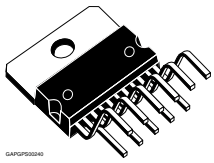
TDA7360

22 W bridge/stereo audio amplifier with clipping detector

Features

- Very few external components
- No Boucherot cells
- No bootstrap capacitors
- High output power
- No switch on/off noise
- Very low standby current
- Fixed gain (20 dB stereo)
- Programmable turn-on delay
- Clipping detector
- Protections:
  - Output AC-DC short circuit to ground and to supply voltage
  - Very inductive loads
  - Loudspeaker protection
  - Overrating chip temperature
  - Load dump voltage
  - Fortuitous open ground
  - ESD



Multiwatt11 (Vertical)

Description

The TDA7360 is a new technology class AB Audio Power Amplifier in the Multiwatt® package designed for car radio applications.

Thanks to the fully complementary PNP/NPN output configuration the high power performance of the TDA7360 is obtained without bootstrap capacitors.

A delayed turn-on mute circuit eliminates audible on/off noise, and a novel short circuit protection system prevents spurious intervention with highly inductive loads.

The device provides a circuit for the detection of clipping in the output stages. The output, an open collector, is able to drive systems with automatic volume control.

Table 1. Device summary

Order code	Package	Packing
TDA7360	Multiwatt11 (vertical)	Tube

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1 Block and pins connection diagram

Figure 1. Block diagram (stereo configuration)

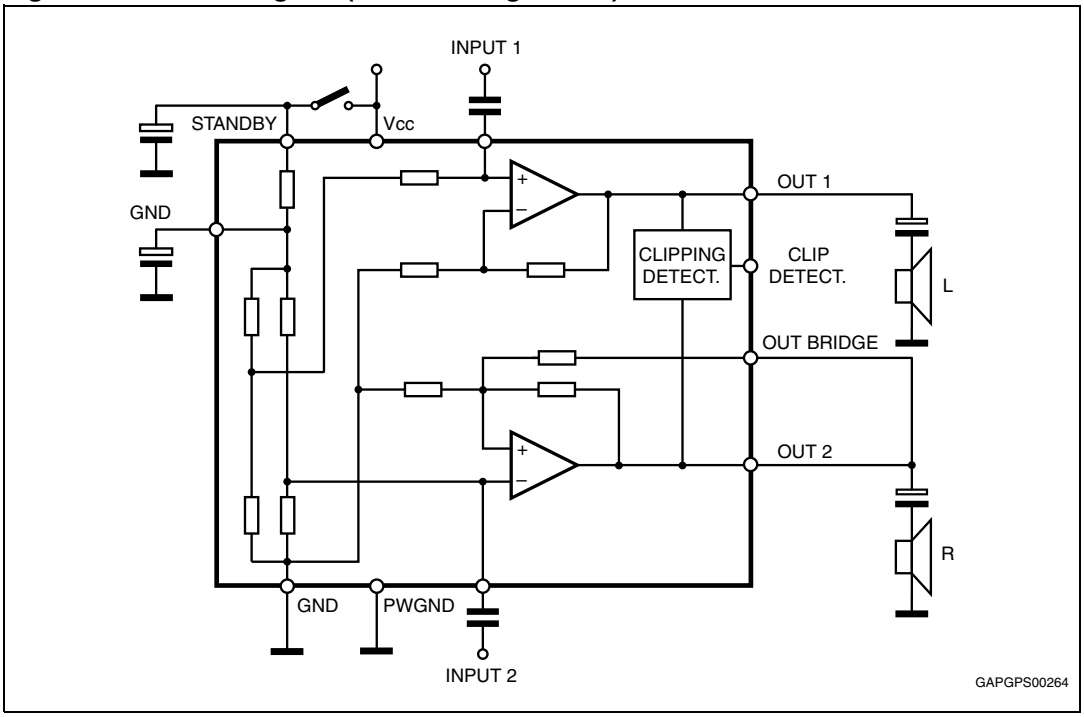


Figure 2. Block diagram (bridge configuration)

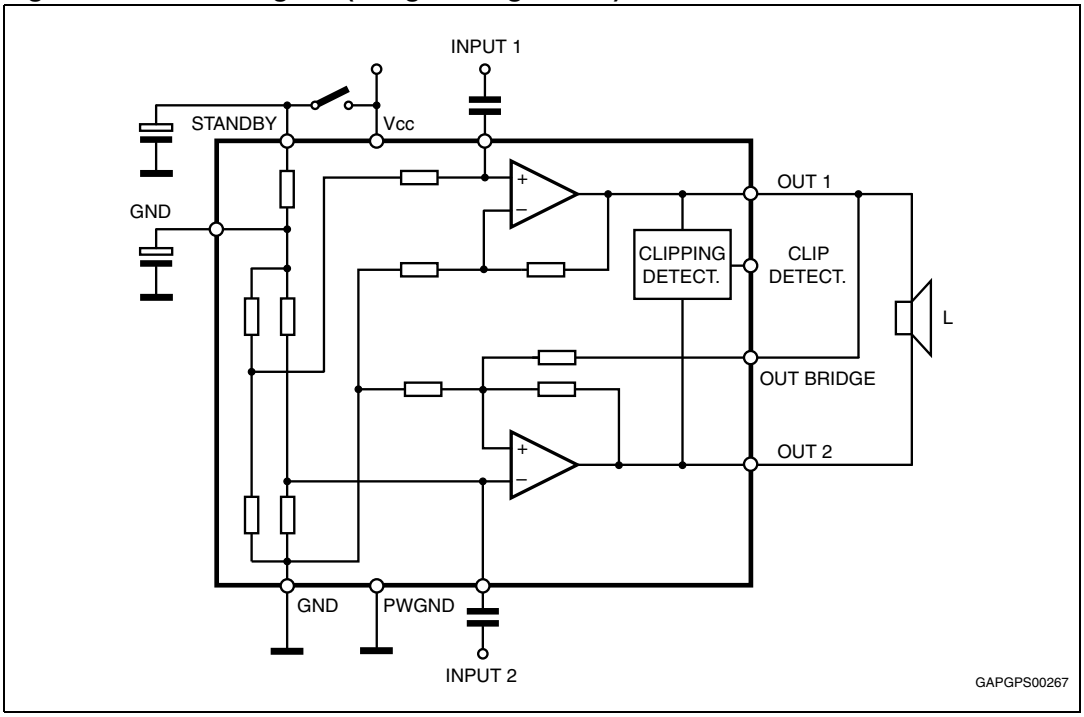
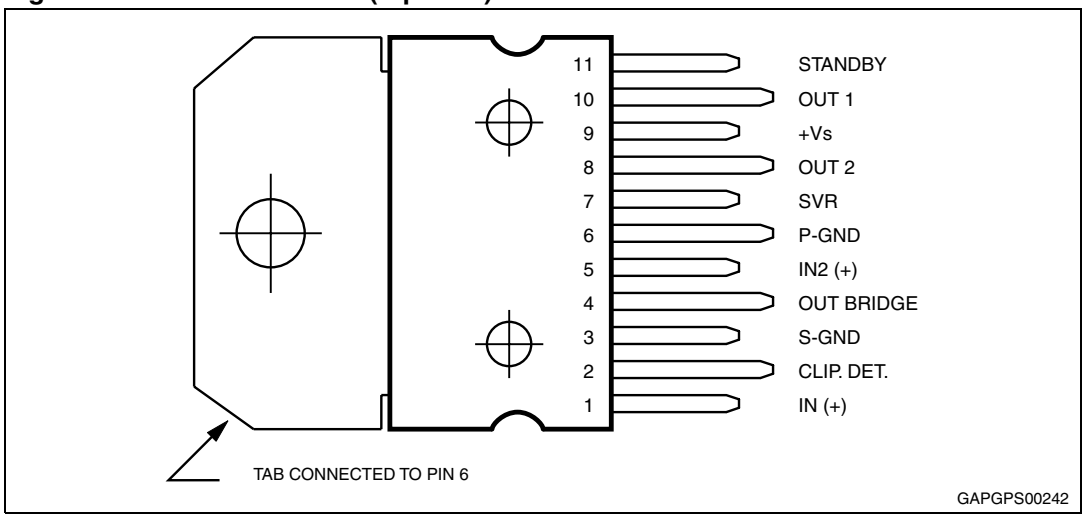


Figure 3. Pins connection (top view)



2 Electrical specifications

2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_S	Operating supply voltage	18	V
V_S	DC supply voltage	28	V
V_S	Peak supply voltage (t = 50 ms)	50	V
I_O	Output peak current (non rep. t = 100 µs)	5	A
I_O	Output peak current (rep. freq. > 10 Hz)	4	A
P_{tot}	Power dissipation at T_{case} = 85 °C	36	W
T_{stg}, T_j	Storage and junction temperature	-40 to 150	°C

2.2 Thermal data

Table 3. Thermal data

Symbol	Parameter		Value	Unit
$R_{thj\text{-}case}$	Thermal resistance junction-to-case	Max.	1.8	°C/W

2.3 Electrical characteristics

Refer to the test circuits, T_{amb} = 25 °C, V_S = 14.4 V, f = 1 kHz unless otherwise specified.

