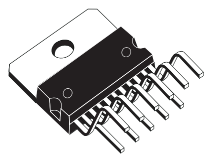
TDA2005

20 W bridge/stereo amplifier for car radio

Features

- High output power:
  - P_o = 10 + 10 W @ R_L = 2 Ω, THD = 10 %
  - P_o = 20 W @ R_L = 4 Ω , THD = 10 %.
- Protection against:
  - Output DC and AC short circuit to ground
  - Overrating chip temperature
  - Load dump voltage surge
  - Fortuitous open ground
  - Very inductive loads
- Loudspeaker protection during short circuit for one wire to ground



Multiwatt11

Description

The TDA2005 is a class B dual audio power amplifier in Multiwatt11 package specifically designed for car radio applications.

Power booster amplifiers can be easily designed using this device that provides a high current capability (up to 3.5 A) and can drive very low impedance loads (down to 1.6 Ω in stereo applications) obtaining an output power of more than 20 W (bridge configuration).

Table 1. Device summary

Order code	Package	Packing
TDA2005R	Multiwatt11	Tube
TDA2005M(1)	Multiwatt11	Tube
TDA2005S(1)	Multiwatt11	Tube

1. Do not use for New Design.

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1 Schematic and pins connection diagrams

Figure 1. Schematic diagram

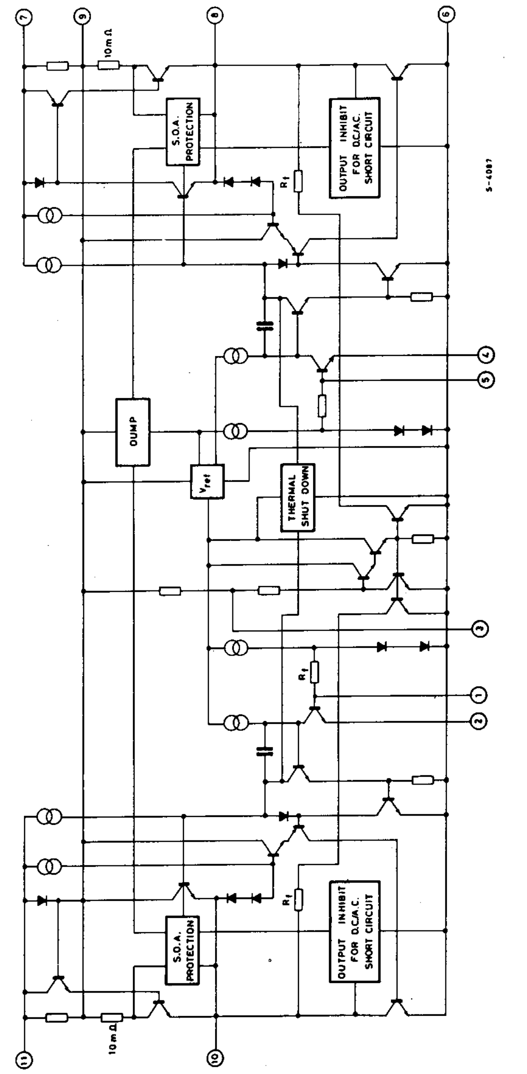
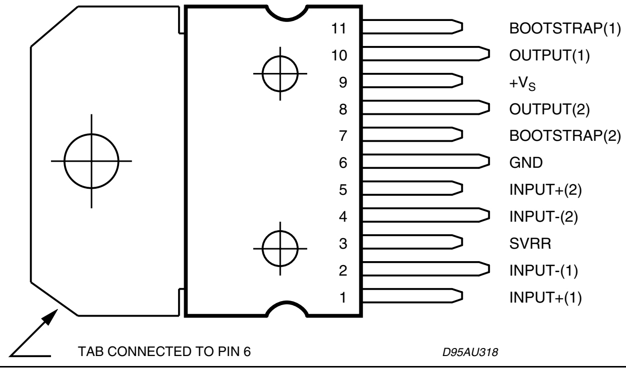


Figure 2. Pins connection diagram (top view)



2 Electrical specifications

2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_S	Peak supply voltage (50 ms)	40	V
	DC supply voltage	28	
	Operating supply voltage	18	
I_o(1)	Output peak current (non repetitive t = 0.1 ms)	4.5	A
	Output peak current (repetitive f ≥10 Hz)	3.5	
P_{tot}	Power dissipation at T_{case} = 60 °C	20	W
T_{stg}, T_j	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
$R_{th\text{-}j\text{-}case}$	Thermal resistance junction-to-case	max	3	°C/W

2.3 Bridge amplifier section

Figure 3. Test and application circuit (bridge amplifier)

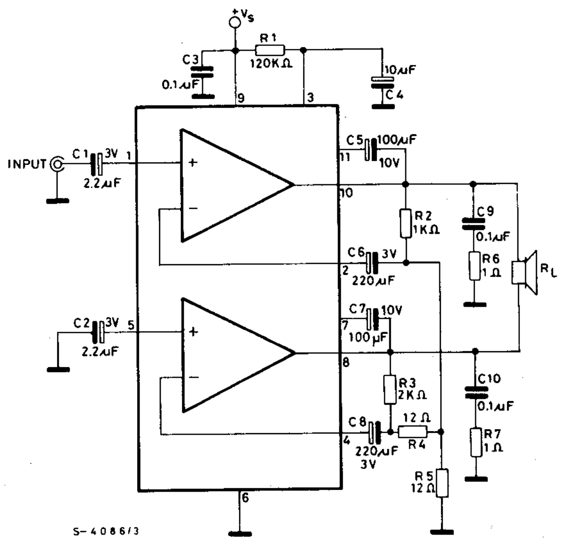
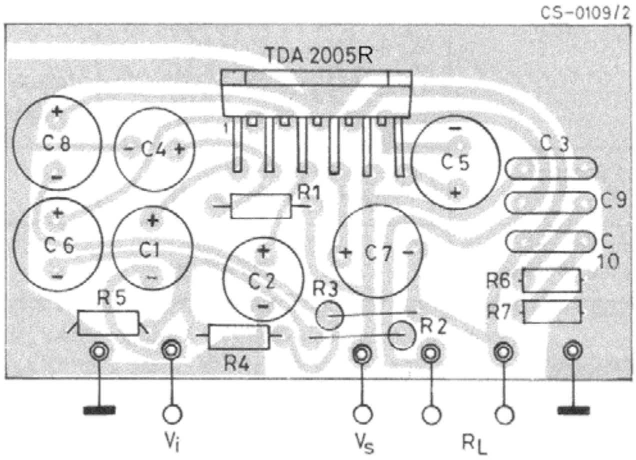


