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STA540SA

4 x 10W DUAL/QUAD POWER AMPLIFIER

TARGET SPECIFICATIONS

1 FEATURES

- HIGH OUTPUT POWER CAPABILITY
  - 4 x 9W / 2Ω @12V; 1KHz; 10%
  - 4 x 10W / 4Ω @17V; 1KHz; 10%
  - 2 x 26W / 4Ω @14.4V; 1KHz; 10%
  - 2 x 15W / 8Ω @16V; 1KHz; 10%
- MINIMUM EXTERNAL COMPONENTS COUNT:
  - NO BOOTSTRAP CAPACITORS
  - NO BOUCHEROT CELLS
  - INTERNALLY FIXED GAIN 20dB
- ST-BY FUNCTION (CMOS COMPATIBLE)
- NO AUDIBLE POP DURING ST-BY OPERATIONS
- DIAGNOSTIC FACILITIES
  - CLIP DETECTOR
  - OUT TO GND SHORT
  - OUT TO VS SHORT
  - SOFT SHORT AT TURN-ON
  - THERMAL SHUTDOWN PROXIMITY

2 PROTECTIONS

- OUPUT AC/DC SHORT CIRCUIT
- SOFT SHORT AT TURN-ON
- OVERRATING CHIP TEMPERATURE WITH SOFT THERMAL LIMITER
- VERY INDUCTIVE LOADS
- ESD

Figure 1. Package

Clipwatt 19

Table 1. Order Codes

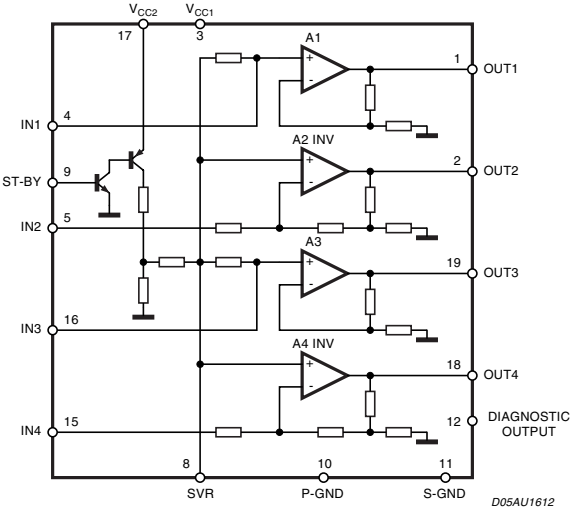
Part Number	Package
STA540SA	Clipwatt 19

3 DESCRIPTION

The amplifier is a class AB Audio amplifier assembled in the Clipwatt19 package designed for high quality sound application.

The STA540SA is a 4 Single ended amplifier with integrated in the device the Short Circuit Protection, the Thermal Protection and the Diagnostics Functions .

Figure 2. Block Diagram



REV. 1

April 2005

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Table 2. Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
V_s	Supply Voltage idle mode (no signal)	24	V
	Supply Voltage operating	22	V
	Supply Voltage AC-DC short safe	20	V
P_{tot}	Total Power Dissipation (T_{case} = 70°C)	35	W
T_{stg}, T_j	Storage and Junction Temperature	-40 to150	°C
T_{op}	Operating Temperature	0 to 70	°C

Table 3. Thermal Data

Symbol	Parameter		Value	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction to case	Max.	2	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction to ambient	Max.	45	°C/W

Figure 3. Pin Connection (Top view)

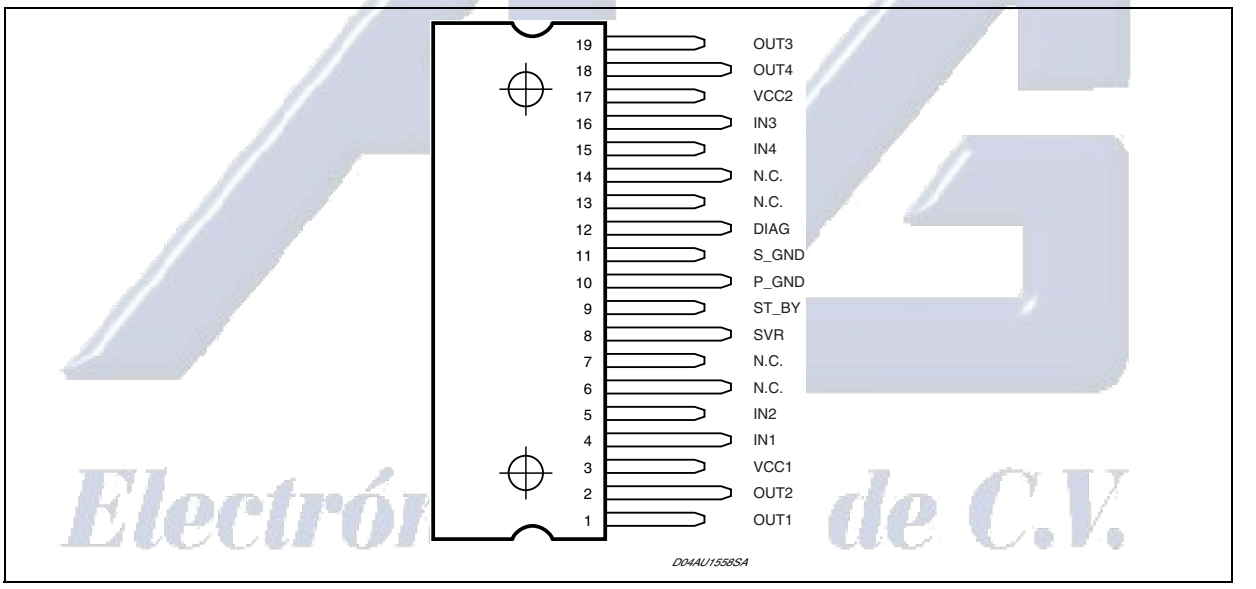

Table 4. Pin Description

N°	Pin Name	Pin Type	Function
1	OUT1	OUTPUT	Channel 1 output
2	OUT2	OUTPUT	Channel 2 output
3	VCC1	POWER	Power supply
4	IN1	INPUT	Channel 1 input
5	IN2	INPUT	Channel 2 input
6	N.C.		Not Connected
7	N.C.		Not Connected
8	SVR	INPUT	Supply Voltage Rejection
9	ST-BY	INPUT	Stand-by control pin
10	P_GND	POWER	Power ground
11	S_GND	POWER	Signal Ground
12	DIAG	OUTPUT	Diagnostics

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Table 4. Pin Description (continued)

N°	Pin Name	Pin Type	Function
13	N.C.		Not Connected
14	N.C.		Not Connected
15	IN4	INPUT	Channel 4 input
16	IN3	INPUT	Channel 3 input
17	VCC2	POWER	Power supply
18	OUT4	OUTPUT	Channel 4 output
19	OUT3	OUTPUT	Channel 3 output

