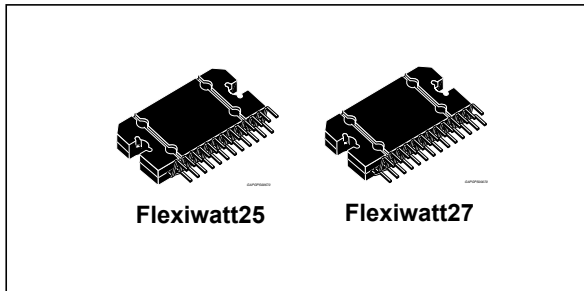


## 4 x 52 W quad bridge power amplifier with low voltage operation

Datasheet - production data



### Features

- High output power capability:
  - 4 x 52 W/4  $\Omega$  max.
  - 4 x 30 W/4  $\Omega$  @ 14.4 V, 1 kHz, 10 %
  - 4 x 85 W/2  $\Omega$  max.
  - 4 x 55 W/2  $\Omega$  @ 14.4V, 1 kHz, 10 %
- MOSFET output power stage
- Stop-start and hybrid engines compliant
- Excellent 2  $\Omega$  driving capability
- Hi-Fi class distortion
- Low output noise
- Standby function and mute function
- Automute at min. supply voltage detection
- Low external component count:
  - Internally fixed gain (26 dB)

- No external compensation
- No bootstrap capacitors
- Protections:
  - Output short circuit to GND, to  $V_S$ , across the load
  - Very inductive loads
  - Overrating chip temperature with soft thermal limiter
  - Output DC offset detection
  - Load dump voltage
  - Fortuitous open GND
  - Reverse battery
  - ESD

### Description

The STPA002 is a MOSFET class AB audio power amplifier, designed for high-power car radio. In addition to the outstanding output current capability and distortion performance, the STPA002 is extremely robust against several kinds of fortuitous misconnections.

It is compliant to the most recent OEM specifications for low voltage operation in start-stop vehicles, and can sustain hybrid vehicles battery transitions.

It includes a DC offset detector and, in Flexiwatt27 package, a clipping detector.

**Table 1. Device summary**

Order code	Package	Packing
STPA002OD-4WX	Flexiwatt25 (with OD)	Tube
STPA002CD-48X	Flexiwatt27 (with CD)	Tube

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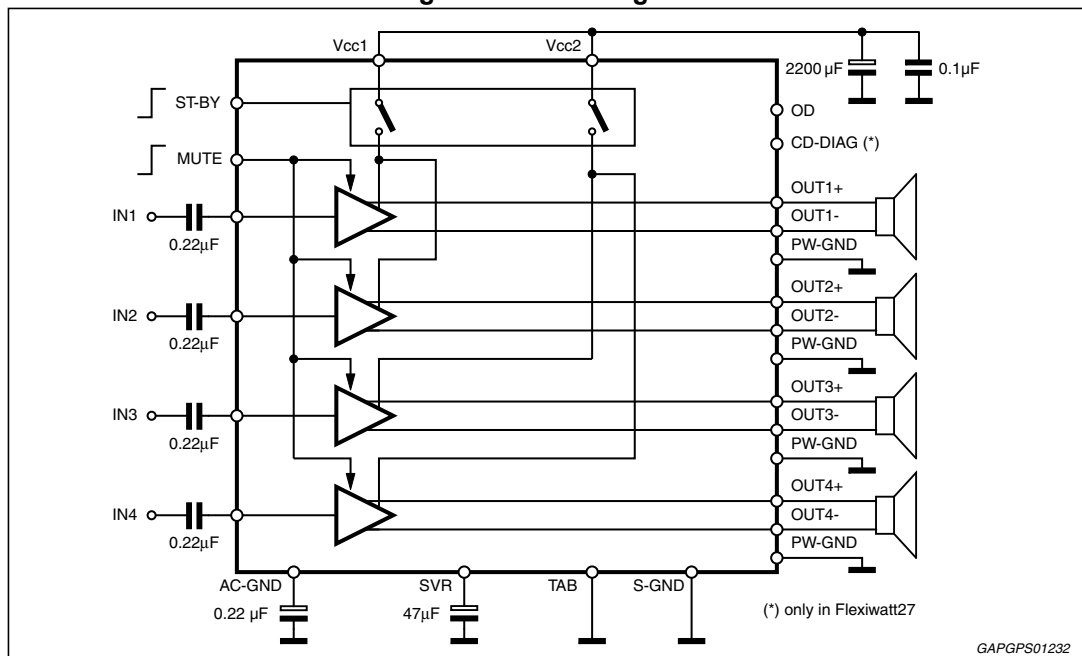
# 1 Overview

The STPA002 is a complementary quad audio power amplifier. It is available in two different packages, Flexiwatt25 and Flexiwatt27. It embeds four independent amplifiers working in class AB, a standby, a mute pin and an offset detector output. In the Flexiwatt27 package also a clipping detection pin with diagnostics information is available. The amplifier is fully operational down to a battery voltage of 6 V, without producing pop noise and continuing to play during battery transitions.

The STPA002 can drive 2 ohm loads and has a very high immunity to disturbs without need of external components or compensation. It is protected against any kind of short or open circuit, over-voltage and over-temperature.

## 1.1 Block diagram

Figure 1. Block diagram



## 1.2 Application circuits

Figure 2. Standard test and application circuit (Flexiwatt25)