Figure 4. PC board and components layout of *Figure 3*



2.3.1 Electrical characteristics (bridge application)

Refer to the bridge application circuit T_{amb} = 25°C; Gv = 50dB; $R_{th(heatsink)}$ = 4°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 (between pin 8 and pin 10)	V_S = 14.4 V V_S = 13.2 V	-	-	150 150	mV mV
I_d	Total quiescent drain current	V_S = 14.4 V; R_L = 4 Ω V_S = 13.2 V; R_L = 3.2 Ω	-	75 70	150 150	mA mA
P_o	Output power	f = 1 kHz, THD = 10 % V_S = 14.4 V; R_L = 4 Ω V_S = 14.4 V; R_L = 3.2 Ω V_S = 13.2 V; R_L = 3.2 Ω	18 20 17	20 22 19	-	W
THD	Total harmonic distortion	f = 1 kHz; V_S = 14.4 V; R_L = 4 Ω; P_o = 50 mW to 15 W;	-	-	1	%
		f = 1 kHz; V_S = 13.2 V; R_L = 3.2 Ω; P_o = 50m W to 13 W;	-	-	1	%
V_i	Input sensitivity	f = 1 kHz R_L = 4 Ω; P_o = 2 W; R_L = 3.2 Ω; P_o = 2 W	-	9 8	-	mW
R_i	Input resistance	f = 1 kHz	70	-	-	kΩ
f_L	Low frequency roll off (-3 dB)	R_L = 3.2 Ω	-	-	40	Hz
f_H	High frequency roll off (-3 dB)	R_L = 3.2 Ω	20	-	-	KHz
Gv	Closed loop voltage gain	f = 1 kHz	-	50	-	dB
e_N	Total Input noise voltage	R_g = 10 Ω [1]	-	3	10	µV
SVR	Supply voltage rejection	V_{ripple} = 0.5 V; f_{ripple} =100 Hz R_g = 10 kΩ; C_4 = 10 µF	45	55	-	dB

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

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

1. Bandwidth filter: 22 Hz to 22 kHz.

Figure 5. Output offset voltage vs. supply voltage

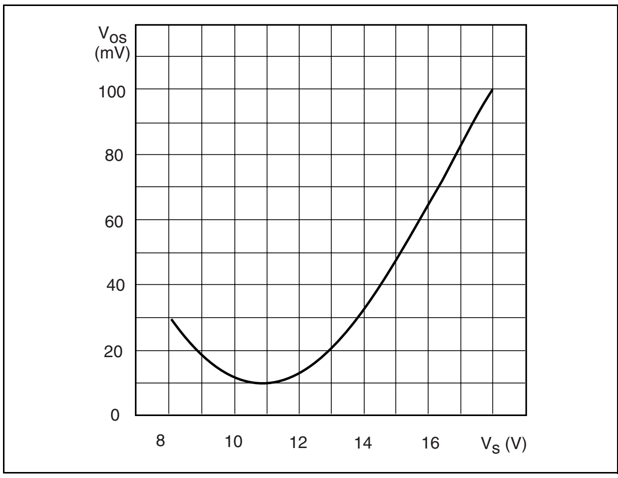


Figure 6. Distortion vs. output power (R_L = 4 Ω)

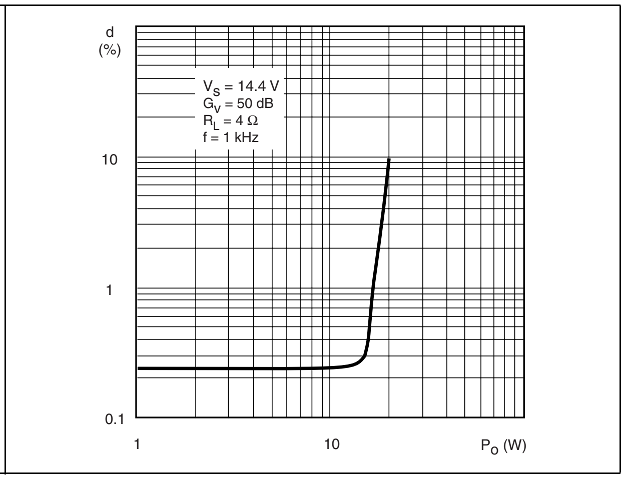
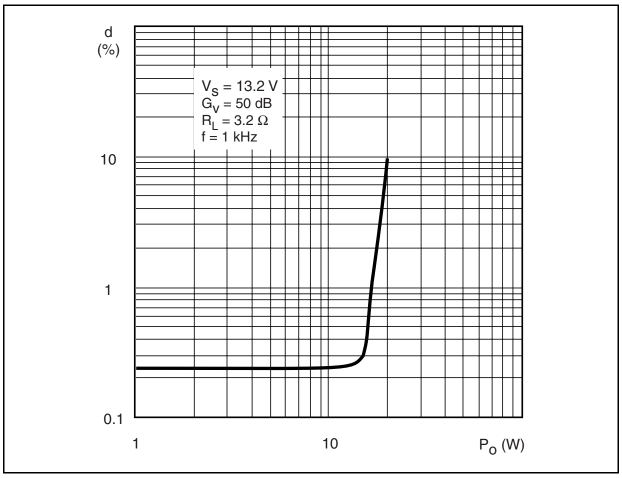


Figure 7. Distortion vs. output power (R_L = 3.2 Ω)



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 order 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 = 14.4V and $V_{CE\ sat}$ = 2V, 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*):

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

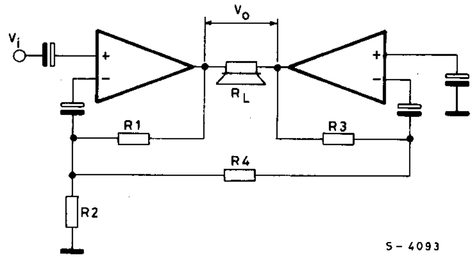
For sufficiently high gains (40 to 50 dB) it is possible to put $R_2 = R_4$ and $R_3 = 2R_1$, simplifying the formula in:

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

Table 6. High gain vs. Rx

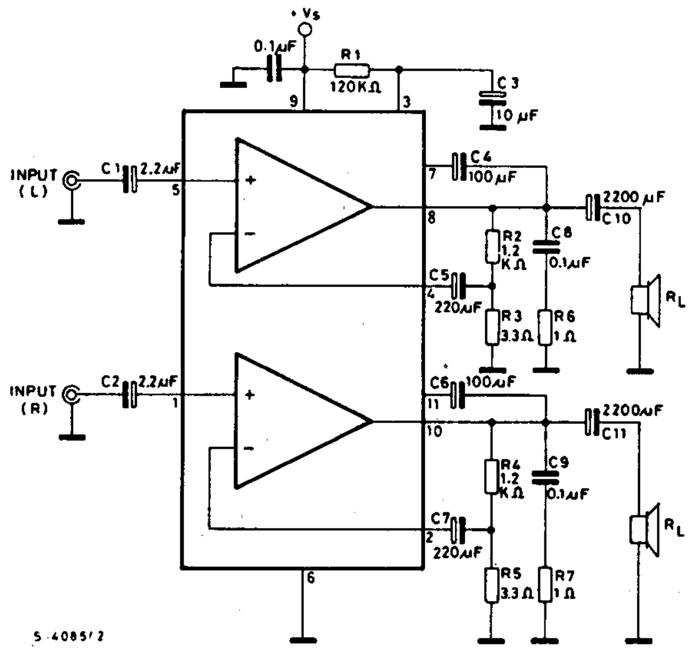
G_v (dB)	R_1 (Ω)	$R_2 = R_4$ (Ω)	R_3 (Ω)
40	1000	39	2000
50	1000	12	2000

