOUCHEROT CELLS
- VERY LOW DISTORTION
- VERY LOW NOISE
- SHORT CIRCUIT PROTECTION
- THERMAL SHUTDOWN

### 2 DESCRIPTION

The TDA7296 is a monolithic integrated circuit in Multiwatt15 package, intended for use as audio class AB amplifier in Hi-Fi field applications (Home Stereo, self powered loudspeakers, Topclass TV).

Figure 1. Package

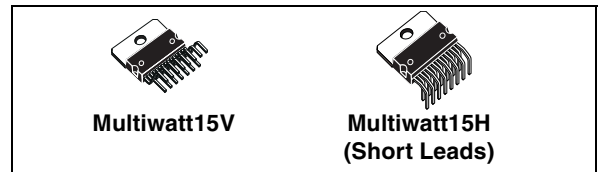


Table 1. Order Codes

| Part Number | Package                    |
|-------------|----------------------------|
| TDA7296     | Multiwatt15V               |
| TDA7296HS   | Multiwatt15H (Short Leads) |

Thanks to the wide voltage range and to the high out current capability it is able to supply the highest power into both 4 $\Omega$  and 8 $\Omega$  loads even in presence of poor supply regulation, with high Supply Voltage Rejection.

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

Figure 2. Typical Application and Test Circuit

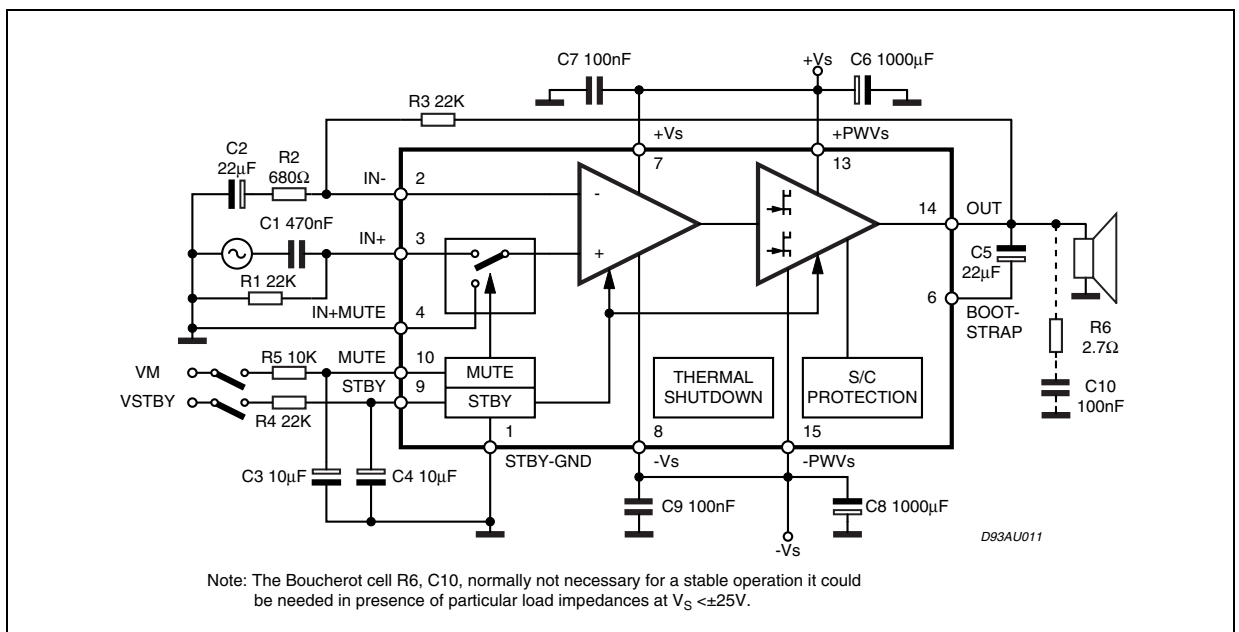


Figure 3. Pin Connection

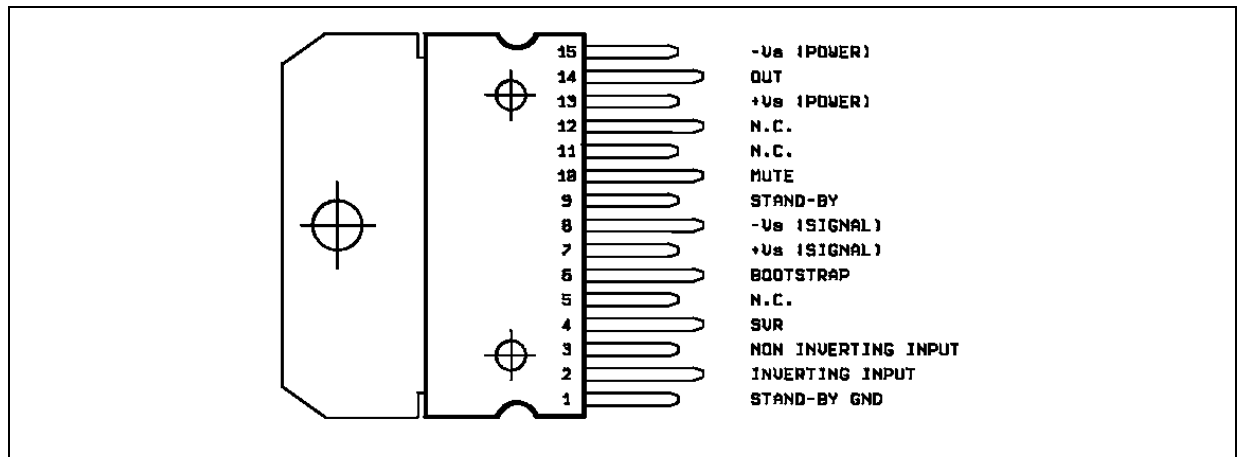


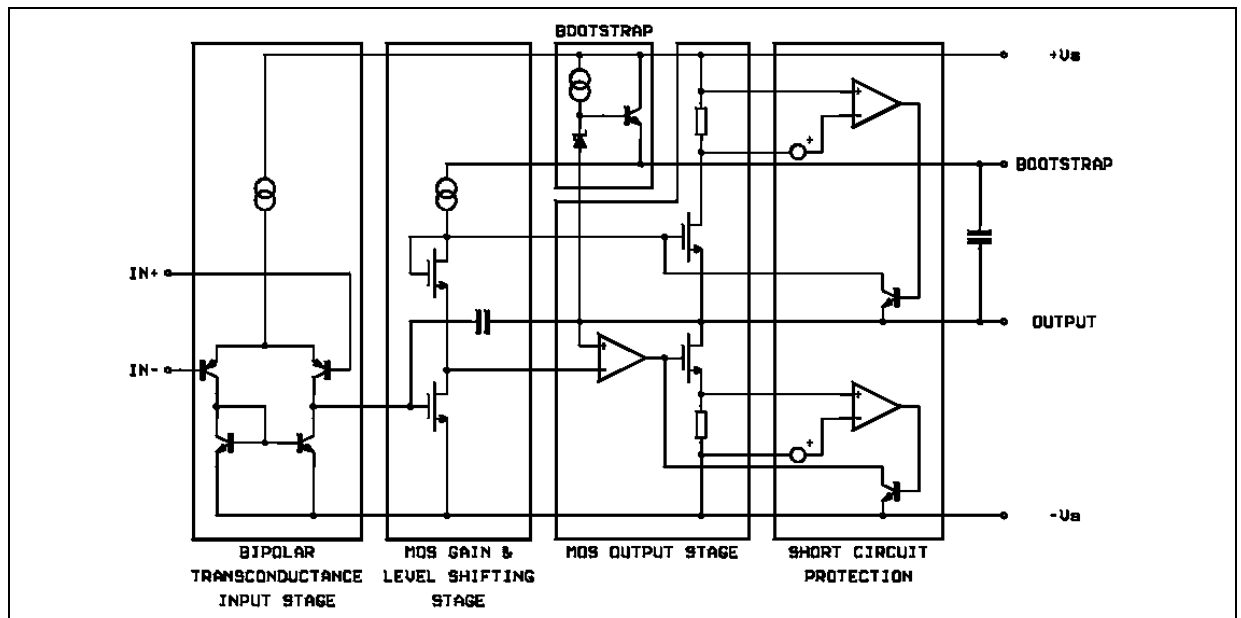
Table 2. Absolute Maximum Ratings

| Symbol                            | Parameter                                  | Value   | Unit |
|-----------------------------------|--|---------|------|
| V <sub>S</sub>                    | Supply Voltage (No Signal)                 | ±35     | V    |
| I <sub>O</sub>                    | Output Peak Current                        | 5       | A    |
| P <sub>tot</sub>                  | Power Dissipation T <sub>case</sub> = 70°C | 50      | W    |
| T <sub>op</sub>                   | Operating Ambient Temperature Range        | 0 to 70 | °C   |
| T <sub>stg</sub> , T <sub>j</sub> | Storage and Junction Temperature           | 150     | °C   |

Table 3. Thermal Data

| Symbol                 | Parameter                        | Typ. | Max | Unit |
|------------------------|----------------------------------|------|-----|------|
| R <sub>th j-case</sub> | Thermal Resistance Junction-case | 1    | 1.5 | °C/W |

Figure 4. Block Diagram



**Table 4. Electrical Characteristics** (Refer to the Test Circuit  $V_S = \pm 24V$ ,  $R_L = 8\Omega$ ,  $G_V = 30dB$ ;  $R_G = 50\Omega$ ;  $T_{amb} = 25^\circ C$ ,  $f = 1\text{ kHz}$ ; unless otherwise specified).

