

# Contents

- 1 Schematic and pins connection diagrams ..... 5**
- 2 Electrical specifications ..... 6**
  - 2.1 Absolute maximum ratings ..... 6
  - 2.2 Thermal data ..... 6
  - 2.3 Bridge amplifier section ..... 6
    - 2.3.1 Electrical characteristics (bridge application) ..... 7
    - 2.3.2 Bridge amplifier design ..... 9
  - 2.4 Stereo amplifier application ..... 10
    - 2.4.1 Electrical characteristics (stereo application) ..... 11
- 3 Application suggestion ..... 15**
- 4 Application information ..... 16**
  - 4.1 Built-in protection systems ..... 20
    - 4.1.1 Load dump voltage surge ..... 20
    - 4.1.2 Short circuit (AC and DC conditions) ..... 21
    - 4.1.3 Polarity inversion ..... 21
    - 4.1.4 Open ground ..... 21
    - 4.1.5 Inductive load ..... 21
    - 4.1.6 DC voltage ..... 21
    - 4.1.7 Thermal shut-down ..... 22
    - 4.1.8 Loudspeaker protection ..... 22
- 5 Package information ..... 23**
- 6 Revision history ..... 24**

## List of tables

|          |   |    |
|----------|---|----|
| Table 1. | Device summary . . . . .  | 1  |
| Table 2. | Absolute maximum ratings . . . . .  | 6  |
| Table 3. | Thermal data . . . . .  | 6  |
| Table 4. | Electrical characteristics (bridge application) . . . . .                       | 7  |
| Table 5. | Bridge amplifier design . . . . .   | 9  |
| Table 6. | High gain vs. Rx . . . . .  | 10 |
| Table 7. | Electrical characteristics (stereo application) . . . . .                       | 11 |
| Table 8. | Recommended values of the component of the bridge application circuit . . . . . | 15 |
| Table 9. | Document revision history . . . . .   | 24 |

## List of figures

|            |   |    |
|------------|---|----|
| Figure 1.  | Schematic diagram . . . . .   | 5  |
| Figure 2.  | Pins connection diagram (top view) . . . . .  | 5  |
| Figure 3.  | Test and application circuit (bridge amplifier) . . . . .                                   | 6  |
| Figure 4.  | PC board and components layout of Figure 3 . . . . .  | 7  |
| Figure 5.  | Output offset voltage vs. supply voltage . . . . .  | 8  |
| Figure 6.  | Distortion vs. output power ( $R_L = 4 \Omega$ ) . . . . .                                  | 8  |
| Figure 7.  | Distortion vs. output power ( $R_L = 3.2 \Omega$ ) . . . . .                                | 8  |
| Figure 8.  | Bridge configuration . . . . .  | 10 |
| Figure 9.  | Typical stereo application circuit . . . . .  | 10 |
| Figure 10. | Quiescent output voltage vs. supply voltage (stereo amplifier) . . . . .                    | 12 |
| Figure 11. | Quiescent drain current vs. supply voltage (stereo amplifier) . . . . .                     | 12 |
| Figure 12. | Distortion vs. output power (stereo amplifier) . . . . .                                    | 12 |
| Figure 13. | Output power vs. supply voltage, $R_L = 2$ and $4 \Omega$ (stereo amplifier) . . . . .      | 12 |
| Figure 14. | Output power vs. supply voltage, $R_L = 1.6$ and $3.2 \Omega$ (stereo amplifier) . . . . .  | 13 |
| Figure 15. | Distortion vs. frequency, $R_L = 2$ and $4 \Omega$ (stereo amplifier) . . . . .             | 13 |
| Figure 16. | Distortion vs. frequency, $R_L = 1.6$ and $3.2 \Omega$ (stereo amplifier) . . . . .         | 13 |
| Figure 17. | Supply voltage rejection vs. C3 (stereo amplifier) . . . . .                                | 13 |
| Figure 18. | Supply voltage rejection vs. frequency (stereo amplifier) . . . . .                         | 13 |
| Figure 19. | Supply voltage rejection vs. C2 and C3, $G_V = 390/1 \Omega$ (stereo amplifier) . . . . .   | 13 |
| Figure 20. | Supply voltage rejection vs. C2 and C3, $G_V = 1000/10 \Omega$ (stereo amplifier) . . . . . | 14 |
| Figure 21. | Gain vs. input sensitivity $R_L = 4 \Omega$ (stereo amplifier) . . . . .                    | 14 |
| Figure 22. | Gain vs. input sensitivity $R_L = 2 \Omega$ (stereo amplifier) . . . . .                    | 14 |
| Figure 23. | Total power dissipation and efficiency vs. output power (bridge) . . . . .                  | 14 |
| Figure 24. | Total power dissipation and efficiency vs. output power (stereo) . . . . .                  | 14 |
| Figure 25. | Bridge amplifier without bootstrap . . . . .  | 16 |
| Figure 26. | PC board and components layout of Figure 25 . . . . .                                       | 16 |
| Figure 27. | Low cost bridge amplifier ( $G_V = 42$ dB) . . . . .  | 17 |
| Figure 28. | PC board and components layout of Figure 27 . . . . .                                       | 17 |
| Figure 29. | 10 + 10 W stereo amplifier with tone balance and loudness control . . . . .                 | 18 |
| Figure 30. | Tone control response (circuit of Figure 29) . . . . .                                      | 18 |
| Figure 31. | 20 W bus amplifier . . . . .  | 19 |
| Figure 32. | Simple 20 W two way amplifier ( $F_C = 2$ kHz) . . . . .                                    | 19 |
| Figure 33. | Bridge amplifier circuit suited for low-gain applications ( $G_V = 34$ dB) . . . . .        | 20 |
| Figure 34. | Example of muting circuit . . . . .   | 20 |
| Figure 35. | Suggested LC network circuit . . . . .  | 21 |
| Figure 36. | Voltage gain bridge configuration . . . . .   | 21 |
| Figure 37. | Maximum allowable power dissipation vs. ambient temperature . . . . .                       | 22 |
| Figure 38. | Output power and drain current vs. case temperature ( $R_L = 4 \Omega$ ) . . . . .          | 22 |
| Figure 39. | Output power and drain current vs. case temperature ( $R_L = 3.2 \Omega$ ) . . . . .        | 22 |
| Figure 40. | Multiwatt11 mechanical data and package dimensions . . . . .                                | 23 |

# 1 Schematic and pins connection diagrams

Figure 1. Schematic diagram

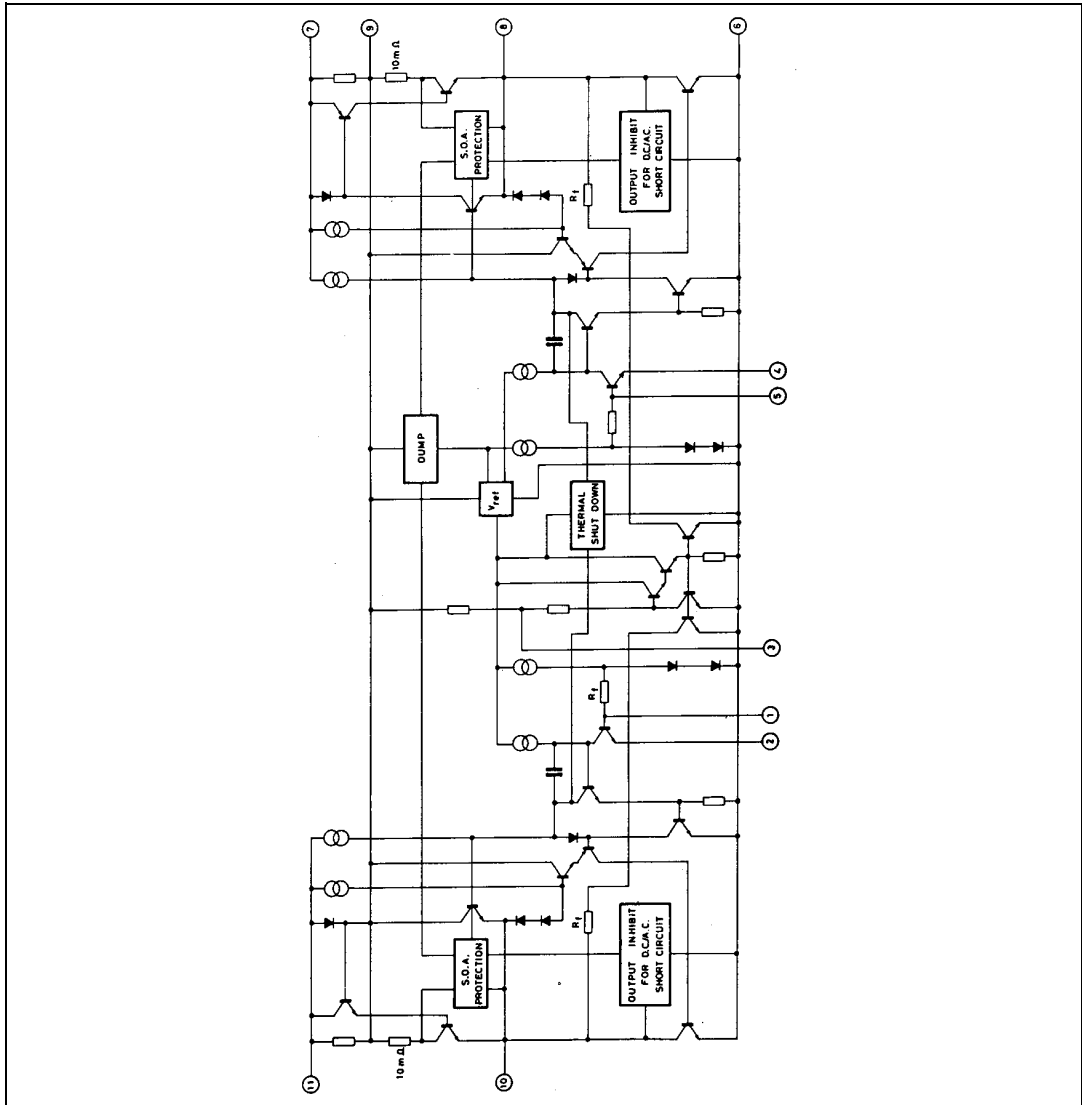
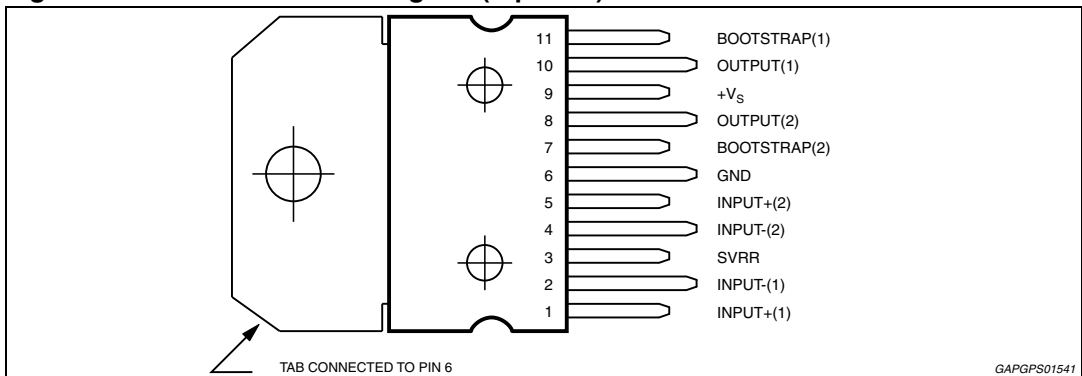