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 °C; G_v = 50 dB; $R_{th(heatsink)}$ = 4°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 V V_S = 13.2 V	6.6 6	7.2 6.6	7.8 7.2	V V
I_d	Total quiescent drain current	V_S = 14.4 V V_S = 13.2 V	-	65 62	120 120	mA mA
P_o	Output power (each channel)	f = 1 kHz; THD = 10 % V_S = 14.4 V; R_L = 4 Ω V_S = 14.4 V; R_L = 3.2 Ω V_S = 14.4 V; R_L = 2 Ω V_S = 14.4 V; R_L = 1.6 Ω	 6 7 9 10	 6.5 8 10 11	-	W
		f = 1 kHz; THD = 10 % V_S = 13.2 V; R_L =3.2 Ω V_S = 13.2 V; R_L = 1.6 Ω V_S = 16 V; R_L = 2 Ω	 6 9	 6.5 10 12	-	W
THD	Total harmonic distortion	f = 1 kHz; V_S = 14.4 V; R_L = 4 Ω; P_o = 50 mW to 4 W;	-	0.2	1	%
		f = 1 kHz; V_S = 14.4 V; R_L = 2 Ω; P_o = 50 mW to 6 W;	-	0.3	1	%
		f = 1 kHz; V_S = 13.2 V; R_L = 3.2 Ω; P_o = 50 mW to 3W;	-	0.2	1	%
		f = 1KHz; V_S = 13.2V; R_L = 1.6Ω; P_o = 40mW to 6W;	-	0.3	1	%
CT	Cross talk	V_S = 14.4 V; V_o = 4 V_{RMS}; R_g = 5 kΩ; R_L = 4 Ω; f = 1 kHz f = 10 kHz	-	 60 45	-	 mW mW
V_i	Input saturation voltage	-	300		-	mW
V_i	Input sensitivity	f = 1 kHz; Po = 1W; R_L = 4 Ω; R_L = 3.2Ω;	-	 6 5.5	-	 mV mV
R_i	Input resistance	f = 1 kHz	70	200	-	kΩ
f_L	Low frequency roll off (-3 dB)	R_L = 2 Ω	-	-	50	Hz
f_H	High frequency roll off (-3 dB)	R_L = 2 Ω	15	-	-	kHz
G_v	Open loop voltage gain	f = 1 kHz	-	90	-	dB
	Closed loop voltage gain	f = 1 kHz	48	50	51	

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

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

1. Bandwidth filter: 22 Hz to 22 kHz.

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

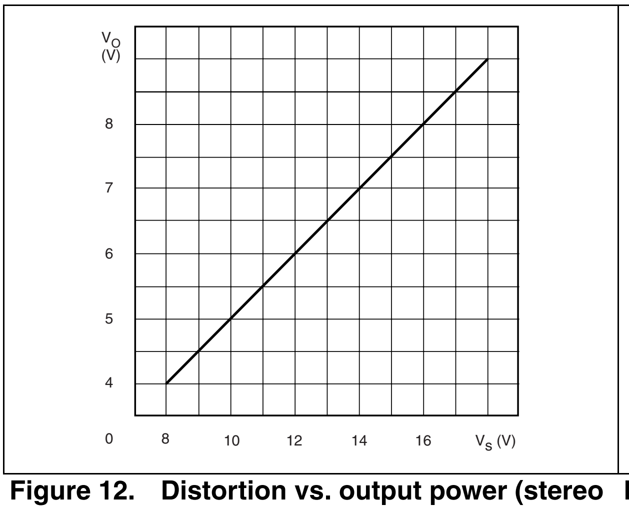


Figure 11. Quiescent drain current vs. supply voltage (stereo amplifier)

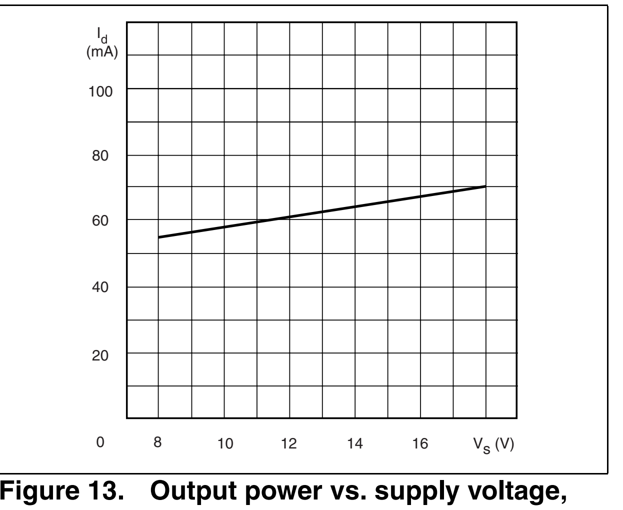


Figure 12. Distortion vs. output power (stereo amplifier)

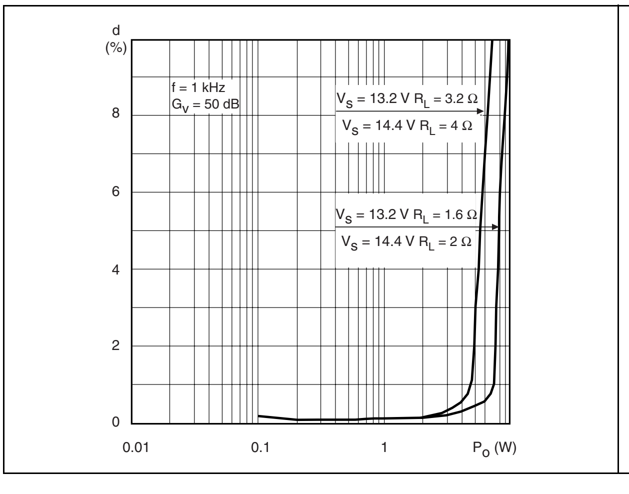


Figure 13. Output power vs. supply voltage, R_L = 2 and 4 Ω (stereo amplifier)