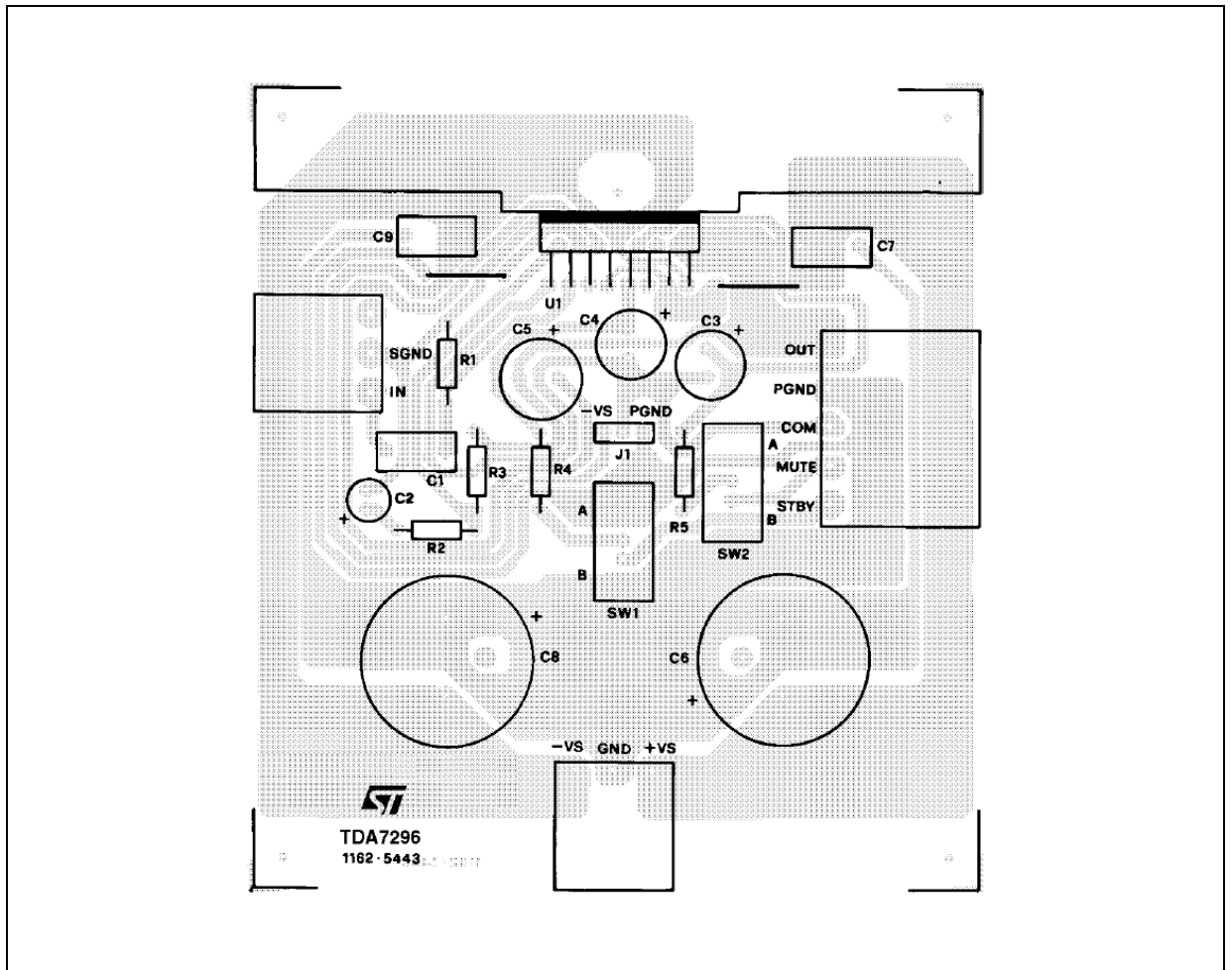
| Symbol                                     | Parameter  | Test Condition  | Min.           | Typ.           | Max.     | Unit             |
|--|--|---|----------------|----------------|----------|------------------|
| $V_S$                                      | Supply Range                                     |   | $\pm 10$       |                | $\pm 35$ | V                |
| $I_q$                                      | Quiescent Current                                |   | 20             | 30             | 65       | mA               |
| $I_b$                                      | Input Bias Current                               |   |                |                | 500      | nA               |
| $V_{OS}$                                   | Input Offset Voltage                             |   | -10            |                | 10       | mV               |
| $I_{OS}$                                   | Input Offset Current                             |   | -100           |                | 100      | nA               |
| $P_O$                                      | RMS Continuous Output Power                      | $d = 05\%$<br>$V_S = \pm 24V$ , $R_L = 8\Omega$ ;<br>$V_S = \pm 21V$ , $R_L = 6\Omega$ ;<br>$V_S = \pm 18V$ , $R_L = 4\Omega$ ;           | 27<br>27<br>27 | 30<br>30<br>30 |          | W<br>W<br>W      |
|  | Music Power (RMS)<br>$\Delta t = 1\text{ s}$ (*) | $d = 10\%$<br>$V_S = \pm 29V$ , $R_L = 8\Omega$ ;<br>$V_S = \pm 24V$ , $R_L = 6\Omega$ ;<br>$V_S = \pm 22V$ , $R_L = 4\Omega$ ;           |                | 60<br>60<br>60 |          | W<br>W<br>W      |
| d  | Total Harmonic Distortion (**)                   | $P_O = 5W$ ; $f = 1\text{ kHz}$<br>$P_O = 0.1\text{ to }20W$ ; $f = 20\text{ Hz to }20\text{ kHz}$  |                | 0.005          | 0.1      | %                |
|  |  | $V_S = \pm 18V$ , $R_L = 4\Omega$ ;<br>$P_O = 5W$ ; $f = 1\text{ kHz}$<br>$P_O = 0.1\text{ to }20W$ ; $f = 20\text{ Hz to }20\text{ kHz}$ |                | 0.01           | 0.1      | %<br>%           |
| SR   | Slew Rate  |   | 7              | 10             |          | V/ $\mu\text{s}$ |
| $G_V$                                      | Open Loop Voltage Gain                           |   |                | 80             |          | dB               |
| $G_V$                                      | Closed Loop Voltage Gain (1)                     |   | 24             | 30             | 40       | dB               |
| $e_N$                                      | Total Input Noise                                | A = curve   |                | 1              |          | $\mu\text{V}$    |
|  |  | $f = 20\text{ Hz to }20\text{ kHz}$   |                | 2              | 5        | $\mu\text{V}$    |
| $f_L, f_H$                                 | frequency response (-3dB)                        | $P_O = 1W$  | 20Hz to 20kHz  |                |          |                  |
| $R_i$                                      | Input Resistance                                 |   | 100            |                |          | k $\Omega$       |
| SVR  | Supply Voltage Rejection                         | $f = 100\text{ Hz}$ ; $V_{ripple} = 0.5V_{rms}$   | 60             | 75             |          | dB               |
| $T_S$                                      | Thermal Shutdown                                 |   |                | 145            |          | $^\circ\text{C}$ |
| <b>STAND-BY FUNCTION</b> (Ref: -Vs or GND) |  |   |                |                |          |                  |
| $V_{ST\ on}$                               | Stand-by on Threshold                            |   |                |                | 1.5      | V                |
| $V_{ST\ off}$                              | Stand-by off Threshold                           |   | 3.5            |                |          | V                |