Table 4. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_S	Supply voltage range	-	8	-	18	V
I_d	Total quiescent drain current	Stereo configuration	-	-	120	mA
A_{SB}	Standby attenuation	-	60	80	-	dB
I_{SB}	Standby current	-	-	-	100	µA
I_{CO}	Clip detector average current	Pin 2 pull up to 5 V with 10 kΩ d = 1% d = 5%	-	 70 130	-	µA
Stereo						
P_o	Output power (each channel)	d = 10% R_L= 1.6 Ω R_L= 2 Ω R_L= 3.2 Ω R_L= 4 Ω	 7 	 12 11 8 6.5	-	W

Table 4. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
d	Distortion	Po = 0.1 to 4 W; R_L = 3.2 Ω	-	0.05	0.5	%
SVR	Supply voltage rejection	R_g = 10 kΩ, f = 100 Hz C3 = 22 µF C3 = 100 µF	45	 62	-	dB
C_T	Crosstalk	f = 1 kHz f = 10 kHz	45	 55	-	dB
R_I	Input resistance	-	-	50	-	kΩ
G_V	Voltage gain	-	-	20	-	dB
G_V	Voltage gain match	-	-		1	dB
E_{IN}	Input noise voltage	22 Hz to 22 kHz R_g = 50 Ω R_g = 10 kΩ R_g = ∞	-	2.5 3 3.5	7	µV
Bridge						
V_{OS}	Output offset voltage	-	-	-	250	mV
P_o	Output power	d = 10%; R_L= 4 Ω d = 10%; R_L= 3.2 Ω	 16	20 22	-	W
d	Distortion	P_o = 0.1 to 10 W; R_L = 3.2 Ω		0.05	1	%
SVR	Supply voltage rejection	R_g = 10kΩ f = 100Hz C3 = 22µF C3 = 100µF	45	 62	-	dB
R_I	Input resistance	-	-	50	-	kΩ
G_V	Voltage gain	-	-	26	-	dB
E_{IN}	Input noise voltage	22 Hz to 22 kHz R_g= 50 Ω R_g= 10 kΩ	-	3.5 4	-	µV

2.4 Test and application circuit

Figure 4. Stereo test and application circuit

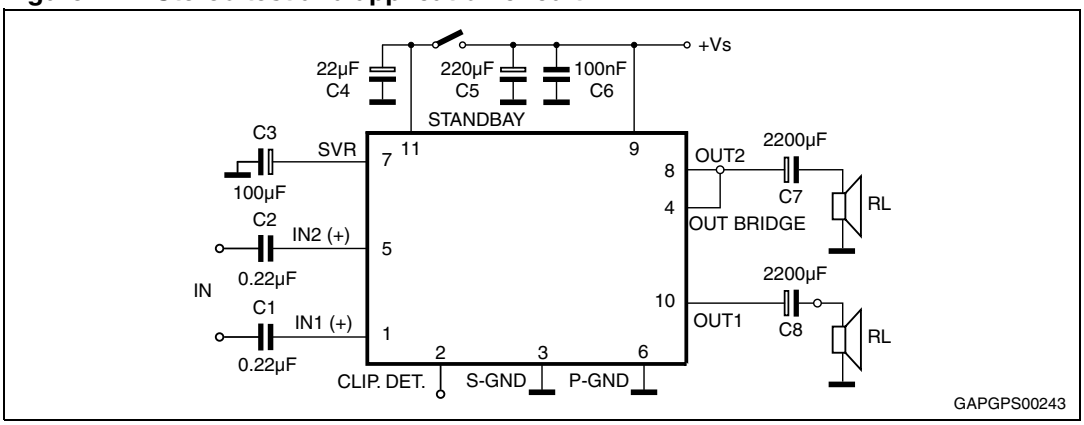


Figure 5. Printed circuit board of the stereo application circuit

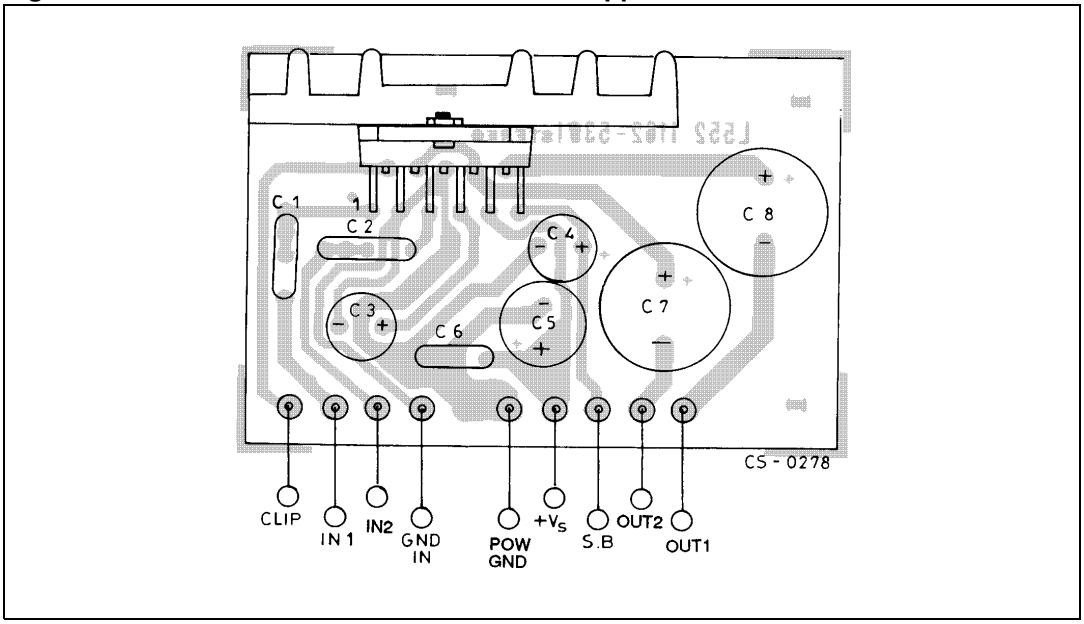


Table 5. External components value of the stereo test and application circuits

Component	Recomm. value	Purpose	Larger than the recomm. value	Smaller than the recomm.value
C1	0.22µF	Input Decoupling (CH1)	-	-
C2	0.22µF	Input Decoupling (CH2)	-	-
C3	100µF	Supply voltage Rejection Filtering Capacitor	Longer turn-on delay time	– Worse supply voltage rejection. – Shorter turn-on delay time – DangEr Of Noise (POP)

Table 5. External components value of the stereo test and application circuits (continued)

Component	Recomm. value	Purpose	Larger than the recomm. value	Smaller than the recomm.value
C4	22µF	Standby ON/OFF delay	Delayed turn-off by standby switch	Danger of noise (POP)
C5	220µF (min)	Supply by-pass	-	Danger of oscillations
C6	100nF (min)	Supply by-pass	-	Danger of oscillations
C7	2200µF	Output Decoupling CH2	– Decrease of low frequency cut-off – Longer turn-on delay	– Increase of low frequency cut-off – Shorter turn-on delay

Figure 6. Bridge test and application circuit

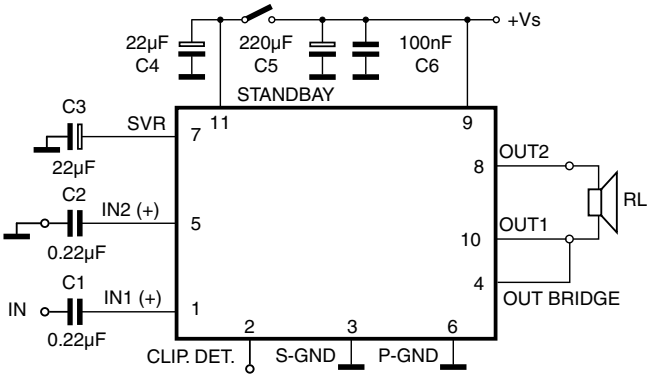
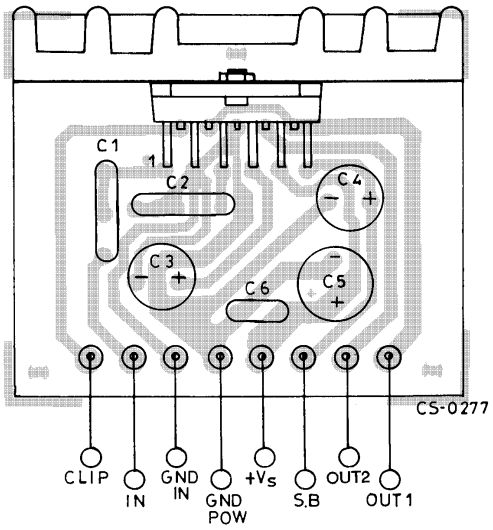


Figure 7. Printed circuit board of the bridge application circuit



2.5 Electrical characteristics curves

Figure 8. Output power vs. supply voltage (Stereo, 4 Ω)

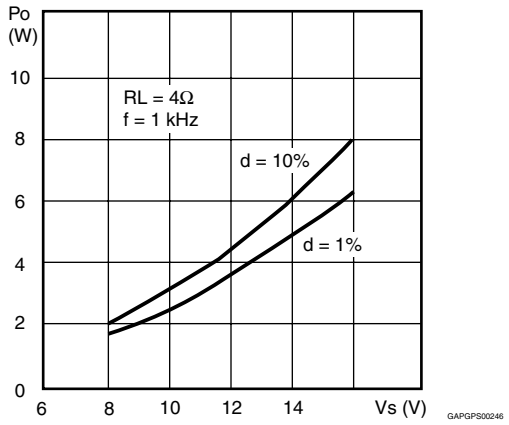


Figure 9. Output power vs. supply voltage (Stereo, 2 Ω)

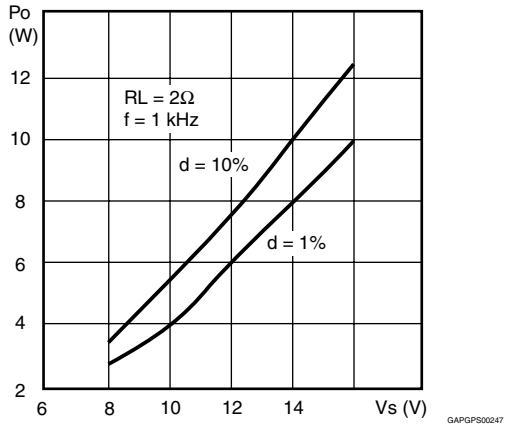


Figure 10. Output power vs. supply voltage (Stereo, 3.2 Ω)

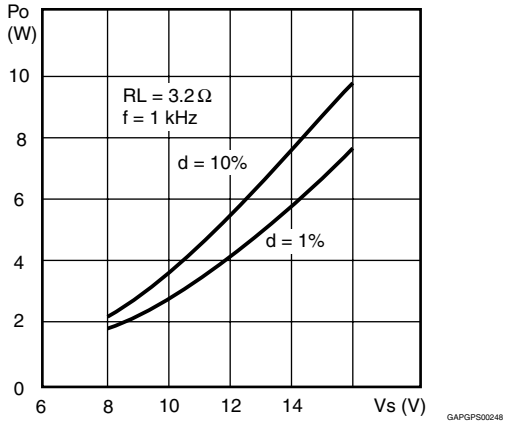


Figure 11. Output power vs. supply voltage (Bridge, 4 Ω)