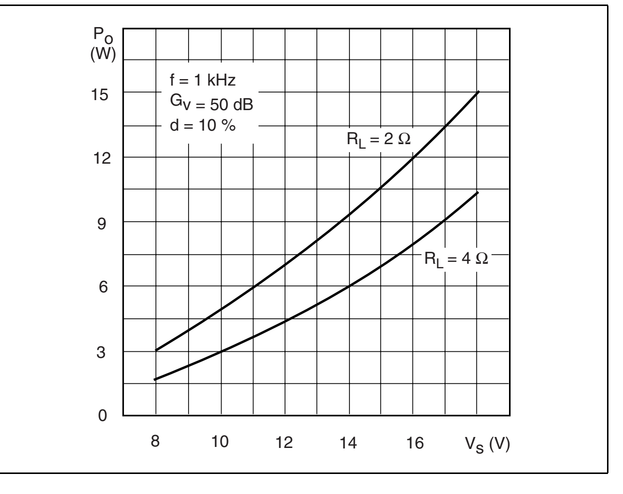


Figure 14. Output power vs. supply voltage, R_L = 1.6 and 3.2Ω (Stereo amplifier)

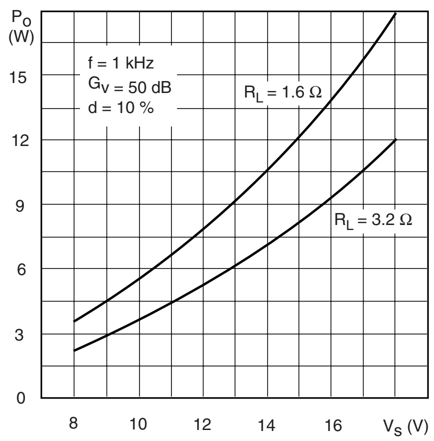


Figure 15. Distortion vs. frequency, R_L = 2 and 4 Ω (stereo amplifier)

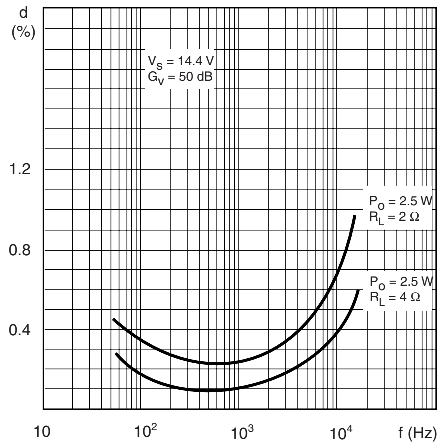


Figure 16. Distortion vs. frequency, R_L = 1.6 and 3.2 Ω (stereo amplifier)

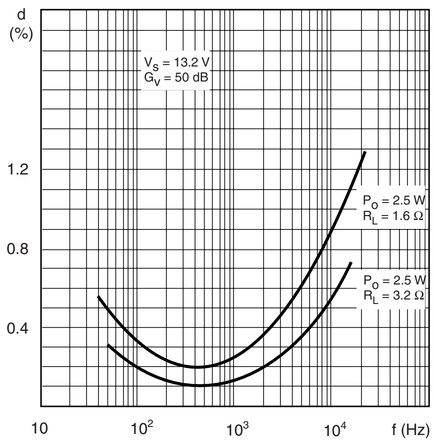


Figure 17. Supply voltage rejection vs. C3 (stereo amplifier)

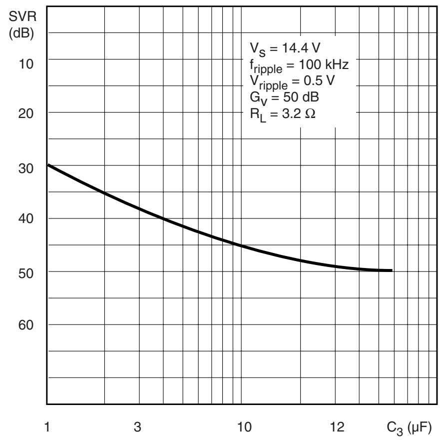


Figure 18. Supply voltage rejection vs. frequency (stereo amplifier)

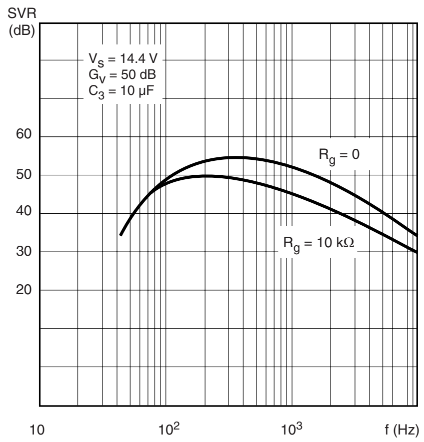


Figure 19. Supply voltage rejection vs. C2 and C3, G_V = 390/1Ω (stereo amplifier)

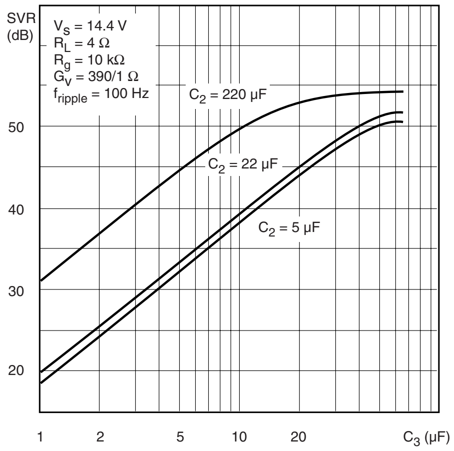


Figure 20. Supply voltage rejection vs. C2 and C3, G_V = 1000/10Ω (stereo amplifier)

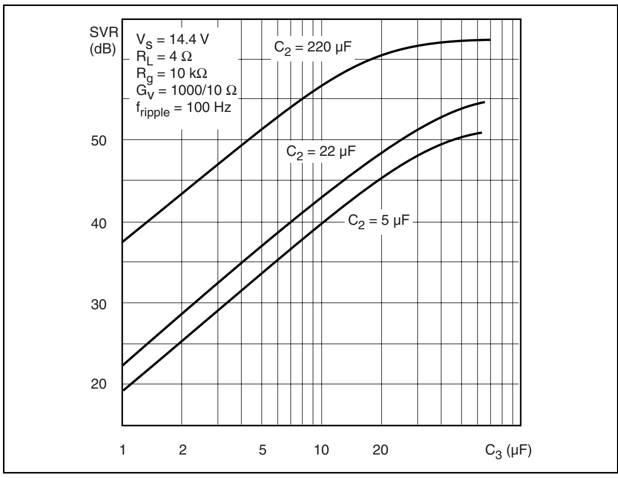


Figure 21. Gain vs. input sensitivity R_L = 4 Ω (stereo amplifier)

