SGS **TDA 2005**

LINEAR INTEGRATED CIRCUIT

20 W BRIDGE AMPLIFIER FOR CAR RADIO

The TDA 2005 is a class B dual audio power amplifier in MULTIWATT® package specifically designed for car radio application: **power booster amplifiers** are easily designed using this device that provides a high current capability (up to 3.5A) and that can drive very low impedance loads (down to 1.6 Ω in stereo applications) obtaining an output power of more than 20W (bridge configuration).

High output power: $P_o = 10 + 10W$ @ $R_L = 2\Omega$, $d = 10\%$; $P_o = 20W$ @ $R_L = 4\Omega$, $d = 10\%$

High reliability of the chip and package with additional complete safety during operation thanks to protection against:

- output DC and AC short circuit to ground.
- overrating chip temperature (150°C)
- load dump voltage surge.
- fortuitous open ground.
- polarity inversion.
- very inductive loads.

Flexibility in use: bridge or stereo booster amplifiers with or without bootstrap and with programmable gain and bandwidth.

Space and cost saving: very low number of external components, very simple mounting system with no electrical isolation between the package and the heatsink (one screw only).
In addition, the circuit offers **loudspeaker protection** during short circuit for one wire to ground.

ABSOLUTE MAXIMUM RATINGS

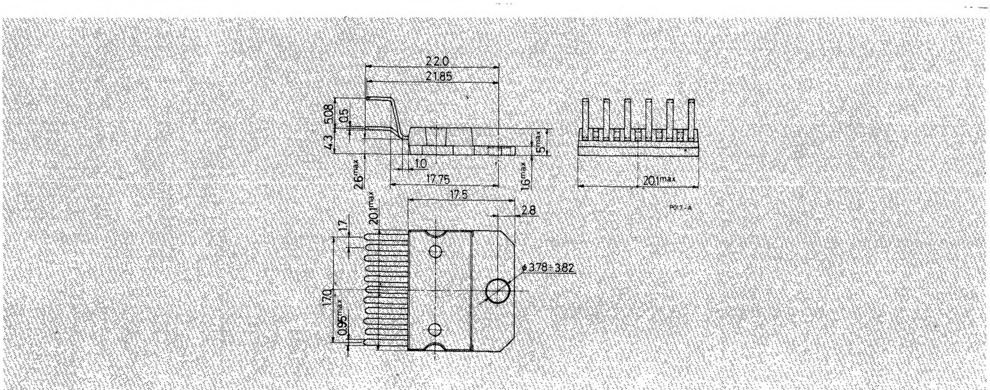
V_s	Operating supply voltage	18	V
V_s	DC supply voltage	28	V
V_s	Peak supply voltage (for 50 ms)	40	V
I_o (*)	Output peak current (non repetitive t = 0.1 ms)	4.5	A
I_o (*)	Output peak current (repetitive f ≥ 10Hz)	3.5	A
P_{tot}	Power dissipation at $T_{case} = 60°C$	30	W
T_{stg}, T_j	Storage and junction temperature	-40 to 150°	C

(*) The max. output current is internally limited

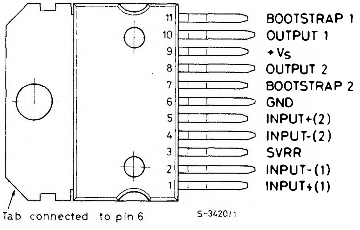
ORDERING NUMBERS: TDA 2005 M - Bridge application
TDA 2005 S - Stereo application