Table 5. Electrical Characteristcs

(Refer to the test circuit, V_S = 15V; R_L = 4Ω; 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
I_d	Total Quiescent Drain Current			80	150	mA
V_{os}	Output Offset Voltage		-250		250	mV
P_o	Output Power	THD = 10%:	6.5	7.5		W
		THD = 10%: V_S = 17V S.E. R_L = 4Ω		10		W
		THD = 10%: V_S = 17V BTL; R_L = 8Ω		20		W
THD	Distortion	R_L = 4Ω, Po = 0.1 to 4W		0.02		%
I_{SC}	Short Circuit Current			3.5		A
C_T	Cross Talk	f = 1 kHz f = 10 kHz		70 60		dB dB
R_{in}	Input Impedance		20	30		kΩ
G_v	Voltage Gain		19	20	21	dB
G_v	Voltage Gain Match				0.5	dB
E_N	Total Output Noise	Rg = 0; “A” weighted Inverting channels Non inverting channels		 50 20		 μV μV
SVR	Supply Voltage Rejection	Rg = 0; f = 300Hz	50			dB
A_{SB}	Stand-by Attenuation		80	90		dB
I_{SB}	ST-BY Current Consumption	V_{ST-BY} = 0 to 1.5V			100	μA
V_{SB}	ST-BY In Threshold Voltage				1.5	V
V_{SB}	ST-BY Out Threshold Voltage		3.5			V
I_{stby}	ST-BY Pin Current	Play Mode V_{stby} = 5V			50	μA
		Max Driving Current Under Fault			5	mA
$I_{cd\ off}$	Clipping Detector Output Average Current	d = 1% (*)		90		μA
$I_{cd\ on}$	Clipping Detector Output Average Current	d = 5% (*)		160		μA
V_{diag}	Voltage Saturation on DIAG	Sink Current at DIAG = 1mA			0.7	V
T_W	Thermal Warning			140		°C
T_M	Thermal Muting			150		°C
T_S	Thermal Shut-down			160		°C

(*) DIAG Pulled-up to 5V with 10 kΩ; R_L = 4Ω

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Figure 4. Test and Application Board

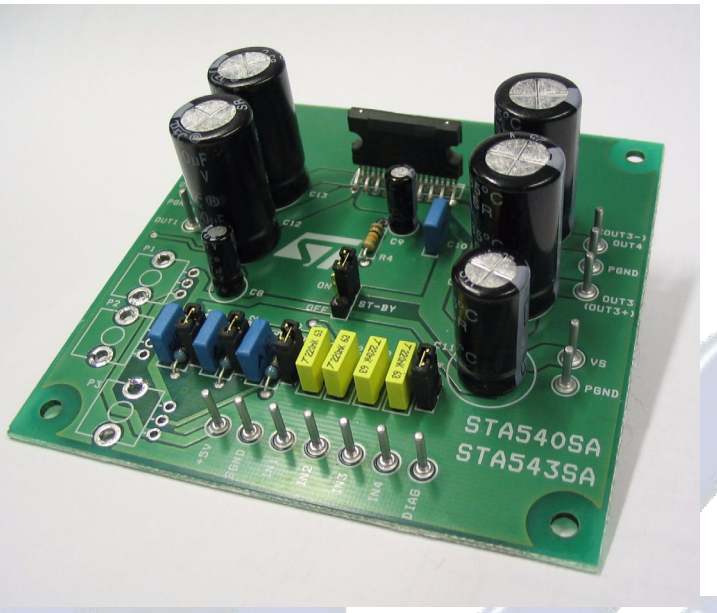
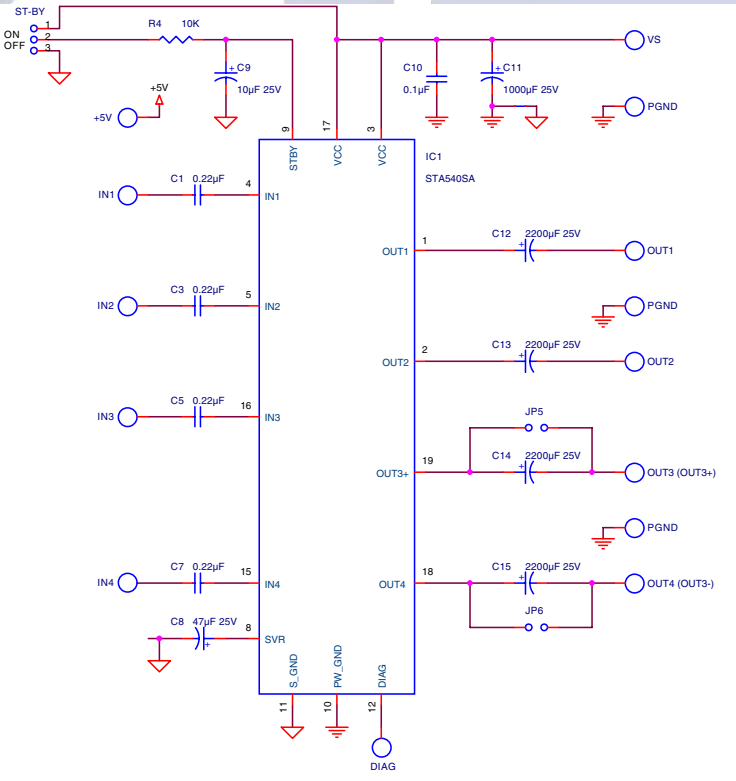


Figure 5. Test Circuit



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4 LAYOUT

Figure 6. Component Layout

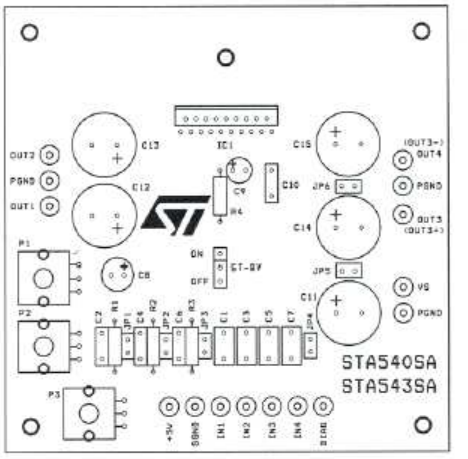


Figure 7. Components Side

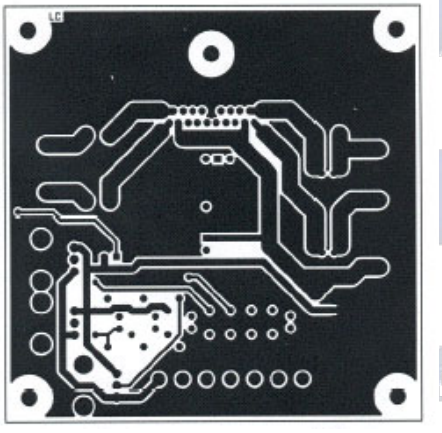
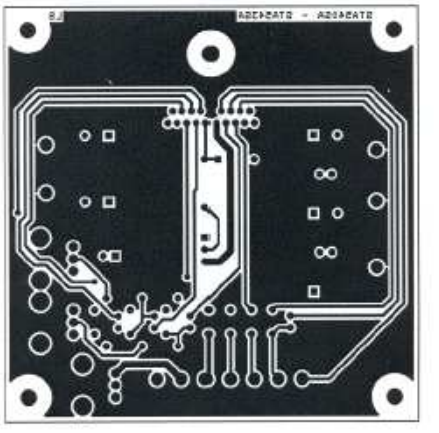


Figure 8. Solder Side



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5 APPLICATION BOARD PART LIST

Table 6.