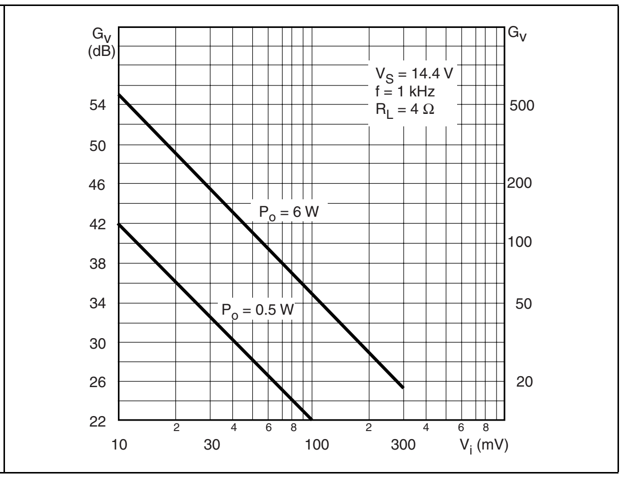


Figure 22. Gain vs. input sensitivity R_L = 2 Ω (stereo amplifier)

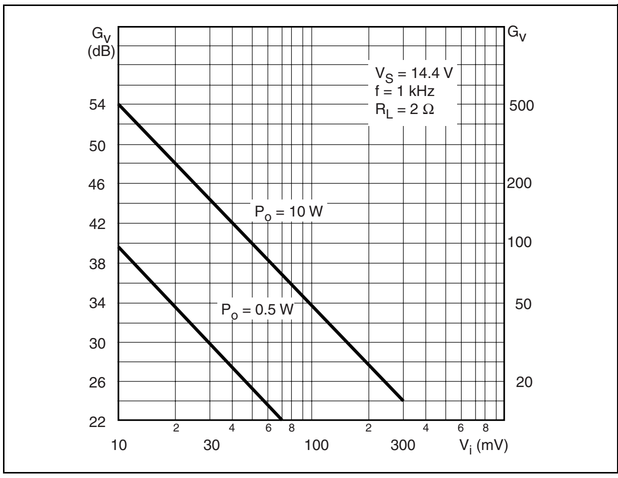


Figure 23. Total power dissipation and efficiency vs. output power (bridge)

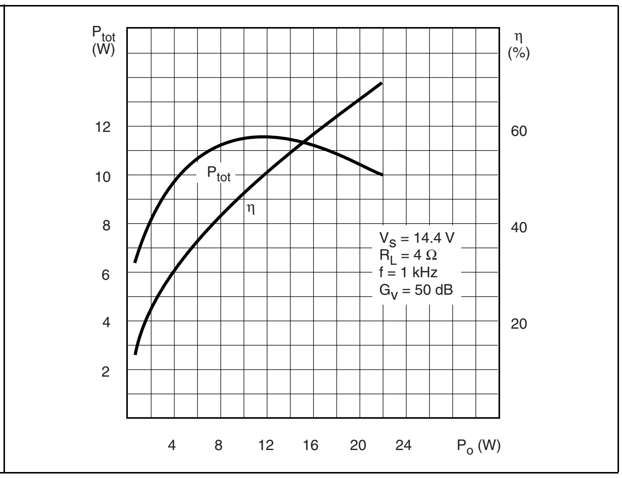
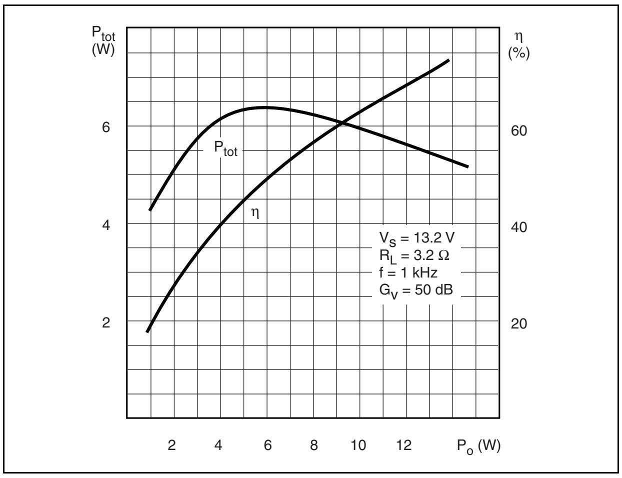


Figure 24. Total power dissipation and efficiency vs. output power (stereo)



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 µF	Input DC decoupling	-	-
C2	2.2 µF	Optimization of turn on Pop and turn on Delay	High turn on delay	High Turn on Pop, Higher low frequency cutoff Increase of Noise
C3	0.1 µF	Supply bypass	-	Danger of oscillation
C4	10 µF	Ripple rejection	Increase of SVR, Increase of the Switch-on Time	Degradation of SVR
C5, C7	100 µF	Bootstrapping	-	Increase of distortion at low frequency
C6, C8	220 µF	Feedback input DC decoupling, low frequency cut-off	-	Danger of oscillation at high frequencies with inductive loads
C9, C10	0.1 µF	Frequency stability	-	Danger of oscillation
R1	120 kΩ	Optimization of the output symmetry	Smaller P_{omax}	Smaller P_{omax}
R2	1 kΩ	-	-	-
R3	2 kΩ	-	-	-
R4, R5	12 Ω	Closed loop gain setting (see Bridge Amplifier Design[1])	-	-
R6, R7	1 Ω	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 boostrap