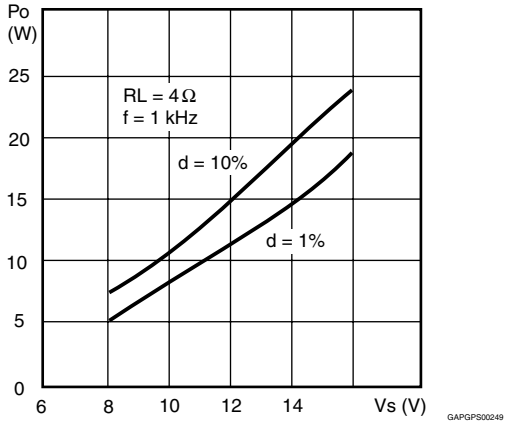


Figure 12. Output power vs. supply voltage (Bridge, 3.2 Ω)

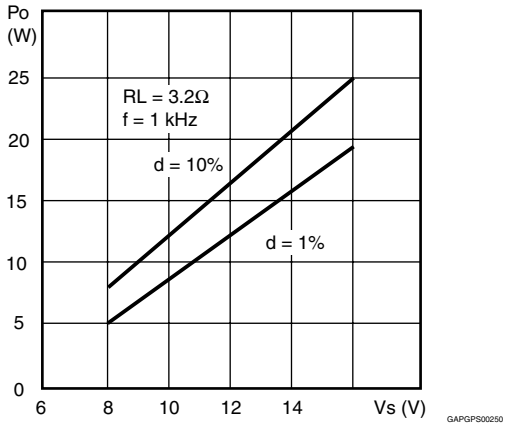


Figure 13. Drain current vs. supply voltage (Stereo)

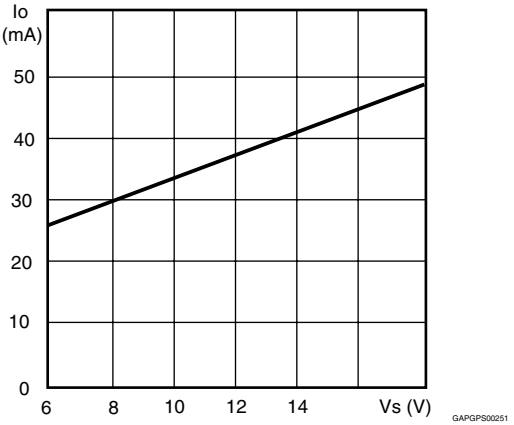


Figure 14. Distortion vs. output power (Stereo, 4 Ω)

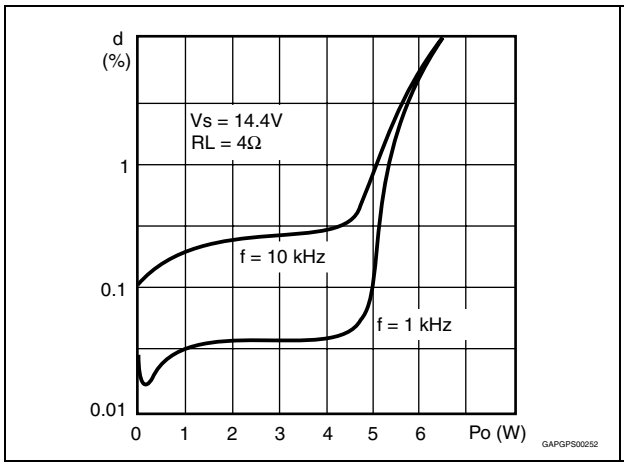


Figure 15. Distortion vs. output power (Stereo, 3.2 Ω)

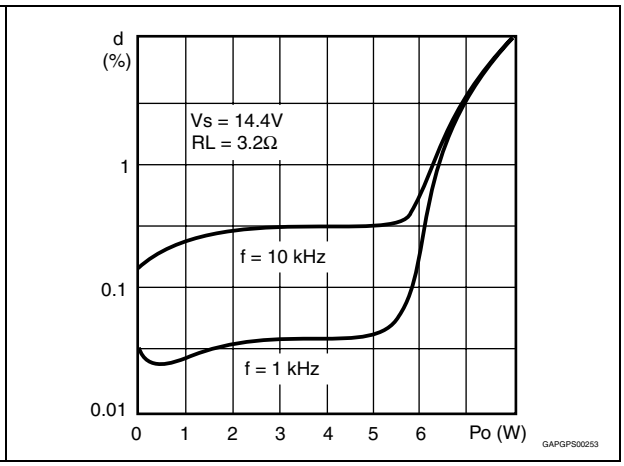


Figure 16. Distortion vs. output power (Stereo, 2 Ω)

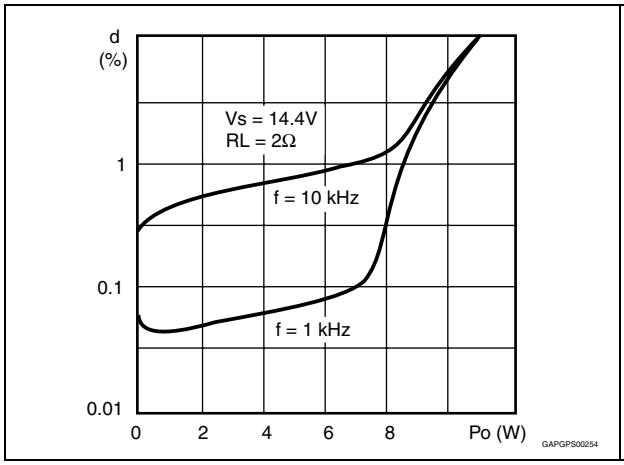


Figure 17. Distortion vs. output power (Bridge, 4 Ω)

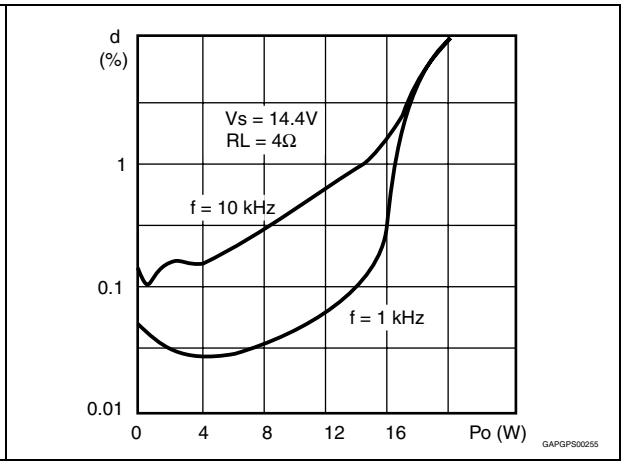


Figure 18. Distortion vs. output power (Bridge, 3.2 Ω)

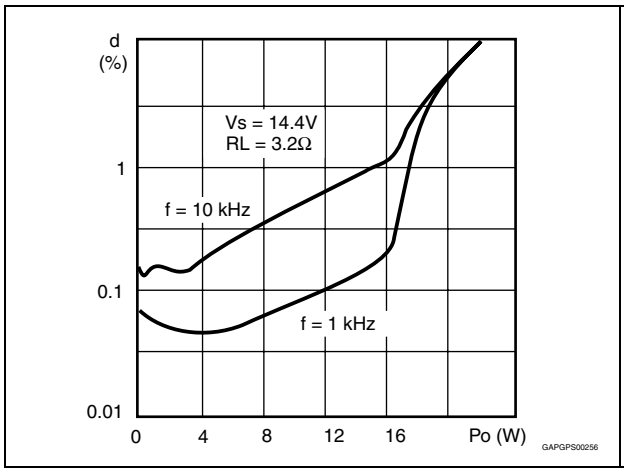


Figure 19. SVR vs. frequency and C3 (Stereo)

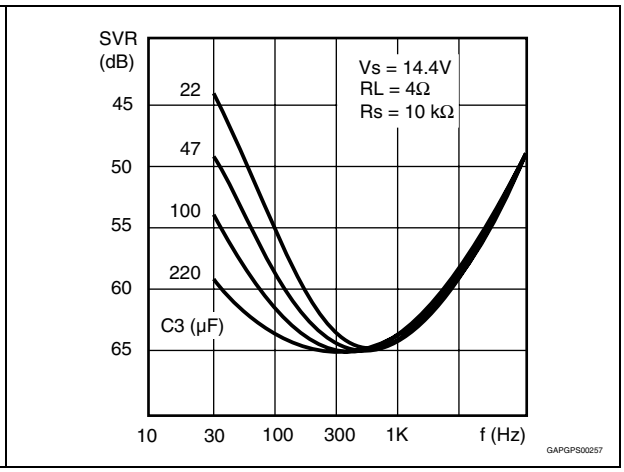


Figure 20. SVR vs. frequency and C3 (Bridge)

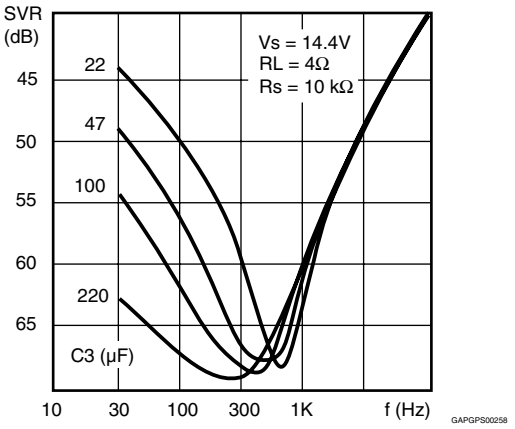


Figure 21. Crosstalk vs. frequency (Stereo)

