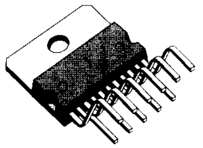
SGS-THOMSON MICROELECTRONICS

TDA7362

2x8W CAR RADIO AMPLIFIER WITH CLIPPING DETECTOR

ADVANCE DATA

- VERY FEW EXTERNAL COMPONENTS
- NO BOUCHEROT CELLS
- NO BOOTSTRAP CAPACITORS
- FIXED GAIN (30dB)
- LOW OUTPUT VOLTAGE DROP
- NO SWITCH ON/OFF NOISE
- VERY LOW STAND-BY CURRENT
- PROGRAMMABLE TURN-ON DELAY
- CLIPPING DETECTION



Multiwatt-11
ORDERING NUMBER: TDA7362

PROTECTIONS:

- OUTPUT AC-DC SHORT CIRCUIT TO GROUND AND TO SUPPLY VOLTAGE
- VERY INDUCTIVE LOADS
- OVERRATING CHIP TEMPERATURE
- LOAD DUMP VOLTAGE
- FORTUITOUS OPEN GROUND
- ESD

DESCRIPTION

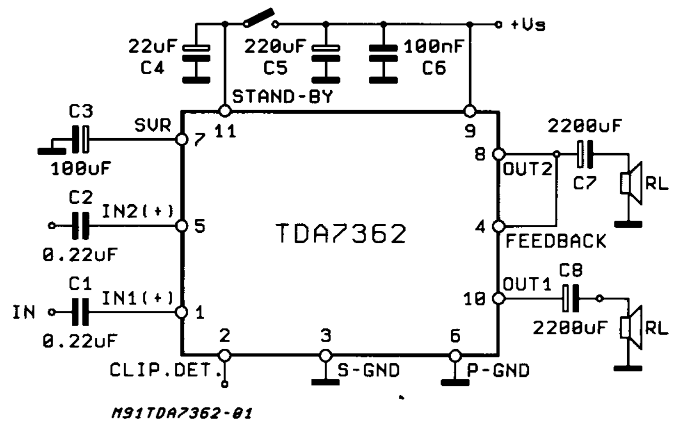
The TDA7362 is a new technology class AB Audio Power Amplifier in Multiwatt package designed for car radio applications.

Thanks to the fully complementary PNP/NPN output configuration the power performances of the TDA7362 are obtained without the boostrap capacitors.

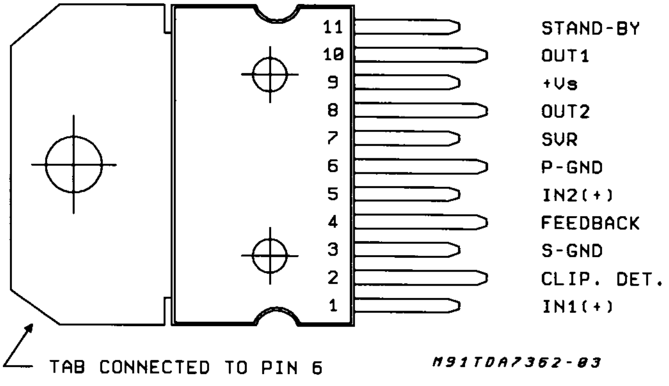
A delayed turn-on mute circuit eliminates audible on/off noise, and a novel short circuit protection system prevents spurious intervention with highly inductive loads.

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.

APPLICATION CIRCUIT



PIN CONNECTION (Top view)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	28	V
V_{OP}	Operating Supply Voltage	18	V
V_{PEAK}	Peak Supply Voltage (t = 50ms)	40	V
I_O	Output Peak Current (non repetitive t = 100μs)	5	A
I_O	Output Peak Current (repetitive f > 10Hz)	4	A
P_{tot}	Power Dissipation T_{case} = 85°C	36	W
T_{stg}, T_j	Storage and Junction Temperature	-40 to 150	°C

THERMAL DATA

Symbol	Description		Value	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max	1.8	°C/W

ELECTRICAL CHARACTERISTICS (Refer to the test circuits, V_S = 14.4V; f = 1KHz, T_{amb} = 25°C, unless otherwise specified

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_S	Supply Voltage Range		8		18	V
Id	Total Quiescent Drain Current				150	mA
A_{SB}	Stand-by attenuation		60	80		dB
I_{SB}	Stand-by Current				100	µA
I_{CO}	Clip Detector Average Current	d = 1% pin2 pull-up to 5V with 10KΩ R_L = 3.2Ω		70		µA
		d = 10% pin2 pull-up to 5V with 10KΩ R_L = 3.2Ω		120		µA
P_O	Output Power (each channel)	d = 10% R_L = 2Ω R_L = 3.2Ω R_L = 4Ω	 7 	 11 8 6.5		 W W W
		d = 10%; V_S = 13.2V R_L = 2Ω R_L = 3.2Ω R_L = 4Ω		 9 6.5 5.5		 W W W
d	Distortion	P_O = 0.1 to 4W; R_L = 3.2Ω			0.5	%
SVR	Supply Voltage Rejection	R_S = 10KΩ f = 100Hz C3 = 22µF C3 = 100µF	 40 	 57		 dB dB
CT	Crosstalk	f = 1KHz f = 10KHz	40 	 57		dB dB
R_i	Input Resistance		30	50		KΩ
G_V	Voltage Gain		27	29	31	dB
G_V	Voltage Gain Match				1	dB
E_{IN}	Input Noise Voltage	R_S = 50Ω (*) R_S = 10KΩ (*) R_S = 50Ω (**) R_S = 10KΩ (**)		1.5 2 2 	 7	µV µV µV µV
T_{sd}	Thermal Shutdown Junction Temperature			145		°C