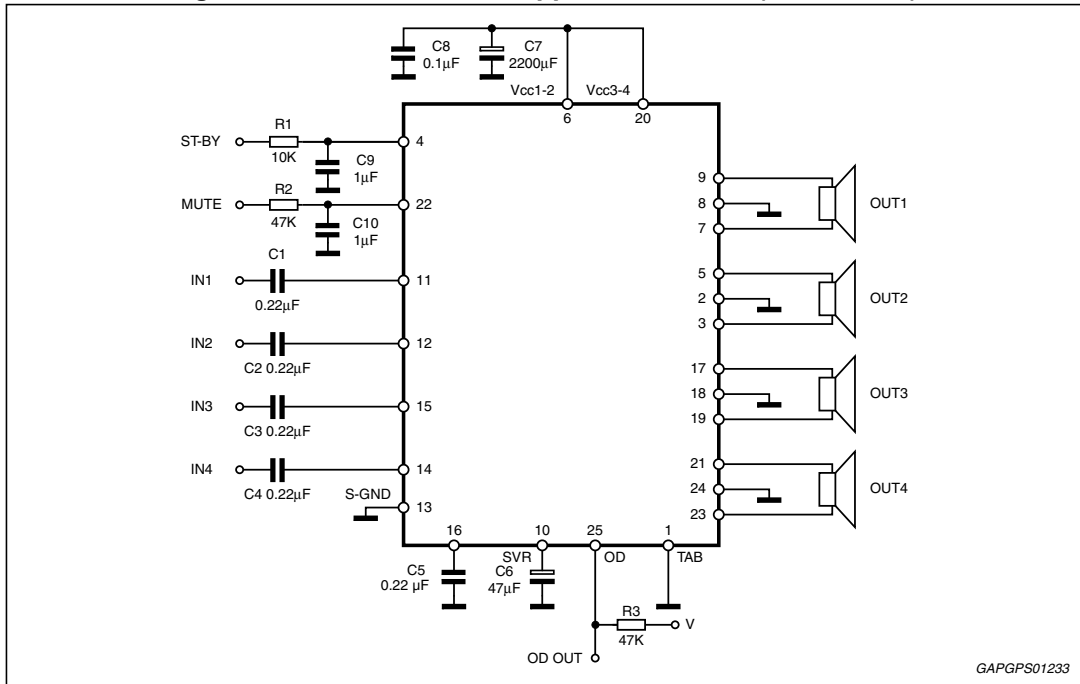
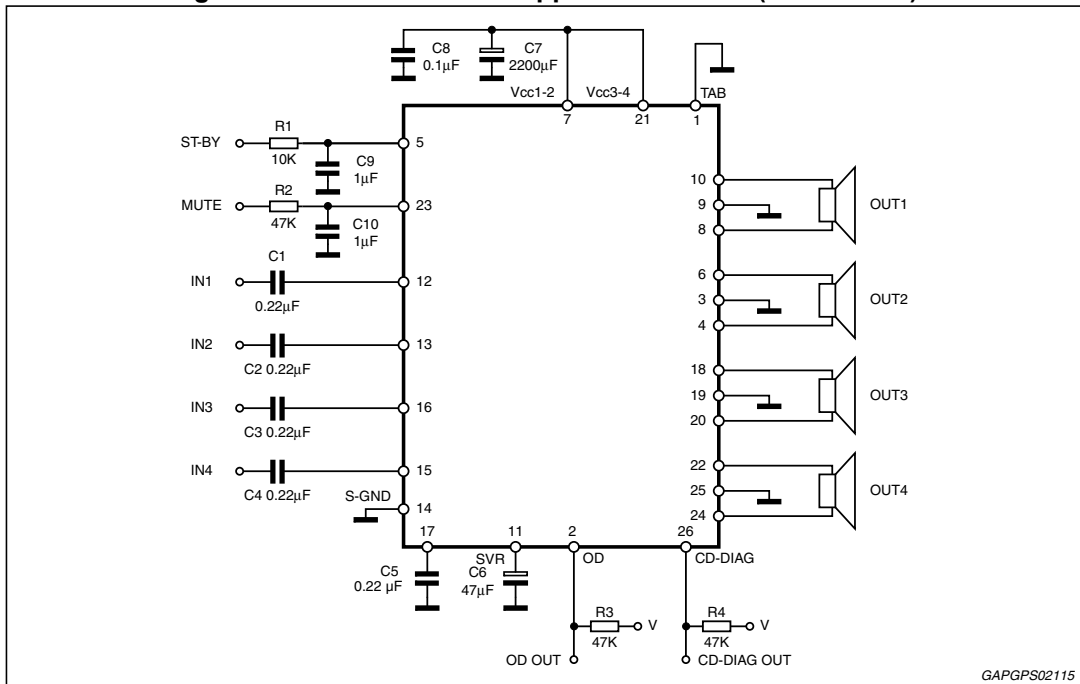


Figure 3. Standard test and application circuit (Flexiwatt27)



## 2 Pin description

Figure 4. Pin connections (top view)

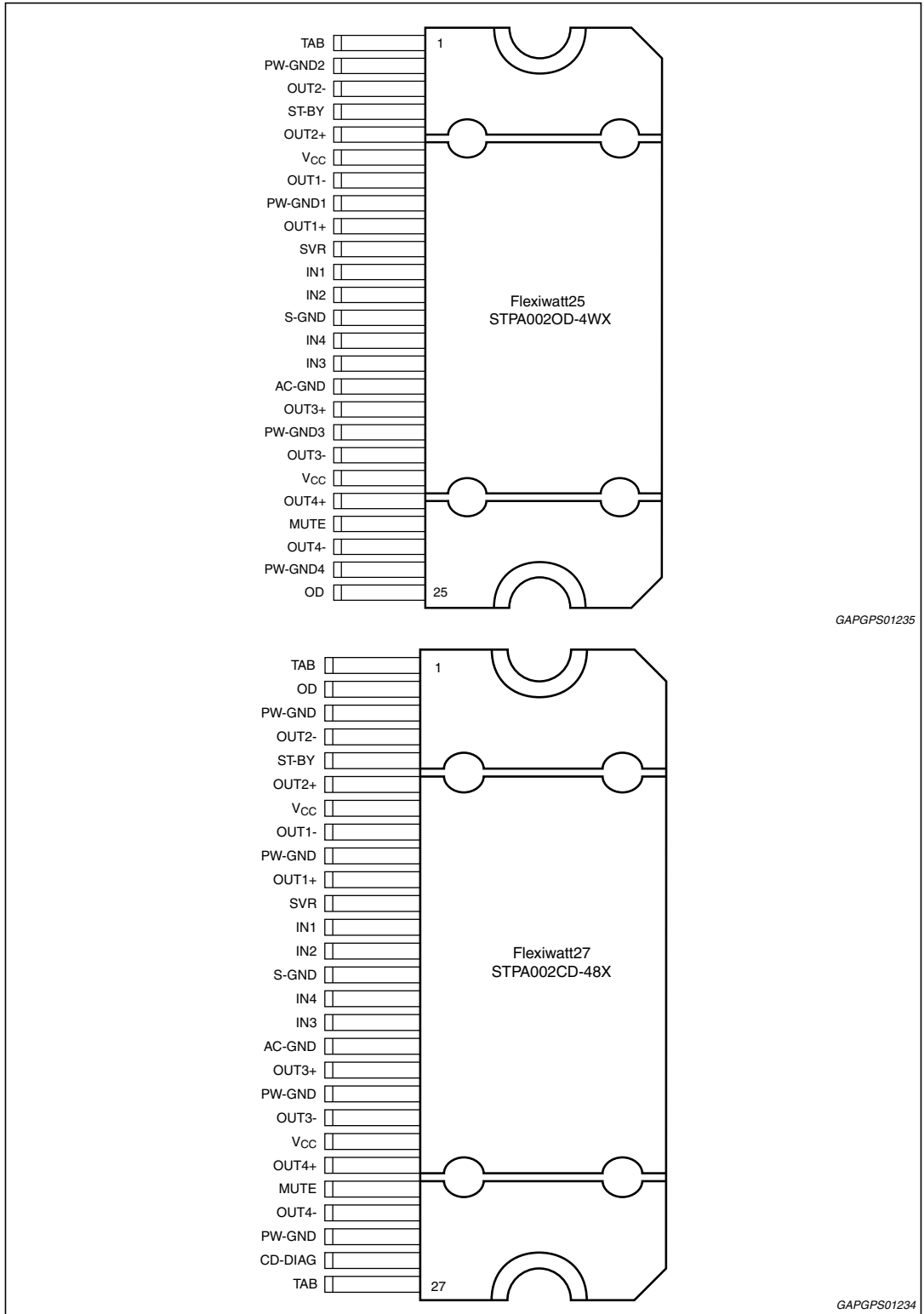


Table 2. Pin functions

Pin number FW27	Pin number FW25	Pin name	Description
1	1	TAB	Device slug connection
2	25	OD	Offset detector output
3	2	PW-GND2	Channel 2, output power ground
4	3	OUT2-	Channel 2, negative output
5	4	ST-BY	Stand-by
6	5	OUT2+	Channel 2, positive output
7	6	VCC	Supply voltage
8	7	OUT1-	Channel 1, negative output
9	8	PW-GND1	Channel 1, output power ground
10	9	OUT1+	Channel 1, positive output
11	10	SVR	Supply voltage rejection pin
12	11	IN1	Channel 1, input
13	12	IN2	Channel 2, input
14	13	S-GND	Signal ground
15	14	IN4	Channel 4, input
16	15	IN3	Channel 3, input
17	16	AC-GND	AC ground
18	17	OUT3+	Channel 3, positive output
19	18	PW-GND3	Channel 3, output power ground
20	19	OUT3-	Channel 3, negative output
21	20	VCC	Supply voltage
22	21	OUT4+	Channel 4, positive output
23	22	MUTE	Mute pin
24	23	OUT4-	Channel 4, negative output
25	24	PW-GND4	Channel 4, output power ground
26	n.a	CD-DIAG	Clipping detector and diagnostics output
27	n.a	TAB	Device slug connection