COMPONENTS	SUGGESTED VALUE	PURPOSE
R4	10KΩ	ST-BY TIME CONSTANT
C1,C3,C5,C7	0.22µF	INPUT DC DECOUPLING
C8	47µF	RIPPLE REJECTION
C9	10µF	ST-BY TIME CONSTANT
C10	0.1µF	SUPPLY VOLTAGE BYPASS
C11	1000µF	SUPPLY VOLTAGE BYPASS
C12,C13,C14,C15	2200µF	OUTPUT DC DECOUPLING

Note: The application board is designed to test also the STA543SA device, so the following components must not be mounted for the STA540SA R1, R2, R3, P1, P2, P3

6 STANDARD APPLICATION CIRCUIT

Figure 9. Quad Stereo

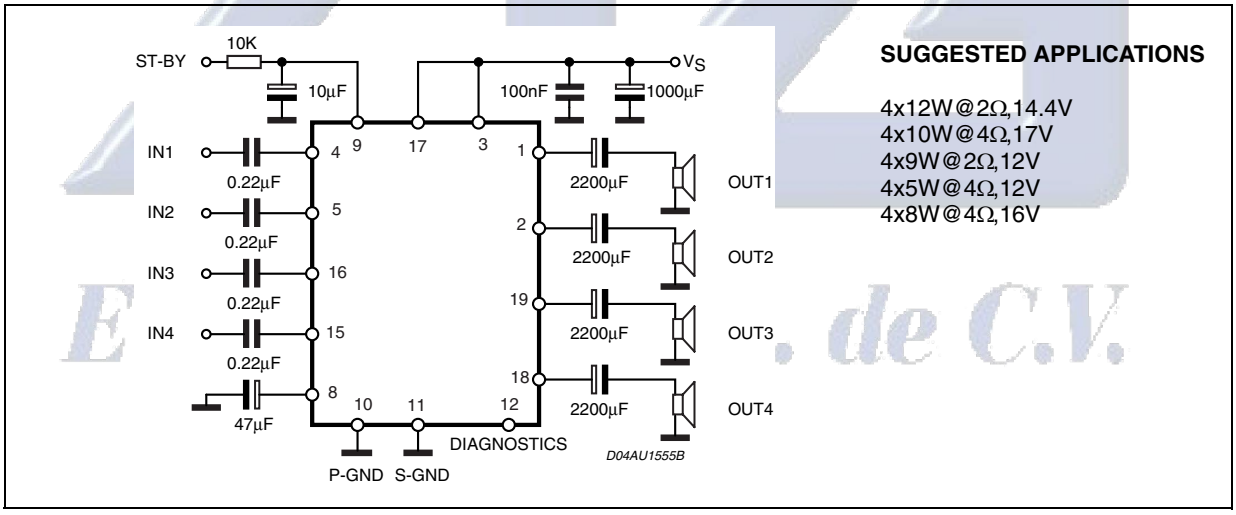
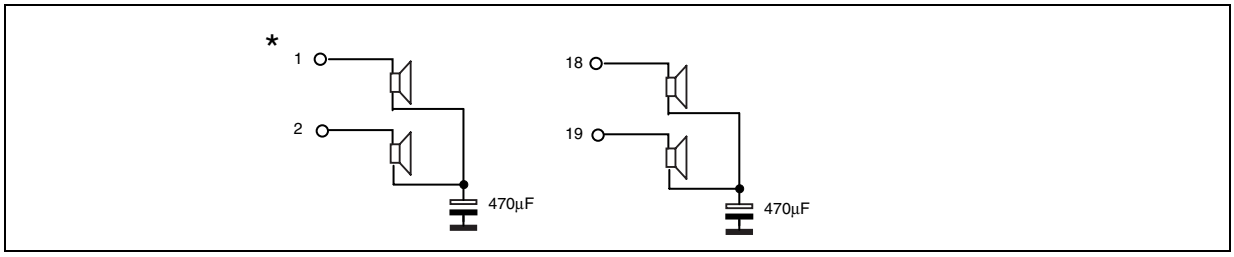


Figure 10.



(*) Note: The best Audio performances are obtained with the configuration where each speaker has its own DC blocking capacitor. If the application allows a little worsening of the spatial image it is possible to connect a couple of speakers with only one low value DC blocking capacitor

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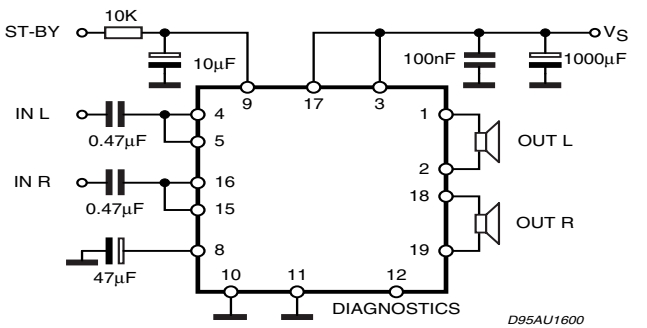
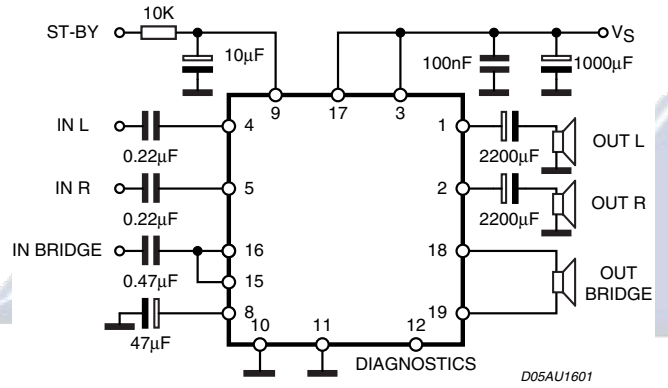
Figure 11. Double Bridge



SUGGESTED APPLICATIONS

2x9W@8Ω,12V
2x18W@4Ω,12V
2x13W@8Ω,14V
2x26W@4Ω,14V
2x15W@8Ω,16V

Figure 12. Stereo Bridge



SUGGESTED APPLICATIONS

2x9W@2Ω, +1x18W(@4Ω) 12V
2x12W@2Ω, +1x26W(@4Ω) 14.4V
2x8W@4Ω, +1x16W(@8Ω) 16V

Figure 13. Quiescent Drain Current vs. Supply Voltage (Single Ended and Bridge).

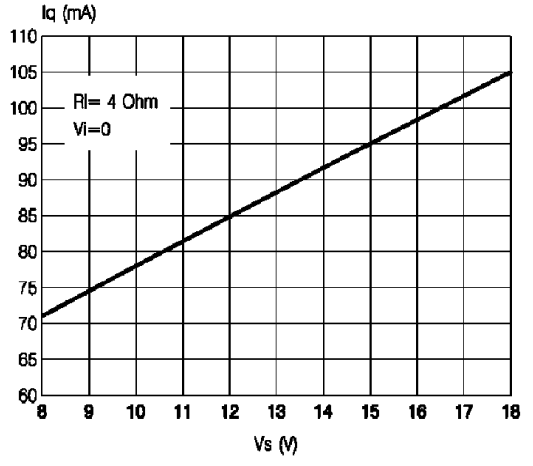


Figure 14. Figure 7: Quiescent Output Voltage vs. Supply Voltage (Single Ended and Bridge).