(*) Curve A
(**) 22Hz to 22KHz

Figure 1: Test and Application Circuit

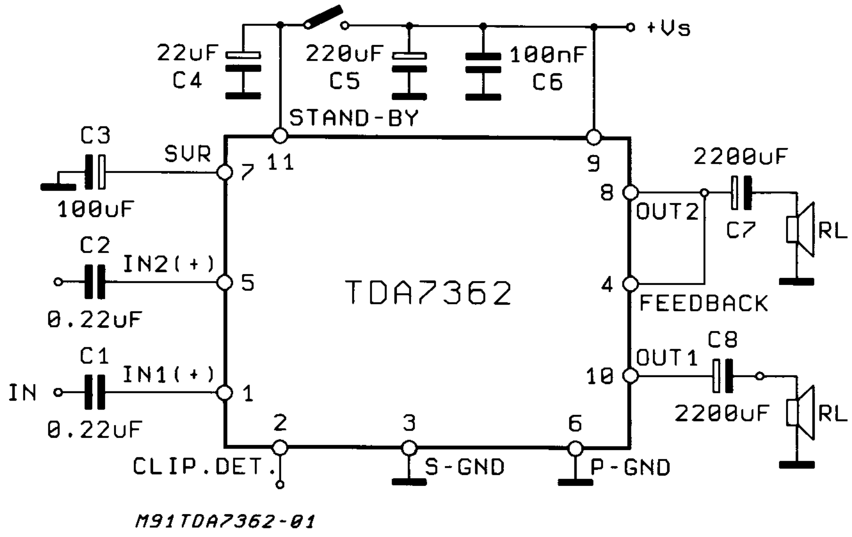
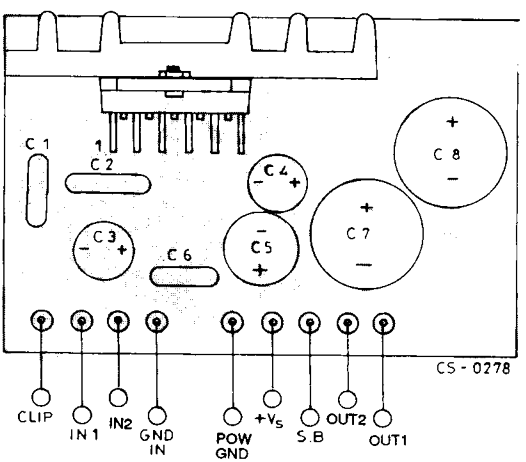


Figure 2: P.C. Board and Component Layout of the Circuit of Fig. 1 (1:1 scale)



RECOMMENDED VALUES OF THE EXTERNAL COMPONENTS (ref to the Test and Application Circuit)

Component	Recommended 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)
C4	22μF	Stand-By ON/OFF Delay	Delayed Turn-Off by Stand-By 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
C8	2200μF	Output Decoupling CH1	- Decrease of Low Frequency Cut Off - Longer Turn On Delay	- Increase of Low Frequency Cut Off - Shorter Turn On Delay