### 3 Electrical specifications

#### 3.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_S$	Operating supply voltage	18	V
$V_{S(DC)}$	DC supply voltage	28	V
$V_{S(pk)}$	Peak supply voltage (for $t = 50$ ms)	50	V
$I_O$	Output peak current Non repetitive ( $t = 100$ $\mu$ s)	10	A
	Repetitive (duty cycle 10 % at $f = 10$ Hz)	9	A
$T_j$	Junction temperature	150	$^{\circ}$ C
$T_{stg}$	Storage temperature	-55 to 150	$^{\circ}$ C
$GND_{max}$	Ground pin voltage	-0.3 to 0.3	V
$V_{in max}$	Input pin max voltage	-0.3 to 8	V
$V_{SB max}$	ST-BY pin max voltage	-0.3 to $V_{S(pk)}$	V
$V_{mute max}$	Mute pin max voltage	-0.3 to 6	V

#### 3.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Value	Unit
$R_{th j-case}$	Thermal resistance junction-to-case Max.	1	$^{\circ}$ C/W

#### 3.3 Electrical characteristics

Refer to the test and application diagram,  $V_S = 14.4$  V;  $R_L = 4$   $\Omega$ ;  $R_g = 600$   $\Omega$ ;  $f = 1$  kHz;  $T_{amb} = 25$   $^{\circ}$ C; unless otherwise specified.

Table 5. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>General characteristics</b>						
$V_S$	Supply voltage range	-	6	-	18	V
$I_{q1}$	Quiescent current	$R_L = \infty$	100	200	300	mA
$V_{OS}$	Output offset voltage	Mute mode	-75	-	+75	mV

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
dV <sub>OS</sub>	During mute ON/OFF output offset voltage	ITU R-ARM weighted	-7.5	-	+7.5	mV
	During standby ON/OFF output offset voltage		-15	-	+15	mV
R <sub>i</sub>	Input impedance	-	45	55	65	kΩ
I <sub>SB</sub>	Standby current consumption	V <sub>St-by</sub> = 1.2 V	-	-	2	μA
		V <sub>St-by</sub> = 0	-	-	1	μA
<b>Audio performances</b>						
P <sub>O</sub>	Output power	V <sub>S</sub> = 14.4 V; THD = 10 %	27	30	-	W
		V <sub>S</sub> = 14.4 V; THD = 1 %	21	24	-	W
		V <sub>S</sub> = 14.4 V; THD = 10 %, 2 Ω	49	55	-	W
		V <sub>S</sub> = 14.4 V; THD = 1 %, 2 Ω	39	43	-	W
P <sub>O max.</sub>	Max. output power <sup>(1)</sup>	V <sub>S</sub> = 15.2 V; R <sub>L</sub> = 4 Ω	-	52	-	W
THD	Distortion	P <sub>O</sub> = 4 W	-	0.01	0.04	%
G <sub>V</sub>	Voltage gain	-	25	26	27	dB
dG <sub>V</sub>	Channel gain unbalance	-	-1	-	+1	dB
e <sub>No</sub>	Output Noise	"A" Weighted	-	40	-	μV
		Bw = 20 Hz to 20 kHz	-	50	70	μV
SVR	Supply voltage rejection	f = 100 Hz; V <sub>r</sub> = 1 V <sub>rms</sub>	60	70	-	dB
f <sub>ch</sub>	High cut-off frequency	P <sub>O</sub> = 0.5 W	100	300	-	kHz
C <sub>T</sub>	Cross talk	f = 1 kHz P <sub>O</sub> = 4 W	65	75	-	dB
		f = 10 kHz P <sub>O</sub> = 4 W	45	60	-	dB
A <sub>M</sub>	Mute attenuation	P <sub>Oref</sub> = 4 W	85	95	-	dB
<b>Control pin characteristics</b>						
I <sub>pin5</sub>	Standby pin current	V <sub>St-by</sub> = 1.2 V to 2.6 V	-	-	0.5	μA
V <sub>SB out</sub>	Standby out threshold voltage	(Amp: ON)	2.6	-	-	V
V <sub>SB in</sub>	Standby in threshold voltage	(Amp: OFF)	-	-	1.2	V
V <sub>M out</sub>	Mute out threshold voltage	(Amp: Play)	2.6	-	-	V
V <sub>M in</sub>	Mute in threshold voltage	(Amp: Mute)	-	-	1.2	V
V <sub>AM in</sub>	V <sub>S</sub> automute threshold	(Amp: Mute) Att ≥ 80 dB; P <sub>Oref</sub> = 4 W	4.5	5	5.5	V
		(Amp: Play) Att < 0.1 dB; P <sub>O</sub> = 0.5 W	-	-	6	V
I <sub>pin23</sub>	Muting pin current	V <sub>MUTE</sub> = 1.2 V (Sourced current)	6	8.5	11	μA

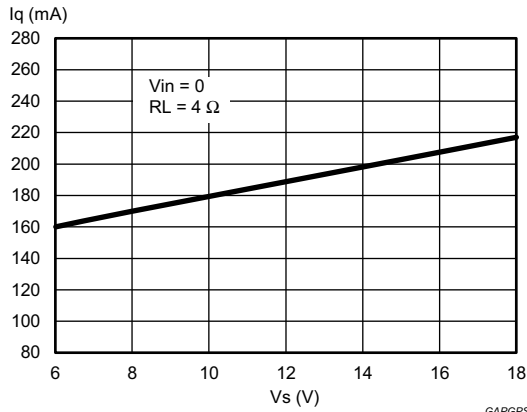
Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Offset detector</b>						
$V_{OFF}$	Detected differential output offset	-	$\pm 1$	$\pm 2$	$\pm 3$	V
$V_{OFF\_SAT}$	Off detector saturation voltage	$V_o > \pm 3$ V, $I_{off\ Det} = 1$ mA	-	0.2	0.4	V
$V_{OFF\_LK}$	Off detector leakage current	$V_o < \pm 1$ V	-	0	15	$\mu$ A
<b>Clipping detector <sup>(2)</sup></b>						
$CD_{LK}$	Clip detector high leakage current	Cd off	-	0	1	$\mu$ A
$CD_{SAT}$	Clip detector saturation voltage	DC On; $I_{CD} = 1$ mA	-	0.2	0.4	V
$CD_{THD}$	Clip detector THD level	-	-	1	-	%

1. Saturated square wave output
2. Clipping detection is guaranteed till a minimum supply voltage of 7 V.

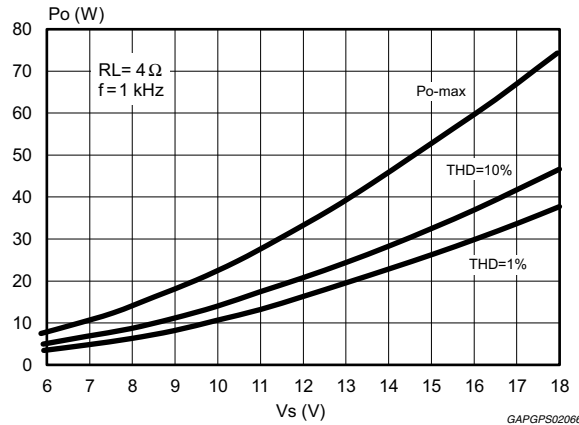
## 4 Electrical characteristics typical curves