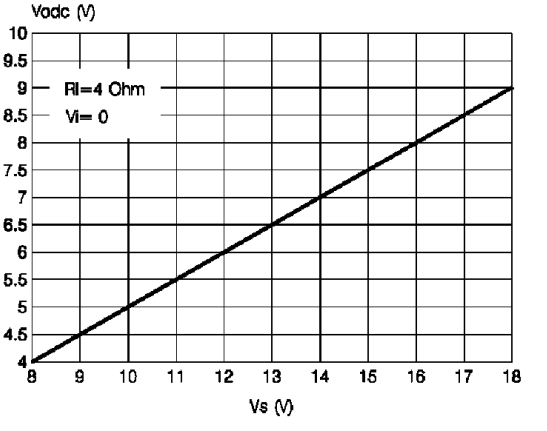


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Figure 15. Output Power vs. Supply Voltage

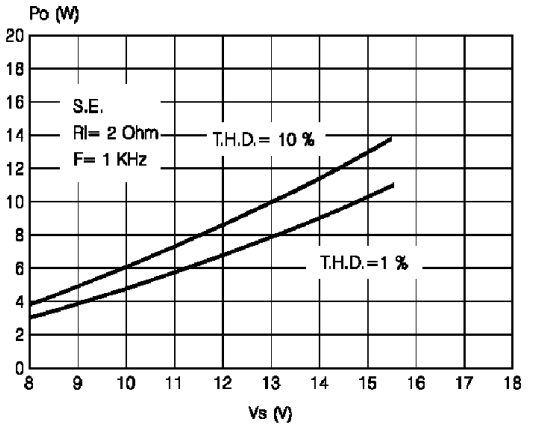

Figure 16. Output Power vs. Supply Voltage

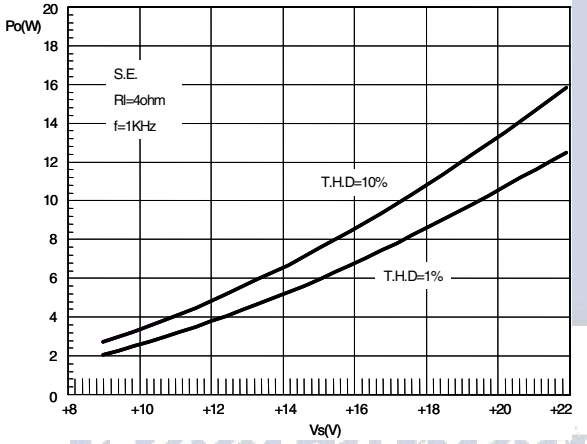

Figure 17. Output Power vs. Supply Voltage

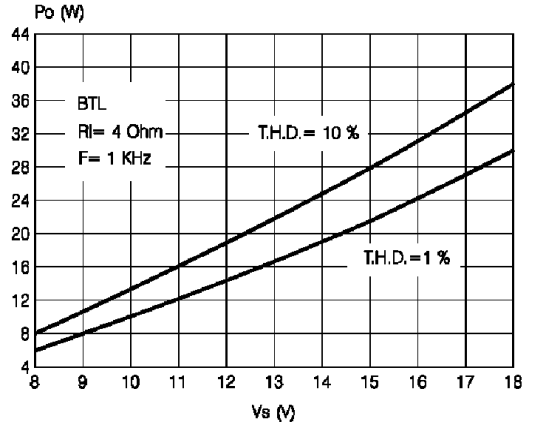

Figure 18. Distortion vs. Output Power

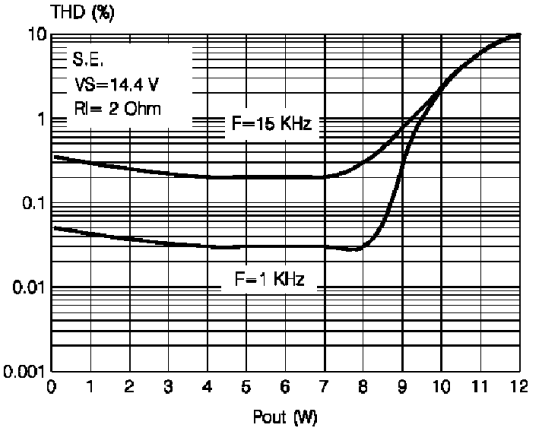

Figure 19. Distortion vs. Output Power

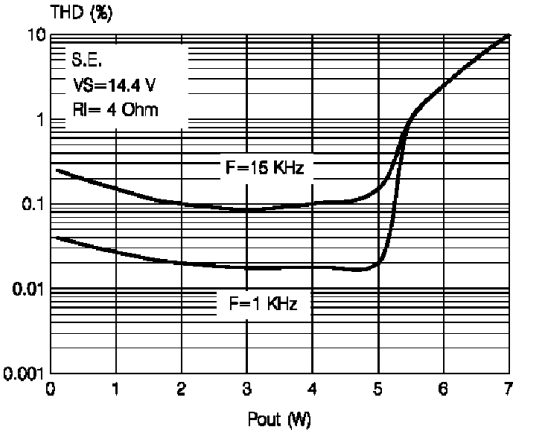

Figure 20. Distortion vs. Output Power

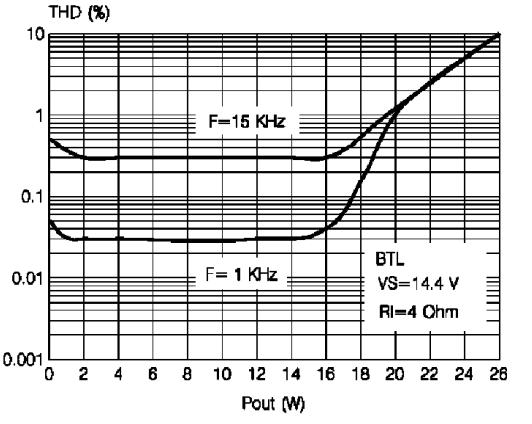

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Figure 21. Output Power vs. Supply Voltage