| $ATT_{st-by}$                              | Stand-by Attenuation                             |   | 70             | 90             |          | dB               |
| $I_{q\ st-by}$                             | Quiescent Current @ Stand-by                     |   |                | 1              | 3        | mA               |
| <b>MUTE FUNCTION</b> (Ref: -Vs ro GND)     |  |   |                |                |          |                  |
| $V_{Mon}$                                  | Mute on Threshold                                |   |                |                | 1.5      | V                |
| $V_{Moff}$                                 | Mute off Threshold                               |   | 3.5            |                |          | V                |
| $ATT_{mute}$                               | Mute Attenuation                                 |   | 60             | 80             |          | dB               |

Note (\*):

MUSIC POWER is the maximal power which the amplifier is capable of producing across the rated load resistance (regardless of non linearity) 1 sec after the application of a sinusoidal input signal of frequency 1KHz.

Note (\*\*): Tested with optimized Application Board (see fig.5)

Figure 5. P.C.B. and Components Layout of the Circuit of figure 2.



Note:  
 The Stand-by and Mute functions can be referred either to GND or -VS.  
 On the P.C.B. is possible to set both the configuration through the jumper J1.

### 3 APPLICATION SUGGESTIONS

(see Test and Application Circuits of the Fig. 2)

The recommended values of the external components are those shown on the application circuit of Figure 2. Different values can be used; the following table can help the designer.

| COMPONENTS | SUGGESTED VALUE | PURPOSE                           | LARGER THAN SUGGESTED    | SMALLER THAN SUGGESTED               |
|------------|-----------------|-----------------------------------|--------------------------|--------------------------------------|
| R1 (*)     | 22k             | Input Resistance                  | Increase Input Impedance | Decrease Input Impedance             |
| R2         | 680Ω            | Closed Loop Gain Set to 30db (**) | Decrease of Gain         | Increase of Gain                     |
| R3 (*)     | 22k             |                                   | Increase of Gain         | Decrease of Gain                     |
| R4         | 22k             | St-by Time Constant               | Larger St-by ON/OFF Time | Smaller St-by ON/OFF Time; Pop Noise |
| R5         | 10k             | Mute Time Constant                | Larger Mute ON/OFF Time  | Smaller Mute ON/OFF Time             |
| C1         | 0.47μF          | Input DC Decoupling               |                          | Higher Low Frequency Cutoff          |
| C2         | 22μF            | Feedback DC Decoupling            |                          | Higher Low Frequency Cutoff          |
| C3         | 10μF            | Mute Time Constant                | Larger Mute ON/OFF Time  | Smaller Mute ON/OFF Time             |
| C4         | 10μF            | St-by Time Constant               | Larger St-by ON/OFF Time | Smaller St-by ON/OFF Time; Pop Noise |
| C5         | 22μF            | Bootstrapping                     |                          | Signal Degradation at Low Frequency  |
| C6, C8     | 1000μF          | Supply Voltage Bypass             |                          | Danger of Oscillation                |
| C7, C9     | 0.1μF           | Supply Voltage Bypass             |                          | Danger of Oscillation                |

(\*) R1 = R3 for pop optimization

(\*\*) Closed Loop Gain has to be  $\geq 24$ dB

### 4 TYPICAL CHARACTERISTICS

(Application Circuit of fig 2 unless otherwise specified)

Figure 6. : Output Power vs. Supply Voltage.