MECHANICAL DATA

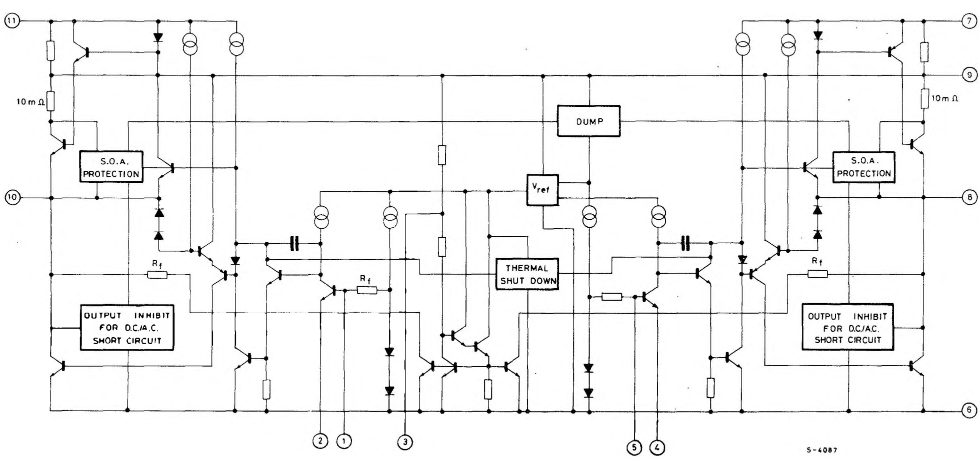
Dimensions in mm



CONNECTION DIAGRAM
(top view)



SCHEMATIC DIAGRAM



THERMAL DATA

$R_{th\ j\text{-}case}$	Thermal resistance junction-case	max	3	°C/W

BRIDGE AMPLIFIER APPLICATION (TDA 2005M)

Fig. 1 - Test and application circuit (Bridge amplifier)

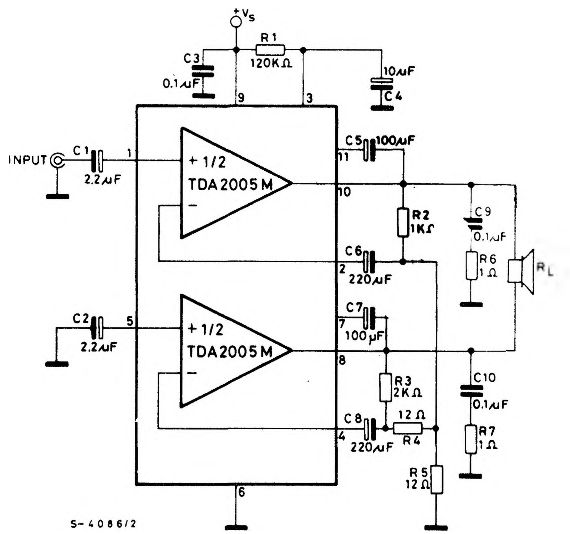
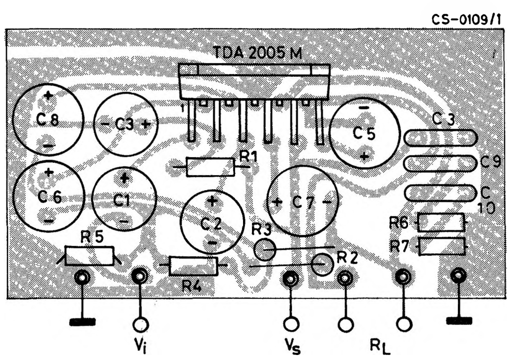


Fig. 2 - P.C. board and component layout (scale 1:1)



ELECTRICAL CHARACTERISTICS (Refer to the **bridge** application circuit, T_{amb} = 25°C, G_v = 50 dB, $R_{th\ (heatsink)}$ = 4 °C/W, unless otherwise specified).