Figure 3: Output Power vs. Supply Voltage

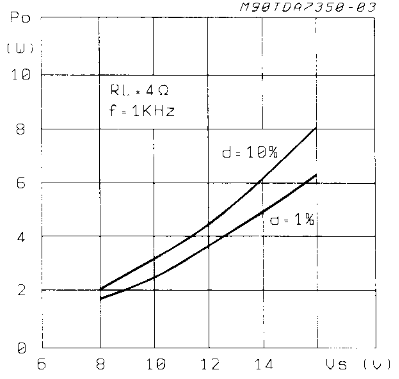


Figure 4: Output Power vs. Supply Voltage

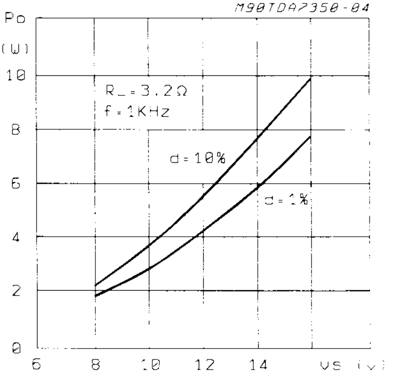


Figure 5: Output Power vs. Supply Voltage

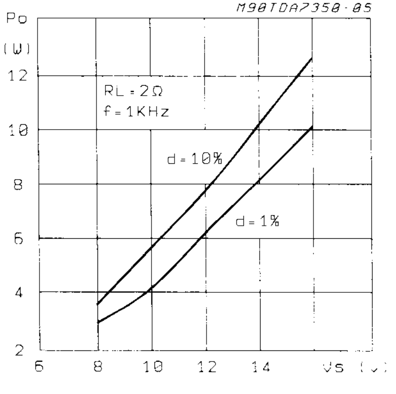


Figure 6: Drain Current vs. Supply Voltage

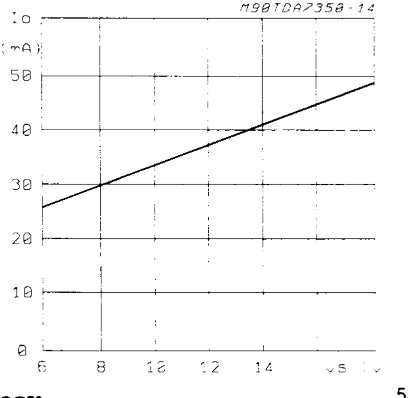


Figure 7: Distortion vs. Output Power

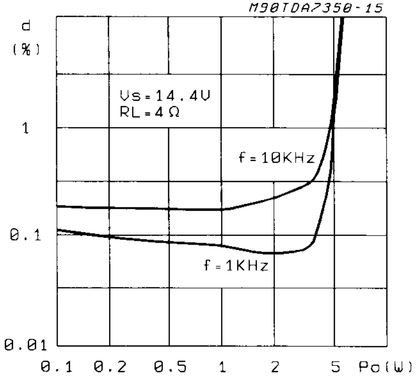


Figure 8: Distortion vs. Output Power

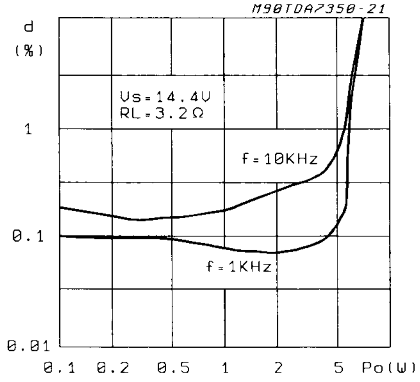


Figure 9: Distortion vs. Output Power

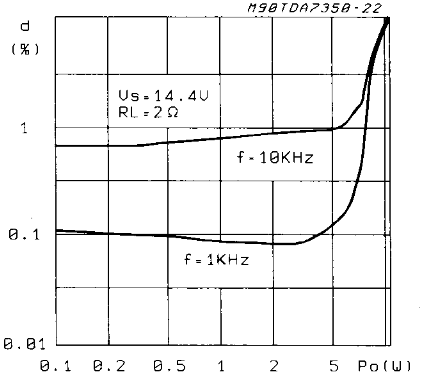


Figure 10: SVR vs. Frequency & C3

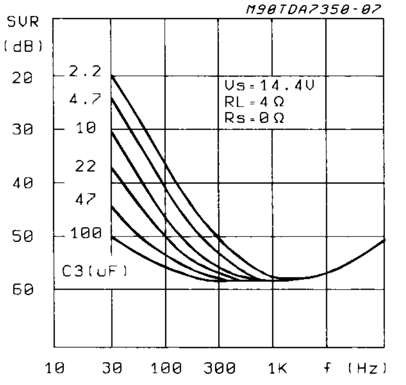


Figure 11: SVR vs. Frequency & C3

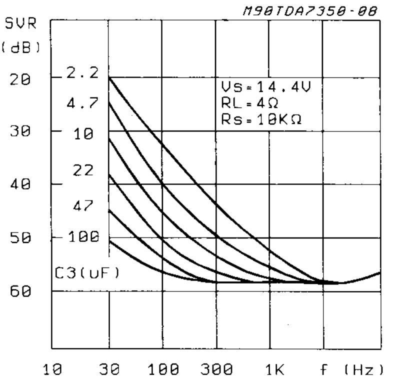


Figure 12: Crosstalk vs. Frequency

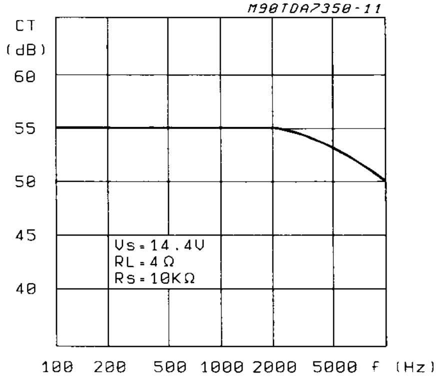


Figure 13: Power Dissipation & Efficiency vs. Output Power

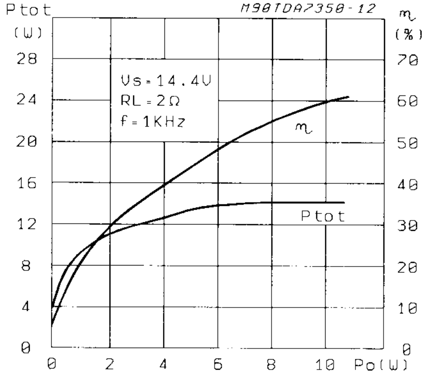
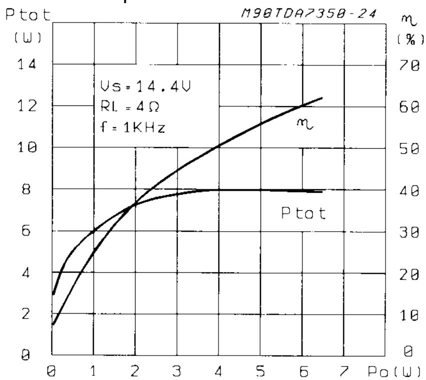


Figure 14: Power Dissipation & Efficiency vs. Output Power



AMPLIFIER ORGANIZATION

The TDA7362 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
- ABSOLUTE STABILITY WITHOUT EXTERNAL COMPENSATION THANKS TO THE INNOVATIVE OUT STAGE CONFIGURATION, ALSO ALLOWING INTERNALLY FIXED CLOSED LOOP LOWER THAN COMPETITORS
- LOW GAIN (30dB FIXED WITHOUT ANY EXTERNAL COMPONENTS) IN ORDER TO MINIMIZE THE OUTPUT NOISE AND OPTIMIZE SVR
- SILENT MUTE/ST-BY FUNCTION FEATURING ABSENCE OF POP ON/OFF NOISE
- HIGH SVR
- AC/DC SHORT CIRCUIT PROTECTION (TO GND, TO V_S, ACROSS THE LOAD)
- LOUDSPEAKER PROTECTION
- DUMP PROTECTION
- ESD PROTECTION

BLOCK DESCRIPTION

Polarization

The device is organized with the gain resistors directly connected to the signal ground pin i.e. without gain capacitors (fig. 15).

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.

SVR

The voltage ripple on the outputs is equal to the one on SVR pin: with appropriate selection of C_{SVR}, more than 55dB of ripple rejection can be obtained.