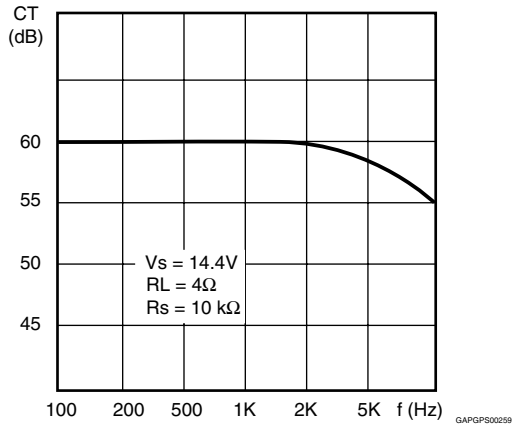


Figure 22. Power dissipation and efficiency vs. output power (Stereo, 2 Ω)

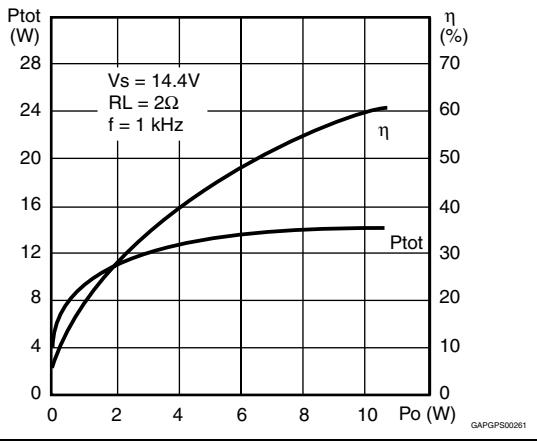


Figure 23. Power dissipation and efficiency vs. output power (Stereo, 4 Ω)

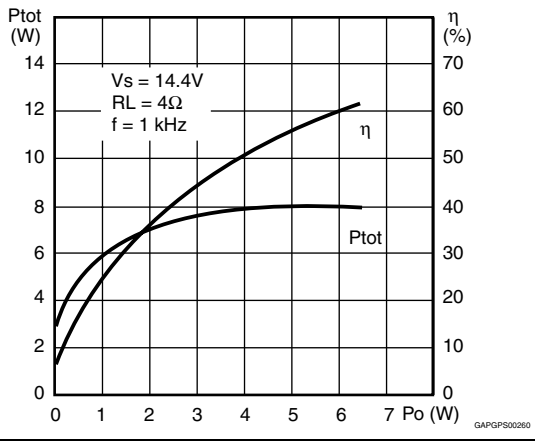


Figure 24. Power dissipation and efficiency vs. output power (Bridge, 4 Ω)

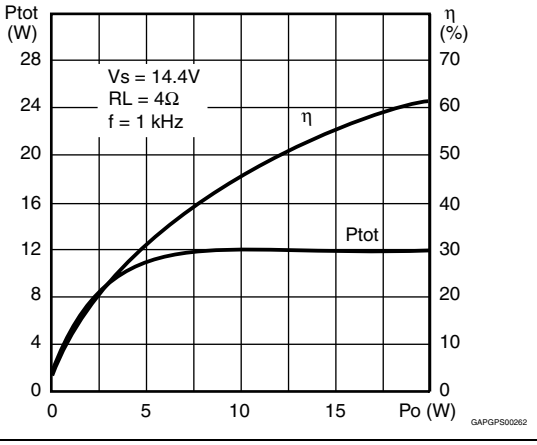
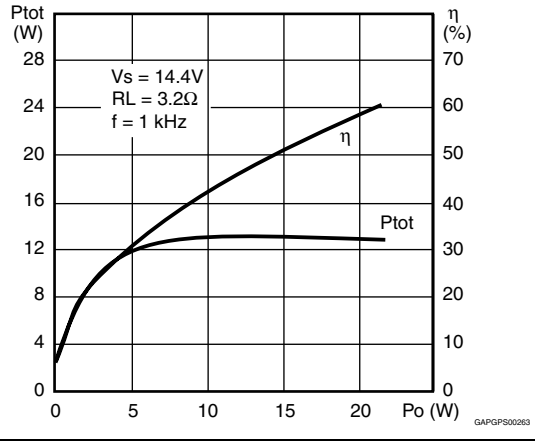


Figure 25. Power dissipation and efficiency vs. output power (Bridge, 3.2 Ω)



3 General description

3.1 Amplifier organization

The TDA7360 has been developed taking care of the key concepts of the modern power audio amplifier for car radio such as: space and costs saving due to the minimized external count, excellent electrical performances, flexibility in use, superior reliability thanks to a built-in array of protections. As a result the following performances has been achieved:

- No need of bootstrap capacitors even at the highest output power levels
- Absolute stability without external compensation thanks to the innovative out stage configuration, also allowing internally fixed closed loop lower than competitors
- Low gain (20 dB stereo fixed without any external components) in order to minimize the output noise and optimize SVR
- Silent Mute/Standby function featuring absence of pop ON/OFF noise
- high SVR
- Stereo/bridge operation without addition of external component
- AC/DC short circuit protection (to GND, to V_S, across the load)
- Loudspeaker protection
- Dump protection
- ESD protection

3.2 Block description

3.2.1 Polarization

The device is organized with the gain resistors directly connected to the signal ground pin i.e. without gain capacitors (*Figure 1*).

The non inverting inputs of the amplifiers are connected to the SVR pin by means of resistor dividers, equal to the feedback networks. This allows the outputs to track the SVR pin which is sufficiently slow to avoid audible turn-on and turn-off transients.

3.2.2 SVR

The voltage ripple on the outputs is equal to the one on SVR pin: with appropriate selection of CSVR, more than 60dB of ripple rejection can be obtained.

3.2.3 Delayed turn-on (muting)

The C_{SVR} sets a signal turn-on delay too. A circuit is included which mutes the device until the voltage on SVR pin reaches ~2.5V typ (*Figure 1*). The mute function is obtained by duplicating the input differential pair (*Figure 27*): it can be switched to the signal source or to an internal mute input. This feature is necessary to prevent transients at the inputs reaching the loudspeaker(s) immediately after power-on).

Figure 1 represents the detailed turn-on transient with reference to the stereo configuration. At the power-on the output decoupling capacitors are charged through an internal path but the device itself remains switched off (Phase 1 of the represented diagram).

When the outputs reach the voltage level of about 1V (this means that there is no presence of short circuits) the device switches on, the SVR capacitor starts charging itself and the output tracks exactly the SVR pin.

During this phase the device is muted until the SVR reaches the "Play" threshold (~2.5V typ.), after that the music signal starts being played.

3.2.4 Stereo/bridge switching

There is also no need for external components for changing from stereo to bridge configuration (*Figure 26*, *27*, *28* and *2*). A simple short circuit between two pins allows phase reversal at one output, yet maintaining the quiescent output voltage.

3.2.5 Standby

The device is also equipped with a stand-by function, so that a low current, and hence low cost switch, can be used for turn on/off.

3.2.6 Stability

The device is provided with an internal compensation which allows to reach low values of closed loop gain.

In this way better performances on S/N ratio and SVR can be obtained.

Figure 26. Turn-on delay circuit

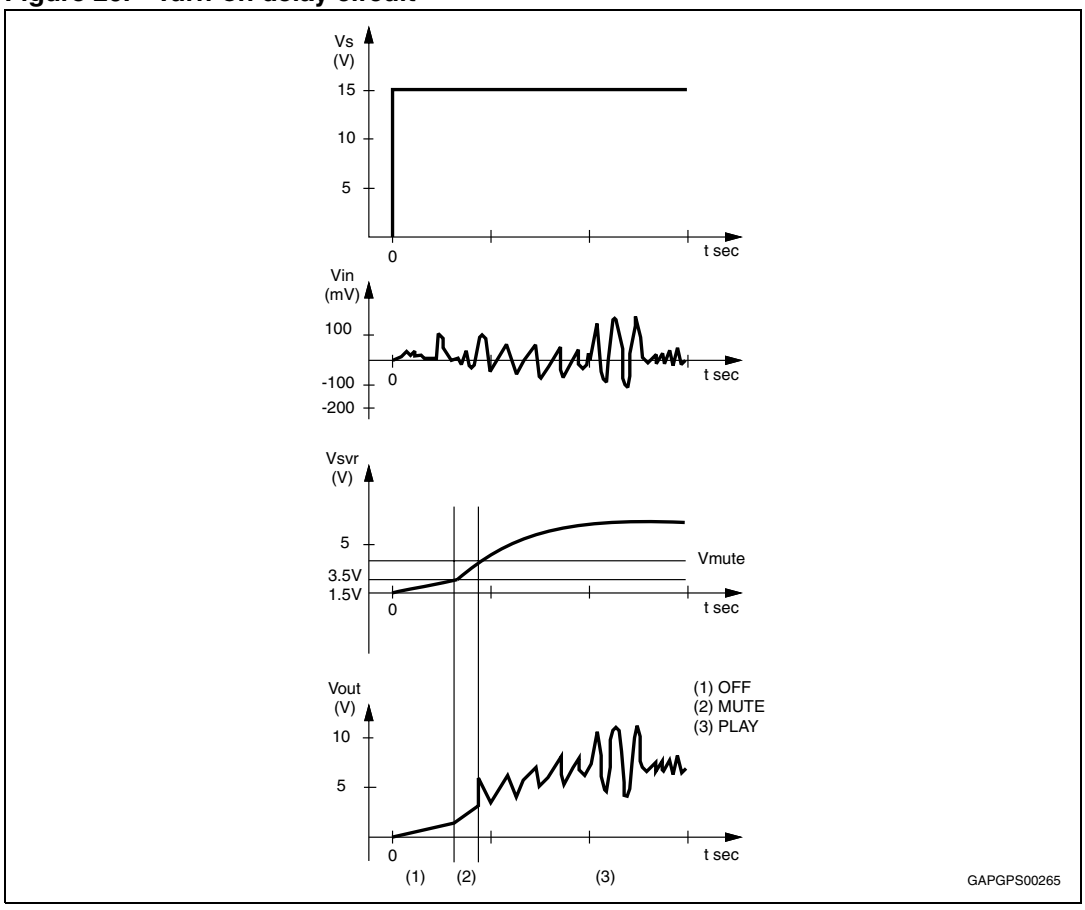
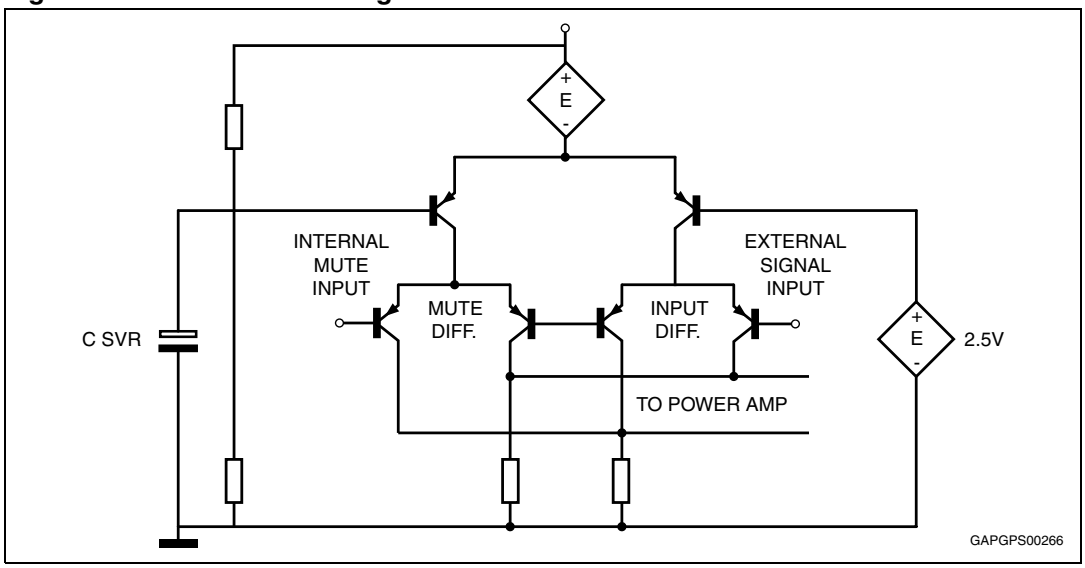