	Parameters	Test conditions	Min.	Typ.	Max.	Unit
V_s	Supply voltage		8		18	V
V_{os}	Output offset voltage(°) (between pin 8 and 10)	V_s = 14.4V V_s = 13.2V			150 150	mV mV
I_d	Total quiescent drain current	V_s = 14.4V R_L = 4Ω		75	150	mA
		V_s = 13.2V R_L = 3.2 Ω		70	160	mA
P_o	Output power	d = 10% f = 1 KHz V_s = 14.4V R_L = 4Ω R_L = 3.2Ω V_s = 13.2V R_L = 3.2Ω	 18 20 17	 20 22 19		 W W W
d	Distortion	f = 1 KHz V_s = 14.4V R_L = 4Ω P_o = 50 mW to 15W V_s = 13.2V R_L = 3.2Ω P_o = 50 mW to 13W			 1 1	 % %
V_i	Input sensitivity	f = 1 KHz P_o = 2W R_L = 4Ω P_o = 2W R_L = 3.2Ω		 9 8		 mV mV
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
G_v	Closed loop voltage gain	f = 1 KHz		50		dB
e_N	Total input noise voltage	R_g = 10 KΩ(°°)		3	10	μV
SVR	Supply voltage rejection	R_g = 10 KΩ C_4 = 10 μF f_{ripple} = 100 Hz V_{ripple} = 0.5 V	45	55		dB
η	Efficiency	V_s = 14.4V f = 1 KHz P_o = 20W R_L = 4Ω P_o = 22W R_L = 3.2Ω V_s = 13.2V f = 1 KHz P_o = 19W R_L = 3.2Ω		 60 60 58		 % % %
T_{sd}	Thermal shut-down case temperature	V_s = 14.4V R_L = 4Ω f = 1 KHz P_{tot} = 13W	100	110		°C
V_{OSH}	Output voltage with one side of the speaker shorted to ground	V_s = 14.4V R_L = 4Ω V_s = 13.2V R_L = 3.2Ω			2	V

(°) For TDA 2005M only.
(°°) Bandwidth filter: 22 Hz to 22 KHz.

Fig. 3 - Output offset voltage vs. supply voltage

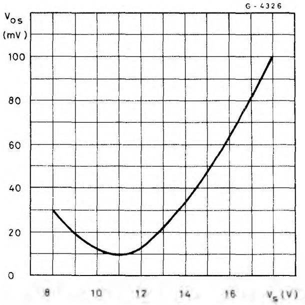


Fig. 4 - Distortion vs. output power (Bridge amplifier)

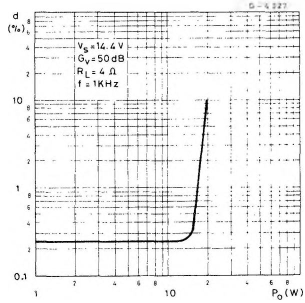
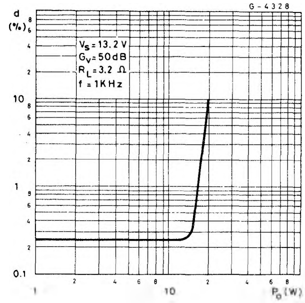


Fig. 5 - Distorsion vs. output power (Bridge amplifier)



BRIDGE AMPLIFIER DESIGN

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

Parameter		Single ended	Bridge
$V_{o\,max}$	Peak output voltage (before clipping)	$\frac{1}{2}(V_s - 2V_{CE\,sat})$	$V_s - 2V_{CE\,sat}$
$I_{o\,max}$	Peak output current (before clipping)	$\frac{1}{2}\frac{(V_s - 2V_{CE\,sat})}{R_L}$	$\frac{V_s - 2V_{CE\,sat}}{R_L}$
$P_{o\,max}$	rms output power (before clipping)	$\frac{1}{4}\frac{(V_s - 2V_{CE\,sat})^2}{2R_L}$	$\frac{(V_s - 2V_{CE\,sat})^2}{2R_L}$

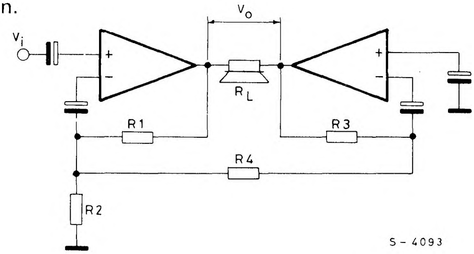
where: $V_{CE\,sat}$ = output transistors saturation voltage
V_S = allowable supply voltage
R_L = load impedance.

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 twice the output power of a single ended amplifier. Care 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 $I_{o\,max}$, assuming V_s = 14.4V and V_{CEsat} = 2V, the minimum load that can be driven by TDA 2005 in bridge configuration is:

$$R_{L\,min} = \frac{V_s - 2V_{CEsat}}{I_{o\,max}} = \frac{14.4 - 4}{3.5} = 2.97\ \Omega$$

BRIDGE AMPLIFIER DESIGN (continued)

Fig. 6 - Bridge configuration.