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 (fig. 16). The mute function is obtained by duplicating the input differential pair (fig. 17): 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).

Fig. 17 represents the detailed turn-on transient.
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), after that the music signal starts being played.

Stand-by
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.

Stability
The device is provided with an internal compensation wich allows to reach low values of closed loop gain.
In this way better performances on S/N ratio and SVR can be obtained.

Figure 15: Block Diagram; Stereo Configuration

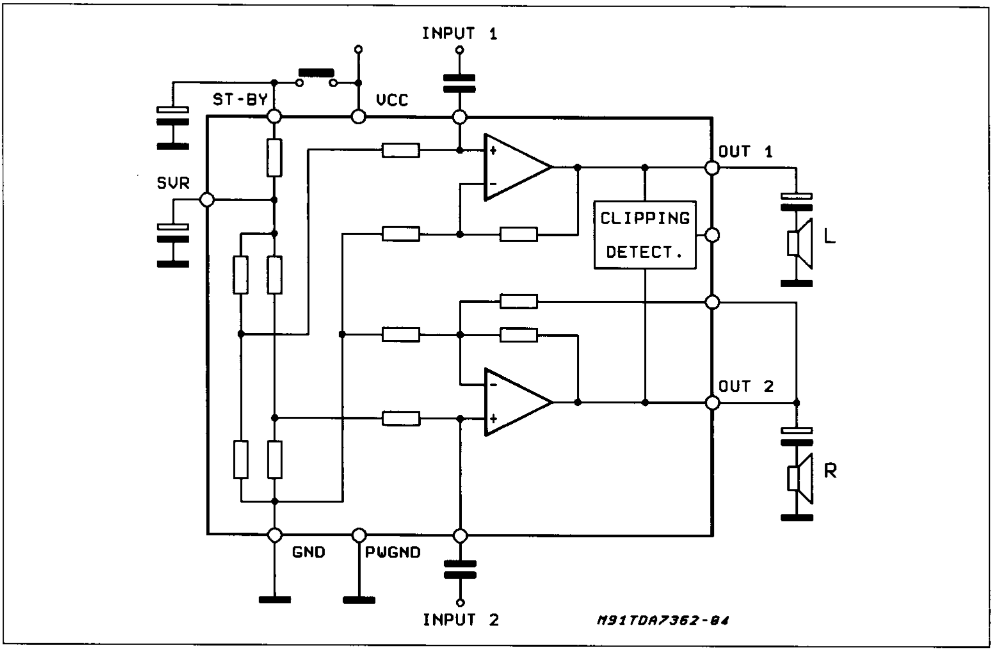


Figure 16: Mute Function Diagram

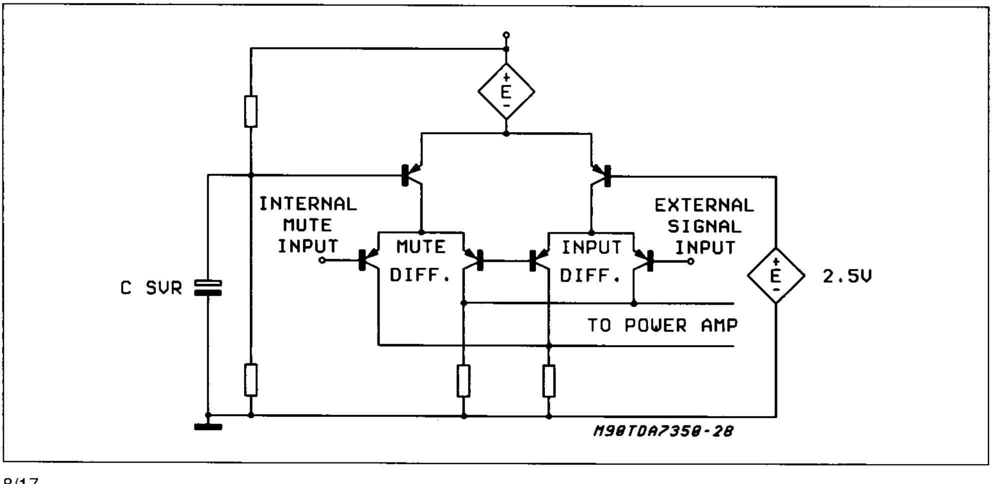
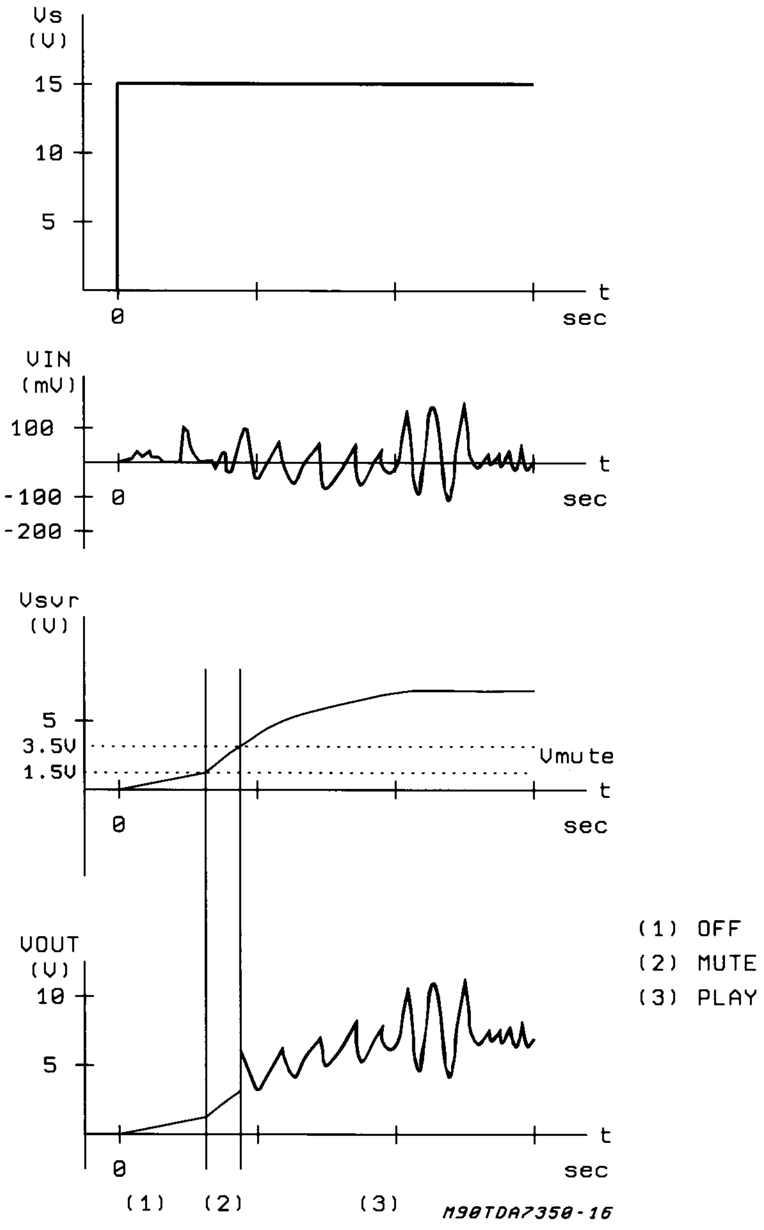