Figure 5. Quiescent current vs. supply voltage



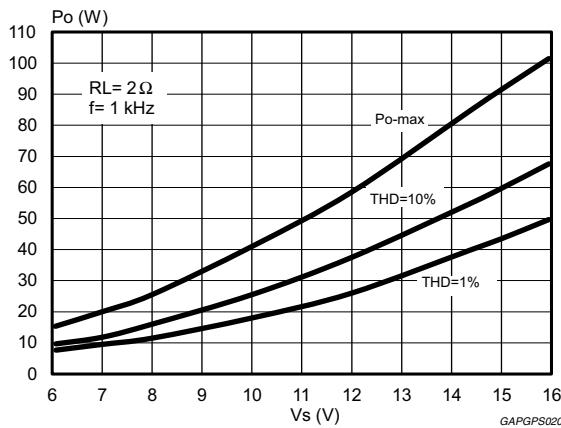
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Figure 6. Output power vs. supply voltage (4  $\Omega$ )



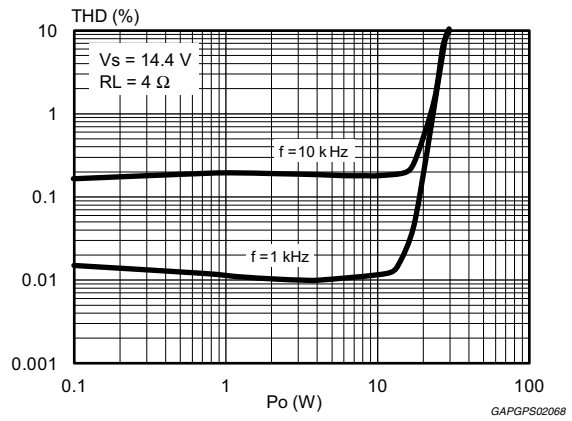
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Figure 7. Output power vs. supply voltage (2  $\Omega$ )



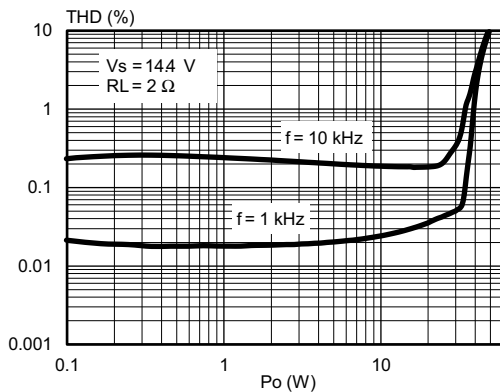
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Figure 8. Distortion vs. output power (4  $\Omega$ )



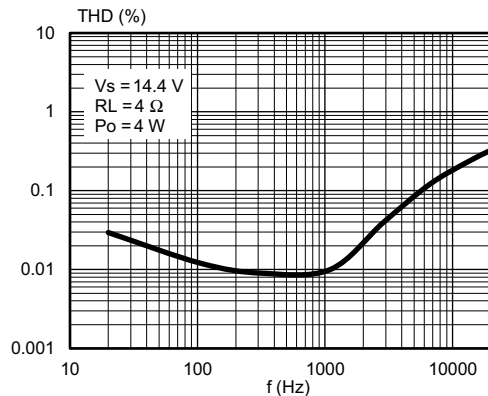
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Figure 9. Distortion vs. output power (2  $\Omega$ )



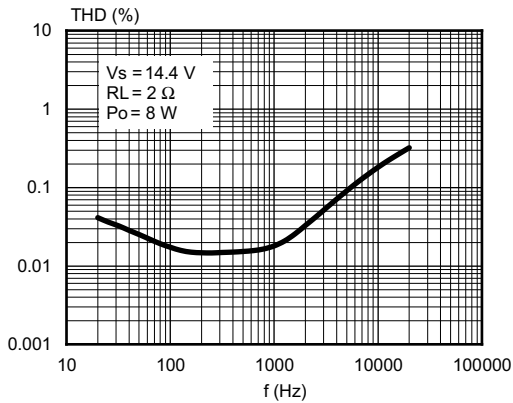
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Figure 10. Distortion vs. frequency (4  $\Omega$ )



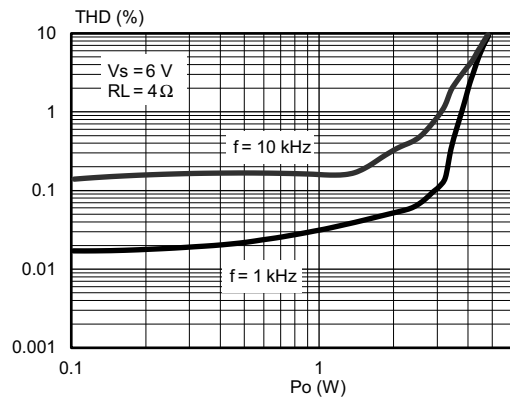
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Figure 11. Distortion vs. frequency (2 Ω)



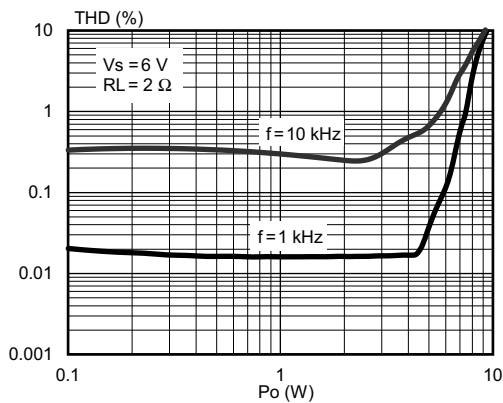
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Figure 12. Distortion vs. output power (4 Ω, Vs = 6 V)



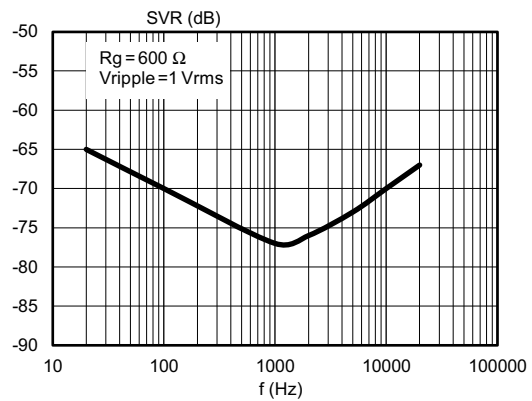
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Figure 13. Distortion vs. output power (2 Ω, Vs = 6 V)



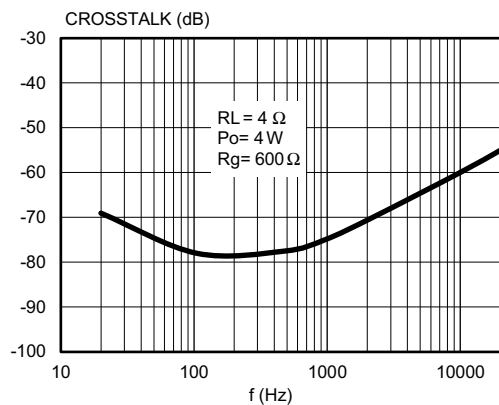
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Figure 14. Supply voltage rejection vs. frequency