Figure 2. Pins connection diagram (top view)



## 2 Electrical specifications

### 2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

| Symbol                            | Parameter                                       | Value      | Unit |
|-----------------------------------|---|------------|------|
| V <sub>S</sub>                    | Peak supply voltage (50 ms)                     | 40         | V    |
|                                   | DC supply voltage                               | 28         |      |
|                                   | Operating supply voltage                        | 18         |      |
| I <sub>o</sub> (1)                | Output peak current (non repetitive t = 0.1 ms) | 4.5        | A    |
|                                   | Output peak current (repetitive f ≥10 Hz)       | 3.5        |      |
| P <sub>tot</sub>                  | Power dissipation at T <sub>case</sub> = 60 °C  | 20         | W    |
| T <sub>stg</sub> , T <sub>j</sub> | Storage and junction temperature                | -40 to 150 | °C   |

1. The max. output current is internally limited.

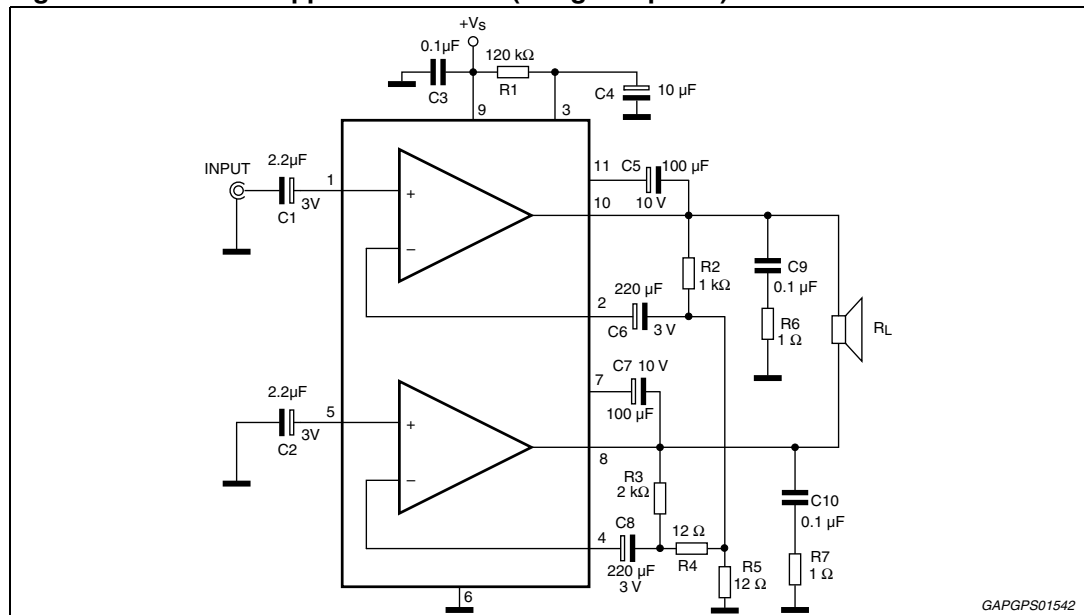
### 2.2 Thermal data

Table 3. Thermal data

| Symbol                 | Parameter                           | Value | Unit |
|------------------------|-------------------------------------|-------|------|
| R <sub>th-j-case</sub> | Thermal resistance junction-to-case | max 3 | °C/W |

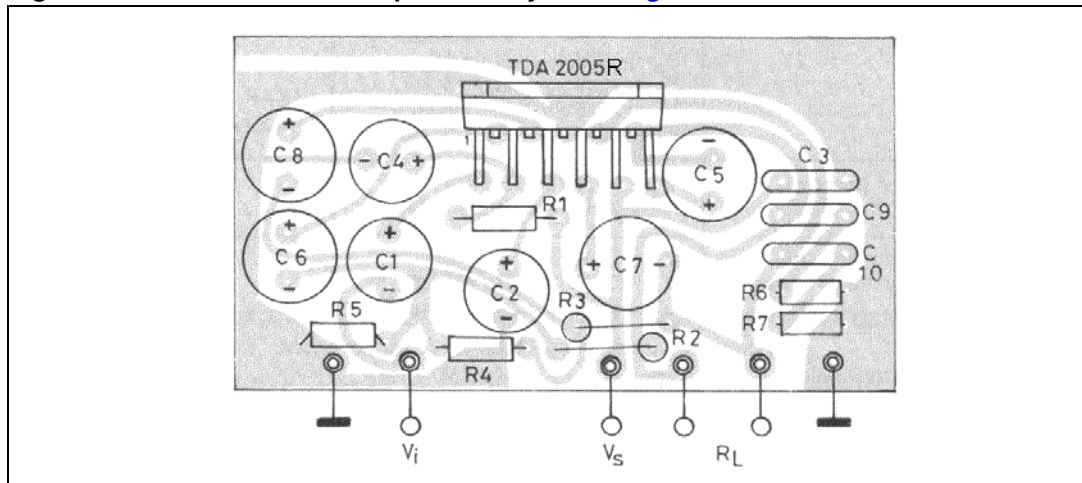
### 2.3 Bridge amplifier section

Figure 3. Test and application circuit (bridge amplifier)



GAPGPS01542

Figure 4. PC board and components layout of Figure 3



### 2.3.1 Electrical characteristics (bridge application)

Refer to the bridge application circuit  $T_{amb} = 25^{\circ}\text{C}$ ;  $G_v = 50\text{dB}$ ;  $R_{th(\text{heatsink})} = 4^{\circ}\text{C/W}$  unless otherwise specified.

Table 4. Electrical characteristics (bridge application)

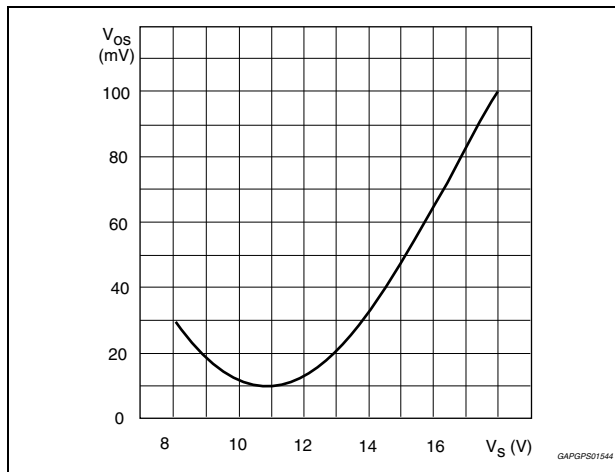
| Symbol   | Parameter   | Test condition  | Min.           | Typ.           | Max.       | Unit          |
|----------|---|---|----------------|----------------|------------|---------------|
| $V_S$    | Supply voltage                                      | -   | 8              | -              | 18         | V             |
| $V_{os}$ | Output offset voltage<br>(between pin 8 and pin 10) | $V_S = 14.4\text{ V}$<br>$V_S = 13.2\text{ V}$  | -              | -              | 150<br>150 | mV<br>mV      |
| $I_d$    | Total quiescent drain current                       | $V_S = 14.4\text{ V}$ ; $R_L = 4\ \Omega$<br>$V_S = 13.2\text{ V}$ ; $R_L = 3.2\ \Omega$  | -              | 75<br>70       | 150<br>150 | mA<br>mA      |
| $P_o$    | Output power  | $f = 1\text{ kHz}$ , THD = 10 %<br>$V_S = 14.4\text{ V}$ ; $R_L = 4\ \Omega$<br>$V_S = 14.4\text{ V}$ ; $R_L = 3.2\ \Omega$<br>$V_S = 13.2\text{ V}$ ; $R_L = 3.2\ \Omega$  | 18<br>20<br>17 | 20<br>22<br>19 | -          | W             |
| THD      | Total harmonic distortion                           | $f = 1\text{ kHz}$ ; $V_S = 14.4\text{ V}$ ;<br>$R_L = 4\ \Omega$ ; $P_o = 50\text{ mW}$ to $15\text{ W}$ ;<br>$f = 1\text{ kHz}$ ; $V_S = 13.2\text{ V}$ ;<br>$R_L = 3.2\ \Omega$ ; $P_o = 50\text{ mW}$ to<br>$13\text{ W}$ ; | -              | -              | 1<br>1     | %<br>%        |
| $V_i$    | Input sensitivity                                   | $f = 1\text{ kHz}$<br>$R_L = 4\ \Omega$ ; $P_o = 2\text{ W}$ ;<br>$R_L = 3.2\ \Omega$ ; $P_o = 2\text{ W}$  | -              | 9<br>8         | -          | mW            |
| $R_i$    | Input resistance                                    | $f = 1\text{ kHz}$  | 70             | -              | -          | k $\Omega$    |
| $f_L$    | Low frequency roll off (-3 dB)                      | $R_L = 3.2\ \Omega$   | -              | -              | 40         | Hz            |
| $f_H$    | High frequency roll off (-3 dB)                     | $R_L = 3.2\ \Omega$   | 20             | -              | -          | KHz           |
| $G_v$    | Closed loop voltage gain                            | $f = 1\text{ kHz}$  | -              | 50             | -          | dB            |
| $e_N$    | Total Input noise voltage                           | $R_g = 10\ \Omega$ <sup>(1)</sup>   | -              | 3              | 10         | $\mu\text{V}$ |
| SVR      | Supply voltage rejection                            | $V_{\text{ripple}} = 0.5\text{ V}$ ; $f_{\text{ripple}} = 100\text{ Hz}$<br>$R_g = 10\text{ k}\Omega$ ; $C_4 = 10\ \mu\text{F}$   | 45             | 55             | -          | dB            |