Figure 17: Turn-on Delay Circuit



CLIP DETECTOR

The TDA7362 is equipped with an internal circuit able to detect the output stage saturation providing a proper current sinking into a open collector out. (pin2) when a certain distortion level is reached at each output. This particular function allows compression facility whenever the amplifier is overdriven, so obtaining high quality sound at all listening levels.

Figure 18: Dual Channel Distortion Detector

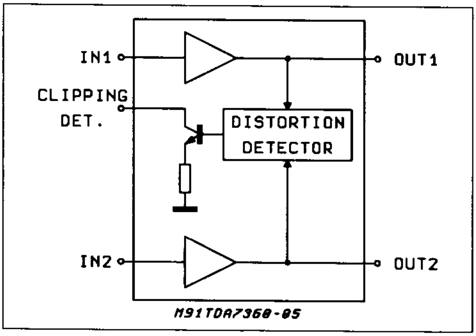


Figure 19: Output at Clipping Detector Pin vs. Signal Distortion

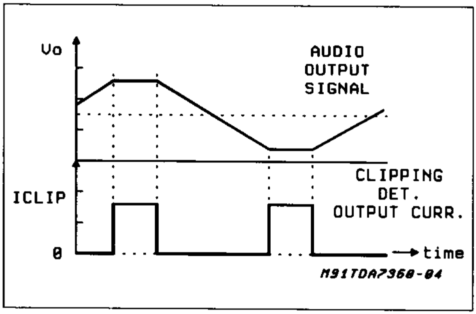


Figure 20: ICV - PNP Gain vs. I_C

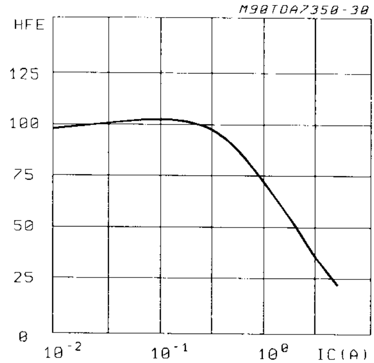


Figure 21: ICV - PNP $V_{CE(sat)}$ vs. I_C

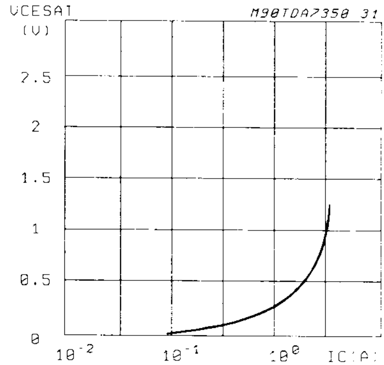
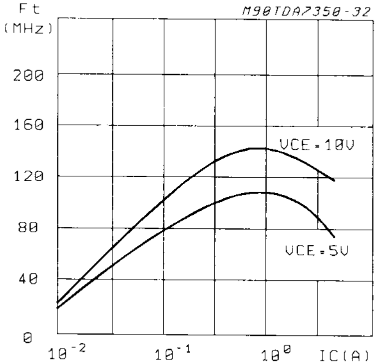


Figure 22: ICV - PNP cut-off Frequency vs. I_C



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 fig. 20, 21, 22 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 fig. 23 has been chosen. First of all because its voltage swing is rail-to-rail, limited only by the VCEsat 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.

In contrast, with the circuit of fig. 24, the solution adopted to reduce the gain at high frequencies is the use of an external RC network.