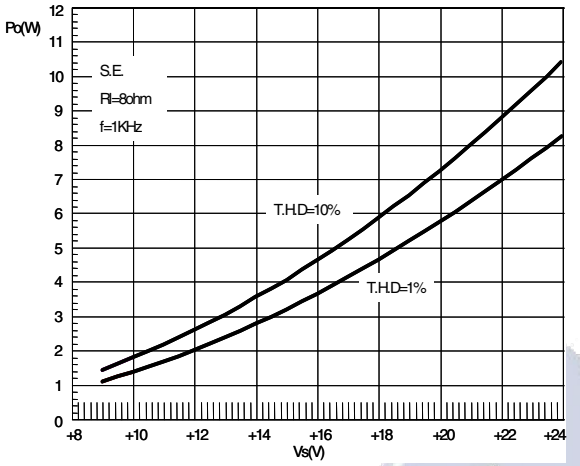

Figure 22. Output Power vs. Supply Voltage

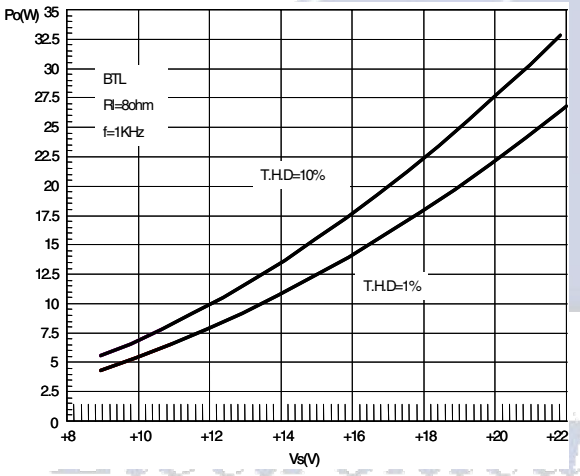

Figure 23. Cross-talk vs. Frequency

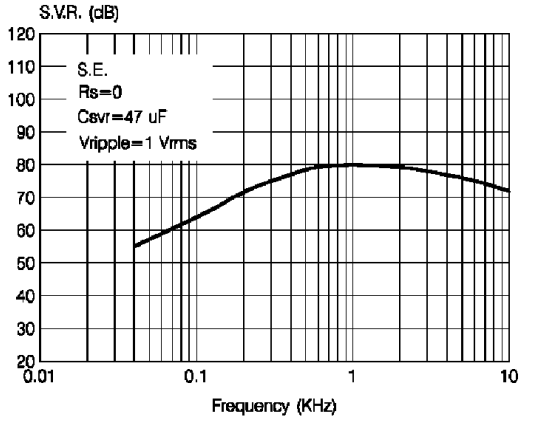

Figure 24. Supply Voltage Rejection vs. Frequency

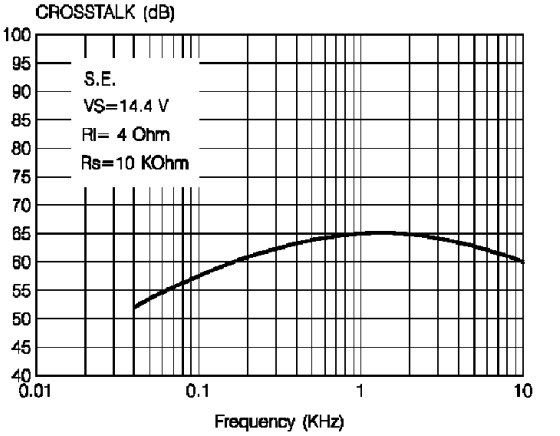

Figure 25. Supply Voltage Rejection vs. Frequency

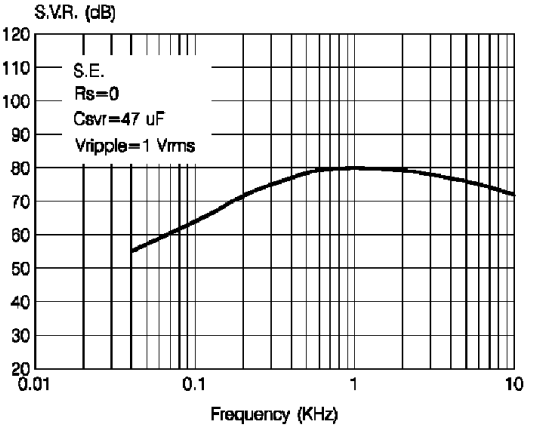

Figure 26. Stand-byAttenuation vs. Threshold Voltage

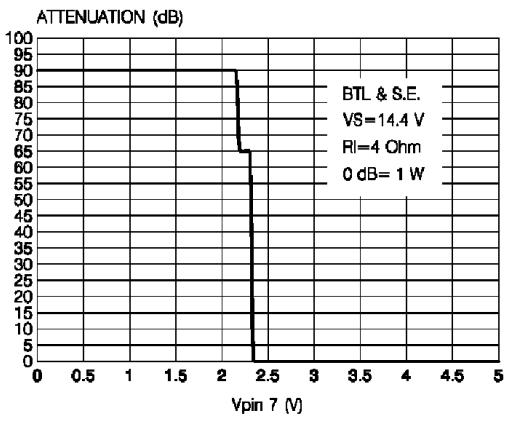

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Figure 27. Total Power Dissipation and Efficiency vs. Output Power

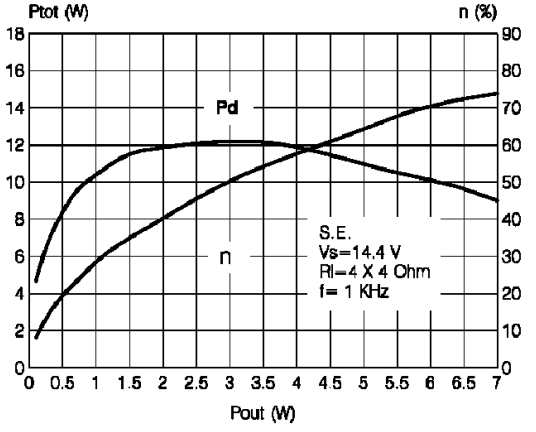
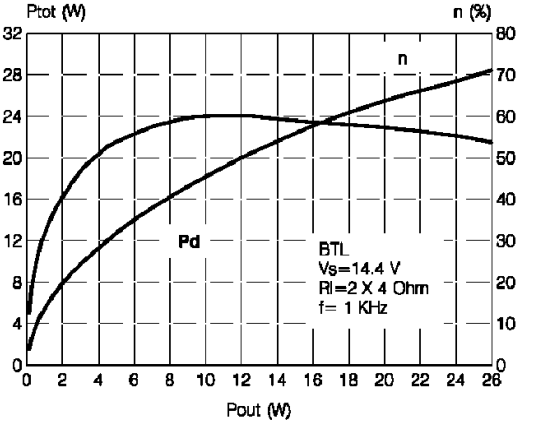


Figure 28. Total Power Dissipation and Efficiency vs. Output Power.



7 THERMAL INFORMATION:

In order to avoid the thermal protection intervention that is placed at T_j =150°C (Thermal Muting) or T_j=160°C (Thermal Shut-down), it is important the Heat Sinker RTH (°C/W) dimensioning.

The parameters that influence the dimensioning are:

- Maximum dissipated power for the device (P_d max)
- Max.Thermal resistance Junction to case ($R_{th\ j\text{-}case}$)
- Max. Ambient temperature Tamb. Max

There is also an additional term that depends on the Iq (quiescent current).

7.1 Example (A): (4 channels Single Ended)

V_{CC} =14.4V , R_{load} = 4Ω x 4 Channels, $R_{th\ j\text{-}case}$ = 2°C/W, Tamb.max = 50°C, P_{out} = 4 x 7W

$$P_{dmax} = NChannel \cdot \frac{V_{CC}^2}{2\Pi^2 R_L} = 4 \cdot 2.62 = 10.5W$$

$$(Heat\ sink)\ R_{thj-amb} = \frac{150 - T_{amb,max}}{P_{dmax}} - R_{th\ j-case} = \frac{150-50}{10.5} - 2 = 7.5°C/W$$

This is the requested R_{th} for the heat sinker.

7.2 Example (B): (2channels Single Ended + 1Ch (BTL)

V_{CC} = 14.4V, R_{load} = 2x 2Ω (SE) + 1x 4Ω (BTL)

P_{out} = 2 x 12W + 1 x 26W

$$P_{dmax} = 2 \cdot \frac{V_{CC}^2}{2\Pi^2 R_L} + \frac{2V_{CC}^2}{\Pi^2 R_L} = 2 \cdot 5.25 + 10.5 = 21W$$

$$(Heat\ sink)\ R_{thj-amb} = \frac{150 - T_{amb,max}}{P_{dmax}} - R_{th\ j-case} = \frac{150-50}{21} - 2 = 2.7°C/W$$

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7.3 NOTE:

The values found gives an heatsinker that is dimensioned to sustain the max. dissipated power, but as explained in the Application Note (AN1965) the heatsinker can be smaller when we consider the real application where a musical program is used.