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

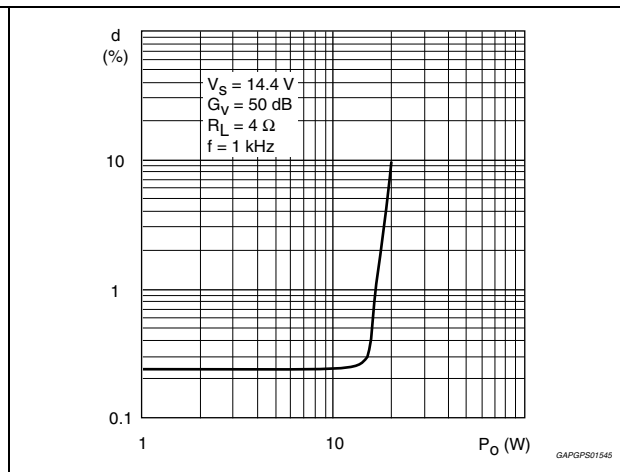
| Symbol           | Parameter   | Test condition  | Min. | Typ. | Max. | Unit               |
|------------------|---|---|------|------|------|--------------------|
| $\eta$           | Efficiency  | $f = 1 \text{ kHz}; V_S = 14.4 \text{ V};$<br>$R_L = 4 \Omega; P_o = 20 \text{ W};$<br>$R_L = 3.2 \Omega; P_o = 22 \text{ W}$ | -    | 60   | -    | %                  |
|                  |   | $f = 1 \text{ kHz}; V_S = 13.2 \text{ V};$<br>$R_L = 3.2 \Omega; P_o = 19 \text{ W}$  | -    | 58   | -    |                    |
| SVR              | Supply voltage rejection                                      | $f = 100 \text{ Hz}; V_{\text{ripple}} = 0.5 \text{ V};$<br>$R_g = 10 \text{ k}\Omega; R_L = 4 \Omega$                        | 30   | 36   | -    | dB                 |
| $T_j$            | Thermal shut-down junction temperature                        | $f = 1 \text{ kHz}; V_S = 14.4 \text{ V};$<br>$R_L = 4 \Omega; P_{\text{tot}} = 13 \text{ W}$                                 | -    | 145  | -    | $^{\circ}\text{C}$ |
| $V_{\text{OSH}}$ | Output voltage with one side of the speaker shorted to ground | $V_S = 14.4 \text{ V}; R_L = 4 \Omega$<br>$V_S = 13.2 \text{ V}; R_L = 3.2 \Omega$  | -    | -    | 2    | V                  |

1. Bandwidth filter: 22 Hz to 22 kHz.

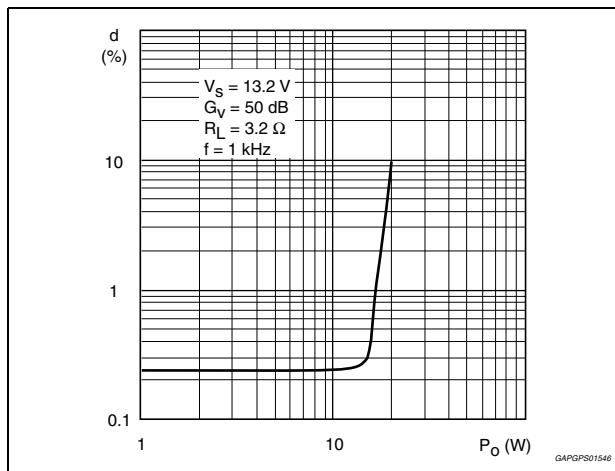
**Figure 5. Output offset voltage vs. supply voltage**



**Figure 6. Distortion vs. output power ( $R_L = 4 \Omega$ )**



**Figure 7. Distortion vs. output power ( $R_L = 3.2 \Omega$ )**



### 2.3.2 Bridge amplifier design

The following considerations can be useful when designing a bridge amplifier.

**Table 5. Bridge amplifier design**

| Parameter    |                                       | Single ended                                    | Bridge                              |
|--------------|---------------------------------------|---|-------------------------------------|
| $V_{o\ max}$ | Peak output voltage (before clipping) | $\frac{1}{2}(V_s - 2V_{CEsat})$                 | $V_s - 2V_{CEsat}$                  |
| $I_{o\ max}$ | Peak Output current (before clipping) | $\frac{1}{2} \frac{V_s - 2V_{CEsat}}{R_L}$      | $\frac{V_s - 2V_{CEsat}}{R_L}$      |
| $P_{o\ max}$ | RMS output power (before clipping)    | $\frac{1}{4} \frac{(V_s - 2V_{CEsat})^2}{2R_L}$ | $\frac{(V_s - 2V_{CEsat})^2}{2R_L}$ |

Where:

$V_{CE\ sat}$  = output transistors saturation voltage

$V_s$  = allowable supply voltage

$R_L$  = load impedance

Voltage and current swings are twice for a bridge amplifier in comparison with single ended amplifier.

In other words, with the same  $R_L$  the bridge configuration can deliver an output power that is four times the output power of a single ended amplifier, while, with the same max output current the bridge configuration can deliver an output power that is four times the output power of a single ended amplifier, while, with the same max output current the bridge configuration can deliver an output power that is twice the output power of a single ended amplifier.

Core must be taken when selecting  $V_s$  and  $R_L$  in order to avoid an output peak current above the absolute maximum rating.

From the expression for  $I_{Omax}$ , assuming  $V_s = 14.4\ V$  and  $V_{CE\ sat} = 2\ V$ , the minimum load that can be driven by TDA2005 in bridge configuration is:

$$R_{Lmin} = \frac{V_s - 2V_{CEsat}}{I_{Omax}} = \frac{14.4 - 4}{3.5} = 2.97\ \Omega$$

The voltage gain of the bridge configuration is given by (see [Figure 36](#)):

$$G_v = \frac{V_0}{V_1} = 1 + \frac{R_1}{\left(\frac{R_2 \cdot R_4}{R_2 + R_4}\right)} + \frac{R_3}{R_4}$$



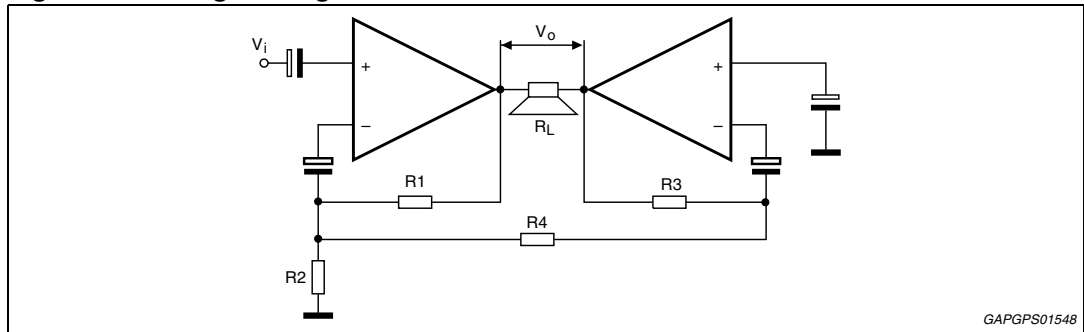
For sufficiently high gains (40 to 50 dB) it is possible to put  $R_2 = R_4$  and  $R_3 = 2R_1$ , simplifying the formula in:

$$G_v = 4 \frac{R_1}{R_2}$$

Table 6. High gain vs. Rx

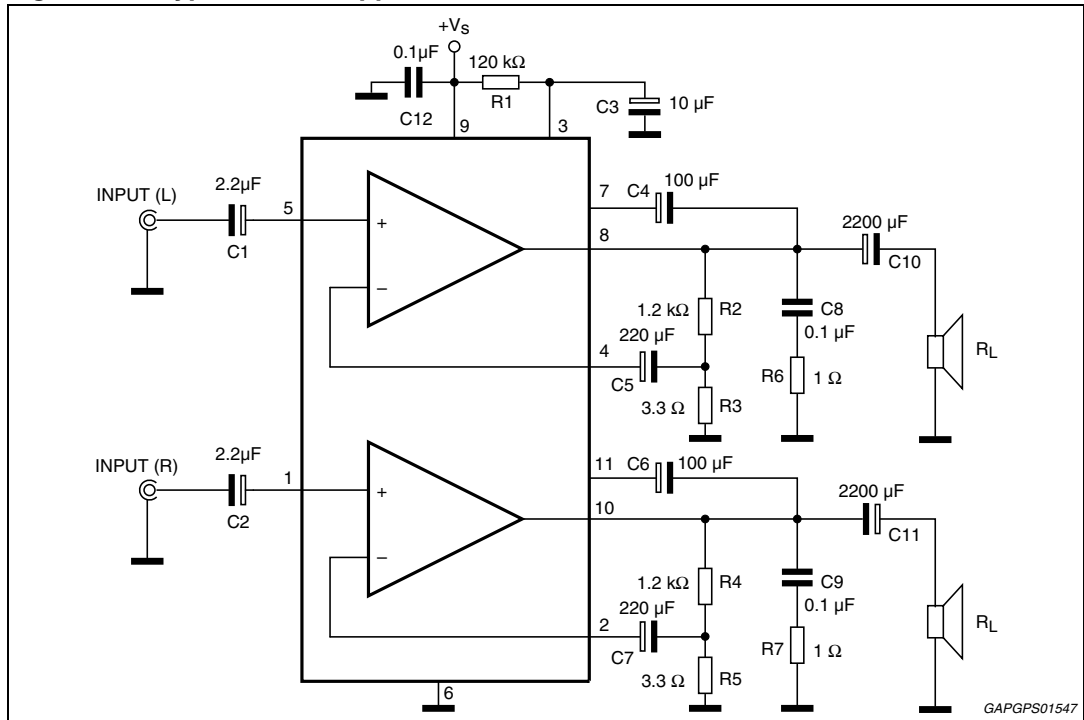
| $G_v$ (dB) | $R_1$ ( $\Omega$ ) | $R_2 = R_4$ ( $\Omega$ ) | $R_3$ ( $\Omega$ ) |
|------------|--------------------|--------------------------|--------------------|
| 40         | 1000               | 39                       | 2000               |
| 50         | 1000               | 12                       | 2000               |

Figure 8. Bridge configuration



## 2.4 Stereo amplifier application

Figure 9. Typical stereo application circuit



### 2.4.1 Electrical characteristics (stereo application)

Refer to the stereo application circuit  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $G_v = 50\text{ dB}$ ;  $R_{th(heatsink)} = 4\text{ }^{\circ}\text{C/W}$  unless otherwise specified