The voltage gain of the bridge configuration is given by (see fig. 6):

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

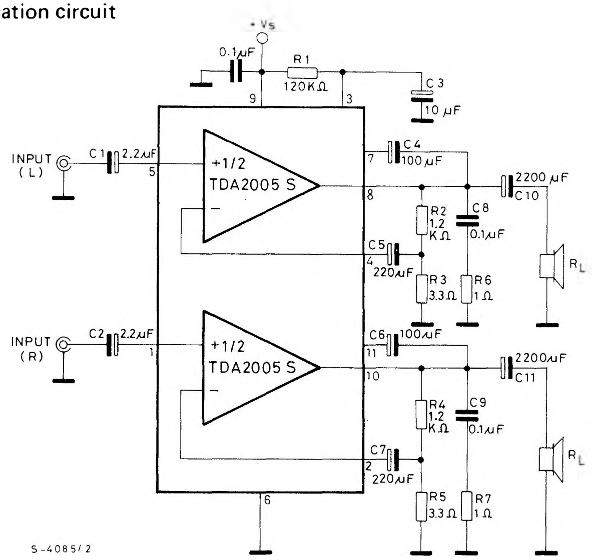
For sufficiently high gains (40 ÷ 50 dB) it is possible to put $R_2 = R_4$ and $R_3 = 2\ R_1$, simplifing the formula in:

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

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

STEREO AMPLIFIER APPLICATION (TDA 2005S)

Fig. 7 - Typical application circuit



ELECTRICAL CHARACTERISTICS (Refer to the **stereo** application circuit, T_{amb} = 25°C, G_v = 50 dB, $R_{th\,(heatsink)}$ = 4°C/W, unless otherwise specified).

	Parameters	Test conditions		Min.	Typ.	Max.	Unit
V_s	Supply voltage			8		18	V
V_o	Quiescent output voltage	V_s = 14.4V V_s = 13.2V		6.6 6	7.2 6.6	7.8 7.2	V V
I_d	Total quiescent drain current	V_s = 14.4V V_s = 13.2V			65 62	120 120	mA mA
P_o	Output power (each channel)	f = 1 KHz V_s = 14.4V V_s = 13.2V V_s = 16V	d = 10% R_L = 4Ω R_L = 3.2Ω R_L = 2Ω R_L = 1.6Ω R_L = 3.2Ω R_L = 1.6Ω R_L = 2Ω	 6 7 9 10 6 9 	 6.5 8 10 11 6.5 10 12		 W W W W W W W
d	Distortion (each channel)	f = 1 KHz V_s = 14.4V R_L = 4Ω P_o = 50 mW to 4W V_s = 14.4V R_L = 2Ω P_o = 50 mW to 6W V_s = 13.2V R_L = 3.2Ω P_o = 50 mW to 3W V_s = 13.2V R_L = 1.6Ω P_o = 40 mW to 6W			 0.2 0.3 0.2 0.3	 1 1 1 1	 % % % %
CT	Cross talk (°)	V_s = 14.4V R_L = 4Ω V_o = 4V_{rms} R_g = 10 KΩ	f = 1 KHz		60		dB
			f = 10 KHz		45		dB
V_i	Input saturation voltage			300			mV
V_i	Input sensitivity	f = 1 KHz	P_o = 1W R_L = 4Ω R_L = 3.2Ω		 6 5.5		mV
R_i	Input resistance	f = 1 KHz	non inverting input	70	200		KΩ
			inverting input		10		KΩ
f_L	Low frequency roll off (-3 dB)	R_L = 2Ω				50	Hz
f_H	High frequency roll off (-3 dB)	R_L = 2Ω		15			KHz
G_v	Voltage gain (open loop)	f = 1 KHz			90		dB
G_v	Voltage gain (closed loop)	f = 1 KHz		48	50	51	dB
ΔG_v	Closed loop gain matching				0.5		dB
e_N	Total input noise voltage	R_g = 10 KΩ (°°)			1.5	5	µV

(°) For TDA 2005S only.
(°°) Bandwidth filter: 22 Hz to 22 KHz.

