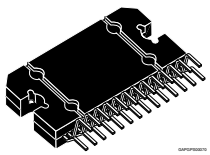
STPA001

4 x 50 W MOSFET quad bridge power amplifier

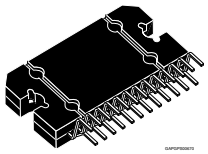
Datasheet – production data

Features

- Multipower BCD technology
- High output power capability:
  - 4 x 50 W/4 Ω Max.
  - 4 x 28 W/4 Ω @ 14.4 V, 1 kHz, 10 %
  - 4 x 72 W/2 Ω Max.
- MOSFET output power stage
- Excellent 2 Ω driving capability
- Hi-Fi class distortion
- Low output noise
- Very high disturbance immunity
- Standby function
- 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 Vs, across the load
  - Very inductive loads
  - Overrating chip temperature with soft thermal limiter
  - Output DC offset detection
  - Load dump voltage
  - Fortuitous open GND
  - Reversed battery
  - ESD



Flexiwatt27



Flexiwatt25

  - Capable to operate down to 6 V (e.g. “Startstop”)

Description

The STPA001 is a breakthrough MOSFET technology class AB audio power amplifier designed for high power car radio. The fully complementary P-Channel/N-Channel output structure allows a rail to rail output voltage swing which, combined with high output current and minimized saturation losses sets new power references in the car-radio field, with unparalleled distortion performances.

The STPA001 can operate down to 6V and this make the IC compliant to the most recent OEM specifications for low voltage operation (so called 'start-stop' battery profile during engine stop), helping car manufacturers to reduce the overall emissions and thus contributing to environment protection.

Table 1. Device summary

Order code	Package	Packing
STPA001	Flexiwatt25	Tube
STPA001A	Flexiwatt27	Tube

Contents

List of tables

List of figures

1 Overview

The STPA001 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 and a mute pin, a clipping detector and diagnostics output and, only for the Flexiwatt27 package, an offset detector pin. 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 STPA001 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 and application circuit