AMPLIFIER BLOCK DIAGRAM

The block diagram of each voltage amplifier is shown in fig. 25. 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 23: The New Output Stage

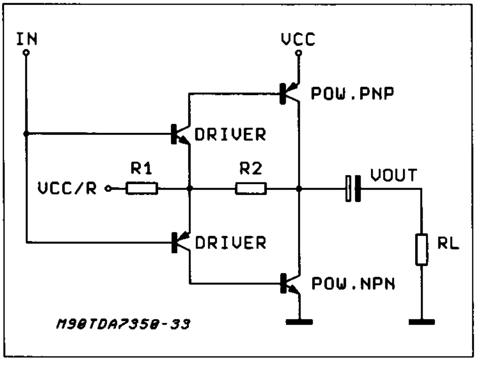


Figure 24: A Classic Output Stage

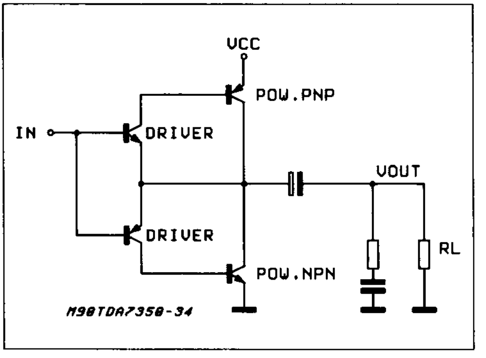
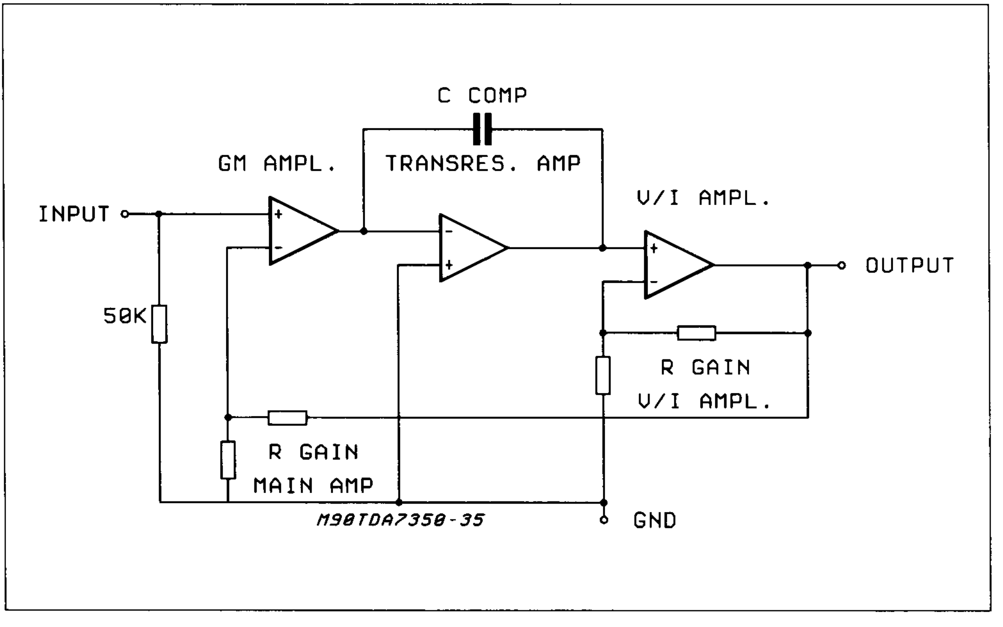


Figure 25: Amplifier Block Diagram



BUILT-IN PROTECTION SYSTEMS

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.

Fig 26 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 cascode.

This cascode 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 (fig. 30). In case of AC short circuit, the device is continuously switched in ON/OFF conditions and the current is limited.

Load Dump Voltage Surge

The TDA7362 has a circuit which enables it to withstand a voltage pulse train on pin 9, of the type shown in fig. 28.
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. 27
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 26: Circuitry for Short Circuit Detection

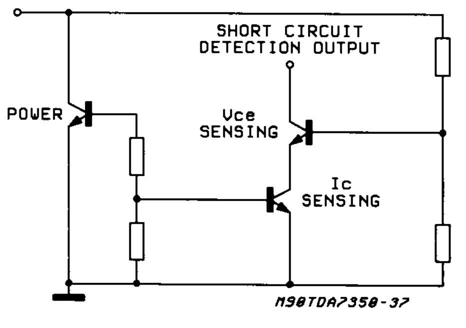


Figure 27.

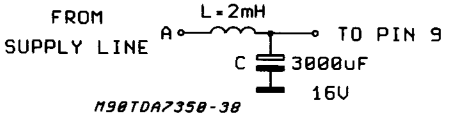


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Figure 28.

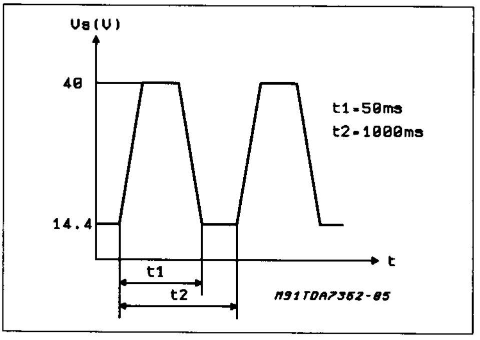


Figure 29: Maximum Allowable Power Dissipation vs. Ambient Temperature

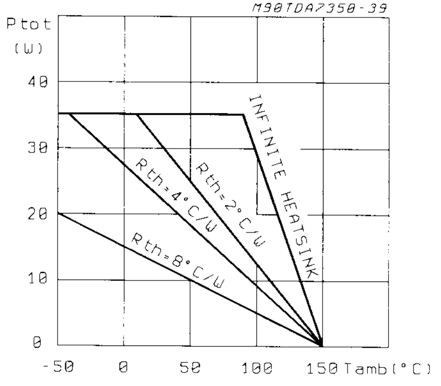
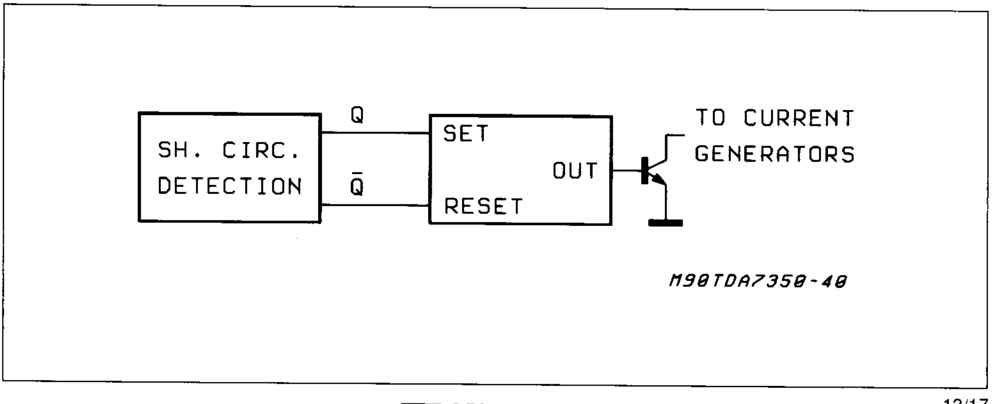


Figure 30: Restart Circuit



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.