ELECTRICAL CHARACTERISTICS (continued)

Parameters		Test conditions	Min.	Typ.	Max.	Unit
SVR	Supply voltage rejection	R_g = 10 KΩ f_{ripple} = 100 Hz C_3 = 10 µF V_{ripple} = 0.5V	35	45		dB
η	Efficiency	V_s = 14.4V f = 1 KHz R_L = 4Ω P_o = 6.5W R_L = 2Ω P_o = 10W V_s = 13.2V f = 1 KHz R_L = 3.2Ω P_o = 6.5W R_L = 1.6Ω P_o = 10W		 70 60 70 60		 % % % %
T_{sd}	Thermal shut-down case temperature	V_s = 14.4V R_L = 2Ω P_{tot} = 6.6W	120	130		°C

Fig. 8 - Quiescent output voltage vs. supply voltage

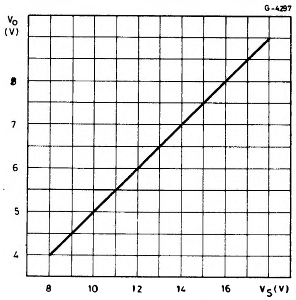


Fig. 9 - Quiescent drain current vs. supply voltage

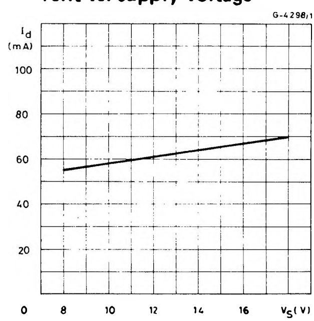


Fig. 10 - Distortion vs. output power

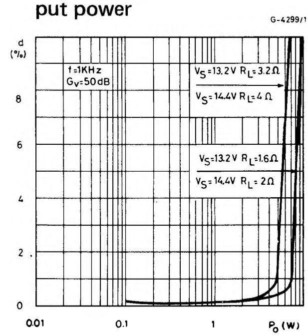


Fig. 11 - Output power vs. supply voltage

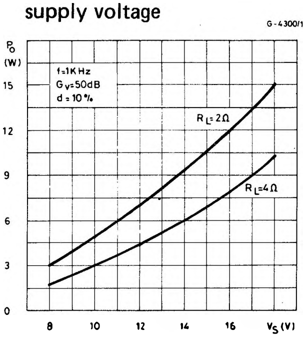


Fig. 12 - Output power vs. supply voltage

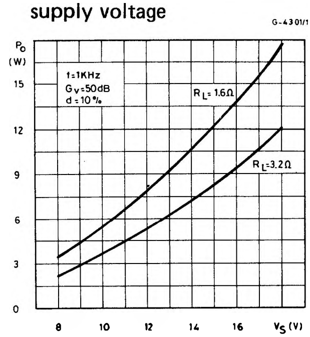


Fig. 13 - Distortion vs. frequency

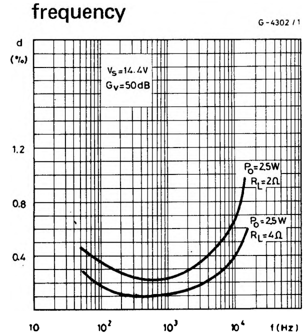


Fig. 14 - Distorsion vs. frequency