Figure 1. Block diagram

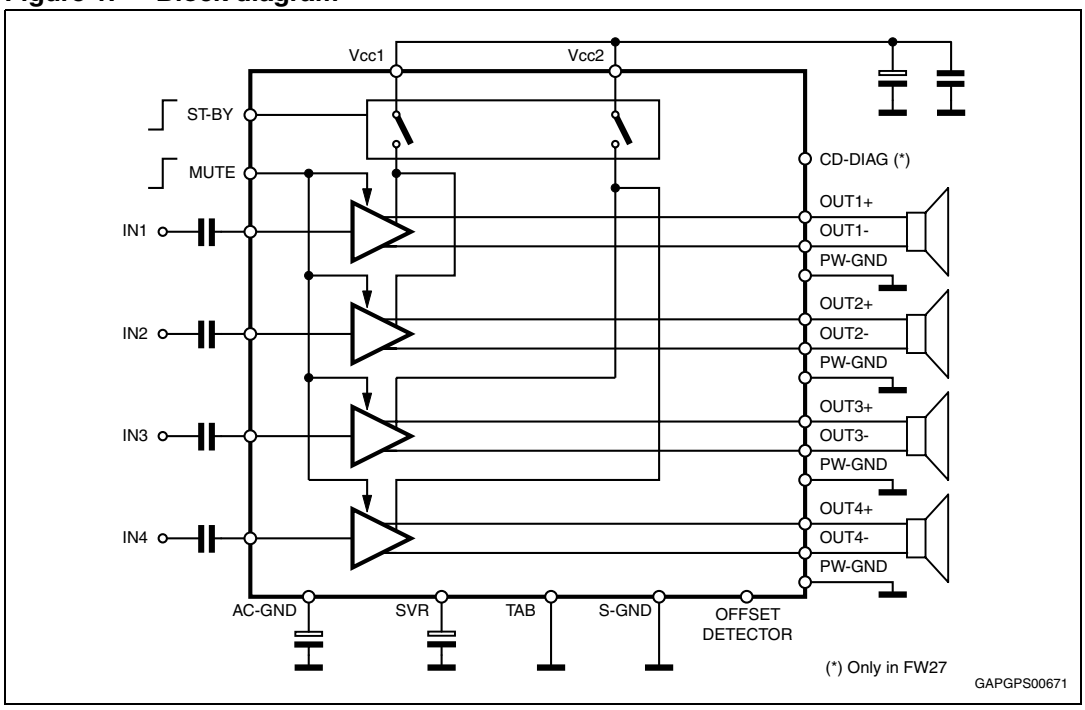
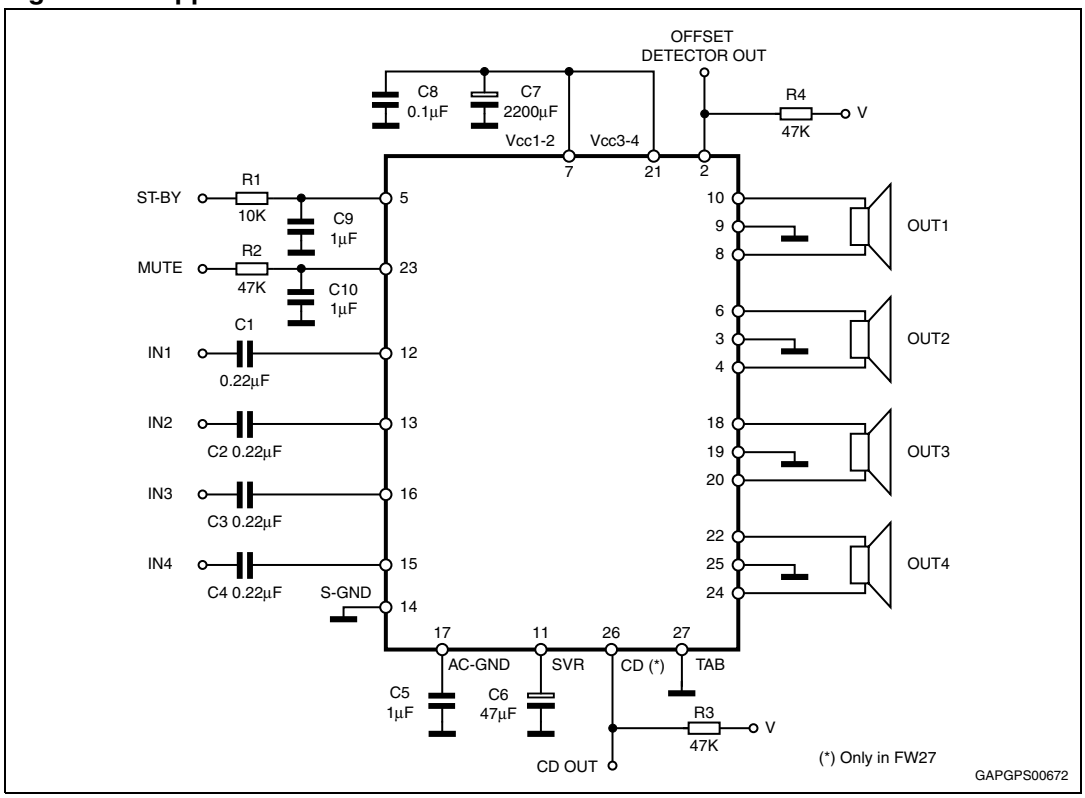