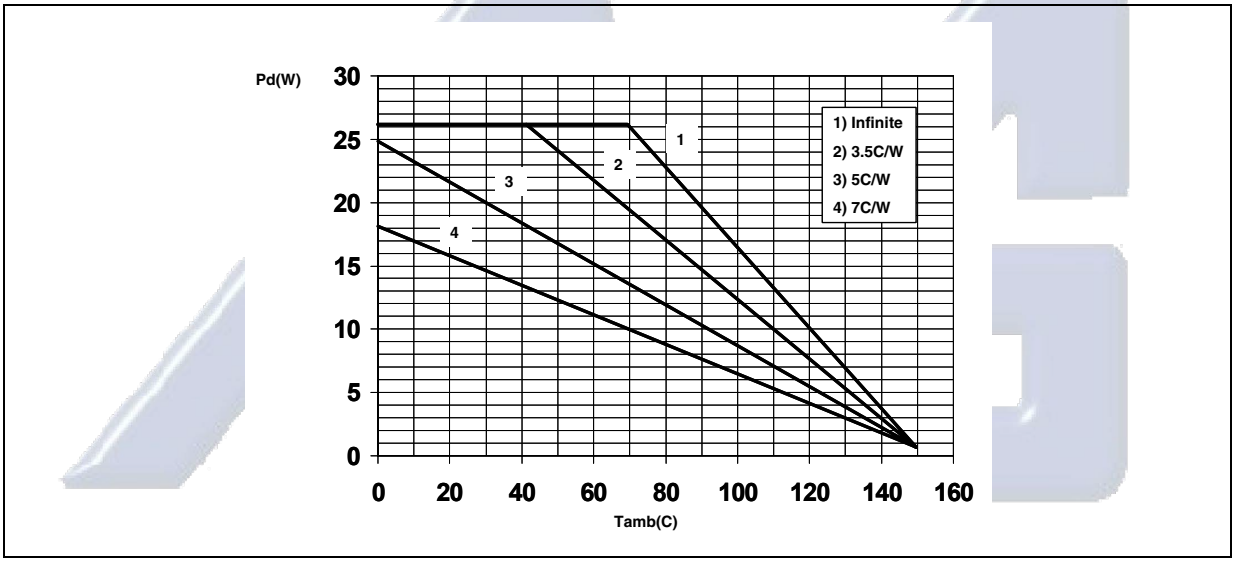
If we consider the so called "Average Listening Dissipated Power" concept we obtain a value that is about 40% less respect the Pdmax (see AN1965 for reference).

So in the examples (A) and (B) we will obtain the value for the Average Listening Dissipated Power that is respectively:

- Example (A) : 10.5 W- 40% = 6.3W that gives $R_{th\ j\text{-}amb}$ = 13.8 °C/W
- Example (B) : 21 W - 40% = 12.6W that gives $R_{th\ j\text{-}case}$ = 5.9 °C/W

In figure 26 is shown the Power Derating curve for the device

Figure 29. Power Derating Curve



8 GENERAL STRUCTURE

8.1 High Application Flexibility

The availability of 4 independent channels makes it possible to accomplish several kinds of applications ranging from 4 speakers stereo (F/R) to 2 speakers bridge solutions.

In case of working in single ended conditions the polarity of the speakers driven by the inverting amplifier must be reversed respect to those driven by non inverting channels. This is to avoid phase inconveniences causing sound alterations especially during the reproduction of low frequencies.

8.2 Easy Single Ended to Bridge Transition

The change from single ended to bridge configurations is made simply by means of a short circuit across the inputs, that is no need of further external components.

8.3 Gain Internally Fixed to 20dB in Single Ended, 26dB in Bridge

Advantages of this design choice are in terms of:

- componentsand space saving
- output noise, supply voltage rejection and distortion optimization.

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8.4 Silent Turn On/Off and Muting/Stand-by Function

The stand-by can be easily activated by means of a CMOS level applied to pin 9 through a RC filter.

Under stand-by condition the device is turned off completely (supply current = 1mA typ.; output attenuation= 80dB min.).

Every ON/OFF operation is virtually pop free. Furthemore, at turn-on the device stays in muting condition for a time determined by the value assigned to the SVR capacitor. While in muting the device outputs becomes insensitive to any kinds of signal that may be present at the input terminals. In other words every transient coming from previous stages produces no unplesantacoustic effect to the speakers.

8.5 STAND-BY DRIVING (pin9)

Some precautions have to be taken in the definition of stand-by driving networks: pin 9 cannot be directly drive by a voltage source whose curent capability is higher than 5mA. In pratical cases a series resistance has always to be inserted, having it the double purpose of limiting the current at pin 9 and to smooth down the stand-by ON/OFF transitions - in combination with a capacitor - for output pop prevention.

In any case, a capacitor of at lest 100nF from pin 9 to S-GND, with no resistance in between, is necessary to ensure correct turn-on.

8.6 Output Stage

The fully complementary output stage was made possible by the development of a new component:

the ST exclusive power ICV PNP.

A novel design based upon the connection shown in fig. 30 has then allowed the full exploitation of its possibilities.

The clear advantages this new approach has over classical output stages are as follows:

8.6.1 Rail-to-Rail Output Voltage Swing With No Need of Bootstrap Capacitors.

The output swing is limited only by the V_{CEsat} of the output transistors, which are in the range of 0.3Ω (R_{sat}) each.

Classical solutions adopting composite PNP-NPN for the upper output stage have higher saturation loss on the top side of the waveform.

This unbalanced saturation causes a significant power reduction. The only way to recover power consists of the addition of expensive bootstrap capacitors.

8.6.2 Absolute Stability Without Any External Compensation.

Referring to the circuit of fig. 30 the gain V_{out}/V_{in} is greater than unity, approximately 1+R2/R1. The DC output (VCC/2) is fixed by an auxiliary amplifier common to all the channels.

By controlling the amount of this local feedback it is possible to force the loop gain ($A^*\beta$) to less than unity at frequency for which the phase shift is 180°. This means that the output buffer is intrinsically stable and not prone to oscillation.

Most remarkably, the above feature has been achieved in spite of the very low closed loop gain of the amplifier.

In contrast, with the classical PNP-NPN stage, the solution adopted for reducing the gain at high frequencies makes use of external RC networks, namely the Boucherot cells.

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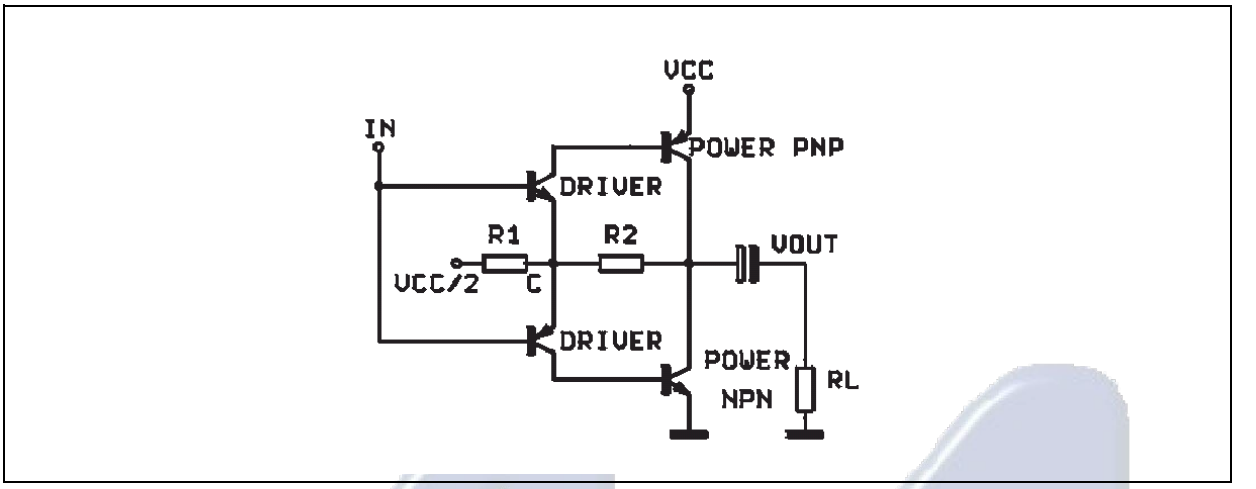
Figure 30. The New Output Stage