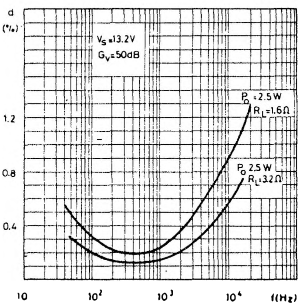


Fig. 15 - Supply voltage rejection vs. C_3

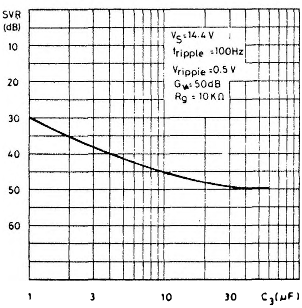


Fig. 16 - Supply voltage rejection vs. frequency

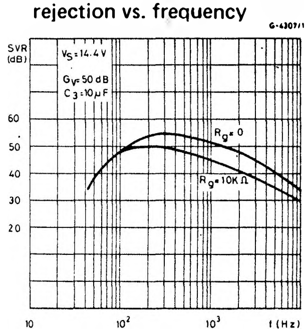


Fig. 17 - Supply voltage rejection vs. values of capacitors C_2 and C_3

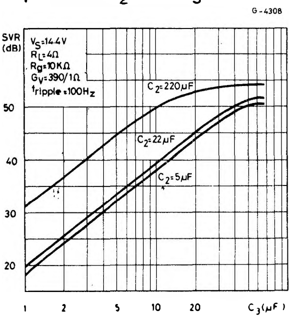


Fig. 18 - Supply voltage rejection vs. values of capacitors C_2 and C_3

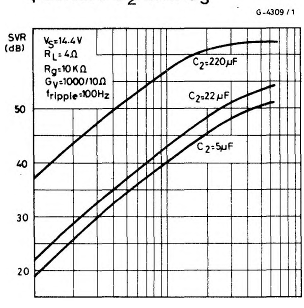


Fig. 19 - Gain vs. input sensitivity

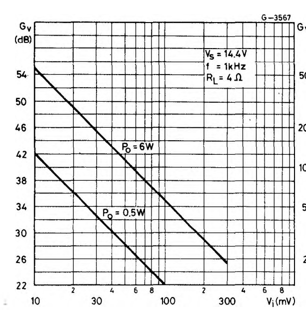


Fig. 20 - Gain vs. input sensitivity

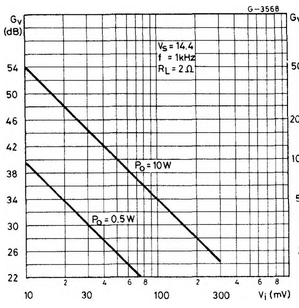


Fig. 21 - Total power dissipation and efficiency vs. output power (bridge)

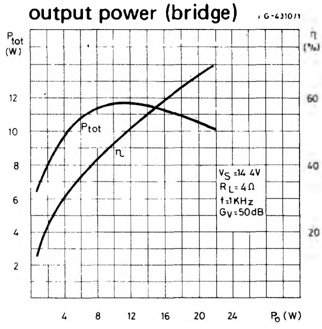
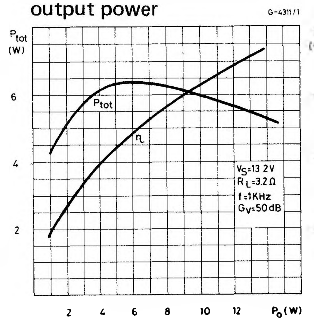


Fig. 22 - Total power dissipation and efficiency vs. output power



APPLICATION INFORMATION

Fig. 23 - 10 + 10W stereo amplifier with tone balance and loudness control

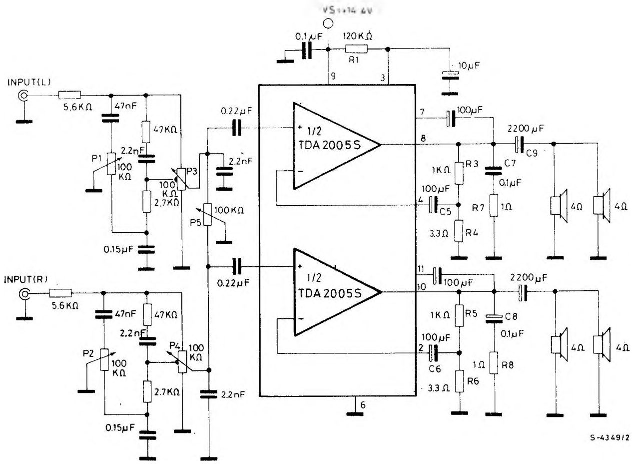


Fig. 24 - Tone control response (circuit of fig. 23)