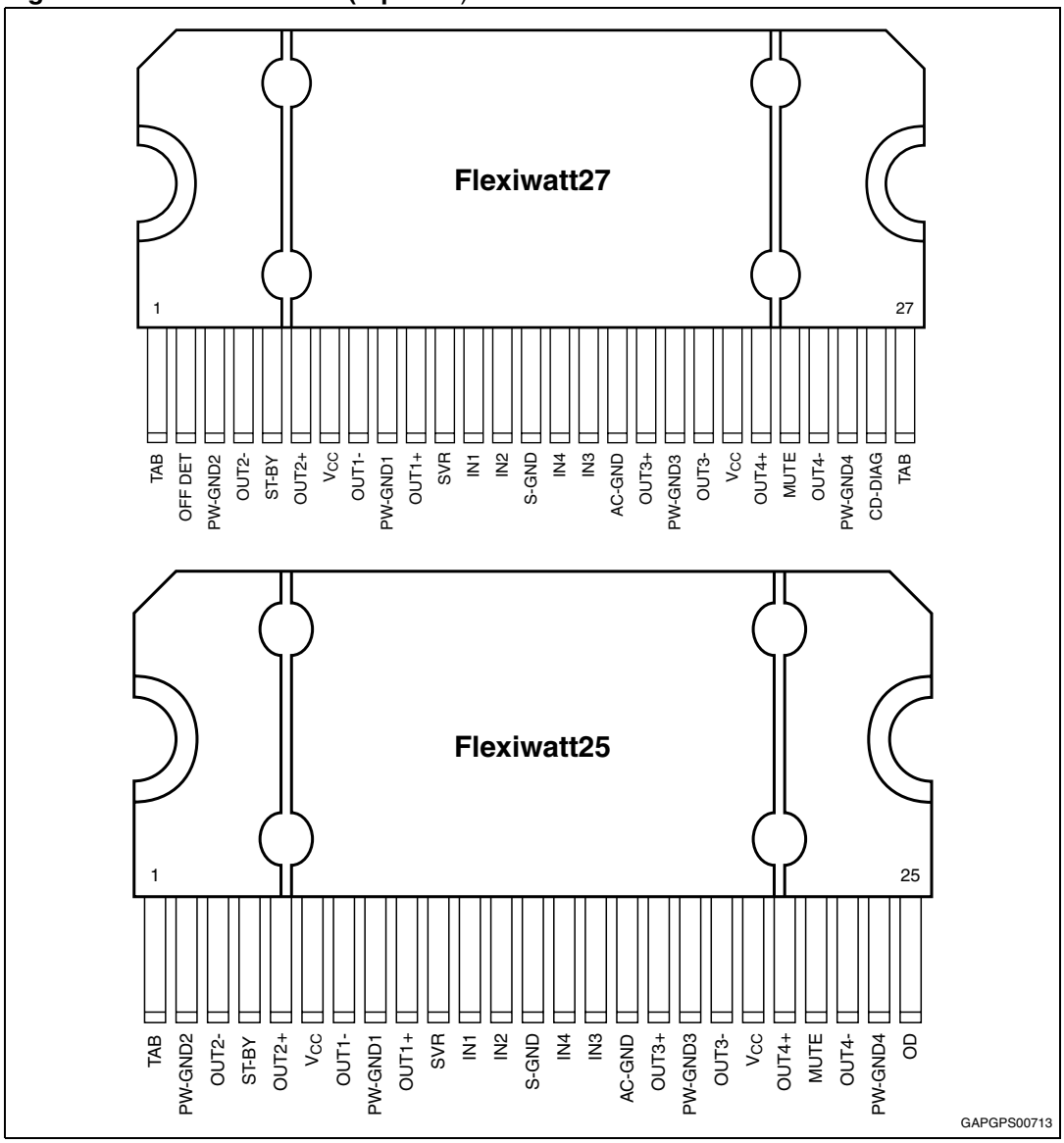
Figure 2. Application circuit



2 Pin description

2.1 Pin connection

Figure 3. Pin connection (top view)



2.2 Pin functions

Table 2. Pin functions

Pin number FW27	Pin number FW25	Pin name	Description
1	1	TAB	-
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	-

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 µs) Repetitive (duty cycle 10 % at f = 10 Hz)	 10 9	 A A
P_{tot}	Power dissipation T_{case} = 70 °C	85	W
T_j	Junction temperature	150	°C
T_{stg}	Storage temperature	-55 to 150	°C
GND_{max}	Ground pin voltage	-0.3 to 0.3	V
$V_{in\ max}$	Input pin max voltage	-0.3 to 0.8	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 3.3	V