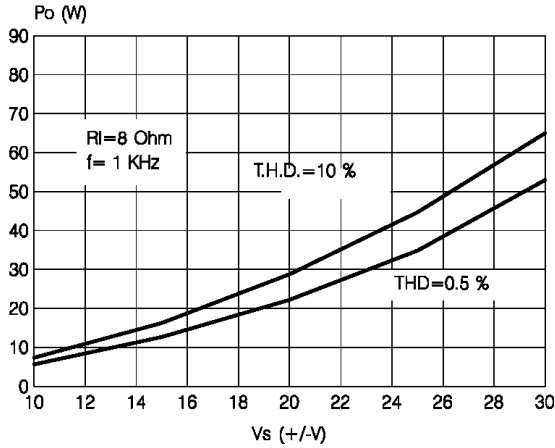


Figure 9. Distortion vs. Output Power

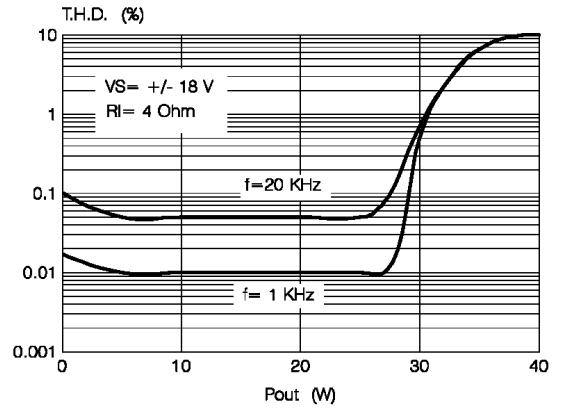


Figure 7. Distortion vs. Output Power

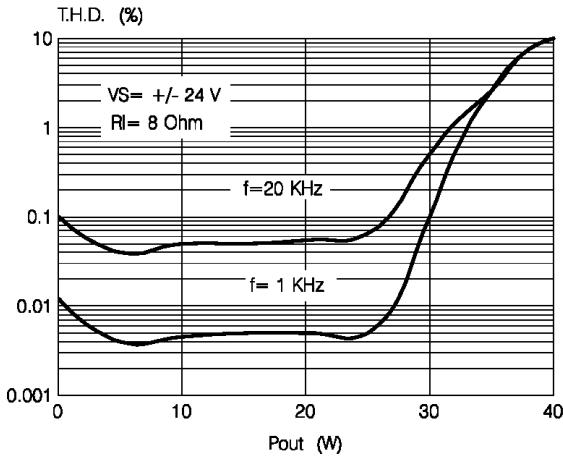


Figure 10. Distortion vs. Frequency

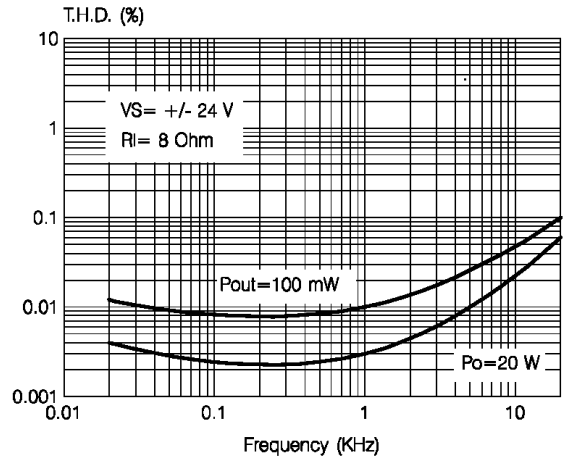


Figure 8. Output Power vs. Supply Voltage

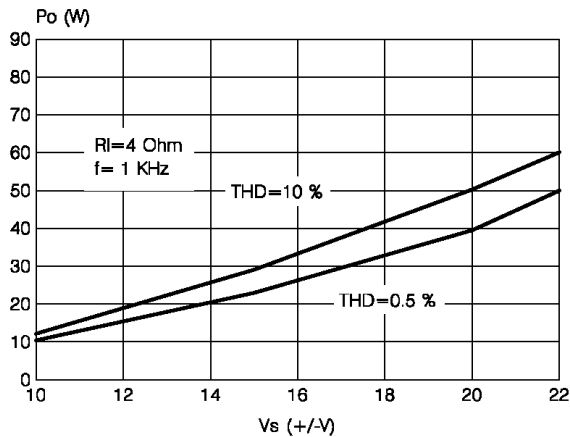


Figure 11. Distortion vs. Frequency

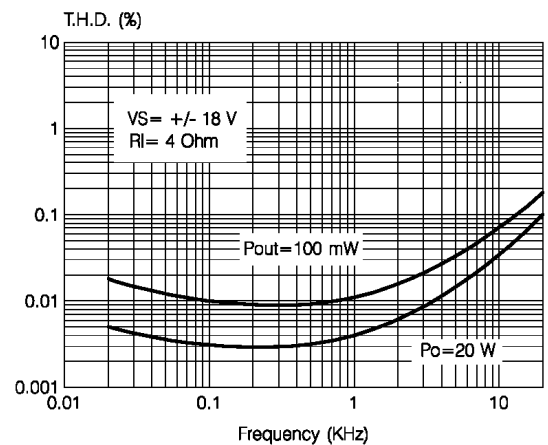


Figure 12. Quiescent Current vs. Supply Voltage

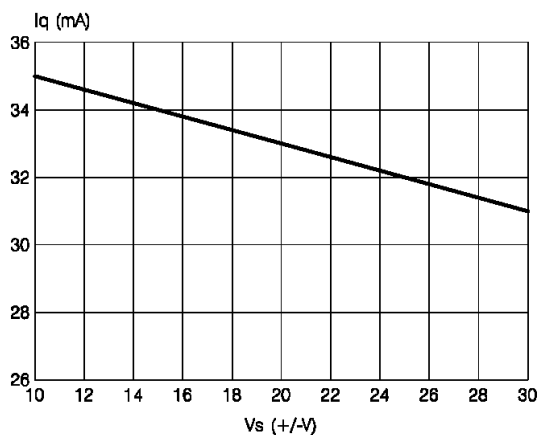


Figure 15. St-by Attenuation vs.  $V_{pin9}$

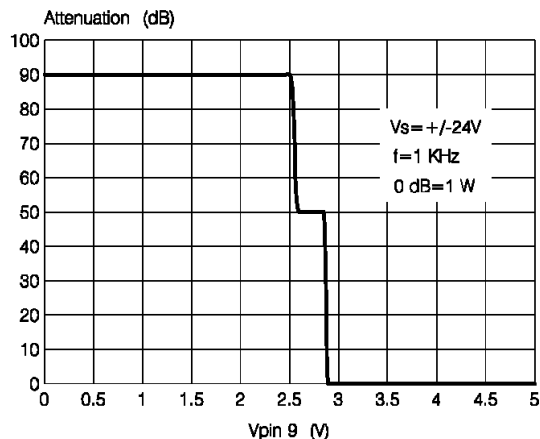


Figure 13. Supply Voltage Rejection vs. Frequency

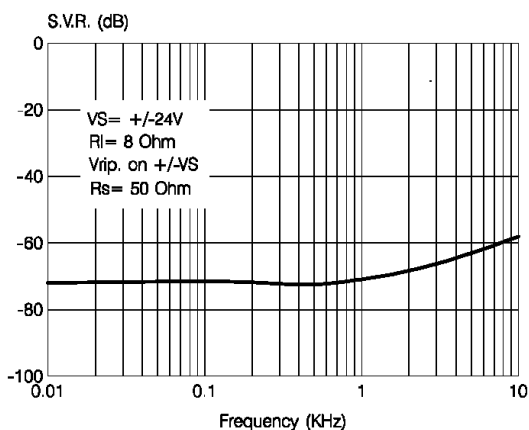


Figure 16. Power Dissipation vs. Output Power

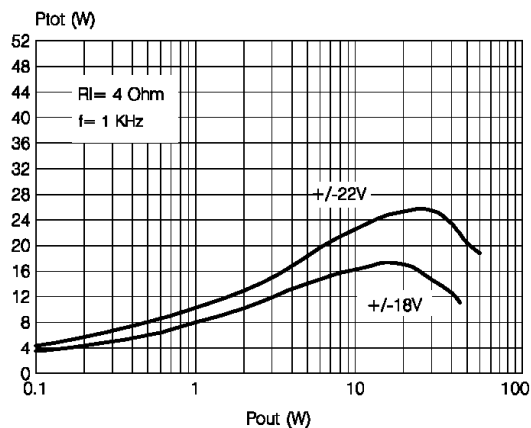


Figure 14. Mute Attenuation vs.  $V_{pin10}$