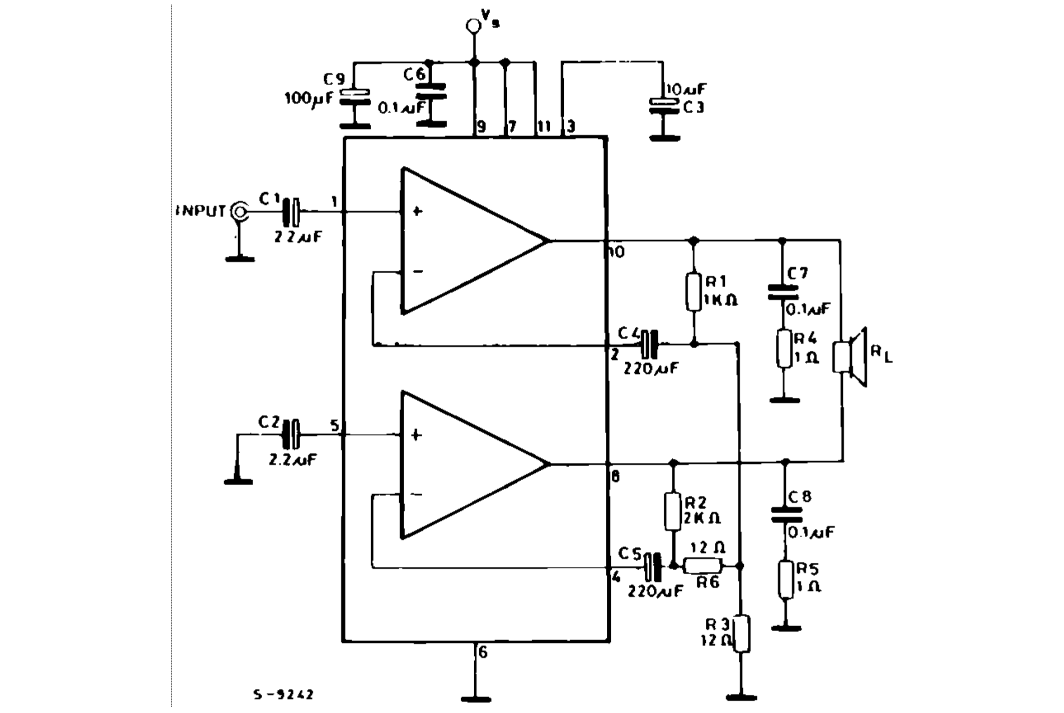


Figure 26. PC board and components layout of *Figure 25*

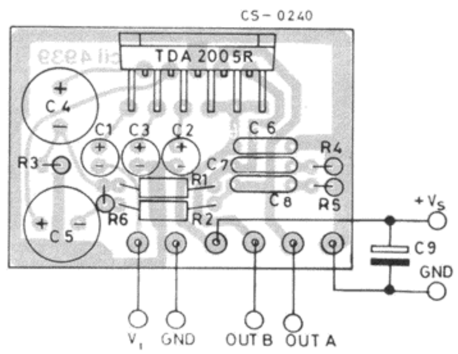


Figure 27. Low cost bridge amplifier (G_V = 42dB)

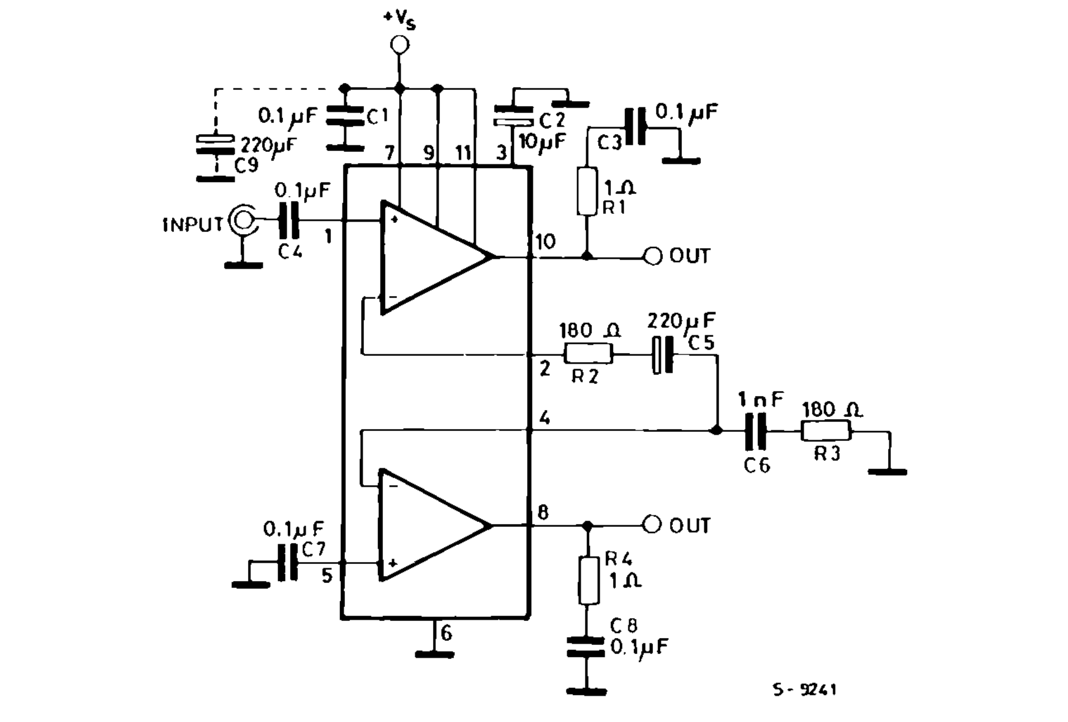


Figure 28. PC board and components layout of *Figure 27*

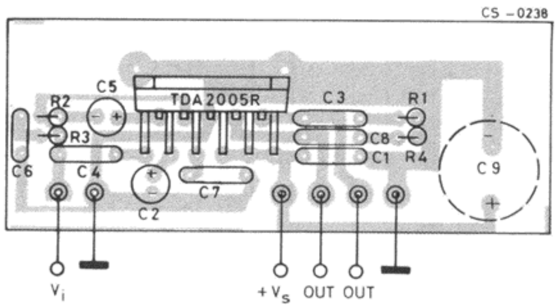


Figure 29. 10 + 10 W stereo amplifier with tone balance and loudness control

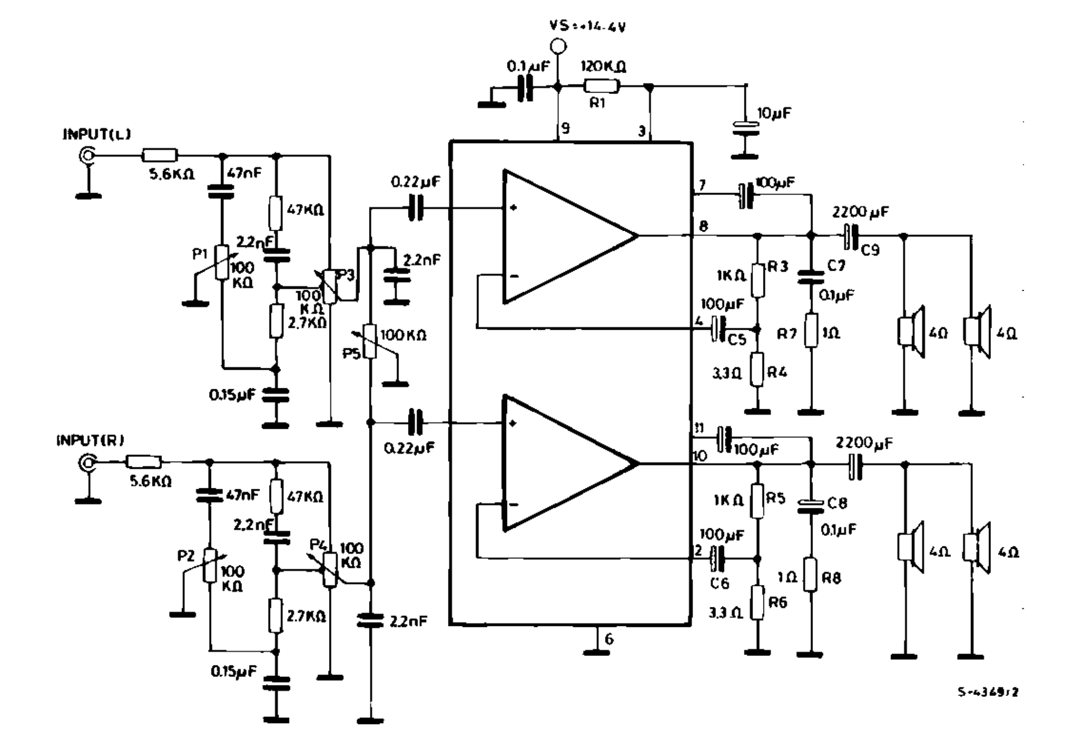


Figure 30. Tone control response (circuit of *Figure 29*)