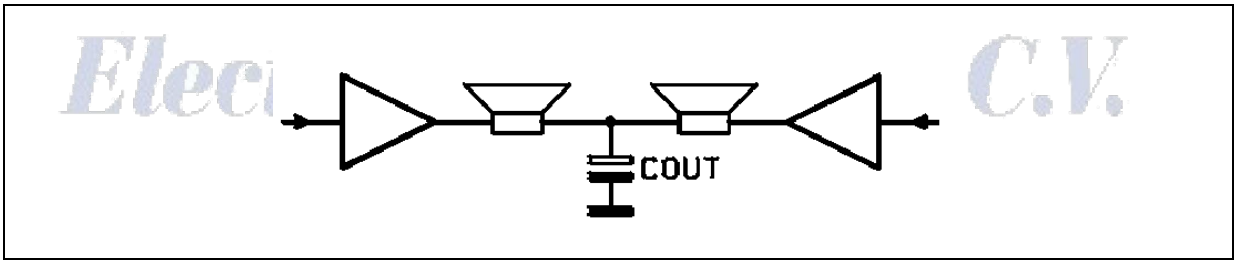
8.7 BUILT–IN SHORTCIRCUIT PROTECTION

Reliable and safe operation, in presence of all kinds of short circuit involving the outputs is assured by BUILT-IN protectors. Additionally to the AC/DC short circuit to GND, to VS, across the speaker, a SOFT SHORT condition is signalled out during the TURN-ON PHASE so assuring correct operation for the device it self and for the loudspeaker.

This particular kind of protection acts in such a way to avoid the device is turned on (by ST-BY) when a resistive path (less than 16 ohms) is present between the output and GND. As the involved circuitry is normally disabled when a current higher than 5mA is flowing into the ST-BY pin, it is important, in order not to disable it, to have the external current source driving the STBY pin limited to 5mA.

This extrafunction becomes particularly attractive when, in the single ended configuration, one capacitor is shared between two outputs (see fig. 31).

Figure 31.



Supposing that the output capacitor Cout for any reason is shorted, the loudspeaker will not be damaged being this soft short circuit condition revealed.

8.7.1 Diagnostic Facilities (Pin 12)

The STA540SA is equipped with a diagnostic circuitry able to detect the following events:

- Clipping in the output signal
- Thermal shutdown
- Output fault:
  - short to GND
  - short to VS
  - soft short at turn on

The information is available across an open collector output (pin 12) through a current sinking when the event is detected

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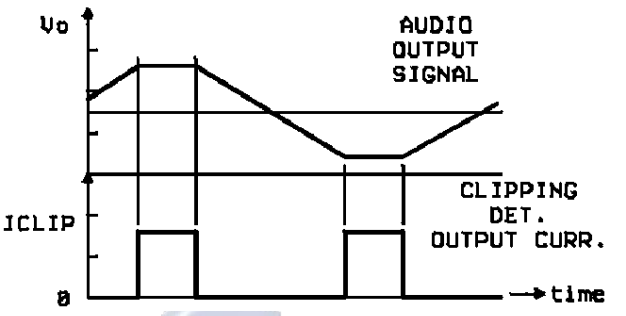
Figure 32. Clipping Detection Waveforms



A current sinking at pin 12 is provided when a certain distortion level is reached at each output. This function allows gain compression facility whenever the amplifier is overdriven.

8.7.2 Thermal Shutdown

In this case the output 12 will signal the proximity of the junction temperature to the shutdown threshold. Typically current sinking at pin 12 will start ~10°C before the shutdown threshold is reached.

Figure 33. Output Fault Waveforms (see fig. 31)

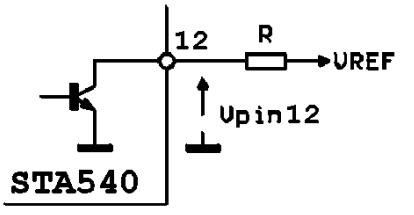
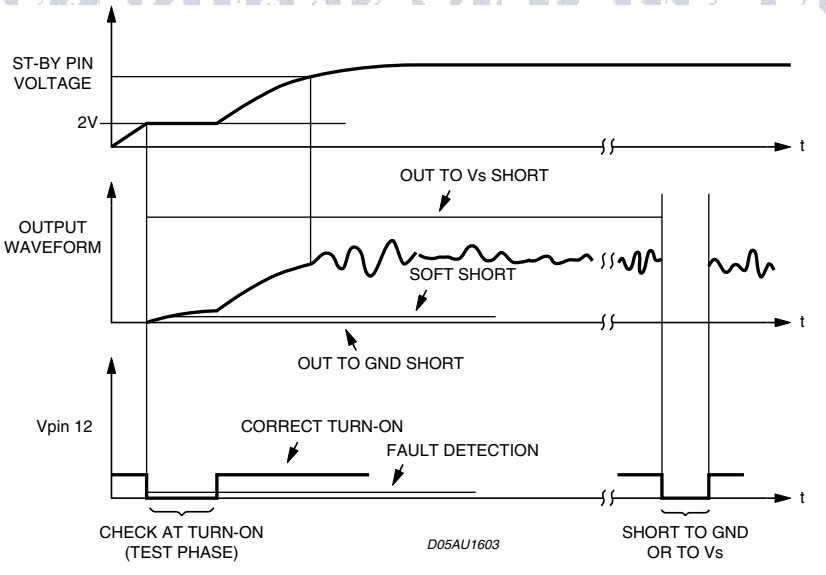


Figure 34. Fault Waveforms



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8.8 HANDLING OF THE DIAGNOSTIC INFORMATION

As different kinds of information is available at the same pin (clipping detection, output fault, thermal proximity), this signal must be handled properly in order to discriminate the event.

This could be done taking into account the different timing of the diagnostic output during each case.

Normally the clip detector signalling produces a

low level at out 12 that present under faulty conditions: based on this assumption an interface circuitry to differentiate the information is the represented in the schematic of fig. 36.