**Table 7. Electrical characteristics (stereo application)**

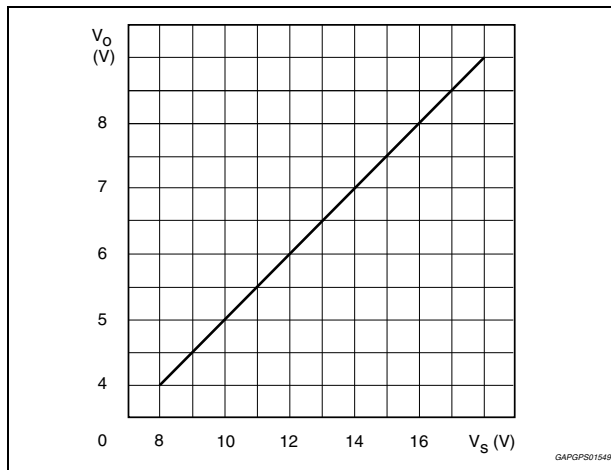
| Symbol | Parameter                       | Test condition   | Min. | Typ. | Max. | Unit       |
|--------|---------------------------------|--|------|------|------|------------|
| $V_S$  | Supply voltage                  |  | 8    |      | 18   | V          |
| $V_o$  | Quiescent offset voltage        | $V_S = 14.4\text{ V}$  | 6.6  | 7.2  | 7.8  | V          |
|        |                                 | $V_S = 13.2\text{ V}$  | 6    | 6.6  | 7.2  | V          |
| $I_d$  | Total quiescent drain current   | $V_S = 14.4\text{ V}$  | -    | 65   | 120  | mA         |
|        |                                 | $V_S = 13.2\text{ V}$  |      | 62   | 120  | mA         |
| $P_o$  | Output power (each channel)     | $f = 1\text{ kHz}$ ; THD = 10 %<br>$V_S = 14.4\text{ V}$ ; $R_L = 4\text{ }\Omega$                                 | 6    | 6.5  |      | W          |
|        |                                 | $V_S = 14.4\text{ V}$ ; $R_L = 3.2\text{ }\Omega$  | 7    | 8    | -    |            |
|        |                                 | $V_S = 14.4\text{ V}$ ; $R_L = 2\text{ }\Omega$  | 9    | 10   |      |            |
|        |                                 | $V_S = 14.4\text{ V}$ ; $R_L = 1.6\text{ }\Omega$  | 10   | 11   |      |            |
| $P_o$  | Output power (each channel)     | $f = 1\text{ kHz}$ ; THD = 10 %<br>$V_S = 13.2\text{ V}$ ; $R_L = 3.2\text{ }\Omega$                               | 6    | 6.5  |      | W          |
|        |                                 | $V_S = 13.2\text{ V}$ ; $R_L = 1.6\text{ }\Omega$  | 9    | 10   | -    |            |
|        |                                 | $V_S = 16\text{ V}$ ; $R_L = 2\text{ }\Omega$  |      | 12   |      |            |
| THD    | Total harmonic distortion       | $f = 1\text{ kHz}$ ; $V_S = 14.4\text{ V}$ ;<br>$R_L = 4\text{ }\Omega$ ; $P_o = 50\text{ mW}$ to $4\text{ W}$ ;   | -    | 0.2  | 1    | %          |
|        |                                 | $f = 1\text{ kHz}$ ; $V_S = 14.4\text{ V}$ ;<br>$R_L = 2\text{ }\Omega$ ; $P_o = 50\text{ mW}$ to $6\text{ W}$ ;   | -    | 0.3  | 1    | %          |
|        |                                 | $f = 1\text{ kHz}$ ; $V_S = 13.2\text{ V}$ ;<br>$R_L = 3.2\text{ }\Omega$ ; $P_o = 50\text{ mW}$ to $3\text{ W}$ ; | -    | 0.2  | 1    | %          |
|        |                                 | $f = 1\text{ kHz}$ ; $V_S = 13.2\text{ V}$ ;<br>$R_L = 1.6\text{ }\Omega$ ; $P_o = 40\text{ mW}$ to $6\text{ W}$ ; | -    | 0.3  | 1    | %          |
| CT     | Cross talk                      | $V_S = 14.4\text{ V}$ ; $V_o = 4\text{ V}_{RMS}$ ;<br>$R_g = 5\text{ k}\Omega$ ; $R_L = 4\text{ }\Omega$ ;         | -    | 60   | -    | mW         |
|        |                                 | $f = 1\text{ kHz}$<br>$f = 10\text{ kHz}$  |      | 45   |      | mW         |
| $V_i$  | Input saturation voltage        | -  | 300  |      | -    | mW         |
| $V_i$  | Input sensitivity               | $f = 1\text{ kHz}$ ; $P_o = 1\text{ W}$ ;<br>$R_L = 4\text{ }\Omega$ ;   | -    | 6    | -    | mV         |
|        |                                 | $R_L = 3.2\text{ }\Omega$ ;  |      | 5.5  |      | mV         |
| $R_i$  | Input resistance                | $f = 1\text{ kHz}$   | 70   | 200  | -    | k $\Omega$ |
| $f_L$  | Low frequency roll off (-3 dB)  | $R_L = 2\text{ }\Omega$  | -    | -    | 50   | Hz         |
| $f_H$  | High frequency roll off (-3 dB) | $R_L = 2\text{ }\Omega$  | 15   | -    | -    | kHz        |
| $G_v$  | Open loop voltage gain          | $f = 1\text{ kHz}$   | -    | 90   | -    | dB         |
|        | Closed loop voltage gain        | $f = 1\text{ kHz}$   | 48   | 50   | 51   |            |

**Table 7. Electrical characteristics (stereo application) (continued)**

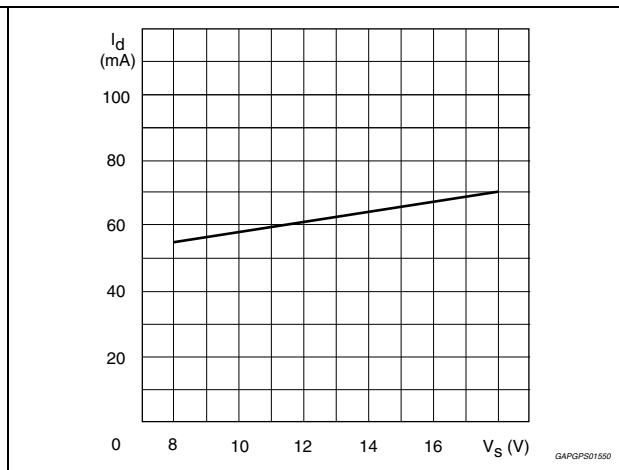
| Symbol       | Parameter                 | Test condition   | Min. | Typ.     | Max. | Unit          |
|--------------|---------------------------|--|------|----------|------|---------------|
| $\Delta G_v$ | Closed loop gain matching | -  | -    | 0.5      | -    | dB            |
| $e_N$        | Total input noise voltage | $R_g = 10\text{ k}\Omega^{(1)}$  | -    | 1.5      | 5    | $\mu\text{V}$ |
| SVR          | Supply voltage rejection  | $V_{\text{ripple}} = 0.5\text{ V}; f_{\text{ripple}} = 100\text{ Hz}$<br>$R_g = 10\text{ k}\Omega; C_3 = 10\text{ }\mu\text{F};$             | 35   | 45       | -    | dB            |
| $\eta$       | Efficiency                | $f = 1\text{ kHz}; V_S = 14.4\text{ V};$<br>$R_L = 4\text{ }\Omega; P_o = 6.5\text{ W};$<br>$R_L = 2\text{ }\Omega; P_o = 10\text{ W};$      | -    | 70<br>60 | -    | %             |
|              |                           | $f = 1\text{ kHz}; V_S = 13.2\text{ V};$<br>$R_L = 3.2\text{ }\Omega; P_o = 6.5\text{ W};$<br>$R_L = 1.6\text{ }\Omega; P_o = 100\text{ W};$ | -    | 70<br>60 | -    | %             |

1. Bandwidth filter: 22 Hz to 22 kHz.

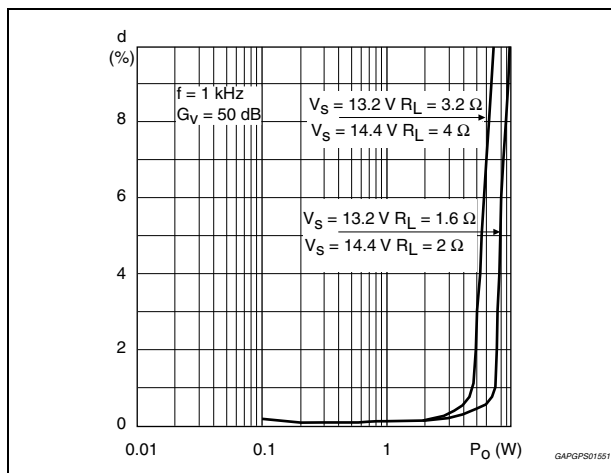
**Figure 10. Quiescent output voltage vs. supply voltage (stereo amplifier)**



**Figure 11. Quiescent drain current vs. supply voltage (stereo amplifier)**



**Figure 12. Distortion vs. output power (stereo amplifier)**



**Figure 13. Output power vs. supply voltage, R\_L = 2 and 4 Ohm (stereo amplifier)**

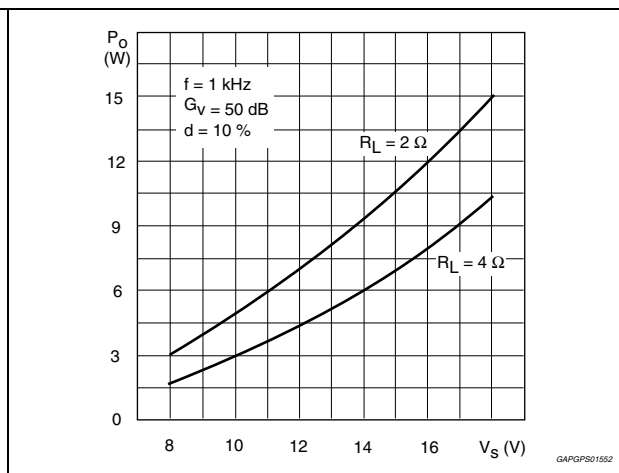


Figure 14. Output power vs. supply voltage,  $R_L = 1.6$  and  $3.2 \Omega$  (stereo amplifier)