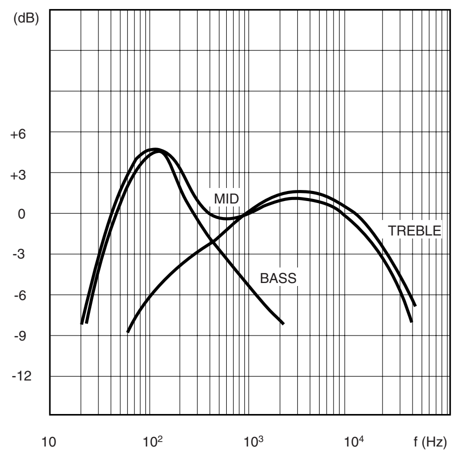


Figure 31. 20 W bus amplifier

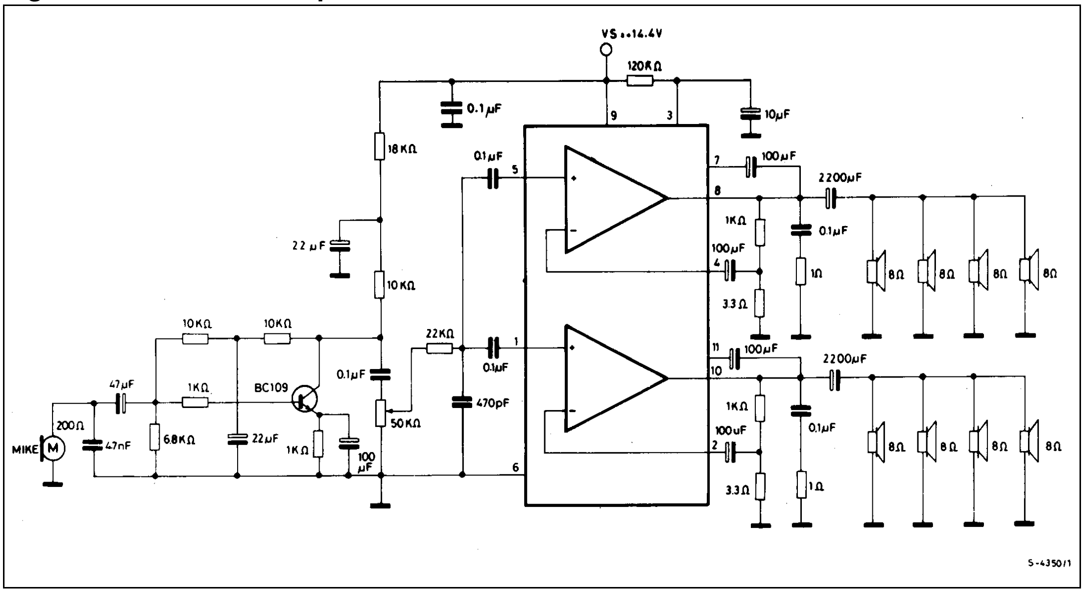


Figure 32. Simple 20 W two way amplifier (F_C = 2 kHz)

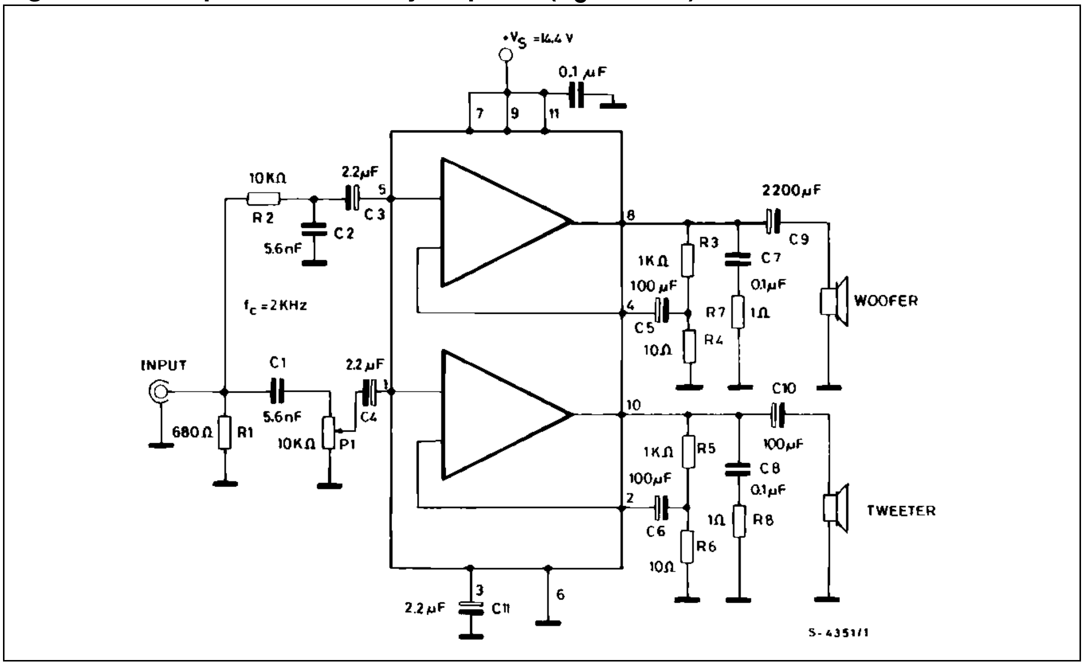


Figure 33. Bridge amplifier circuit suited for low-gain applications (G_V = 34 dB)