Figure 27. Mute function diagram



3.2.7 Clip detector

The TDA7360 is equipped with an internal circuit able to detect the output stage saturation providing a proper current sinking into an open collector out. pin 2) when a certain distortion level is reached at each output. This particular function allows compression facility whenever the amplifier is over driven, so obtaining high quality sound at all listening levels.

Figure 28. Dual channel distortion detector

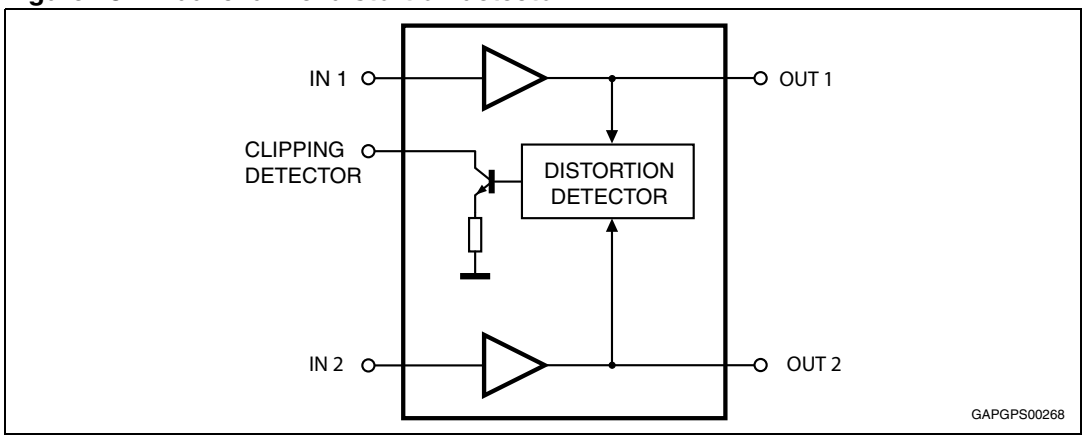


Figure 29. Output at clipping detector pin vs. signal distortion

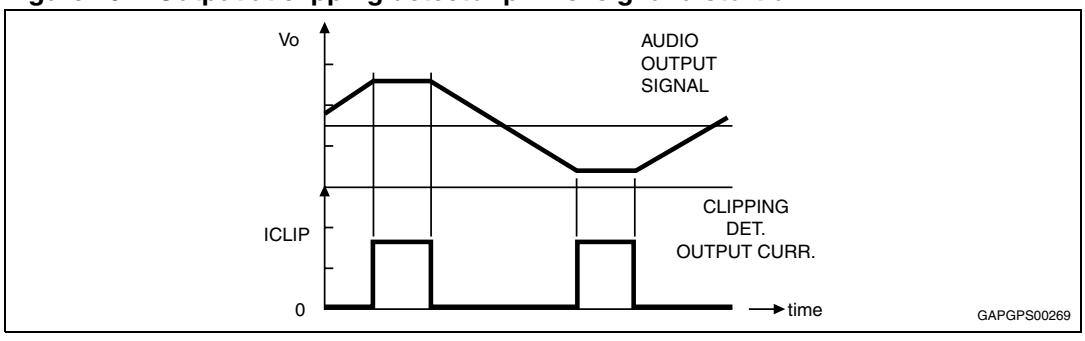


Figure 30. ICV - PNP gain vs. I_C

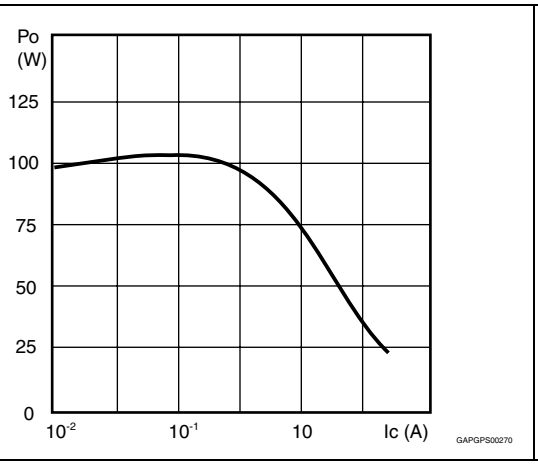


Figure 31. ICV - PNP $V_{CE(sat)}$ vs. I_C

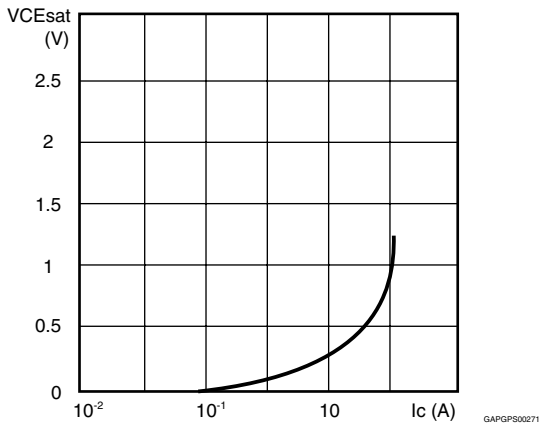
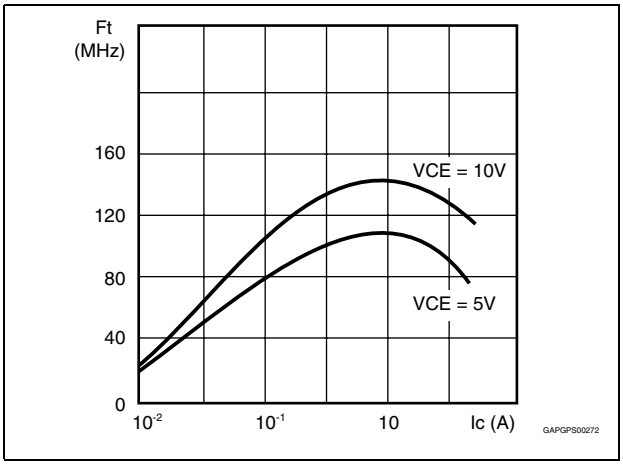


Figure 32. ICV - PNP cut-off frequency vs. I_C



3.2.8 Output stage

Poor current capability and low cutoff frequency are well known limits of the standard lateral PNP.

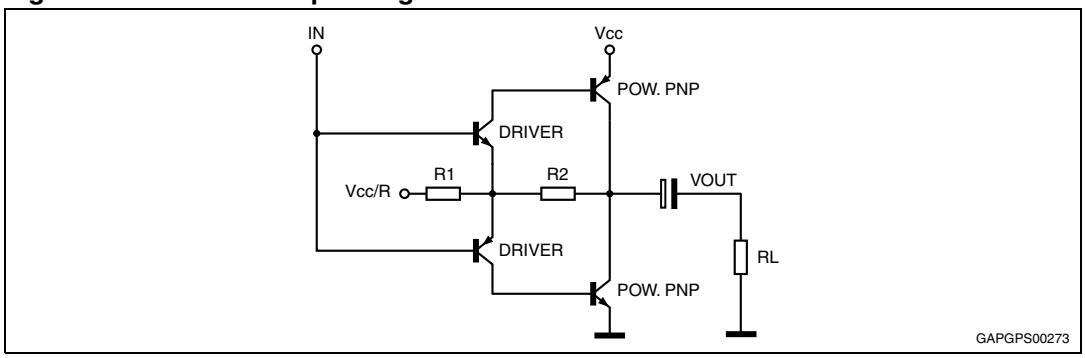
Composite PNP-NPN power output stages have been widely used, regardless their high saturation drop. This drop can be overcome only at the expense of external components, namely, the bootstrap capacitors. The availability of 4A isolated collector PNP (ICV PNP) adds versatility to the design.

The performance of this component, in terms of gain, V_{CEsat} and cut-off frequency, is shown in *Figure 30*, *31*, *32* respectively. It is realized in a new bipolar technology, characterized by top bottom isolation techniques, allowing the implementation of low leakage diodes, too. It guarantees BV_{CEO} > 20V and BV_{CBO} > 50V both for NPN and PNP transistors.

Basically, the connection shown in *Figure 33* has been chosen. First of all because its voltage swing is rail-to-rail, limited only by the V_{CEsat} of the output transistors, which are in the range of 0.3Ω each. Then, the gain VOUT/VIN is greater than unity, approximately 1+R2/R1. (VCC/2 is fixed by an auxiliary amplifier common to both channel).