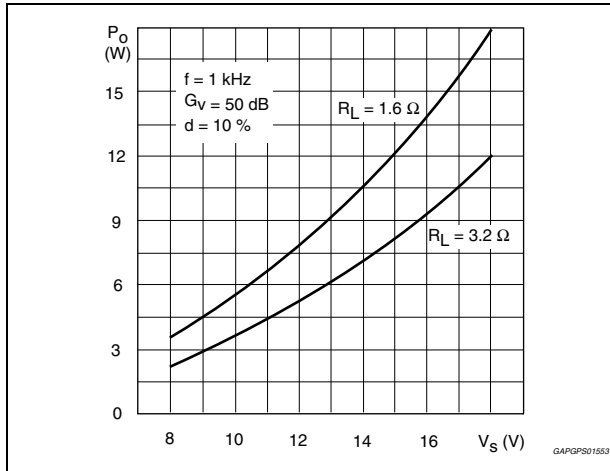


Figure 15. Distortion vs. frequency,  $R_L = 2$  and  $4 \Omega$  (stereo amplifier)

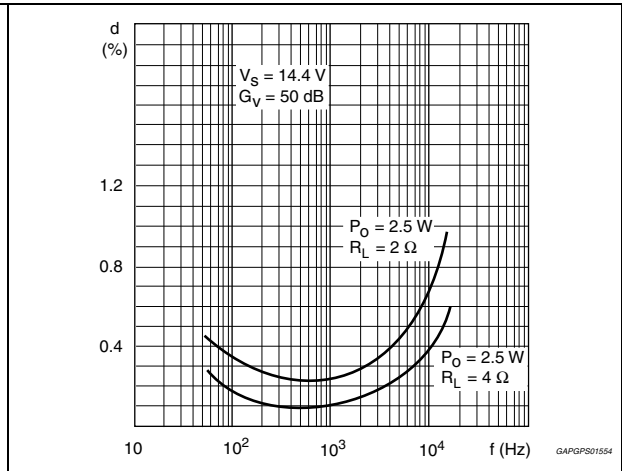


Figure 16. Distortion vs. frequency,  $R_L = 1.6$  and  $3.2 \Omega$  (stereo amplifier)

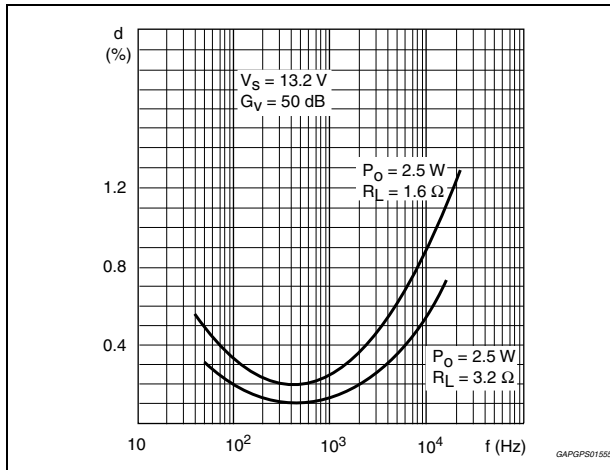


Figure 17. Supply voltage rejection vs.  $C_3$  (stereo amplifier)

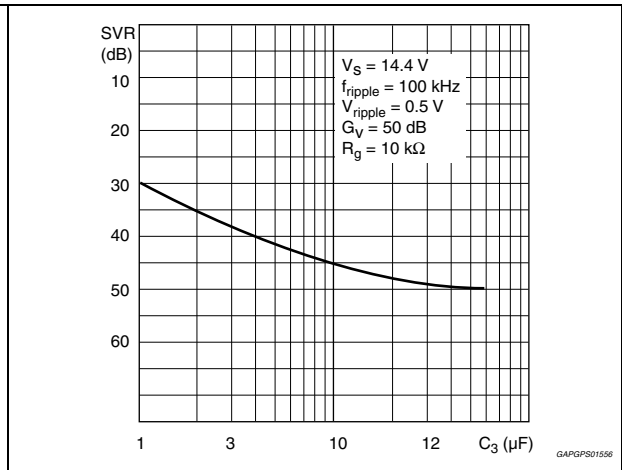


Figure 18. Supply voltage rejection vs. frequency (stereo amplifier)

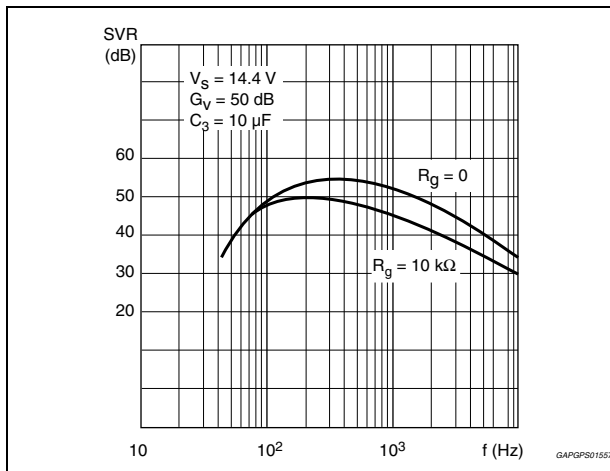


Figure 19. Supply voltage rejection vs.  $C_2$  and  $C_3$ ,  $G_V = 390/1 \Omega$  (stereo amplifier)

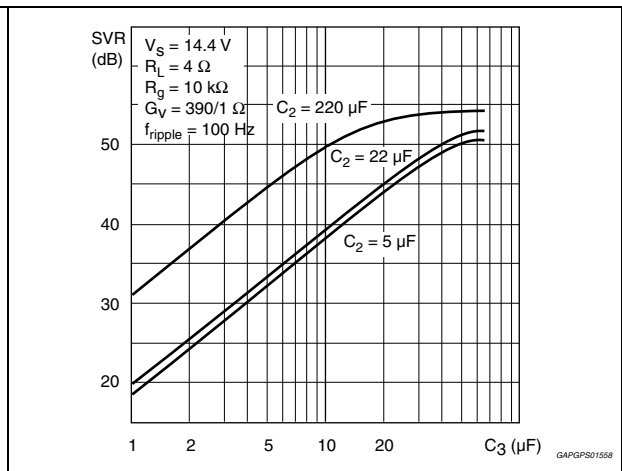


Figure 20. Supply voltage rejection vs. C2 and C3,  $G_V = 1000/10 \Omega$  (stereo amplifier)

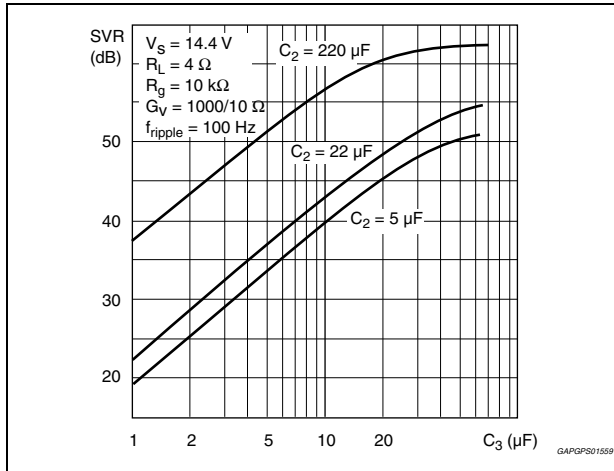


Figure 21. Gain vs. input sensitivity  $R_L = 4 \Omega$  (stereo amplifier)

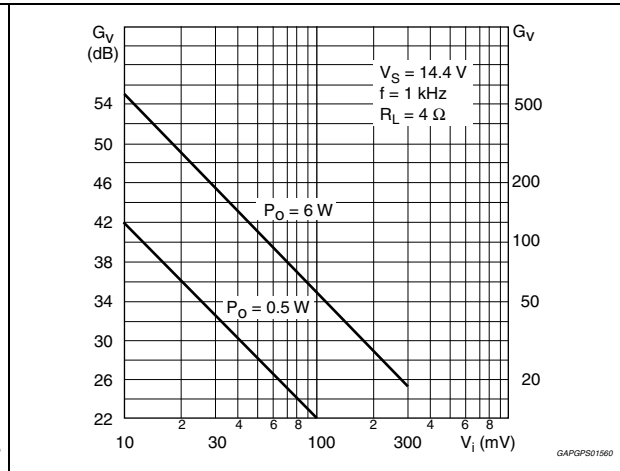


Figure 22. Gain vs. input sensitivity  $R_L = 2 \Omega$  (stereo amplifier)

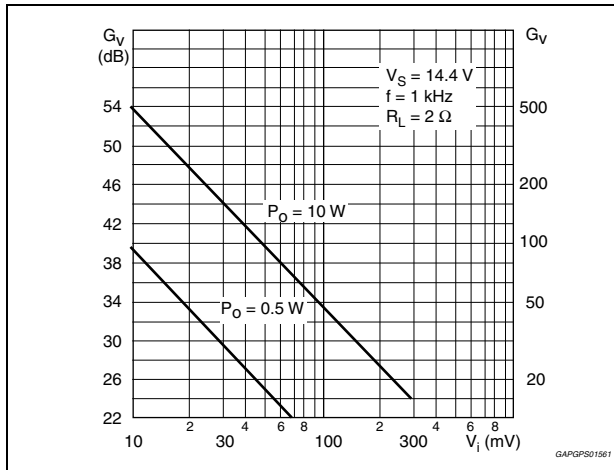


Figure 23. Total power dissipation and efficiency vs. output power (bridge)

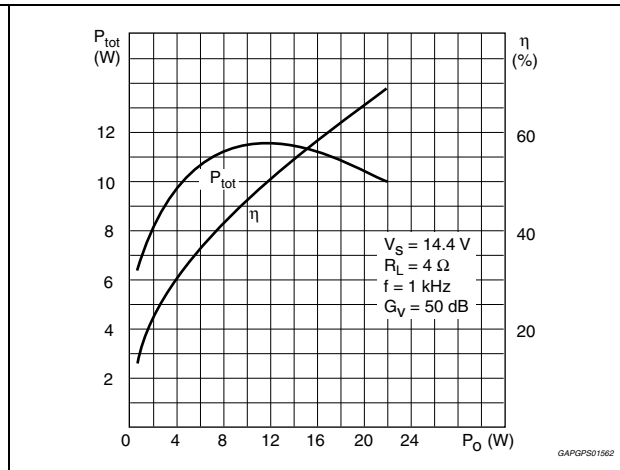
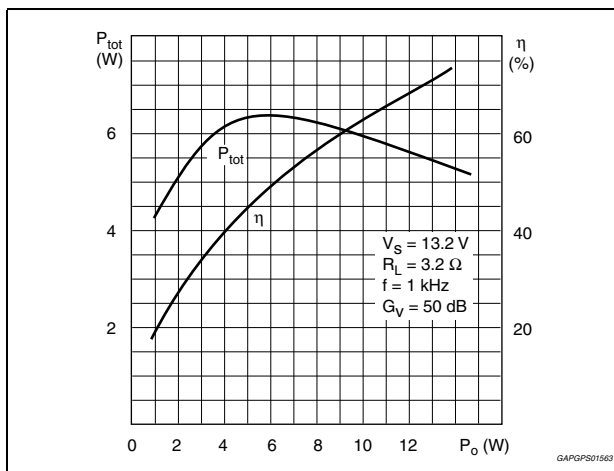


Figure 24. Total power dissipation and efficiency vs. output power (stereo)



### 3 Application suggestion

The recommended values of the components are those shown on bridge application circuit of [Figure 3](#). Different values can be used; the following table can help the designer.