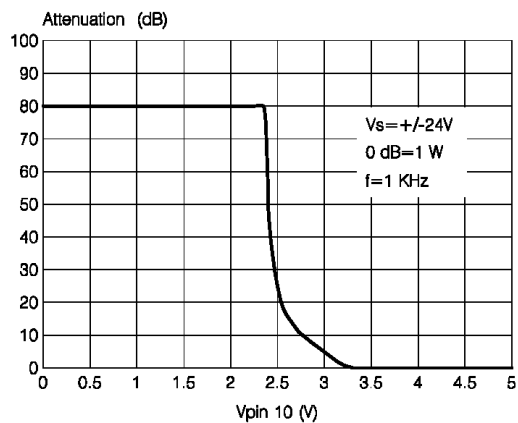
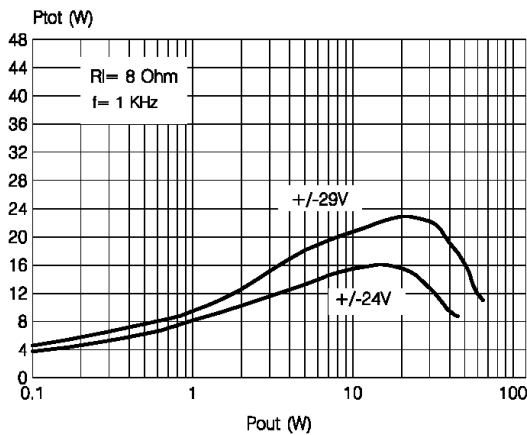


Figure 17. Power Dissipation vs. Output Power



## 5 INTRODUCTION

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 occurrence of 2nd breakdown phenomenon. 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 for 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 BCD 80.

### 5.1 Output Stage

The main design task one is confronted with while developing an integrated circuit as a power operational amplifier, independently of the technology used, is that of realising the output stage. The solution shown as a principle schematic by Fig 18 represents the DMOS unity-gain output buffer of the TDA7296.

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 fulfill 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.

### 5.2 Protections

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.