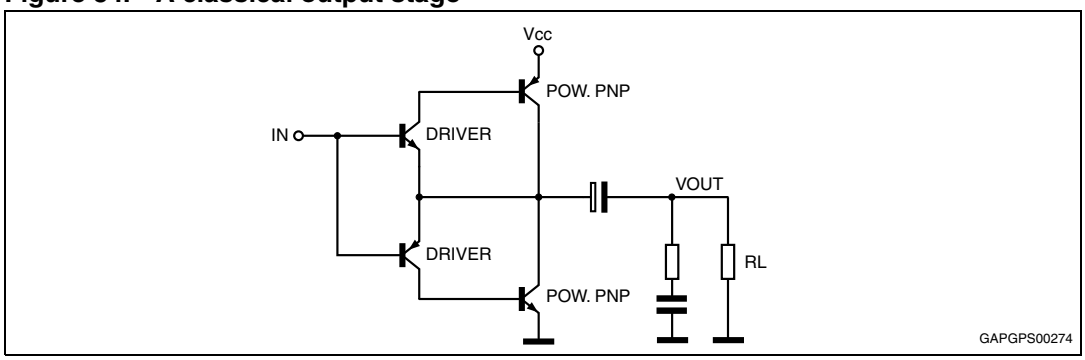
It is possible, controlling the amount of this local feedback, to force the loop gain (A. β) to less than unity at frequencies for which the phase shift is 180°. This means that the output buffer is intrinsically stable and not prone to oscillation.

Figure 33. The new output stage



In contrast, with the circuit of *Figure 34*, the solution adopted to reduce the gain at high frequencies is the use of an external RC network.

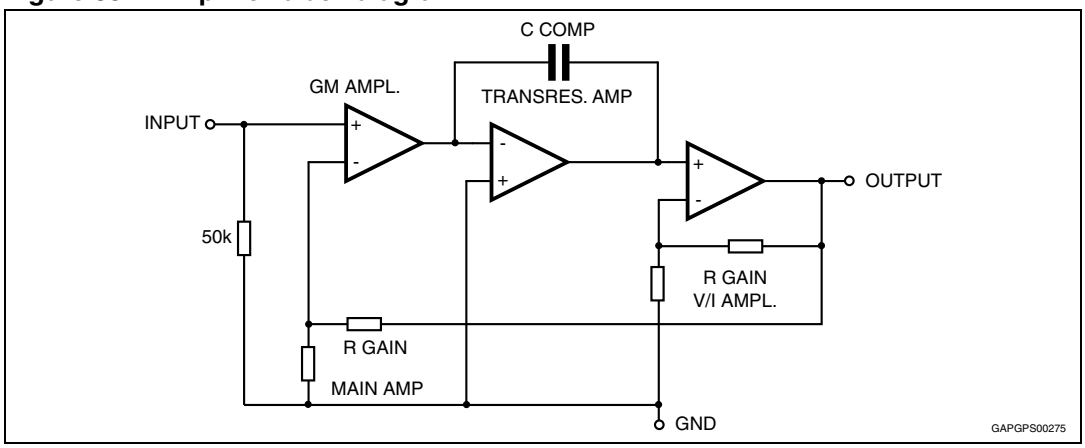
Figure 34. A classical output stage



3.2.9 Amplifier block diagram

The block diagram of each voltage amplifier is shown in *Figure 35*. Regardless of production spread, the current in each final stage is kept low, with enough margin on the minimum, below which cross-over distortion would appear.

Figure 35. Amplifier block diagram



3.3 Built-in protection systems

3.3.1 Short circuit protection

The maximum current the device can deliver can be calculated by considering the voltage that may be present at the terminals of a car radio amplifier and the minimum load impedance.

Apart from consideration concerning the area of the power transistors it is not difficult to achieve peak currents of this magnitude (5A peak).

However, it becomes more complicated if AC and DC short circuit protection is also required.In particular, with a protection circuit which limits the output current following the SOA curve of the output transistors it is possible that in some conditions (highly reactive loads, for example) the protection circuit may intervene during normal operation. For this reason each amplifier has been equipped with a protection circuit that intervenes when the output current exceeds 4A.

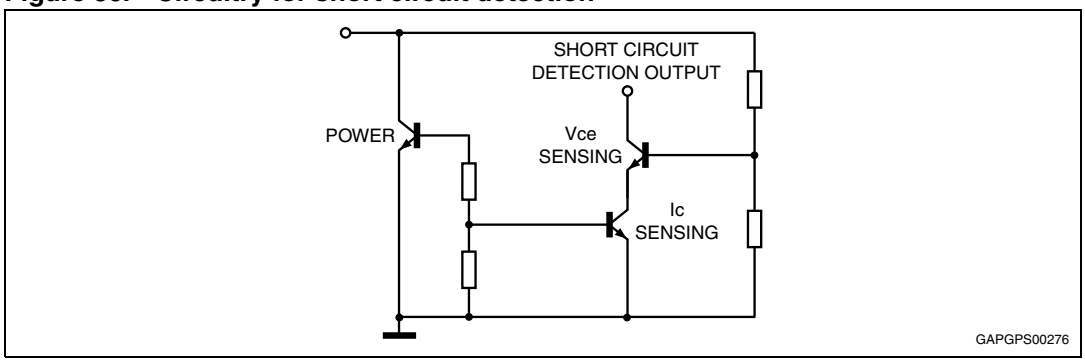
Figure 36 shows the protection circuit for an NPN power transistor (a symmetrical circuit applies to PNP).The VBE of the power is monitored and gives out a signal, available through a cascade.

This cascade is used to avoid the intervention of the short circuit protection when the saturation is below a given limit.

The signal sets a flip-flop which forces the amplifier outputs into a high impedance state.

In case of DC short circuit when the short circuit is removed the flip-flop is reset and restarts the circuit (*Figure 40*). In case of AC short circuit or load shorted in Bridge configuration, the device is continuously switched in ON/OFF conditions and the current is limited.

Figure 36. Circuitry for short circuit detection



3.3.2 Load dump voltage surge

The TDA7360 has a circuit which enables it to withstand a voltage pulse train on pin 9, of the type shown in *Figure 37*.

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 *Figure 37*. With this network, a train of pulses with amplitude up to 120V and width of 2ms 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.

Figure 37. Suggested LC network circuit

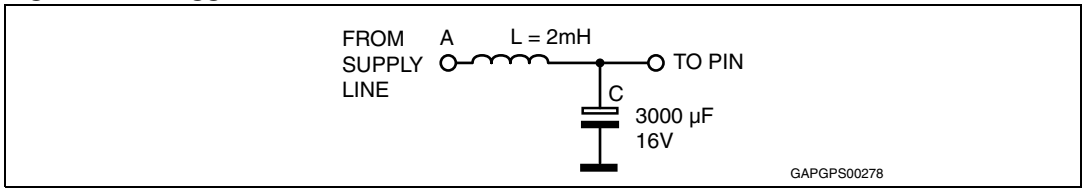
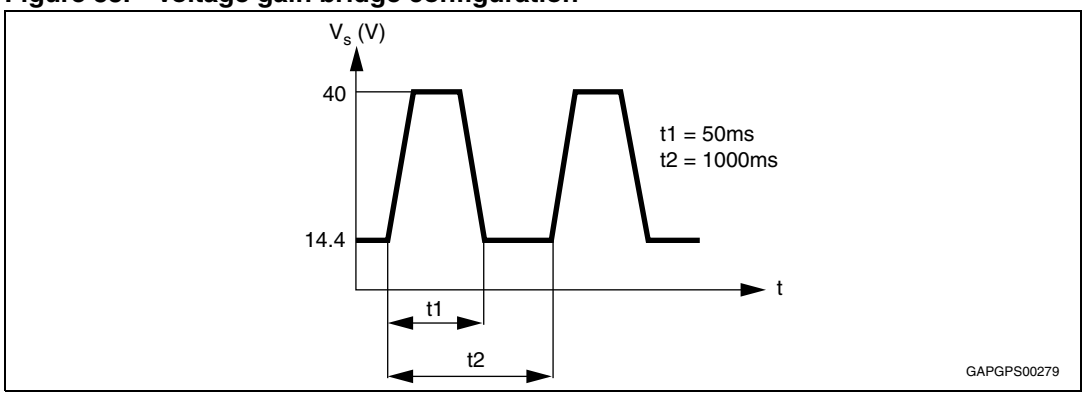


Figure 38. Voltage gain bridge configuration



3.3.3 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 features is added to avoid destruction, if during fitting to the car, a mistake on the connection of the supply is made.

3.4 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 TDA7360 protection diodes are included to avoid any damage.

3.4.1 DC voltage

The maximum operating DC voltage for the TDA7360 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.

3.4.2 Thermal shut-down

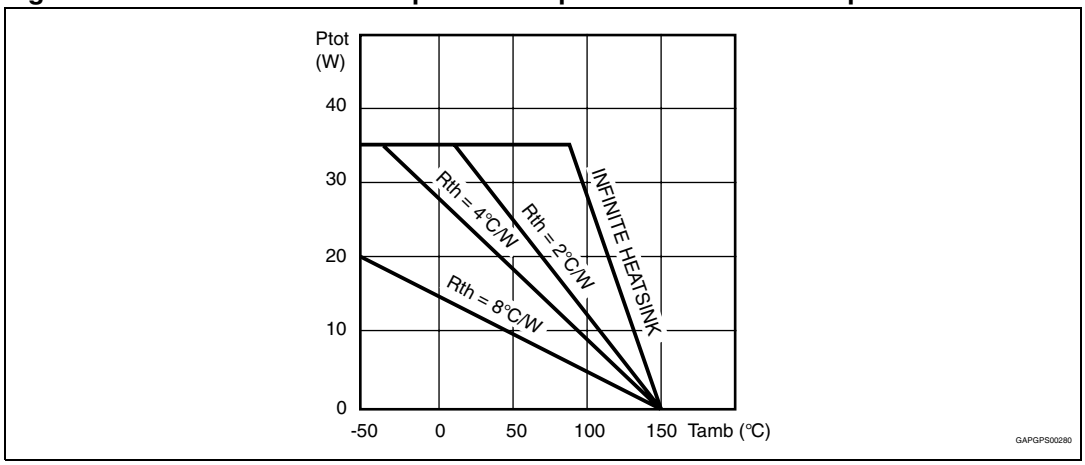
The presence of a thermal limiting circuit offers the following advantages:

an overload on the output (even if it is permanent), or an excessive ambient temperature can be easily withstood.