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 TDA7362 protection diodes are included to avoid any damage.

DC Voltage

The maximum operating DC voltage for the TDA7362 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 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. 29 shows the dissipable power as a function of ambient temperature for different thermal resistance.

APPLICATION HINTS

This section explains briefly how to get the best from the TDA7362 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.

Reducing Turn On-Off Pop

The TDA7362 has been designed in a way that the turn on(off) transients are controlled through the charge(discharge) of the Csvr capacitor (C3).

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.

TURN-ON

Fig 31 shows the output waveform (before and after the "A" weighting filter) compared to the value of Csvr.

Better pop-on performance is obtained with higher Csvr values (the recommended range is from 22uF to 220uF).

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:

$$T1+T2$$

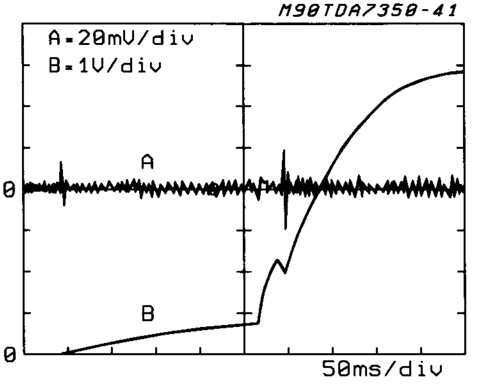
The best performance is obtained by driving the st-by pin with a ramp having a slope slower than 2V/ms.

TURN-OFF

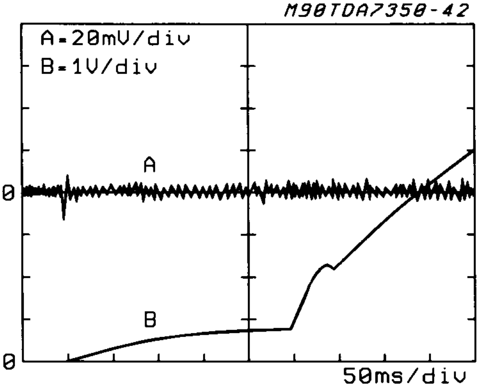
A turn-off pop can occur if the st-by pin goes low with a short time constant (this can occur if other

Figure 31:

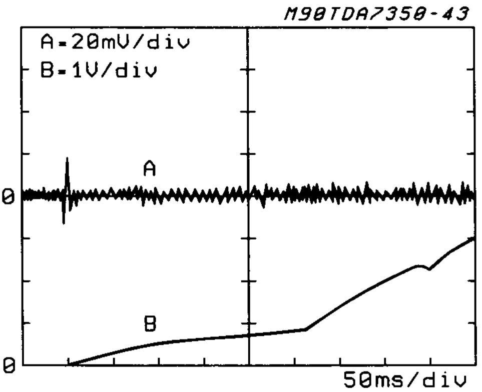
a) C_{SVT} = 22µF



b) C_{SVT} = 47µF



c) C_{SVT} = 100µF



car radio sections, preamplifiers,radio.. are supplied through the same st-by 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 Cout,Rload.

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

- the st-by capacitor Cst-by (C3)
- the SVR capacitor Csvr (C3)
- resistors connected from st-by pin to ground (Rext)

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 :

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

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

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

Figg 32, 33 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 $V_{CE} \leq 150mV$).

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 TDA7362.

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 Vsvr overcomes 3.5 V.

With the circuit of fig 34 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 fig 35. 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 fig 36.