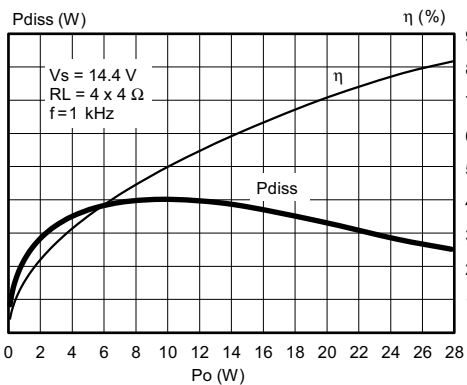
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Figure 15. Crosstalk vs. frequency



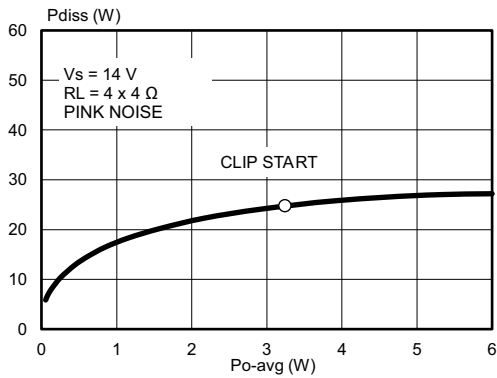
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Figure 16. Total power dissipation & efficiency vs. Po (4 Ω, Sine)



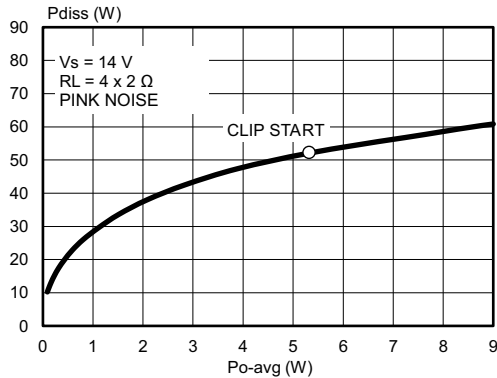
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**Figure 17. Power dissipation vs. average output power (4 Ω, audio program simulation)**



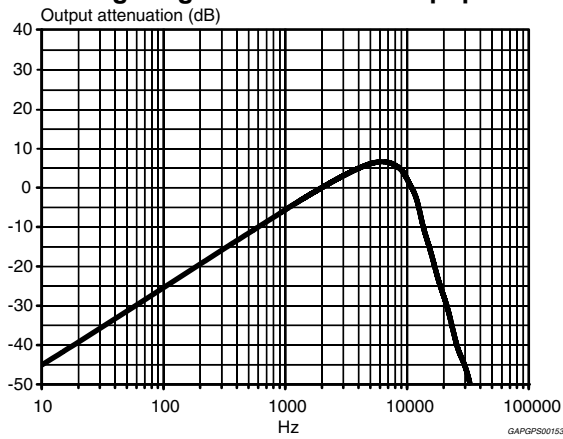
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**Figure 18. Power dissipation vs. average output power (2 Ω, audio program simulation)**



GAPGPS02078

**Figure 19. ITU R-ARM frequency response, weighting filter for transient pop**



GAPGPS0153

## 5 General information

### 5.1 Operation

The STPA002's inputs are ground-compatible. If the standard value for the input capacitors (0.22  $\mu\text{F}$ ) is adopted, the low frequency cut-off will amount to 16 Hz. The input capacitors should have the same value of the capacitor connected to AC-GND pin for optimum pop performances (see [Figure 2: Standard test and application circuit \(Flexiwatt25\)](#)).

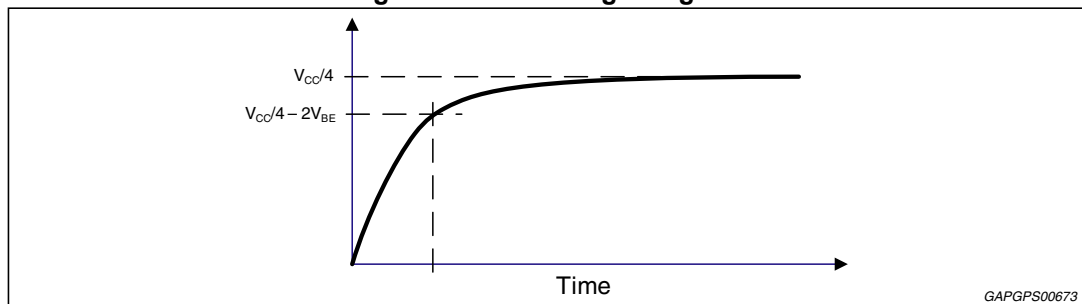
Standby and mute pins are 3.3 V and 5 V compatible.

RC cells at both mute and stand-by pins have always to be used in order to smooth the transitions for preventing any audible transient noise. A time constant slower than 2.5 V/ms is suggested for the stand-by pin and 0.5 V/ms for the mute pin.

In case the standby function is not used, it could steadily be connected to  $V_s$  through a 470 k $\Omega$  resistor.

The capacitance on SVR sets the start-up and shut-down times and helps to have pop-noise free transitions. Its minimum recommended value is 10  $\mu\text{F}$ . However, to have a fast start-up time, the internal resistor on SVR pin, used to set the time constant, is reduced from 100 k $\Omega$  to 3 k $\Omega$  till voltage on SVR reaches  $V_{CC}/4 - 2V_{BE}$  and then released. In this way the capacitor on SVR is charged very quickly to  $V_{CC}/4$ , as shown in the following figure.

Figure 20. SVR charge diagram



SVR pin accomplishes multiple functions:

- it is used as a reference voltage for input pins ( $V_{CC}/4$ )
- the capacitor connected to SVR helps the supply voltage ripple rejection
- it is used as a reference to generate the half supply voltage for the output

When the amplifier goes in stand-by mode or goes out from this condition, it is suggested to put the amplifier in mute to ensure the absence of audible noise. Then the standby pin can be set to the appropriate value (ground or  $> 2.6$  V) and the capacitance on SVR pin is discharged or charged consequently.

## 5.2 Battery variations

### 5.2.1 Low voltage operation

The most recent OEM specifications require automatic stop of car engine at traffic lights, in order to reduce emissions of polluting substances. The STPA002, thanks to its innovating design, allows a continuous operation when battery falls down. At 6 V it is still fully operational, only the maximum output power is reduced accordingly to the available voltage supply.

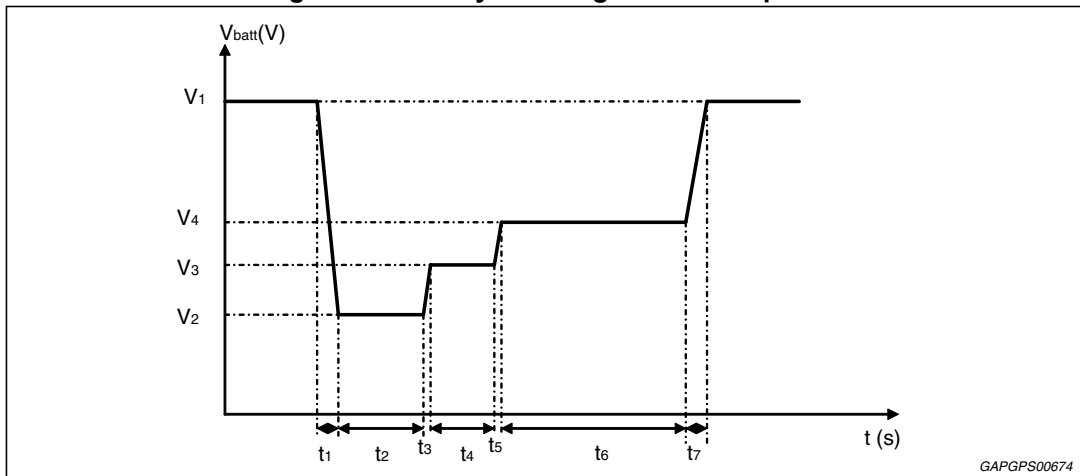
If the battery voltage drops below the minimum operating voltage of 6 V the amplifier is fast muted, the capacitor on SVR is discharged and the amplifier restarts when the battery voltage returns to the correct voltage.