3.2 Thermal data

Table 4. Thermal data

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

3.3 Electrical characteristics

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

Table 5. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
General characteristics						
V_S	Supply voltage range	-	6	-	18	V
I_{q1}	Quiescent current	$R_L = \infty$	100	200	300	mA
V_{OS}	Output offset voltage	Play mode / Mute mode	-90	-	+90	mV

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
dV_{OS}	During mute ON/OFF output offset voltage	ITU R-ARM weighted	-10	-	+10	mV
	During standby ON/OFF output offset voltage		-15	-	+15	mV
R_i	Input impedance	-	40	55	70	kΩ
I_{SB}	Standby current consumption	$V_{St\text{-}by}$ = 1.2 V	-	-	20	µA
		$V_{St\text{-}by}$ = 0	-	-	10	µA
Audio performances						
P_o	Output power	THD = 10 % THD = 1 %	26 20	28 22	- -	W W
		THD = 10 %, 2 Ω THD = 1 %, 2 Ω	43 34	48 38	- -	W W
$P_{o\ max.}$	Max. output power	Square wave input (2 Vrms) R_L = 4 Ω R_L = 2 Ω V_S = 15.2 V; R_L = 4 Ω	 41 68 46	 45 75 50	 - - -	 W W W
THD	Distortion	P_o = 4 W	-	0.01	0.05	%
G_v	Voltage gain	-	25	26	27	dB
dG_v	Channel gain unbalance	-	-1	-	+1	dB
e_{No}	Output Noise	"A" Weighted Bw = 20 Hz to 20 kHz	- -	35 50	- 100	µV µV
SVR	Supply voltage rejection	f = 100 Hz; V_r = 1 Vrms	50	70	-	dB
f_{ch}	High cut-off frequency	P_O = 0.5 W	100	300	-	kHz
C_T	Cross talk	f = 1 kHz P_O = 4 W f = 10 kHz P_O = 4 W	60 -	70 60	- -	dB dB
A_M	Mute attenuation	P_{Oref} = 4 W	80	90	-	dB
Control pin characteristics						
I_{pin5}	Standby pin current	$V_{St\text{-}by}$ = 1.2 V to 2.6 V	-	-	1	µA
$V_{SB\ out}$	Standby out threshold voltage	(Amp: ON)	2.6	-	-	V
$V_{SB\ in}$	Standby in threshold voltage	(Amp: OFF)	-	-	1.2	V
$V_{M\ out}$	Mute out threshold voltage	(Amp: Play)	2.6	-	-	V
$V_{M\ in}$	Mute in threshold voltage	(Amp: Mute)	-	-	1.2	V
$V_{AM\ in}$	V_S automute threshold	(Amp: Mute) Att ≥ 80 dB; P_{Oref} = 4 W (Amp: Play) Att < 0.1 dB; P_O = 0.5 W	4.5 -	5 -	5.5 6	V V

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Ipin23	Muting pin current	V_{MUTE} = 1.2 V (Sourced current)	5	8	12	µA
Offset detector						
V_{OFF}	Detected differential output offset	$V_{St\text{-}by}$ = 5 V	±1	±2	±3	V
V_{OFF_SAT}	Off detector saturation voltage	V_o > ±3 V, $I_{off\ Det}$ = 1 mA 0 V < $V_{off\ Det}$ < 18 V	-	0.1	0.2	V
V_{OFF_LK}	Off detector leakage current	V_o < ±1 V	-	0	15	µA
Clipping detector						
CD_{LK}	Clip detector high leakage current	Cd off	-	0	1	µA
CD_{SAT}	Clip detector saturation voltage	DC On; I_{CD} = 1 mA	-	0.1	0.2	V
CD_{THD}	Clip detector THD level	V_{CC} > 6.5 V	-	1	-	%

4 General information

4.1 Operation

The STPA001's inputs are ground-compatible. If the standard value for the input capacitors (0.22 µF) is adopted, the low frequency cut-off will amount to 16 Hz. The input capacitors should be 1/4 of the capacitor connected to AC-GND pin for optimum pop performances (see *Figure 2: Application circuit*).