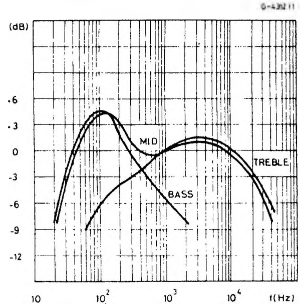


Fig. 25 - 20W Bus amplifier

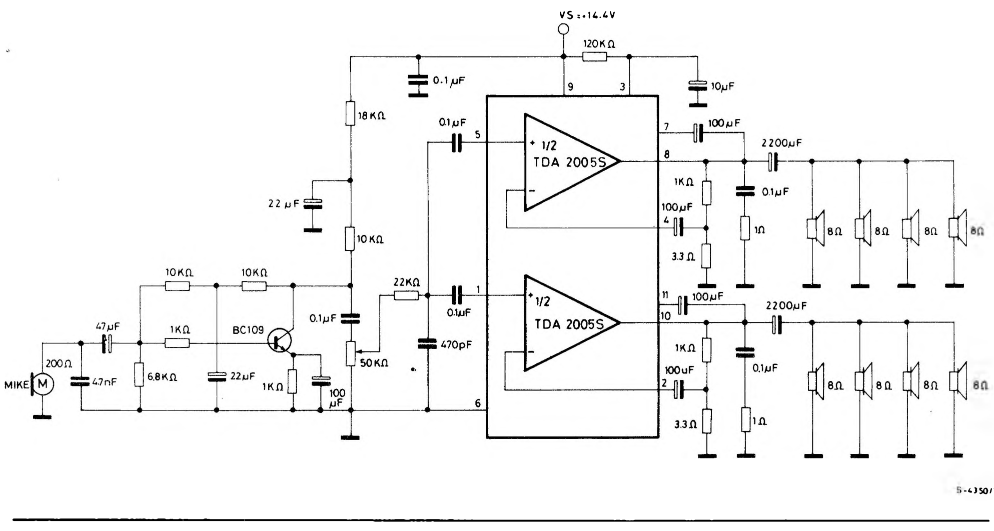


Fig. 26 - Simple 20W two way amplifier (f_c = 2 KHz)

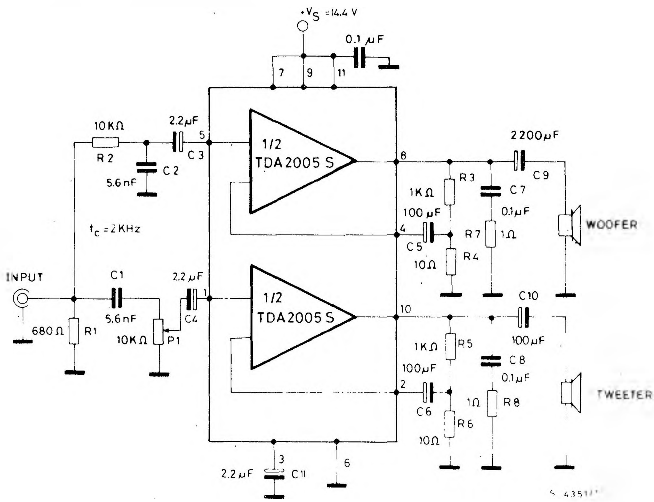
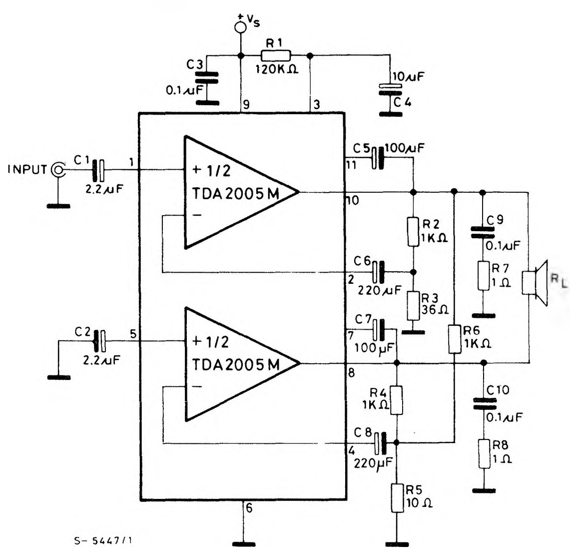


Fig. 27 - Bridge amplifier circuit suited for low-gain applications (G_v= 34 dB)



APPLICATION SUGGESTION

The recommended values of the components are those shown on Bridge application circuit of fig. 1. Different values can be used, the following table can help the designer.