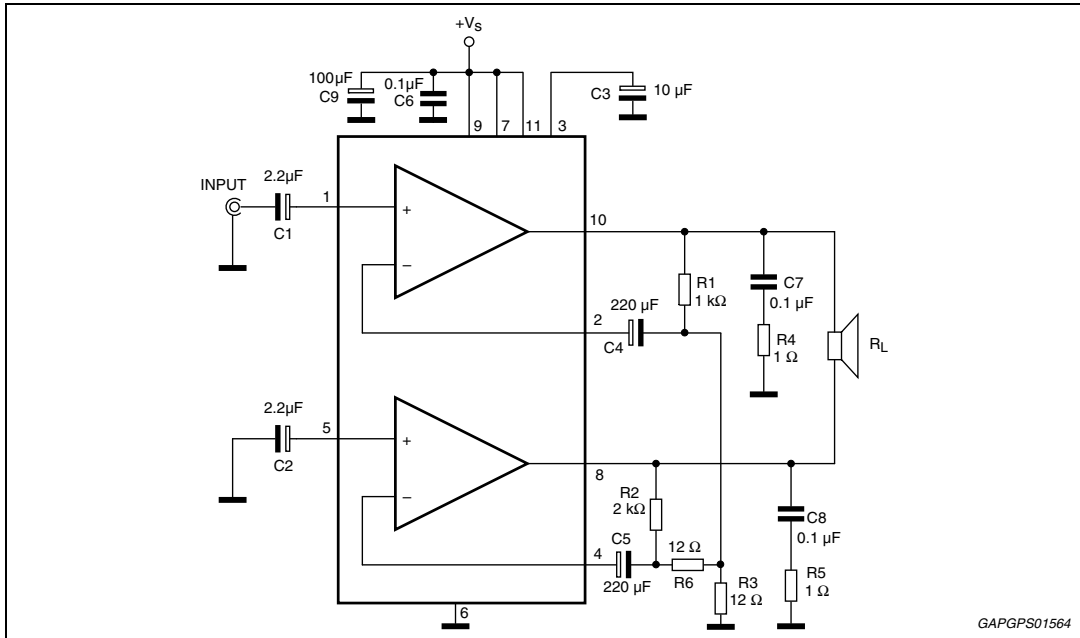
**Table 8. Recommended values of the component of the bridge application circuit**

| Component | Recommended value | Purpose  | Larger than  | Smaller than r   |
|-----------|-------------------|--|--|--|
| C1        | 2.2 $\mu$ F       | Input DC decoupling  | -  | -  |
| C2        | 2.2 $\mu$ F       | Optimization of turn on Pop and turn on Delay                          | High turn on delay   | High Turn on Pop, Higher low frequency cutoff<br>Increase of Noise |
| C3        | 0.1 $\mu$ F       | Supply bypass  | -  | Danger of oscillation  |
| C4        | 10 $\mu$ F        | Ripple rejection   | Increase of SVR,<br>Increase of the Switch-on Time             | Degradation of SVR   |
| C5, C7    | 100 $\mu$ F       | Bootstrapping  | -  | Increase of distortion at low frequency                            |
| C6, C8    | 220 $\mu$ F       | Feedback input DC decoupling, low frequency cut-off                    | -  | Danger of oscillation at high frequencies with inductive loads     |
| C9, C10   | 0.1 $\mu$ F       | Frequency stability  | -  | Danger of oscillation  |
| R1        | 120 k $\Omega$    | Optimization of the output symmetry                                    | Smaller P <sub>omax</sub>                                      | Smaller P <sub>omax</sub>  |
| R2        | 1 k $\Omega$      | -  | -  | -  |
| R3        | 2 k $\Omega$      | -  | -  | -  |
| R4, R5    | 12 $\Omega$       | Closed loop gain setting (see Bridge Amplifier Design <sup>(1)</sup> ) | -  | -  |
| R6, R7    | 1 $\Omega$        | Frequency stability  | Danger of oscillation at high frequencies with inductive loads | -  |

1. The closed loop gain must be higher than 32 dB.

# 4 Application information

Figure 25. Bridge amplifier without bootstrap



GAPGPS01564

Figure 26. PC board and components layout of [Figure 25](#)

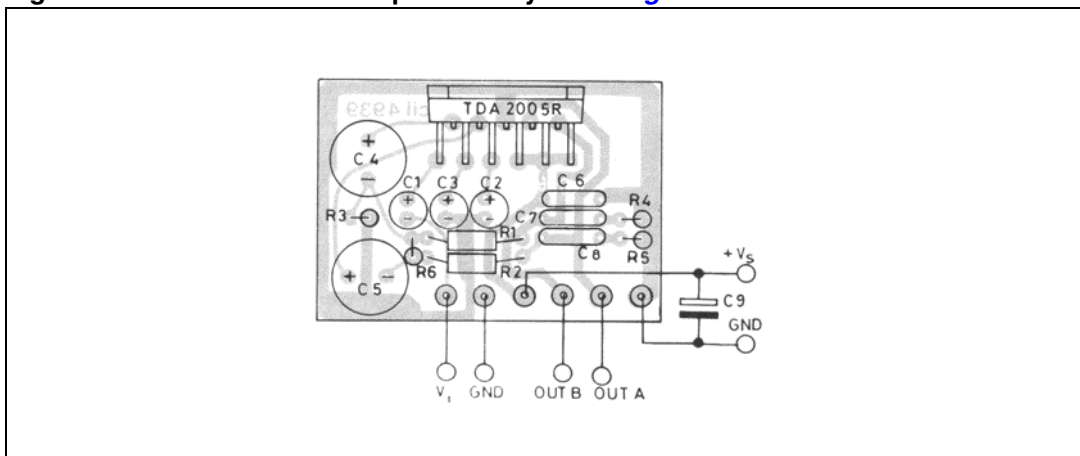
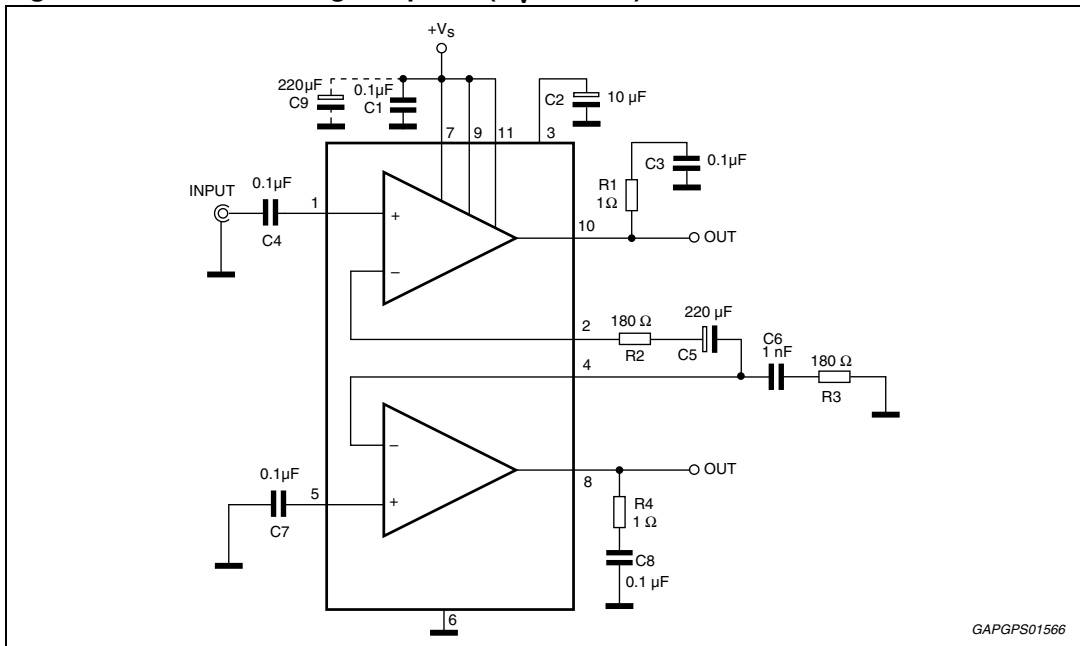


Figure 27. Low cost bridge amplifier ( $G_V = 42$  dB)



GAPGPS01566

Figure 28. PC board and components layout of [Figure 27](#)