### 5.2.2 Cranks

STPA002 can sustain worst case cranks from 16 V to 6 V, continuing to play and without producing any pop noise.

Examples of battery cranking curves are shown below, indicating the shape and duration of allowed battery transitions.

Figure 21. Battery cranking curve example 1

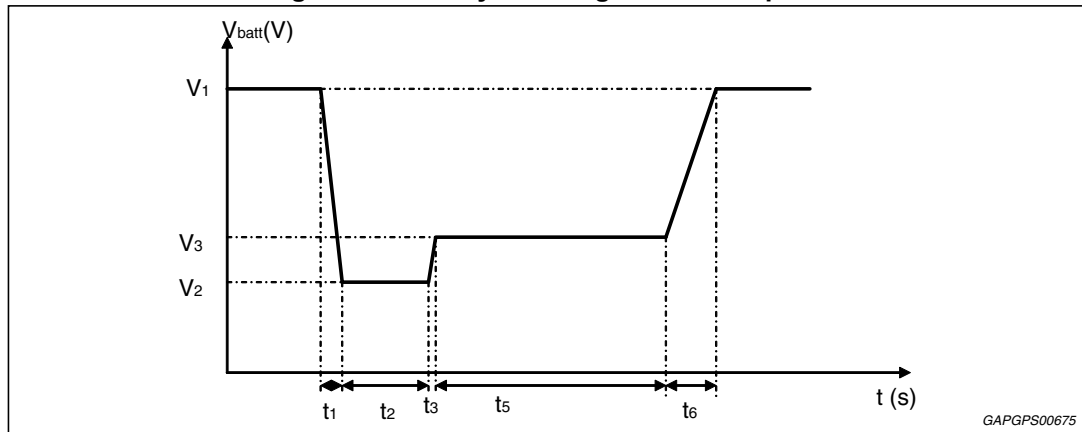


$V_1 = 16\text{ V}; V_2 = 6\text{ V}; V_3 = 7\text{ V}; V_4 = 8\text{ V}$

$t_1 = 2\text{ ms}; t_2 = 50\text{ ms}; t_3 = 5\text{ ms}; t_4 = 300\text{ ms}; t_5 = 10\text{ ms}; t_6 = 1\text{ s}; t_7 = 2\text{ ms}$



Figure 22. Battery cranking curve example 2



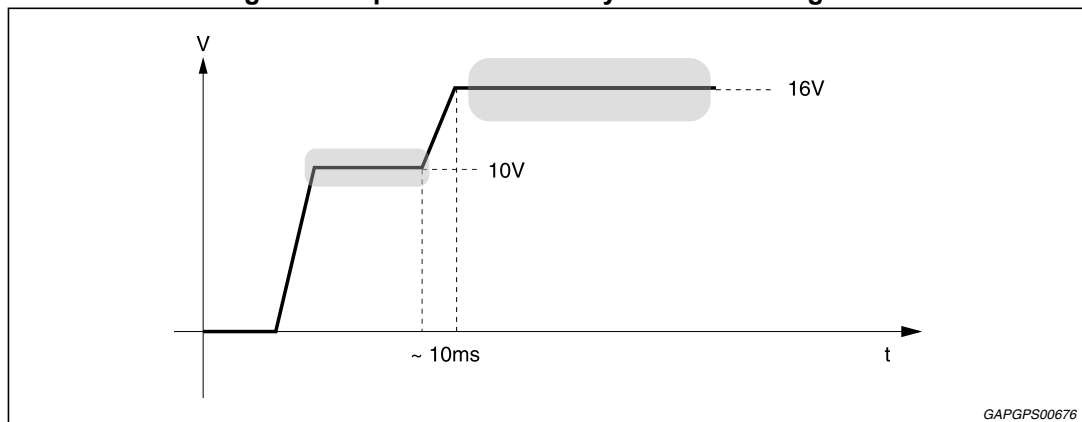
$V1 = 16 \text{ V}; V2 = 6 \text{ V}; V3 = 7 \text{ V}$

$t1 = 2 \text{ ms}; t2 = 5 \text{ ms}; t3 = 15 \text{ ms}; t5 = 1 \text{ s}; t6 = 50 \text{ ms}$

### 5.2.3 Advanced battery management (hybrid vehicles)

In addition to compatibility with low  $V_{batt}$ , the STPA002 is able to sustain upwards fast battery transitions without causing unwanted audible effects, like pop noise, and without any sound interruption thanks to the innovative circuit topology. In fact, in hybrid vehicles, the engine ignition causes a fast increase of battery voltage which can reach 16 V in less than 10 ms.

Figure 23. Upwards fast battery transitions diagram



### 5.3 Protections

#### 5.3.1 Short circuits and open circuit operation

When the IC detects a short circuit to ground, to  $V_{supply}$  or across the load, the output of the amplifier is put in three-state (high impedance condition). The power stage remains in this condition until the short is removed.

In case of short circuit to ground or  $V_{cc}$ , the amplifier exits from the three-state condition only when the output returns inside the limits imposed by an internal voltage comparator.

When a short across the load is present, the power stage sees an over-current and is brought in protection mode for 150  $\mu s$ . After this time, if the short circuit condition is removed the amplifier returns to play, otherwise the high impedance state is maintained and the check is repeated every 150  $\mu s$ .

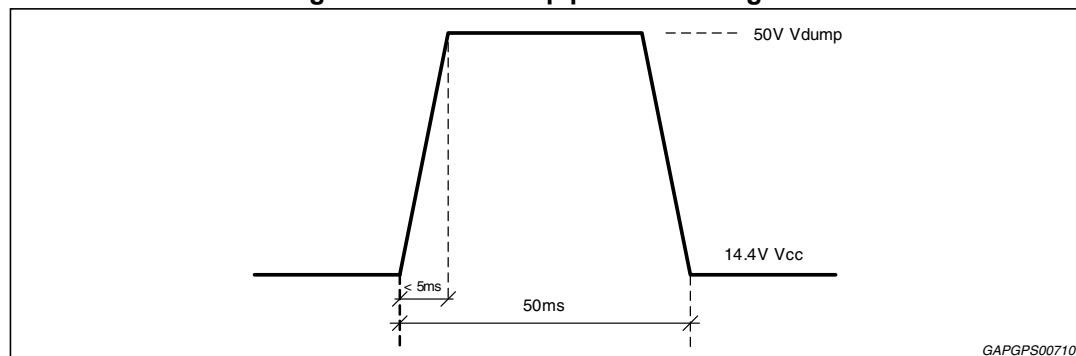
Disconnection of load (open load condition) doesn't damage the amplifier, which continues to play.

#### 5.3.2 Over-voltage and load dump protection

When the battery voltage is higher than 19 V, the amplifier is switched to a high impedance state. It stops playing till the supply voltage returns in the permitted range.

The amplifier is protected against load dump surges having amplitude as high as 50 V and a rising time lower than 5 ms (see *Figure 24*).