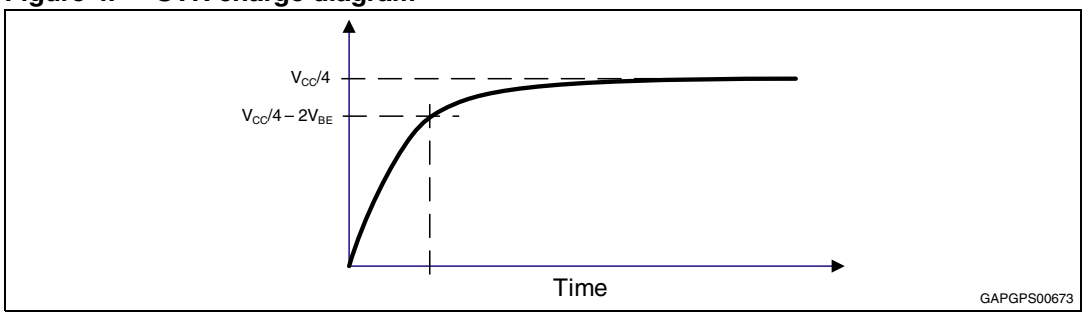
Standby and mute pins are both CMOS compatible.

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.

In case muting and stand-by functions are not used, they could steadily be connected to V_S, but a 470 kohm resistance should be present between the power supply and the pins.

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 µF. However, to have a fast start-up time, the internal resistor on SVR pin, used to set the time constant, is reduced from 50 kΩ to 3 kΩ till voltage on SVR reaches VCC/4 -2V_{BE} and then released. In this way the capacitor on SVR is charged very quickly to VCC/4, as shown in the following figure.
The time constant to be assigned to the standby pin in order to obtain a virtually pop-free transition has to be slower than 2.5 V/ms.

Figure 4. SVR charge diagram



SVR pin accomplishes multiple functions:

- it is used a reference voltage for input pins (VCC/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 stand-by pin can be set to the appropriate value (ground or > 2.6 V) and the capacitance on SVR pin is discharged or charged consequently.

4.2 Battery variations

4.2.1 Low voltage operation

The most recent OEM specifications are requiring automatic stop of car engine at traffic lights, in order to reduce emissions of polluting substances. The STPA001, thanks to its

innovating design, allows a continuous operation when battery falls down. At 6V it is still fully operational, only the maximum output power is reduced accordingly to the available voltage supply.

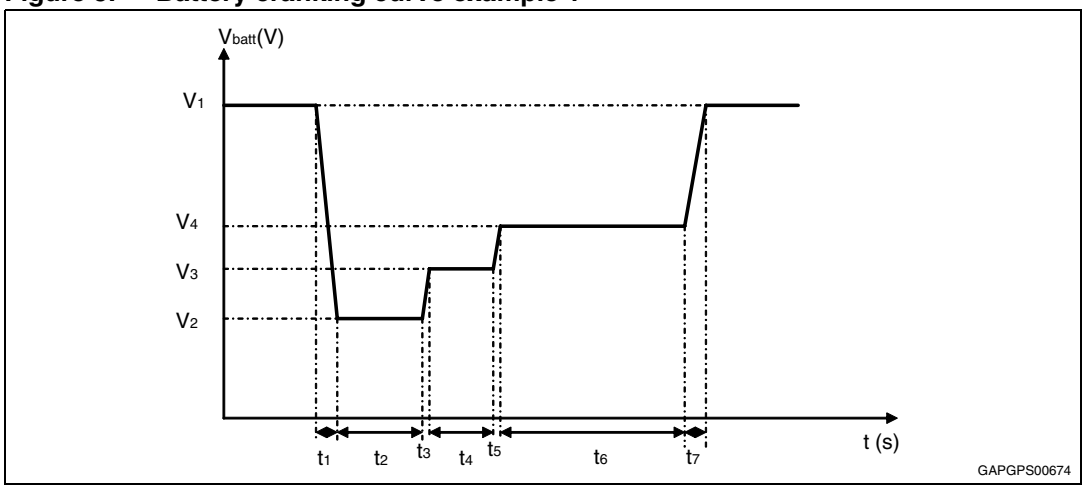
If the battery voltage drops below the minimum operating voltage of 6V the amplifier is fast muted, the capacitor on SVR is discharged and the amplifier restarts when the battery voltage returns to the correct voltage.