**Figure 18. Principle Schematic of a DMOS Unity-gain Buffer.**

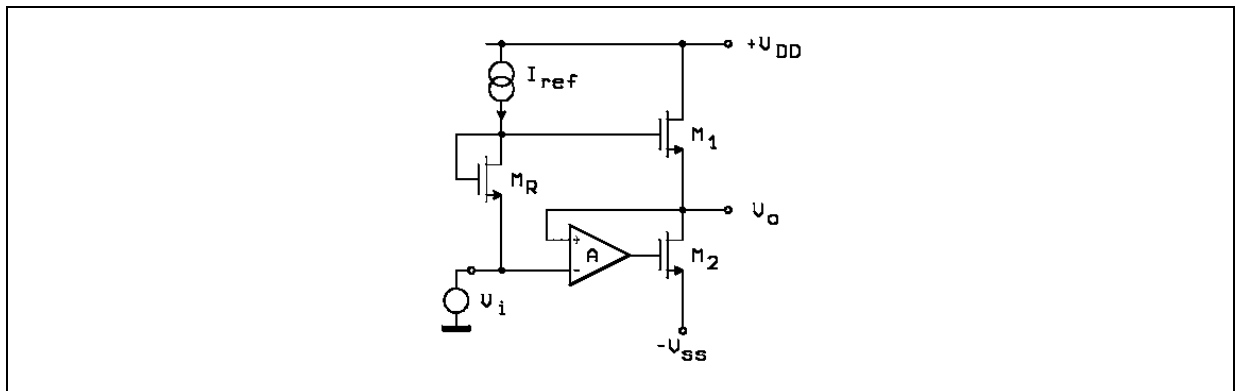
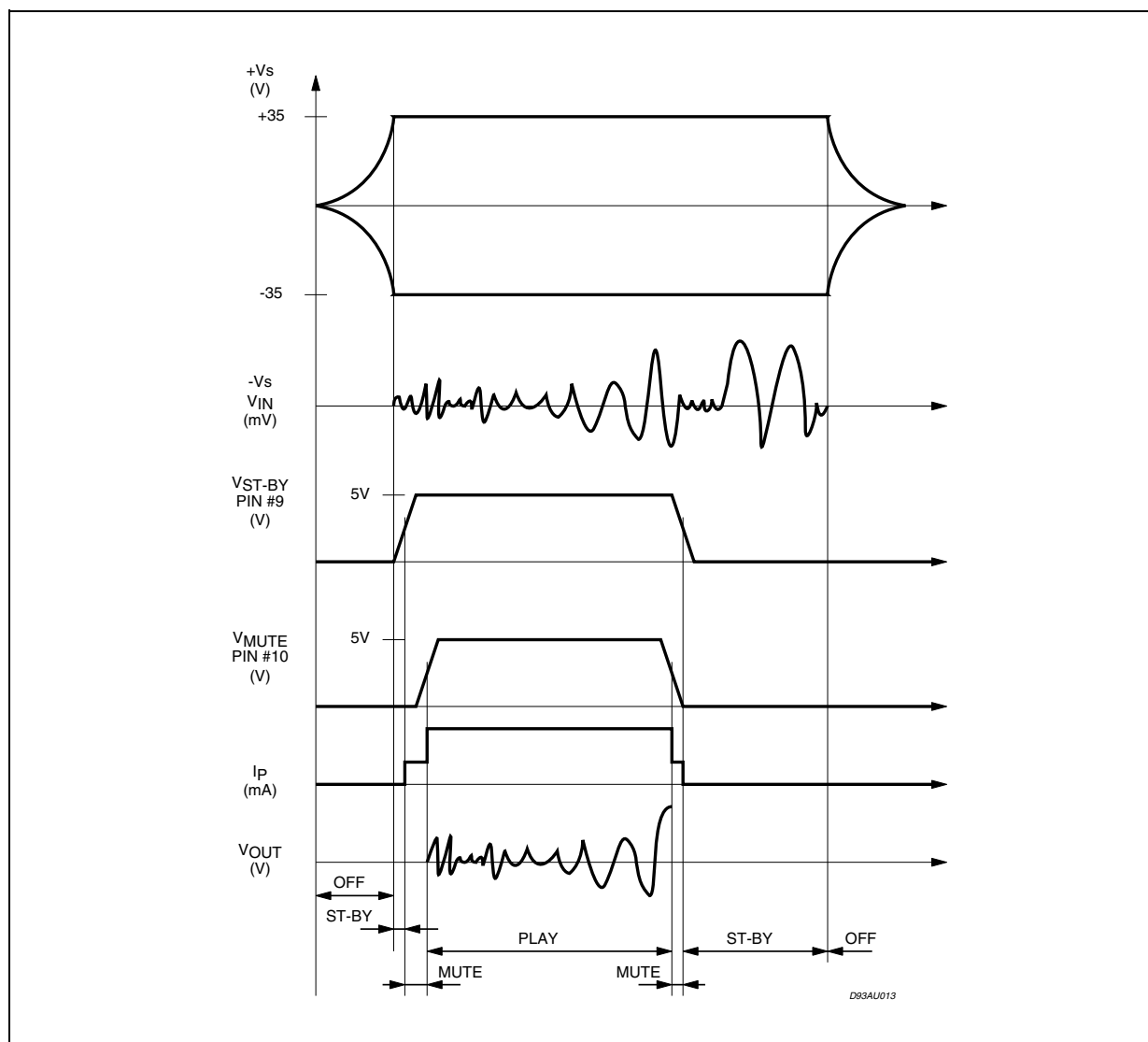




Figure 19. Turn ON/OFF Suggested Sequence



In addition to the overload protection described above, the device features a thermal shutdown circuit which initially puts the device into a muting state (@  $T_j = 145^\circ\text{C}$ ) and then into stand-by (@  $T_j = 150^\circ\text{C}$ ).

Full protection against electrostatic discharges on every pin is included.

### 5.3 Other Features

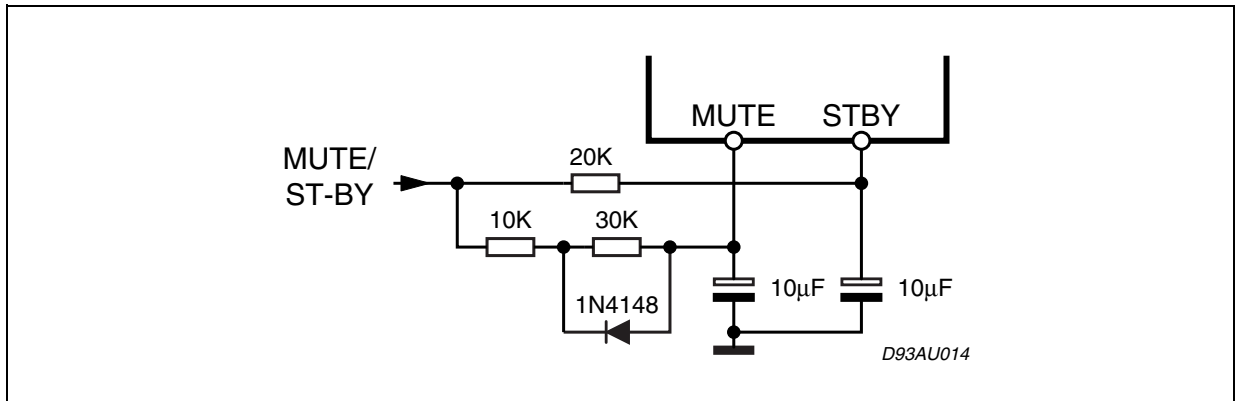
The device is provided with both stand-by and mute functions, independently driven by two CMOS logic compatible input pins.

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 by Figure 19.

The application of figure 20 shows the possibility of using 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 20. Single Signal ST-BY/MUTE Control Circuit



### 6 BRIDGE APPLICATION

Another application suggestion is the BRIDGE configuration, where two TDA7296 are used, as shown by the schematic diagram.

In this application, the value of the load must not be lower than 8 Ohm for dissipation and current capability reasons. A suitable field of application includes HI-FI/TV subwoofers realizations. The main advantages offered by this solution are:

- High power performances with limited supply voltage level.
- Considerably high output power even with high load values (i.e. 16 Ohm).