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 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 39* shows the dissipable power as a function of ambient temperature for different thermal resistance.

Figure 39. Maximum allowable power dissipation vs. ambient temperature

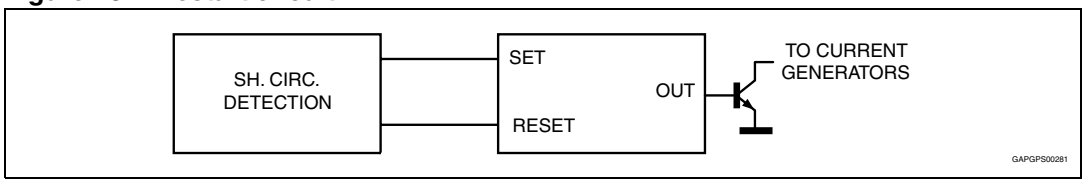


3.4.3 Loudspeaker protection

The TDA7360 guarantees safe operations even for the loudspeaker in case of accidental short-circuit.

Whenever a single OUT to GND, OUT to V_S short circuit occurs both the outputs are switched OFF so limiting dangerous DC current flowing through the loudspeaker.

Figure 40. Restart circuit



4 Application hints

This section explains briefly how to get the best from the TDA7360 and presents some application circuits with suggestions for the value of the components.These values can change depending on the characteristics that the designer of the car radio wants to obtain, or other parts of the car radio that are connected to the audio block.

To optimize the performance of the audio part it is useful (or indispensable) to analyze also the parts outside this block that can have an interconnection with the amplifier.

This method can provide components and system cost saving.

4.1 Reducing turn on-off pop

The TDA7360 has been designed in a way that the turn-on (off) transients are controlled through the charge (discharge) of the Csvr capacitor.

As a result of it, the turn-on (off) transient spectrum contents is limited only to the subsonic range.The following section gives some brief notes to get the best from this design feature (it will refer mainly to the stereo application which appears to be in most cases the more critical from the pop viewpoint.The bridge connection in fact, due to the common mode waveform at the outputs, does not give pop effect).

4.2 Turn-on

Figure 41 shows the output waveform (before and after the "A" weighting filter) compared to the value of C_{svr}.

Better pop-on performance is obtained with higher C_{svr} values (the recommended range is from 22µF to 220µF).

The turn-on delay (during which the amplifier is in mute condition) is a function essentially of: C_{out}, C_{svr}. Being:

$$T1 \approx 120 \cdot C_{out}$$

$$T2 \approx 1200 \cdot C_{svr}$$

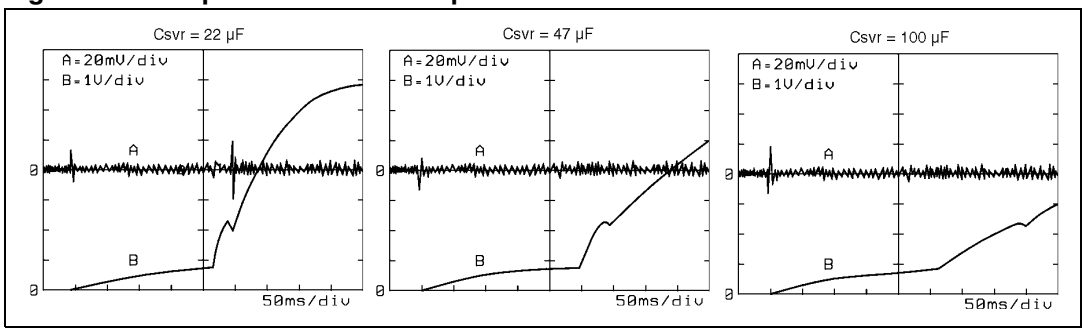
The turn-on delay is given by:

$$T1+T2 \text{ STEREO}$$

$$T2 \text{ BRIDGE}$$

The best performance is obtained by driving the st-by pin with a ramp having a slope slower than 2V/ms.

Figure 41. Output waveforms compared to the values of Csvr



4.3 Turn-off

A turn-off pop can occur if the standby pin goes low with a short time constant (this can occur if other car radio sections, preamplifiers, radio are supplied through the same standby switch).

This pop is due to the fast switch-off of the internal current generator of the amplifier.

If the voltage present across the load becomes rapidly zero (due to the fast switch off) a small pop occurs, depending also on C_{out}, R_{load}.

The parameters that set the switch off time constant of the st-by pin are:

- the standby capacitor ($C_{st\text{-}by}$)
- the SVR capacitor (C_{SVR})
- resistors connected from st-by pin to ground (R_{ext})

The time constant is given by:

$$T \approx Csvr \cdot 2000\Omega \,//\, Rext + Cst\text{-}by \cdot 2500\Omega \,//\, Rext$$

The suggested time constants are:

$T > 120$ ms with $C_{out} = 1000\mu F$, $R_L = 4$ ohm, stereo

$T > 170$ ms with $C_{out} = 2200\mu F$, $R_L = 4$ ohm, stereo

If Rext is too low the C_{svr} can become too high and a different approach may be useful (see next section).

Figure 42 and *43* show some types of electronic switches (µP compatible) suitable for supplying the st-by pin (it is important that Qsw is able to saturate with $V_{CE} \leq 150$ mV).

Also for turn off pop the bridge configuration is superior, in particular the st-by pin can go low faster.

4.4 Global approach to solving pop problem by using the muting/turn-on delay function

In the real case turn-on and turn-off pop problems are generated not only by the power amplifier, but also (very often) by preamplifiers, tone controls, radios etc. and transmitted by the power amplifier to the loudspeaker.

A simple approach to solving these problems is to use the mute characteristics of the TDA7360. If the SVR pin is at a voltage below 1.5 V, the mute attenuation (typ) is 30dB.The amplifier is in play mode when V_{svr} overcomes 3.5 V.

With the circuit of *Figure 44* we can mute the amplifier for a time Ton after switch-on and for a time Toff after switch-off. During this period the circuitry that precedes the power amplifier can produce spurious spikes that are not transmitted to the loudspeaker.

This can give back a very simple design of this circuitry from the pop point of view. A timing diagram of this circuit is illustrated in *Figure 45*. Other advantages of this circuit are:

- A reduced time constant allowance of stand-by pin turn off. Consequently it is possible to drive all the car-radio with the signal that drives this pin.
- A better turn-off noise with signal on the output. To drive two stereo amplifiers with this circuit it is possible to use the circuit of *Figure 46*.