Figure 35. Waveforms

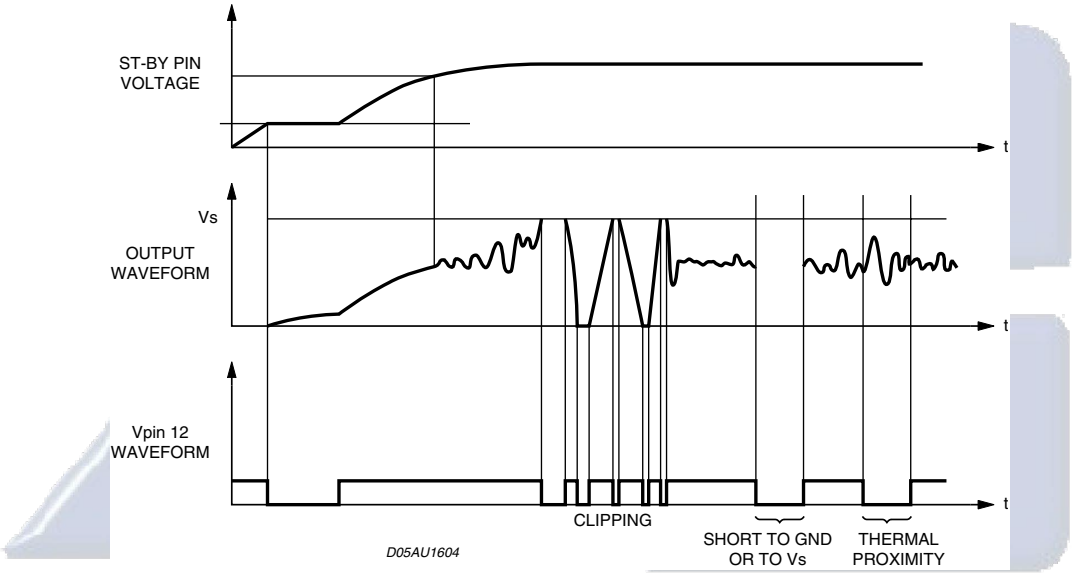
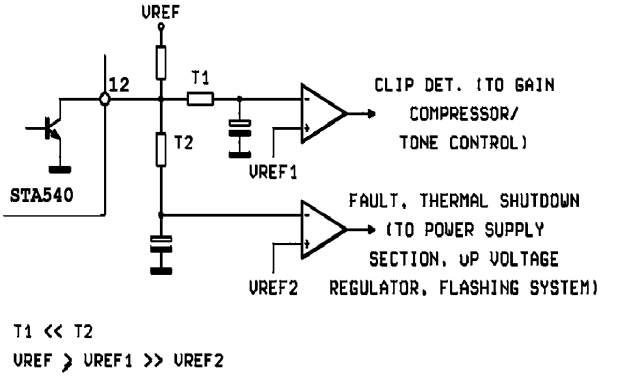


Figure 36.



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8.9 PCB-LAYOUT GROUNDING (general rules)

The device has 2 distinct ground leads, P-GND (POWER GROUND) and S-GND (SIGNAL GROUND) which are practically disconnected from each other at chip level. Proper operation requires that P-GND and S-GND leads be connected together on the PCB-layout by means of reasonably low-resistance tracks.

As for the PCB-ground configuration, a star-like arrangement whose center is represented by the supply-filtering electrolytic capacitor ground is highly advisable. In such context, at least 2 separate paths have to be provided, one for P-GND and one for S-GND.

The correct ground assignments are as follows:

STANDBY CAPACITOR, pin 9 (or any other standby driving networks): on S-GND

SVR CAPACITOR (pin 8): on S-GND and to be placed as close as possible to the device.

INPUT SIGNAL GROUND (from active/passive signal processor stages): on S-GND.

SUPPLY FILTERING CAPACITORS (pins 3,17): on P-GND. The (-) terminal of the electrolytic capacitor has to be directly tied to the battery (-) line and this should represent the starting point for all the ground paths.

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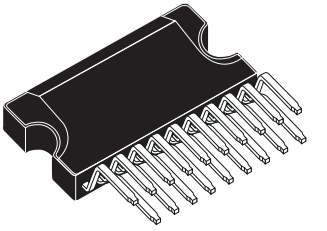
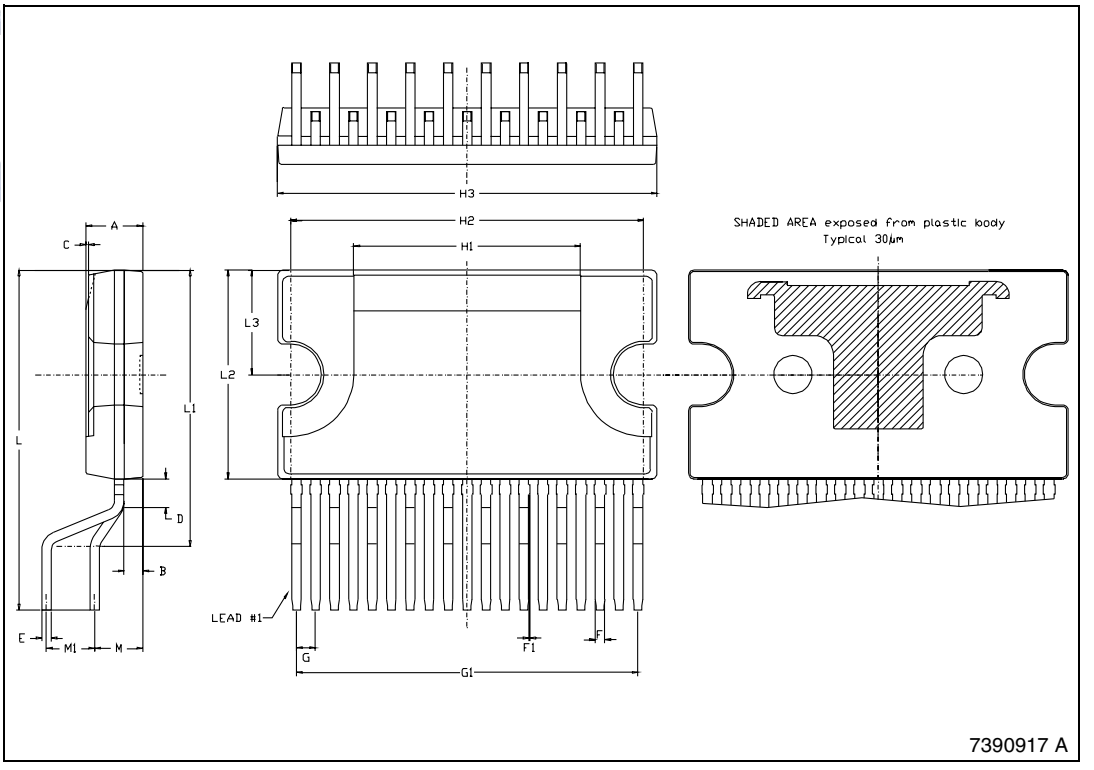
Figure 37. Clipwatt 19 Mechanical Data & Package Dimensions

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.2			0.126
B			1.05			0.041
C		0.15			0.006	
D		1.50			0.061	
E	0.49		0.55	0.019		0.022
F	0.47	0.50	0.58	0.018		0.020
F1			0.1			0.004
G	0.87	1.00	1.13	0.034	0.039	0.044
G1	17.87	18.0	18.13	0.703	0.708	0.713
H1		12.0			0.480	
H2		18.6			0.732	
H3	19.85			0.781		
L		17.9			0.704	
L1		14.55			0.572	
L2	10.7	11.0	11.2	0.421	0.433	0.441
L3		5.50			0.217	
M		2.54			0.100	
M1		2.54			0.100	

OUTLINE AND MECHANICAL DATA



Clipwatt19



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9 REVISION HISTORY

Table 7.

Date	Revision	Description of Changes
April 2005	1	First Issue

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