4.2.2 Cranks

STPA001 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 durations of allowed battery transitions.

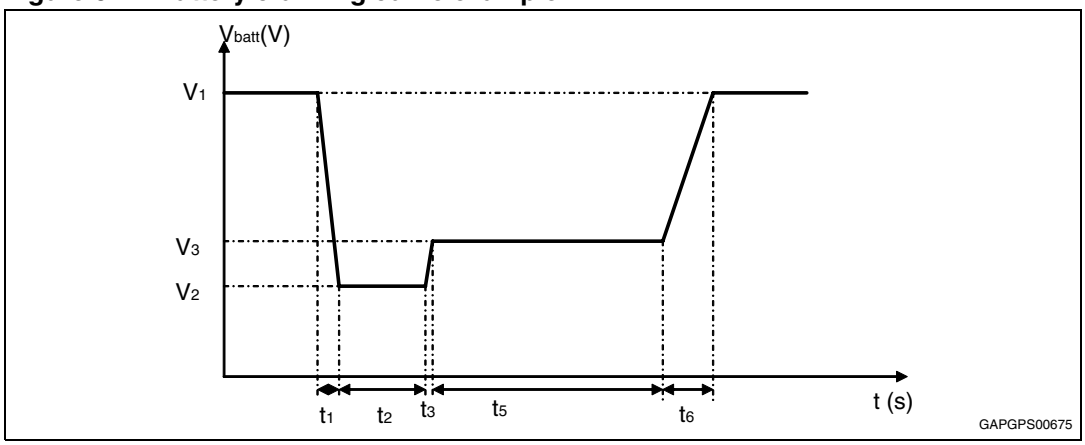
Figure 5. Battery cranking curve example 1