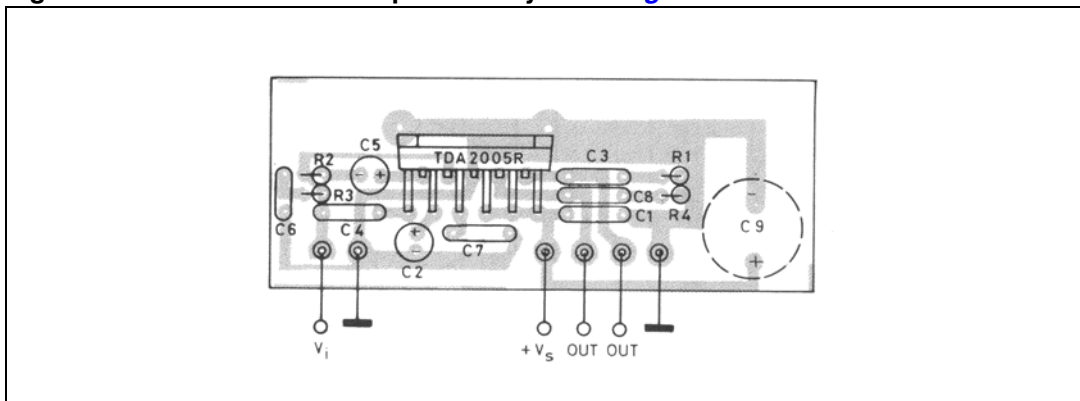
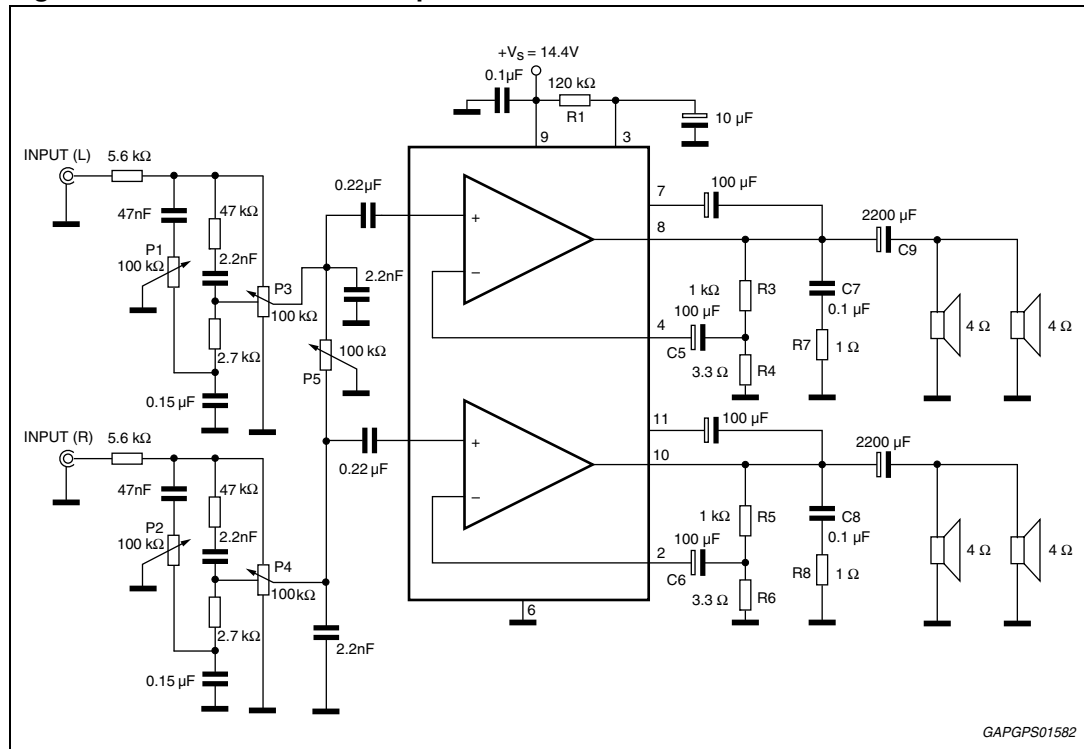


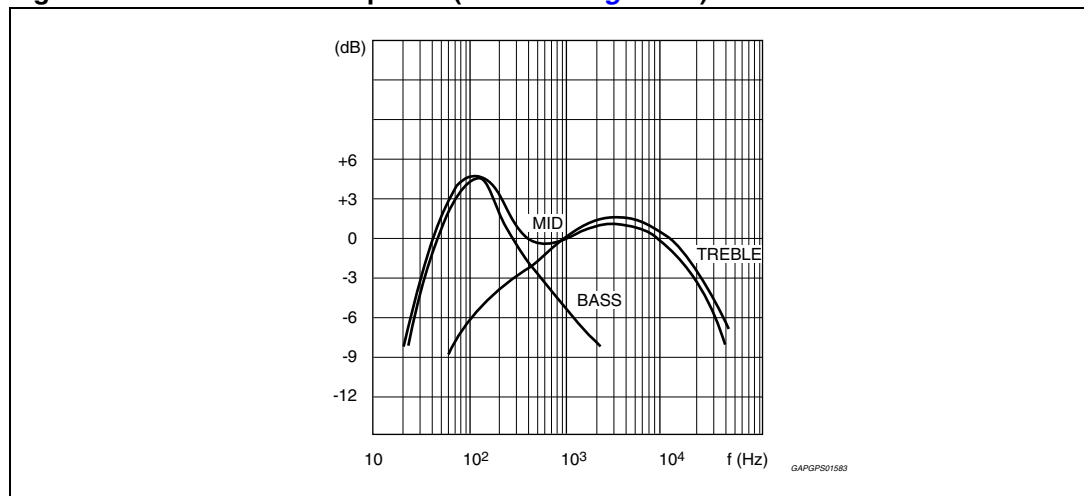


Figure 29. 10 + 10 W stereo amplifier with tone balance and loudness control



GAPGPS01582

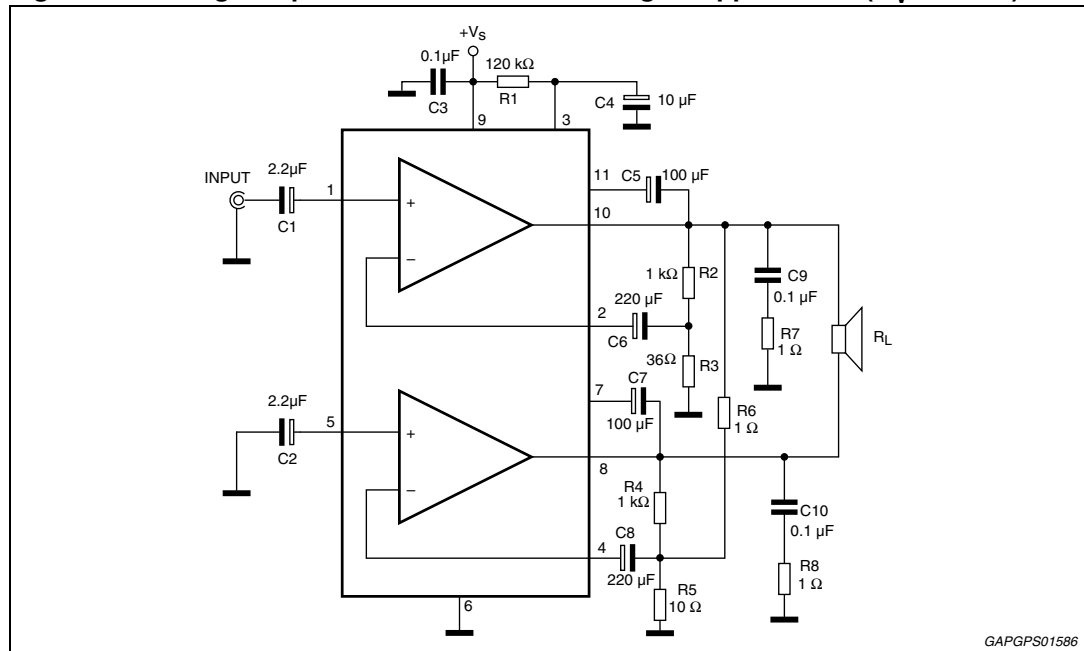
Figure 30. Tone control response (circuit of Figure 29)



GAPGPS01583

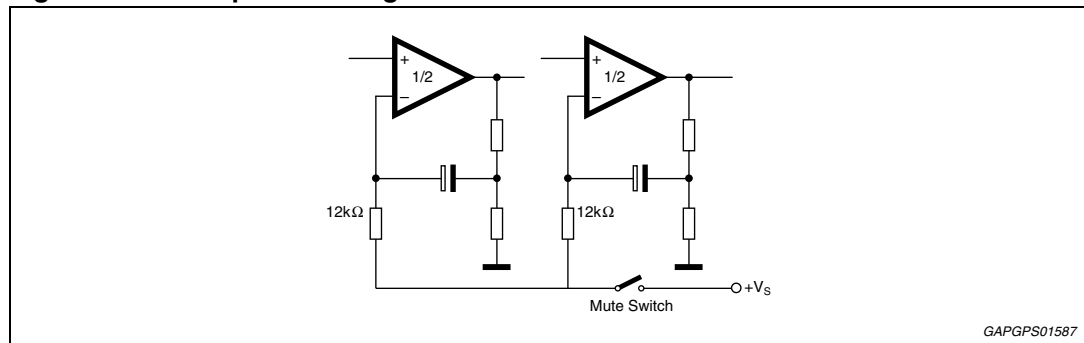


Figure 33. Bridge amplifier circuit suited for low-gain applications ( $G_V = 34 \text{ dB}$ )



GAPGPS01586

Figure 34. Example of muting circuit



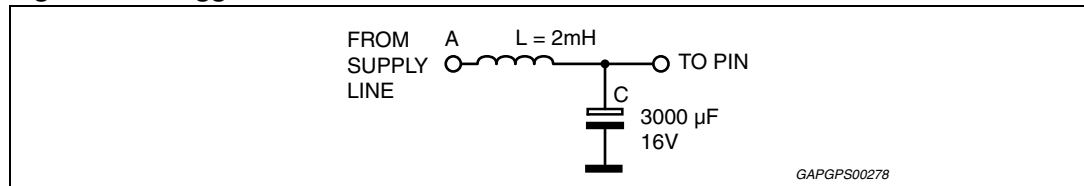
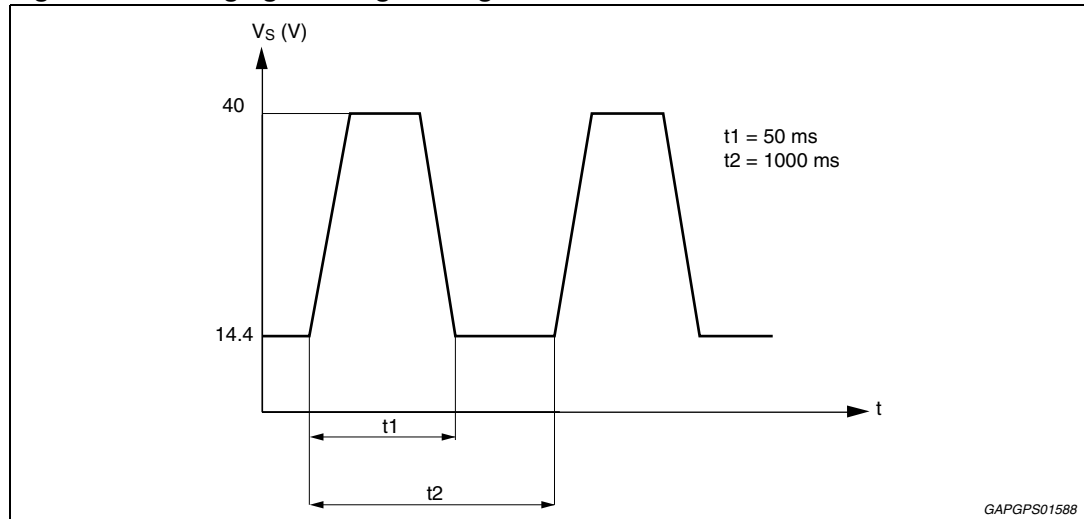
GAPGPS01587

## 4.1 Built-in protection systems

### 4.1.1 Load dump voltage surge

The TDA2005 has a circuit which enables it to withstand voltage pulse train, on Pin 9, of the type shown in [Figure 36](#). If the supply voltage peaks to more than 40 V, then an LC filter must be inserted between the supply and pin 9, in order to assure that the pulses at pin 9 will be held within the limits shown.