The characteristics shown by figures 23 and 24, measured with loads respectively 8 Ohm and 16 Ohm. With  $R_l = 8 \text{ Ohm}$ ,  $V_s = \pm 18\text{V}$  the maximum output power obtainable is 60W, while with  $R_l = 16 \text{ Ohm}$ ,  $V_s = \pm 24\text{V}$  the maximum  $P_{out}$  is 60W.

Figure 21. Bridge Application Circuit

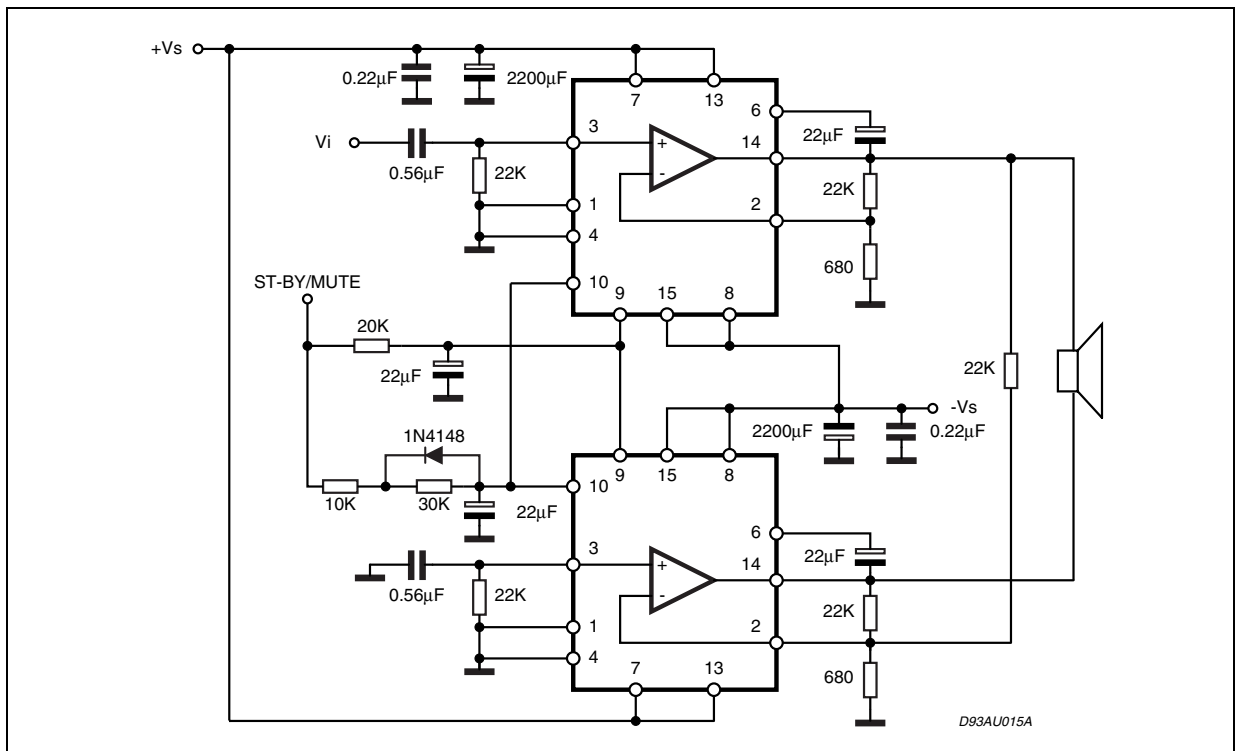


Figure 22. Frequency Response of the Bridge Application

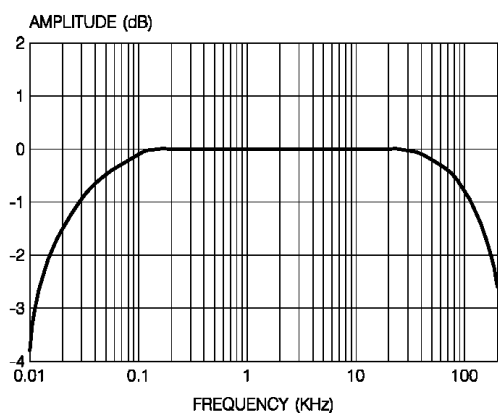


Figure 24. Distortion vs. Output Power

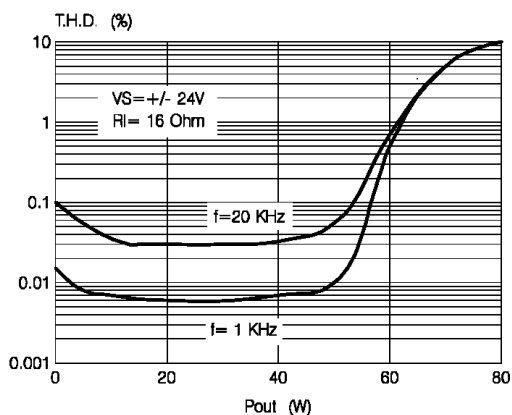


Figure 23. Distortion vs. Output Power

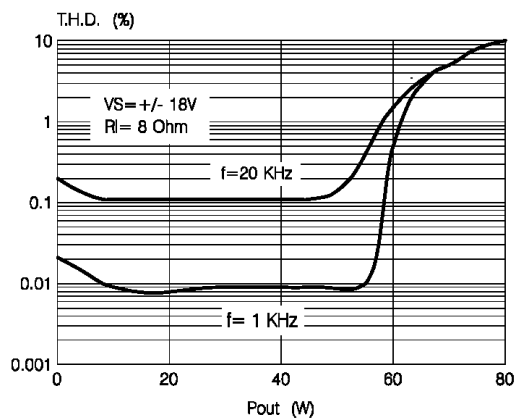
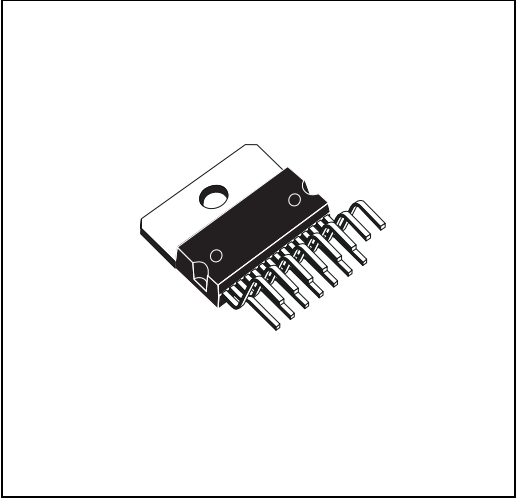