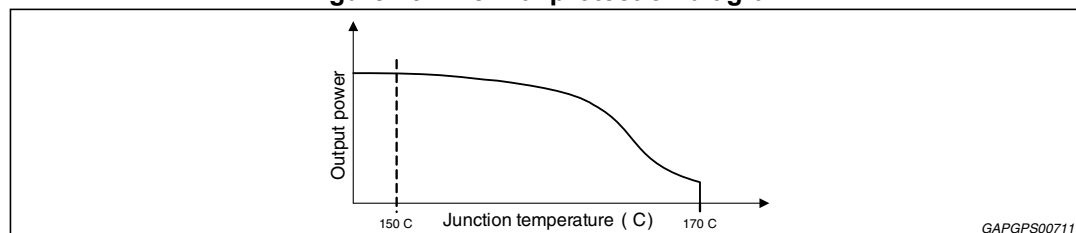
Figure 24. Load dump protection diagram



#### 5.3.3 Thermal protection

If the junction temperature of the IC reaches  $T_j = 150\text{ }^\circ\text{C}$ , a smooth mute is applied to reduce output power and limit power dissipation. If this is not enough and the junction temperature continues to increase, the amplifier is switched off when it reaches the maximum temperature of  $170\text{ }^\circ\text{C}$ .

Figure 25. Thermal protection diagram



## 5.4 Warnings

### 5.4.1 DC offset detection (OD pin)

The STPA002 integrates a DC offset detector to avoid that an anomalous input DC offset is multiplied by the amplifier gain producing a dangerous large offset at the output. In fact an output offset may lead to speakers damage for overheating. To correctly detect a DC offset, the power amplifier has to be un-muted with no input signal.

When the differential output voltage is out of a window comparator with thresholds  $\pm 2\text{ V}$  (typ), the OD pin is pulled down.

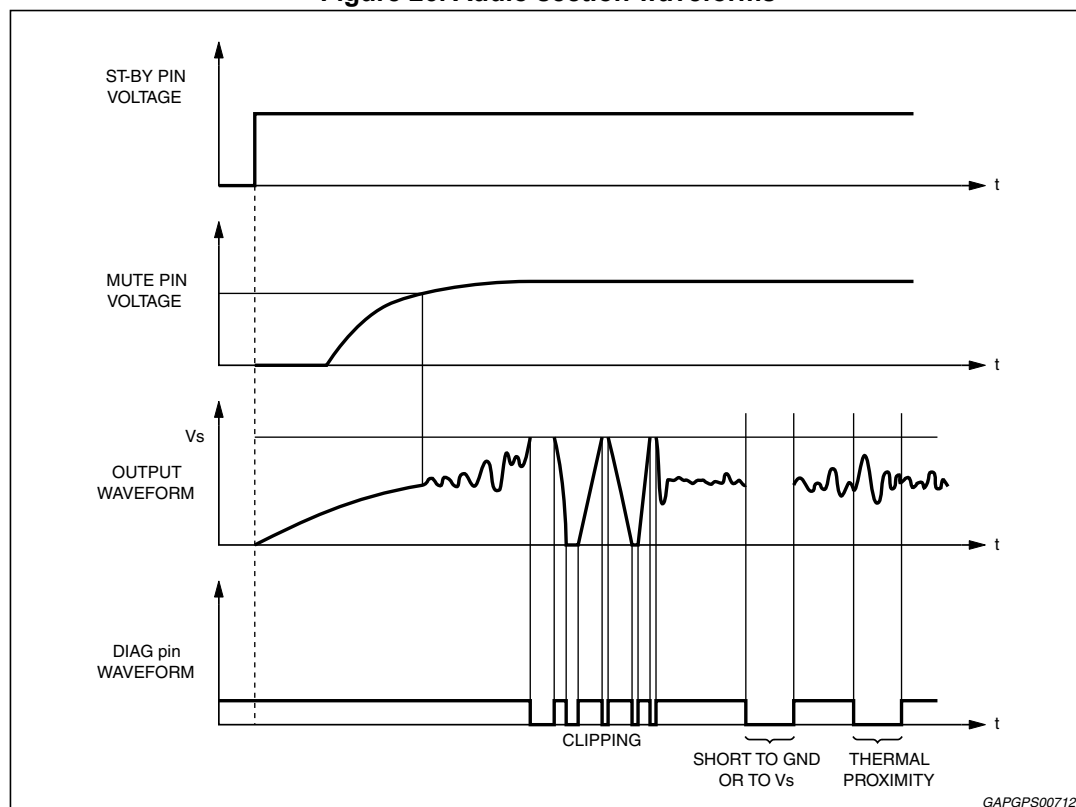
### 5.4.2 Clipping detection and diagnostics (CD-DIAG pin)

When clipping occurs, the output signal is distorted. If the signal distortion on one of the output channels exceeds 1 %, the CD-DIAG pin is pulled down. This information can be sent to an audio processor in order to reduce the input signal of the amplifier and reduce the clipping. Thanks to a particular internal circuitry, the clip detector is always functional till 7 V.

A short to ground and short to  $V_{cc}$  is signaled by CD-DIAG. This pin is pulled down to ground till these shorts are present to inform the user a protection occurred.

CD-DIAG acts also as thermal warning. In fact every time  $T_j$  exceeds  $140\text{ }^\circ\text{C}$ , it is pulled down to notify this occurrence.

Figure 26. Audio section waveforms



## 5.5 Heat sink definition

Assuming we have a dissipated power of 26 W (e.g. in the worst case situation of frequent clipping occurrence, with music signal), considering  $T_j$  max is 150 °C and assuming ambient temperature is 70 °C, the available temperature gap for a correct dissipation is 80 °C. This means the thermal resistance of the system  $R_{th}$  has to be  $80\text{ °C}/26\text{ W} = 3\text{ °C/W}$ .

The junction to case thermal resistance is 1 °C/W. So the heat sink thermal resistance should be approximately 2 °C/W. This would avoid any thermal shutdown occurrence even after long-term and full-volume operation.

# 6 Package information

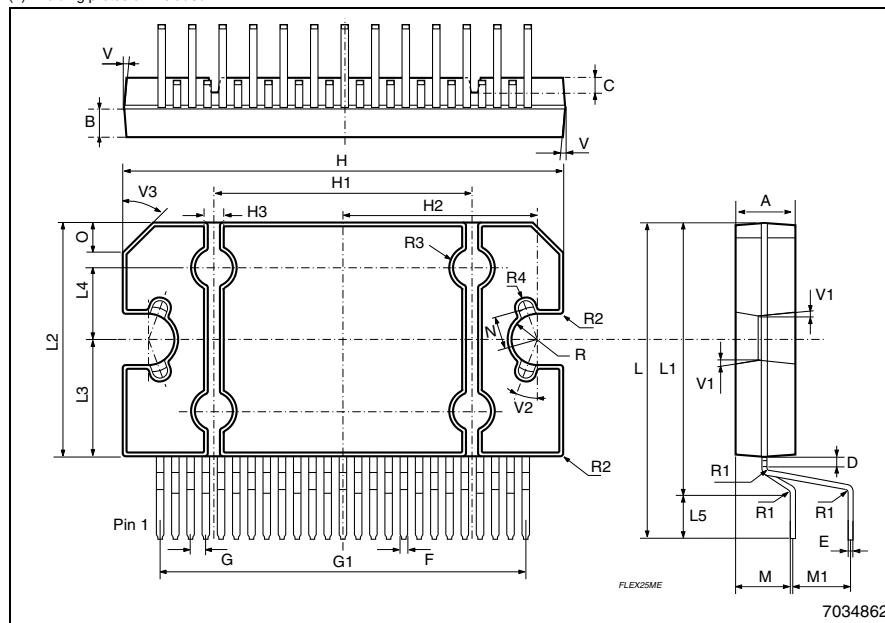
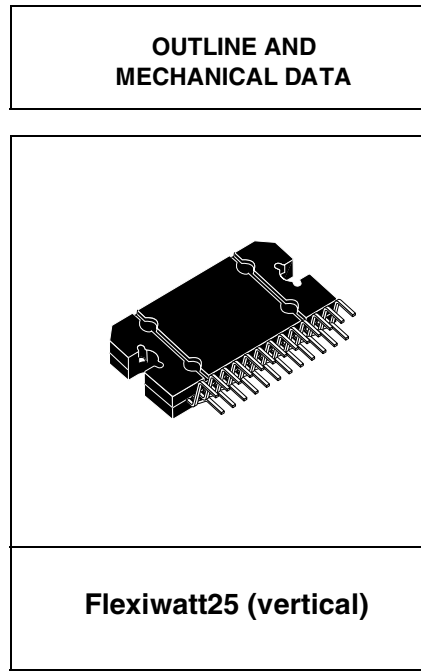
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com).