Component	Recommended Value	Purpose	Larger than	Smaller than
R_1	120 KΩ	Optimization of the output symmetry	Smaller $P_{o\ max}$	Smaller $P_{o\ max}$
R_2	1 KΩ	Closed loop gain setting (see BRIDGE AMPLIFIER DESIGN)		
R_3	2 KΩ			
R_4 and R_5	12 Ω			
R_6 and R_7	1 Ω	Frequency stability	Danger of oscillation at high frequency with inductive loads	
C_1	2.2 μF	Input DC decoupling	High turn on delay	Higher turn on pop. Higher low frequency cutoff. Increase of noise.
C_2	2.2 μF	Optimization of turn on pop and turn on delay.		
C_3	0.1 μF	Supply by pass		Danger of oscillation.
C_4	10 μF	Ripple Rejection	Increase of SVR. Increase of the switch-on time.	Degradation of SVR.
C_5 and C_7	100 μF	Bootstrapping		Increase of distortion at low frequency.
C_6 and C_8	220 μF	Feedback input DC decoupling, low frequency cutoff.		Higher low frequency cutoff.
C_9 and C_{10}	0.1 μF	Frequency stability.		Danger of oscillation.

BUILT-IN PROTECTION SYSTEMS

Load dump voltage surge

The TDA 2005 has a circuit which enables it to withstand a voltage pulse train, on pin 9, of the type shown in fig. 29.
If the supply voltage peaks to more than 40V, 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 fig. 28. With this network, a train of pulses with amplitude up to 120V 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 18V. For this reason the maximum operating supply voltage is 18V.

Fig. 28

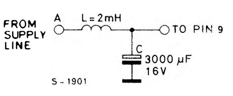
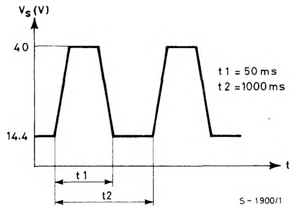


Fig. 29



Short circuit (AC and DC conditions)

The TDA 2005 can withstand a permanent short-circuit on the output for a supply voltage up to 16V.

Polarity inversion

High current (up to 10A) can be handled by the device with no damage for a longer period than the blow-out time of a quick 2A 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.

Open ground

When the radio is in the ON condition and the ground is accidentally opened, a standard audio amplifier will be damaged. On the TDA 2005 protection diodes are included to avoid any damage.

Inductive load

A protection diode is provided to allow use of the TDA 2005 with inductive loads.

DC voltage

The maximum operating DC voltage for the TDA 2005 is 18V.
However the device can withstand a DC voltage up to 28V with no damage. This could occur during winter if two batteries are series connected to crank the engine.

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); fig. 30 shows this dissipable power as a function of ambient temperature for different thermal resistance.

Fig. 30 - Maximum allowable power dissipation vs. ambient temperature

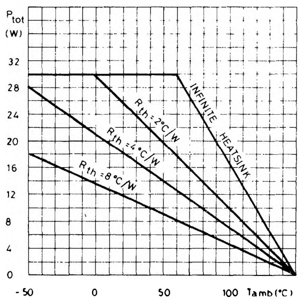


Fig. 31 - Output power and drain current vs. case temperature

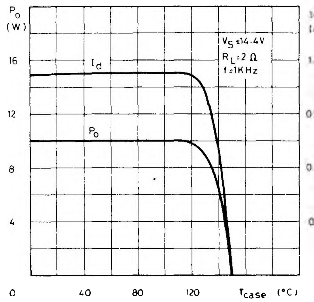
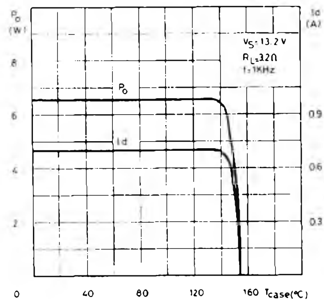


Fig. 32 - Output power and drain current vs. case temperature



Loudspeaker protection

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

MOUNTING INSTRUCTIONS

The power dissipated in the circuit must be removed by adding an external heatsink.
Thanks to the MULTIWATT® package attaching the heatsink is very simple, a screw or a compression spring (clip) being sufficient. Between the heatsink and the package it is better to insert a layer of silicon grease, to optimize the thermal contact; no electrical isolation is needed between the two surfaces.

Fig. 33 - Mounting examples