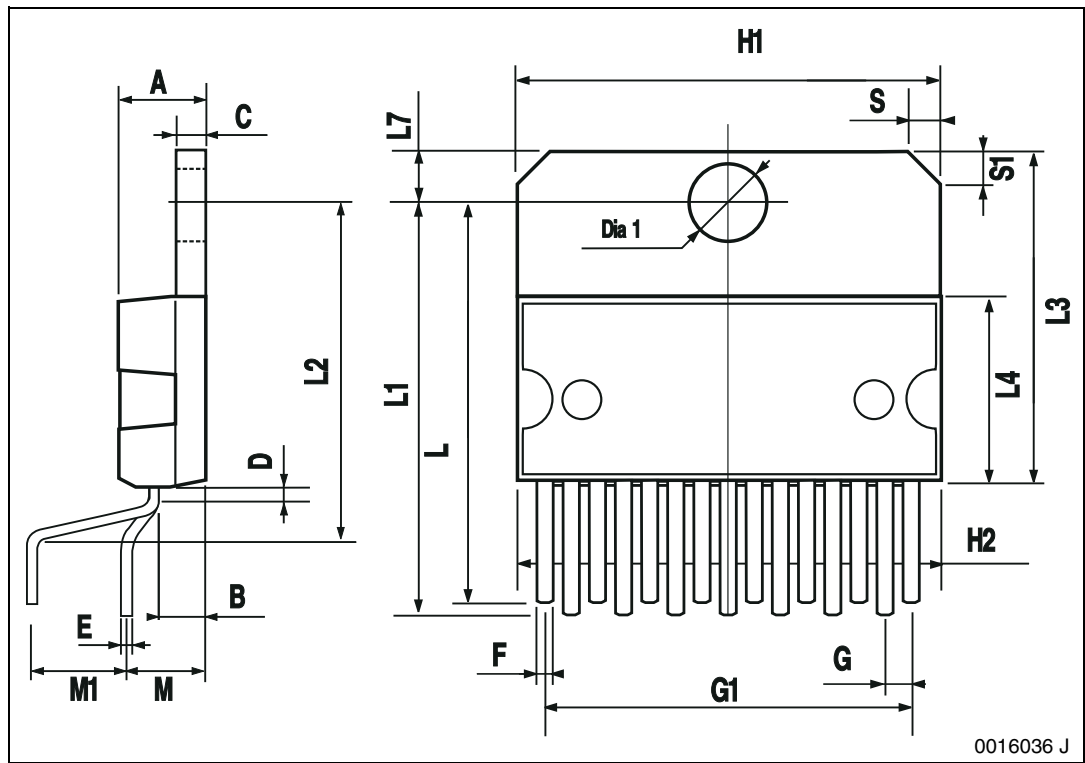
Figure 25. Multiwatt15V Mechanical Data & Package Dimensions

| 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)**



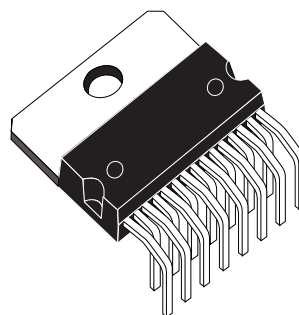
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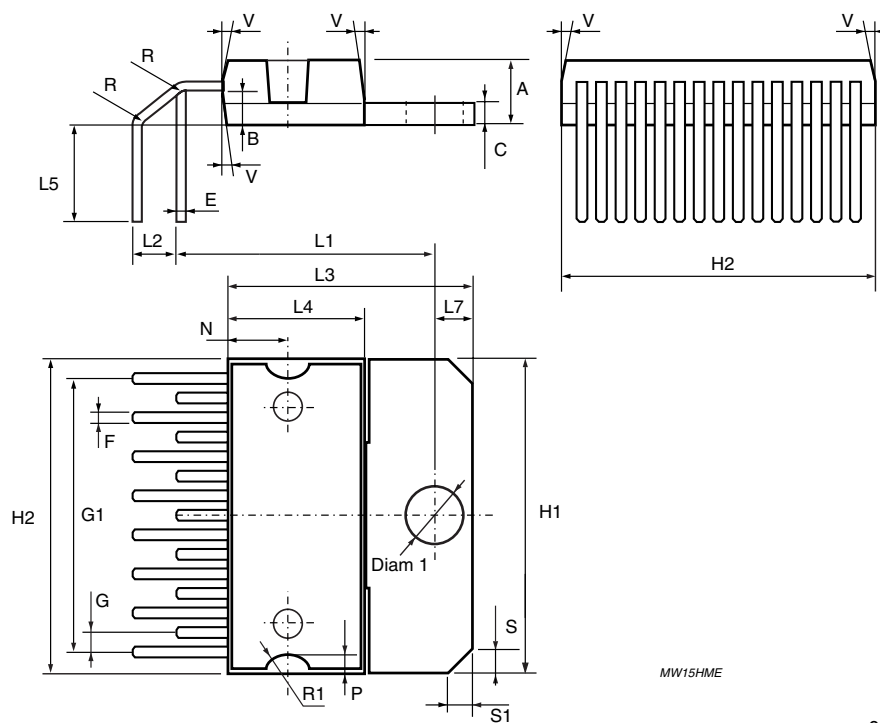
Figure 26. Multiwatt15 Horizontal (Short leads) Mechanical Data &amp; Package Dimensions

| DIM. | mm    |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |       |       | 5     |       |       | 0.197 |
| B    |       |       | 2.65  |       |       | 0.104 |
| C    |       |       | 1.6   |       |       | 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 | 0.709 |
| H1   | 19.6  |       | 20.2  | 0.772 |       | 0.795 |
| H2   | 19.6  |       | 20.2  | 0.772 |       | 0.795 |
| L1   | 17.80 | 18.00 | 18.20 | 0.701 | 0.709 | 0.717 |
| L2   |       | 2.54  |       |       | 0.100 |       |
| 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 |
| L5   | 2.70  | 3.00  | 3.30  | 0.106 | 0.118 | 0.130 |
| L7   | 2.65  |       | 2.9   | 0.104 |       | 0.114 |
| R    |       | 1.5   |       |       | 0.059 |       |
| 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 H (Short leads)



0067558 E

**Table 5. Revision History**

| <b>Date</b>    | <b>Revision</b> | <b>Description of Changes</b>                      |
|----------------|-----------------|--|
| January 2004   | 8               | First Issue in EDOCS DMS                           |
| September 2004 | 9               | Added Package Multiwatt15 Horizontal (Short leads) |
| February 2005  | 10              | Corrected mistyping error in Table 2.              |

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