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**Figure 27. Flexiwatt25 (vertical) mechanical data and package dimensions**

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.45	4.50	4.65	0.175	0.177	0.183
B	1.80	1.90	2.00	0.070	0.074	0.079
C		1.40			0.055	
D	0.75	0.90	1.05	0.029	0.035	0.041
E	0.37	0.39	0.42	0.014	0.015	0.016
F (1)			0.57			0.022
G	0.80	1.00	1.20	0.031	0.040	0.047
G1	23.75	24.00	24.25	0.935	0.945	0.955
H (2)	28.90	29.23	29.30	1.139	1.150	1.153
H1		17.00			0.669	
H2		12.80			0.503	
H3		0.80			0.031	
L (2)	22.07	22.47	22.87	0.869	0.884	0.904
L1	18.57	18.97	19.37	0.731	0.747	0.762
L2 (2)	15.50	15.70	15.90	0.610	0.618	0.626
L3	7.70	7.85	7.95	0.303	0.309	0.313
L4		5			0.197	
L5		3.5			0.138	
M	3.70	4.00	4.30	0.145	0.157	0.169
M1	3.60	4.00	4.40	0.142	0.157	0.173
N		2.20			0.086	
O		2			0.079	
R		1.70			0.067	
R1		0.5			0.02	
R2		0.3			0.12	
R3		1.25			0.049	
R4		0.50			0.019	
V					5° (Typ.)	
V1					3° (Typ.)	
V2					20° (Typ.)	
V3					45° (Typ.)	

(1): dam-bar protrusion not included  
 (2): molding protrusion included



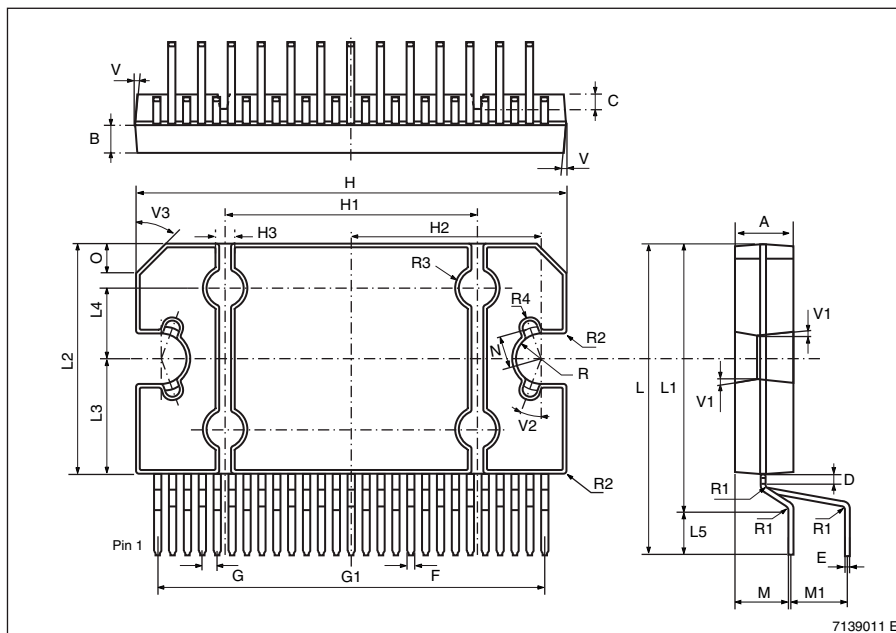
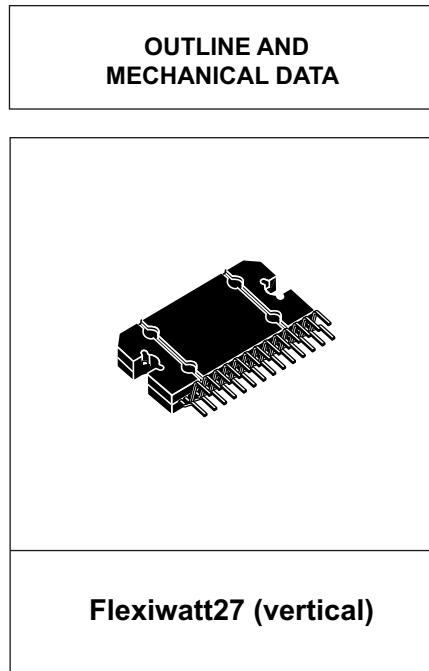
GAPGPS00669



Figure 28. Flexiwatt27 (Vertical) mechanical data and package dimensions

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.45	4.50	4.65	0.175	0.177	0.183
B	1.80	1.90	2.00	0.070	0.074	0.079
C		1.40			0.055	
D	0.75	0.90	1.05	0.029	0.035	0.041
E	0.37	0.39	0.42	0.014	0.015	0.016
F <sup>(1)</sup>			0.57		0.022	
G	0.80	1.00	1.20	0.031	0.040	0.047
G1	25.75	26.00	26.25	1.014	1.023	1.033
H <sup>(2)</sup>	28.90	29.23	29.30	1.139	1.150	1.153
H1		17.00			0.669	
H2		12.80			0.503	
H3		0.80			0.031	
L <sup>(2)</sup>	22.07	22.47	22.87	0.869	0.884	0.904
L1	18.57	18.97	19.37	0.731	0.747	0.762
L2 <sup>(2)</sup>	15.50	15.70	15.90	0.610	0.618	0.626
L3	7.70	7.85	7.95	0.303	0.309	0.313
L4		5			0.197	
L5		3.5			0.138	
M	3.70	4.00	4.30	0.145	0.157	0.169
M1	3.60	4.00	4.40	0.142	0.157	0.173
N		2.20			0.086	
O		2			0.079	
R		1.70			0.067	
R1		0.5			0.02	
R2		0.3			0.12	
R3		1.25			0.049	
R4		0.50			0.019	
V	5° (Typ.)					
V1	3° (Typ.)					
V2	20° (Typ.)					
V3	45° (Typ.)					

(1): dam-bar protusion not included; (2): molding protusion included.



## 7 Revision history

**Table 6. Document revision history**

Date	Revision	Changes
14-Mar-2013	1	Initial release.
05-Sep-2013	2	Updated <i>Figure 17 &amp; 18</i> .
18-Sep2013	3	Updated Disclaimer.

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