A suggested LC network is shown in [Figure 35](#). With this network, a train of pulses with amplitude up to 120 V and width of 2 ms can be applied at point A. This type of protection is ON when the supply voltage (pulse or DC) exceeds 18 V. For this reason the maximum operating supply voltage is 18 V.

**Figure 35. Suggested LC network circuit****Figure 36. Voltage gain bridge configuration**

#### 4.1.2 Short circuit (AC and DC conditions)

The TDA2005 can withstand a permanent short-circuit on the output for a supply voltage up to 16 V.

#### 4.1.3 Polarity inversion

High current (up to 10 A) can be handled by the device with no damage for a longer period than the blow-out time of a quick 2 A fuse (normally connected in series with the supply). This feature is added to avoid destruction, if during fitting to the car, a mistake on the connection of the supply is made.

#### 4.1.4 Open ground

When the ratio is in the ON condition and the ground is accidentally opened, a standard audio amplifier will be damaged. On the TDA2005 protection diodes are included to avoid any damage.

#### 4.1.5 Inductive load

A protection diode is provided to allow use of the TDA2005 with inductive loads.

#### 4.1.6 DC voltage

The maximum operating DC voltage for the TDA2005 is 18 V. However the device can withstand a DC voltage up to 28 V with no damage. This could occur during winter if two batteries are series connected to crank the engine.

### 4.1.7 Thermal shut-down

The presence of a thermal limiting circuit offers the following advantages:

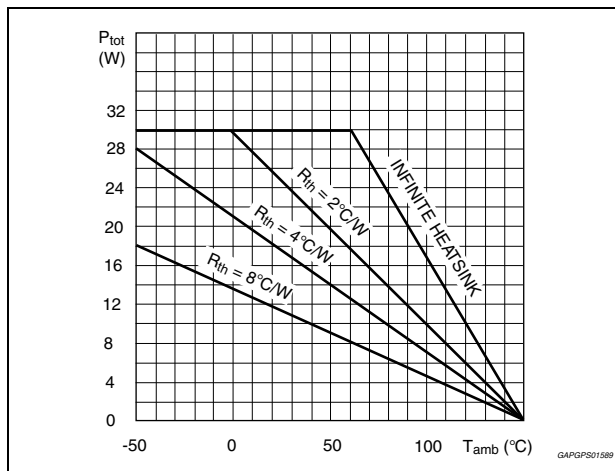
1. an overload on the output (even if it is permanent), or an excessive ambient temperature can be easily withstood.
2. the heatsink can have a smaller factor of safety compared with that of a conventional circuit. There is no device damage in the case of excessive junction temperature : all that happens is that  $P_o$  (and therefore  $P_{tot}$ ) and  $I_d$  are reduced.

The maximum allowable power dissipation depends upon the size of the external heatsink (i.e. its thermal resistance); *Figure 37* shows the power dissipation as a function of ambient temperature for different thermal resistance.

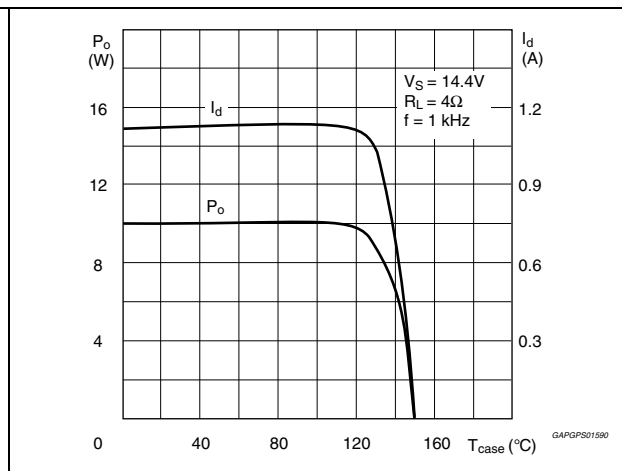
### 4.1.8 Loudspeaker protection

The circuit offers loudspeaker protection during short circuit for one wire to ground.

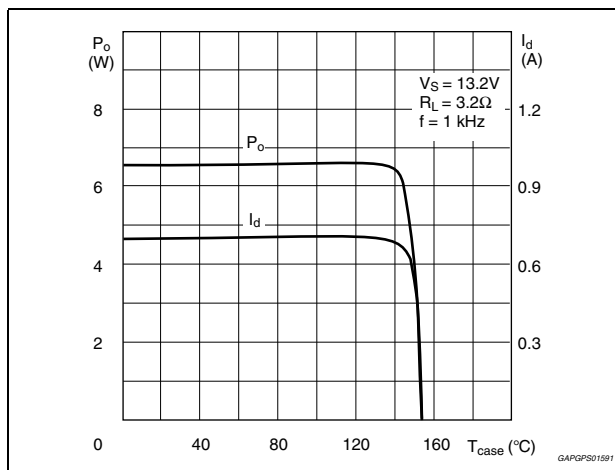
**Figure 37. Maximum allowable power dissipation vs. ambient temperature**



**Figure 38. Output power and drain current vs. case temperature ( $R_L = 4 \Omega$ )**



**Figure 39. Output power and drain current vs. case temperature ( $R_L = 3.2 \Omega$ )**

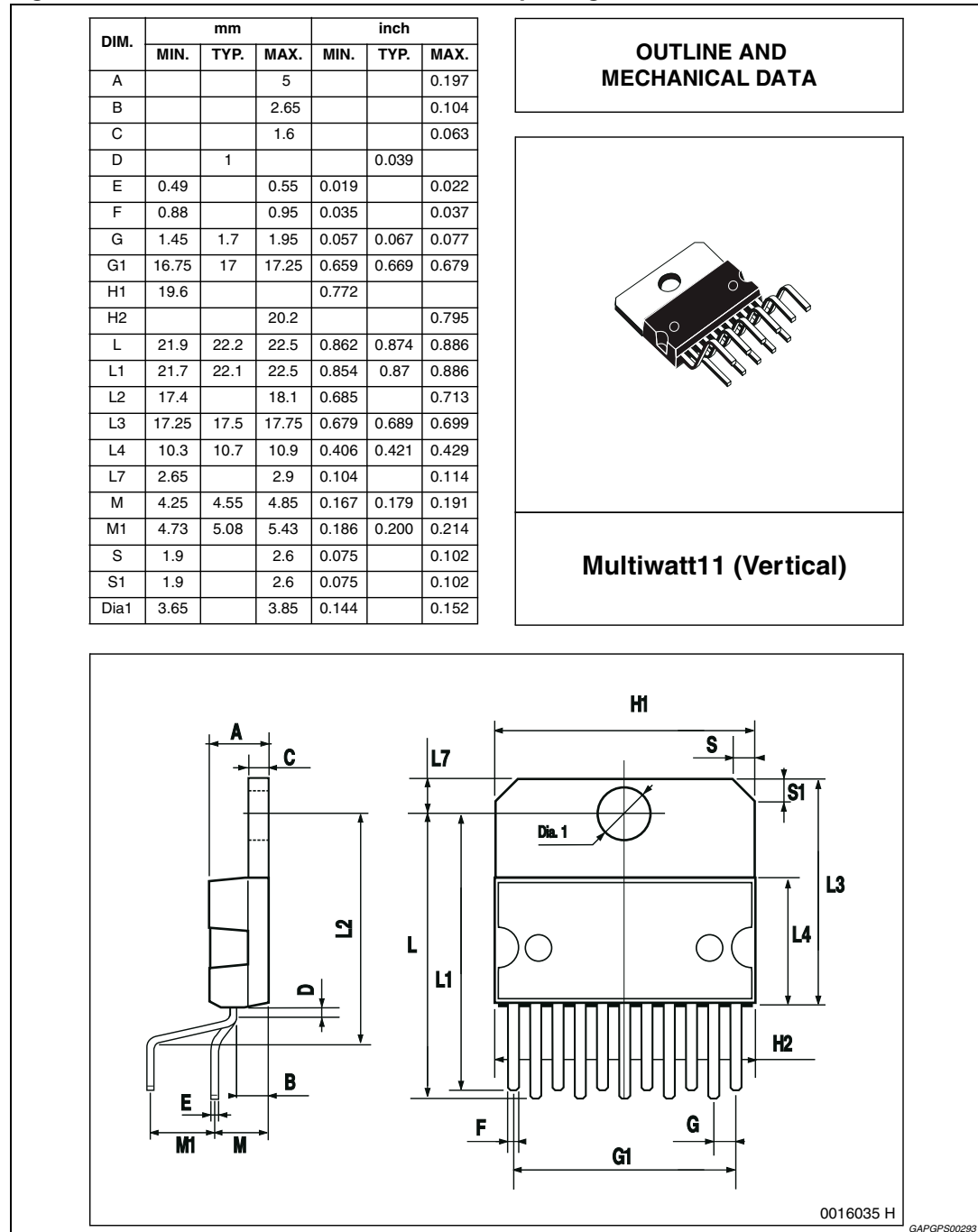


# 5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com).

ECOPACK® is an ST trademark.

**Figure 40. Multiwatt11 mechanical data and package dimensions**



## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 09-Jun-1998 | 1        | Initial release.  |
| 20-May-2000 | 2        | Update logo.  |
| 10-Sep-2003 | 3        | Update package drawing.   |
| 28-Jan-2010 | 4        | Document reformatted.<br>Updated <i>Features</i> , <i>Description</i> and <i>Table 1: Device summary</i> in cover page. |
| 02-May-2012 | 5        | Updated <i>Table 1: Device summary on page 1</i> .  |
| 17-Sep-2013 | 6        | Updated Disclaimer.   |

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