Figure 32

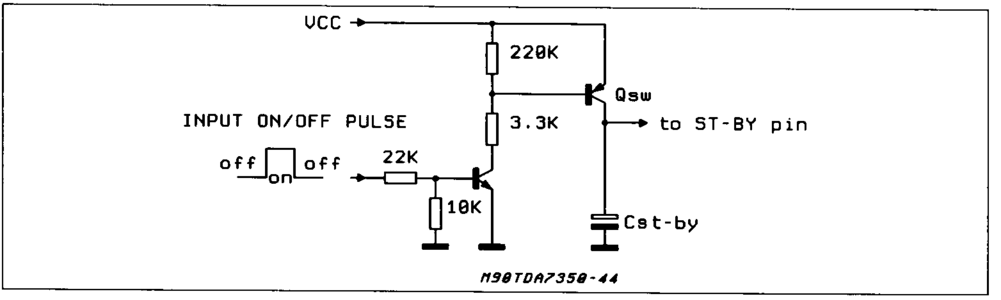


Figure 33

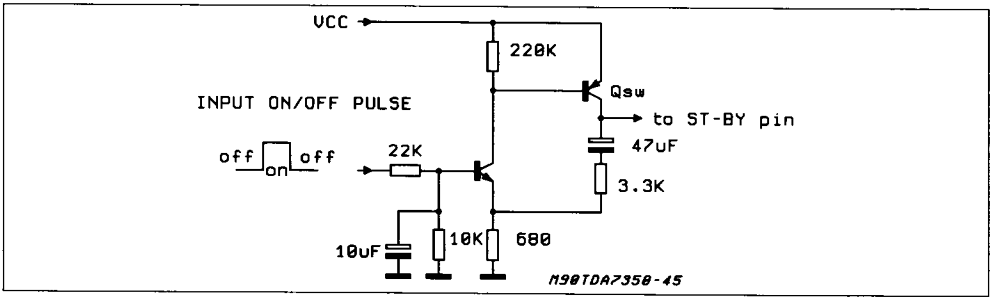


Figure 34

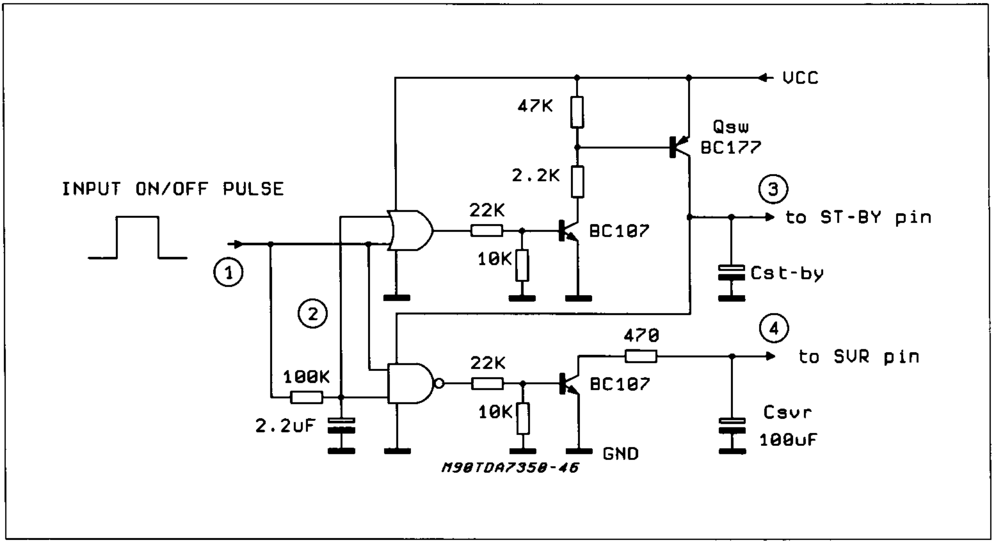
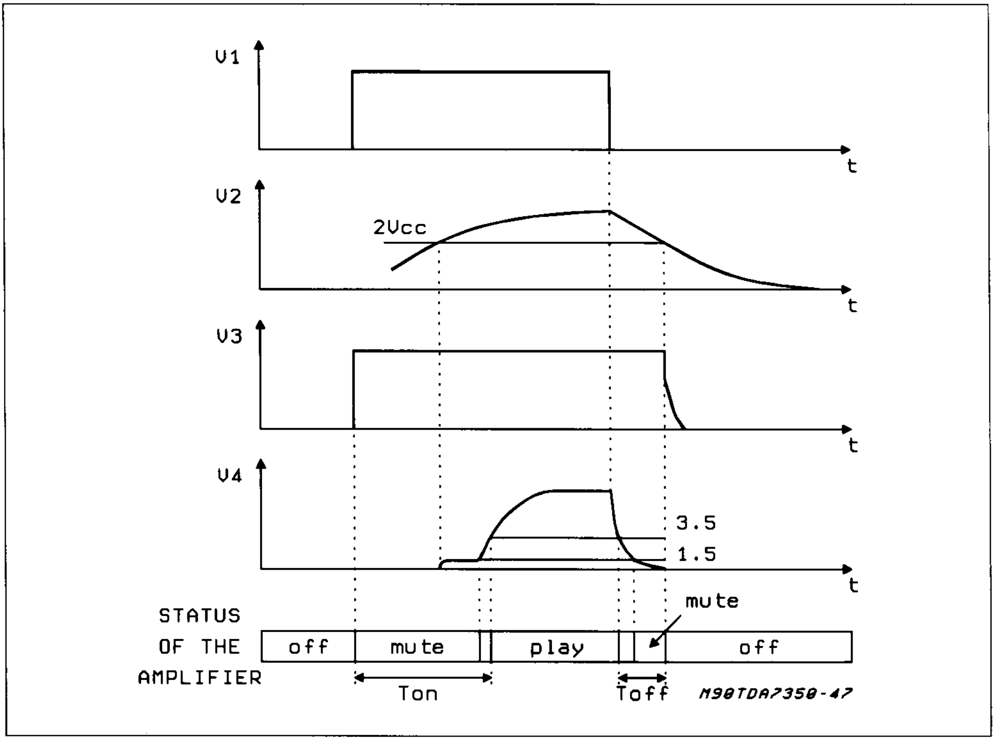
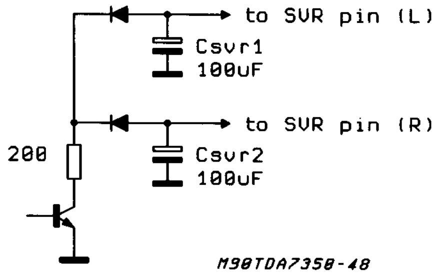


Figure 35



SGS-THOMSON MICROELECTRONICS

Figure 36



HIGH GAIN ,LOW NOISE APPLICATION
The following section describes a flexible preamplifier having the purpose to increase the gain of the TDA7362.

A two transistor network (fig. 37) has been adopted whose components can be changed in order to achieve the desired gain without affecting the good performances of the audio amplifier itself.

The recommended values for 40 dB overall gain are :

Resistance	Value
R1	10KΩ
R2	4.3KΩ
R3	10KΩ
R4	50KΩ

Figure 37