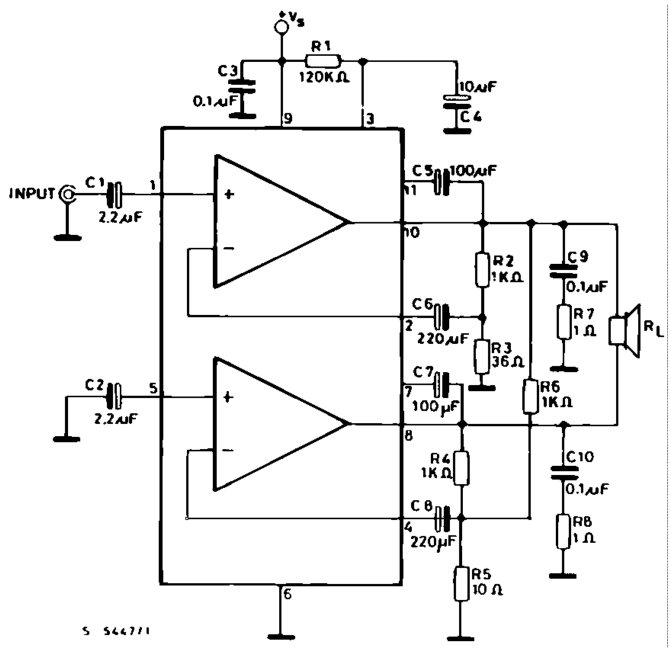
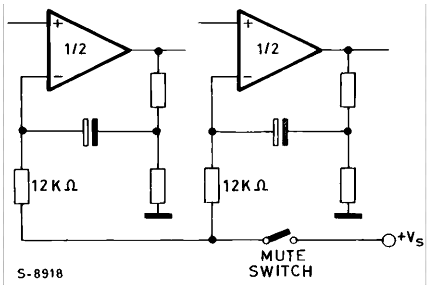


Figure 34. Example of muting circuit



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

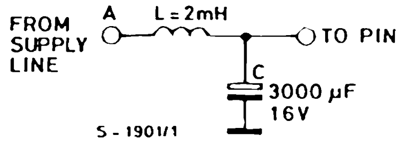
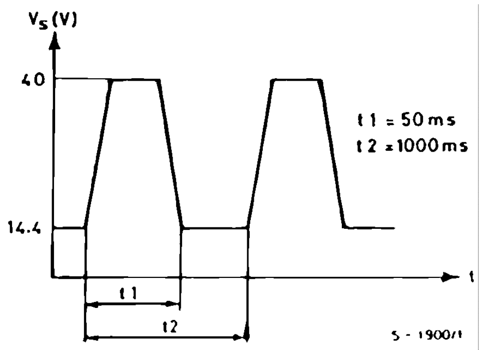


Figure 36. Voltage gain bridge configuration



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 Id 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

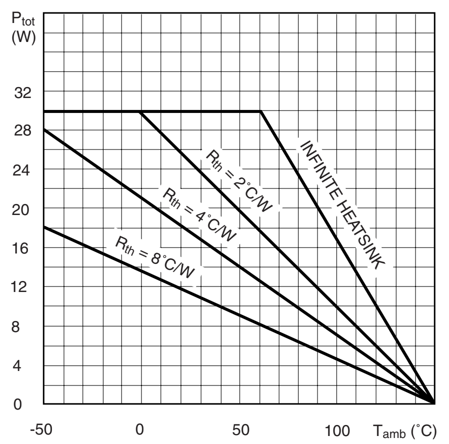


Figure 38. Output power and drain current vs. case temperature (R_L = 4 Ω)

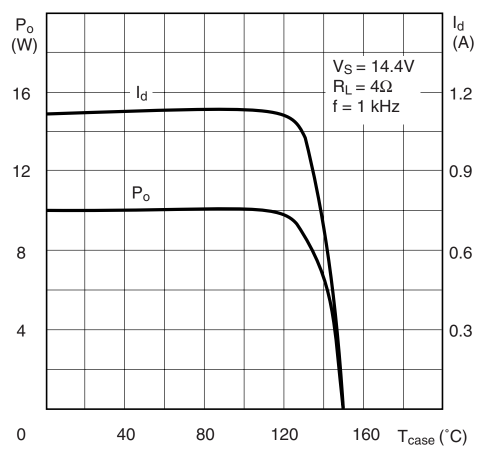
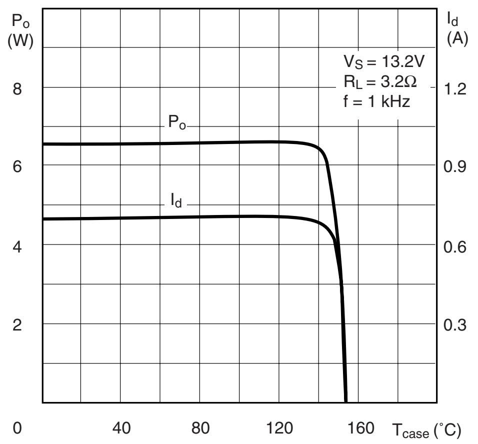


Figure 39. Output power and drain current vs. case temperature (R_L = 3.2 Ω)



5 Package information

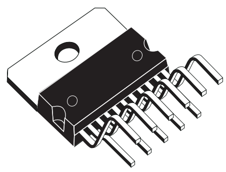
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com.

ECOPACK® is an ST trademark.

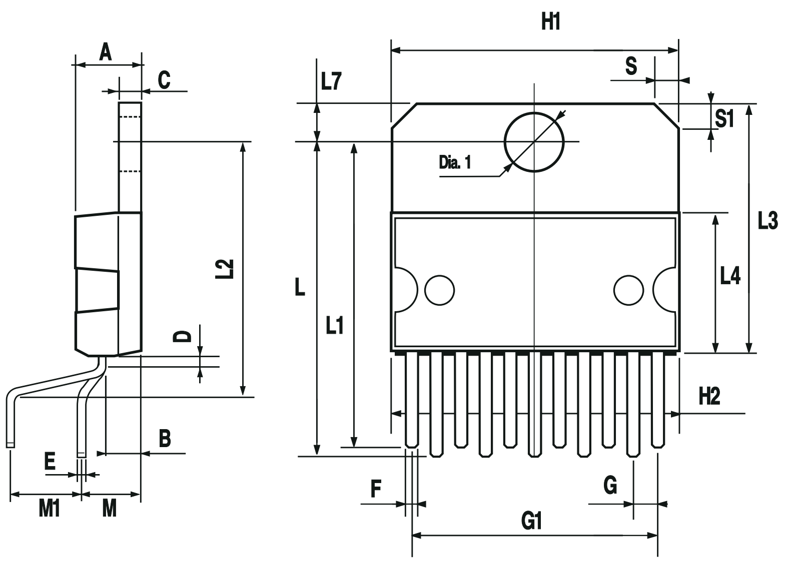
Figure 40. Multiwatt11 mechanical data and package dimensions

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.88		0.95	0.035		0.037
G	1.45	1.7	1.95	0.057	0.067	0.077
G1	16.75	17	17.25	0.659	0.669	0.679
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	17.4		18.1	0.685		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



Multiwatt11 (Vertical)



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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. Updated *Features*, *Description* and *Table 1: Device summary* in cover page.