Figure 42. ST-BY pin supply circuit, example 1

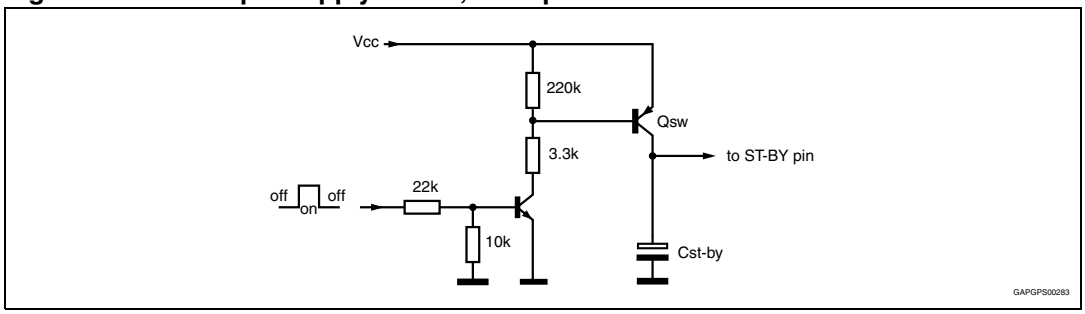


Figure 43. ST-BY pin supply circuit, example 2

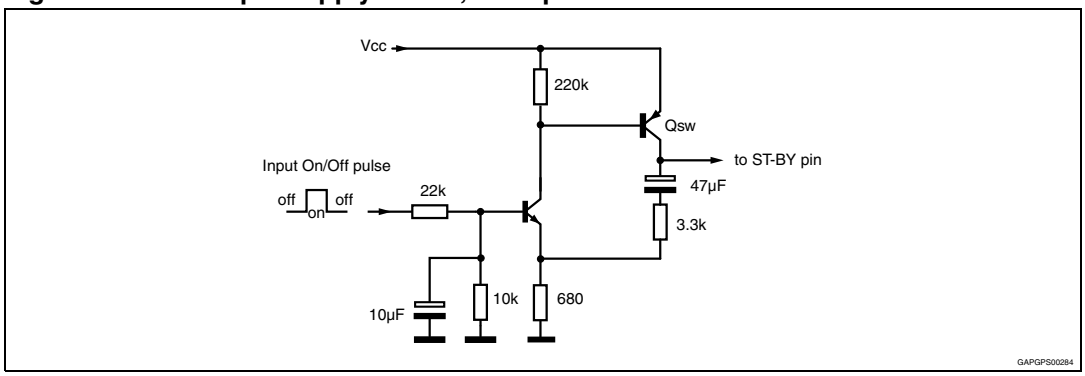


Figure 44. Suggested muting circuit during amplifier switch-on and switch-off

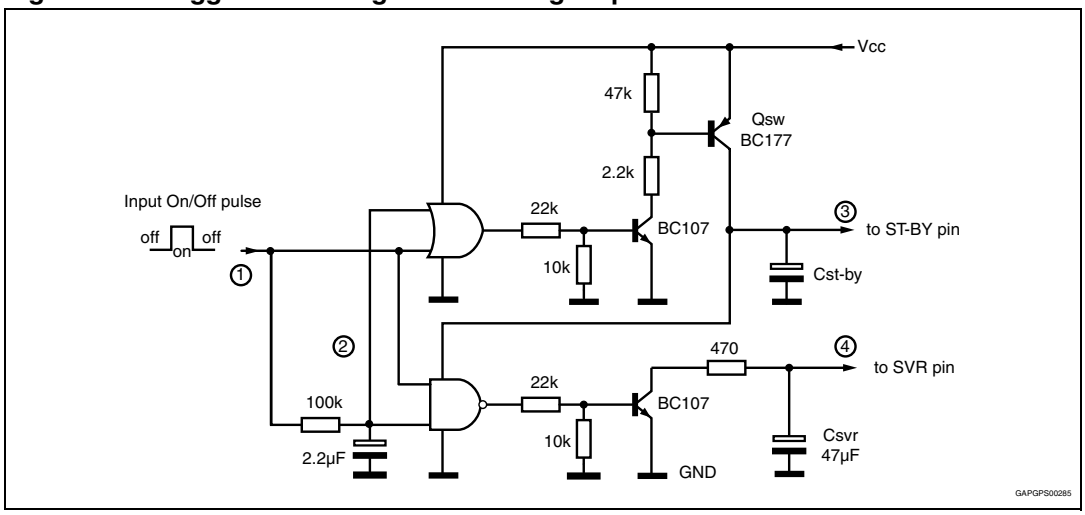


Figure 45. Timing diagram for the circuit depicted in fig. 44

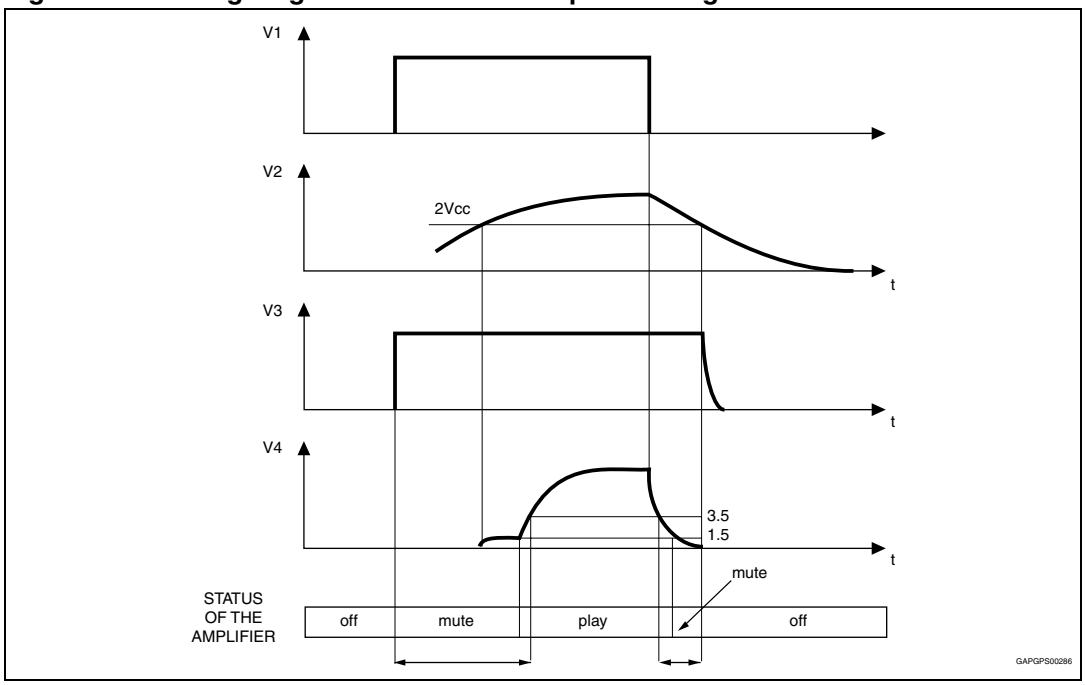
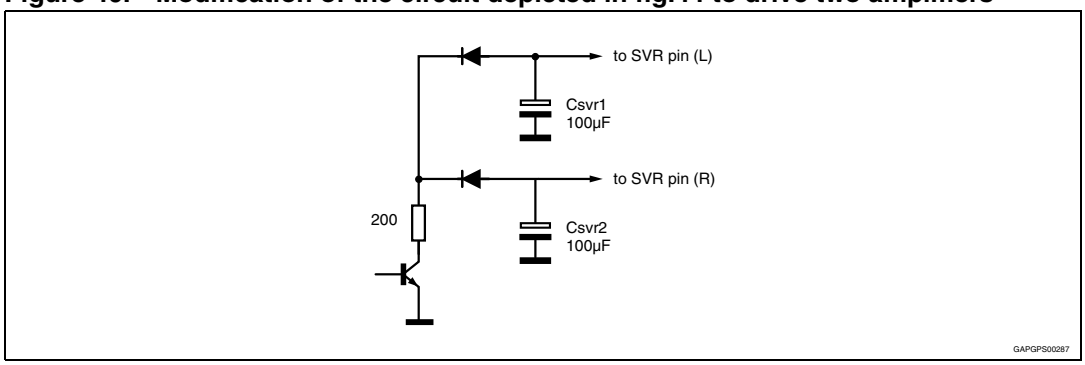


Figure 46. Modification of the circuit depicted in fig.44 to drive two amplifiers



4.5 Balance input in bridge configuration

A helpful characteristic of the TDA7360 is that, in bridge configuration, a signal present on both the input capacitors is amplified by the same amount and it is present in phase at the outputs, so this signal does not produce effects on the load.The typical value of CMRR is 46dB.

Looking at *Figure 47*, we can see that a noise signal from the ground of the power amplifier to the ground of the hypothetical preamplifier is amplified of a factor equal to the gain of the amplifier (2 · Gv). Using a configuration of *Figure 48* the same ground noise is present at the output multiplied by the factor 2 · Gv/200.

This means less distortion, less noise (e.g. motor cassette noise) and/or a simplification of the layout of PC board.

The only limitation of this balanced input is the maximum amplitude of common mode signals (few tens of millivolt) to avoid a loss of output power due to the common mode signal on the output, but in a large number of cases this signal is within this range.

Figure 47. Balance input bridge configuration, example 1

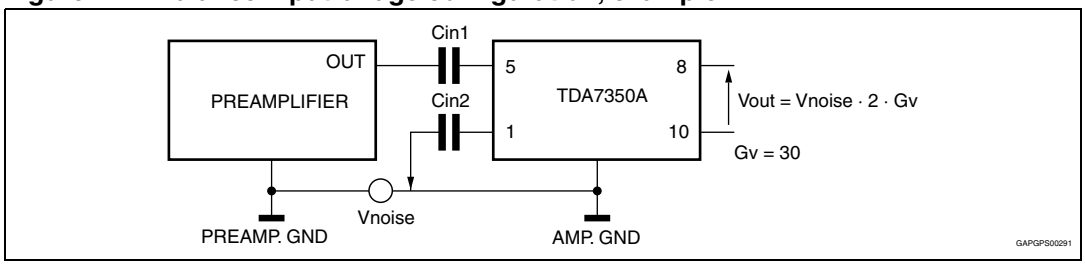
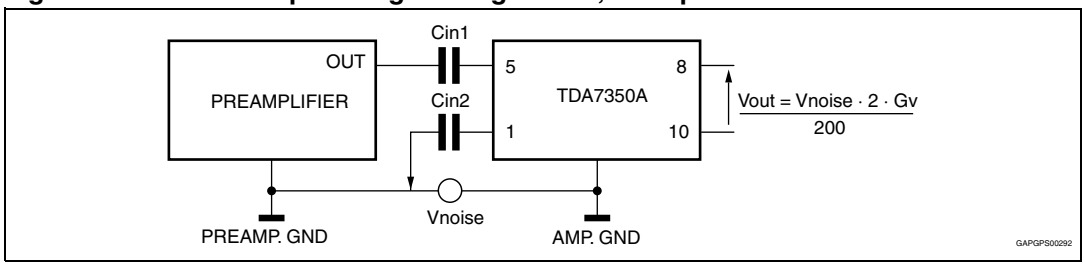


Figure 48. Balance input bridge configuration, example 2



5 Package information

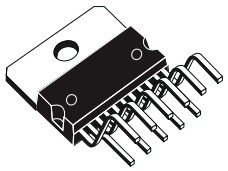
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*.

ECOPACK® is an ST trademark.

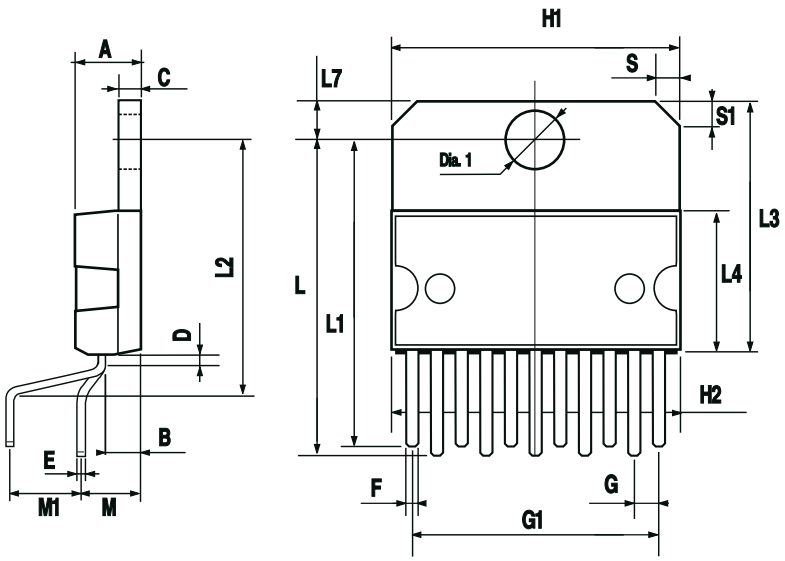
Figure 49. Multiwatt11 (vertical) mechanical data and package dimensions

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)



GAPGPS00293

6 Revision history

Table 6. Document revision history

Date	Revision	Changes
09-Jul-1997	1	Initial release.
20-Oct-1998	2	Document status promoted from preliminary data to datasheet.
24-Feb-2011	3	Document reformatted. Updated order code in *Table 1: Device summary.* Updated *Section 5: Package information*.

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