V1 = 16 V; V2 = 6 V; V3 = 7 V; V4 = 8 V

t1 = 2 ms; t2 = 50 ms; t3 = 5 ms; t4 = 300 ms; t5 =10 ms; t6 = 1 s; t7 = 2 ms

Figure 6. Battery cranking curve example 2



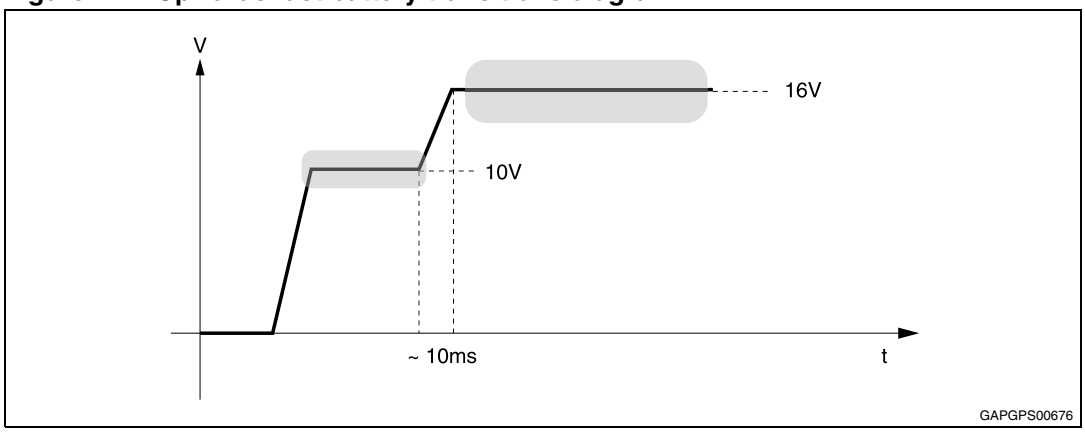
V1 = 16 V; V2 = 6 V; V3 = 7 V

t1 = 2 ms; t2 = 5 ms; t3 = 15 ms; t5 = 1 s; t6 = 50 ms

4.2.3 Advanced battery management (hybrid vehicles)

In addition to compatibility with low Vbatt, the STPA001 is able to sustain upwards fast battery transitions without causing unwanted audible effect, 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 7. Upwards fast battery transitions diagram



4.3 Protections

4.3.1 Short circuits and open circuit operation

When the IC detects a short circuit to ground, to Vs 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 Vcc, 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 100 µs. After this time, if the short circuit condition is removed the amplifier returns to play, otherwise the high impedance state in maintained and the check is repeated every 100 µs.

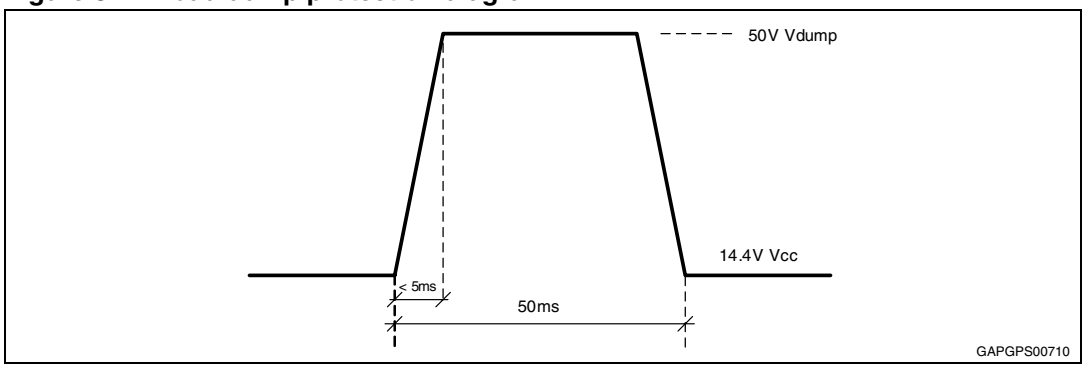
Disconnection of load (open load condition) doesn't damage the amplifier, which continues to play.

4.3.2 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 to play 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 8*).

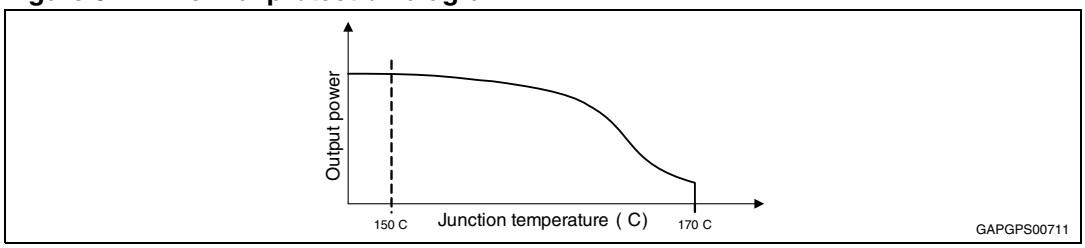
Figure 8. Load dump protection diagram



4.3.3 Thermal protection

If the junction temperature of the IC reaches T_j = 150 °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 reaches the maximum temperature of 170 °C.

Figure 9. Thermal protection diagram



4.4 Warnings

4.4.1 DC offset detection (OD pin)

The STPA001 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. The detector works with the amplifier un-muted and no signal at the inputs.

When the differential output voltage is out of a window comparator with thresholds ± 2V (typ), the OD pin is pulled down.

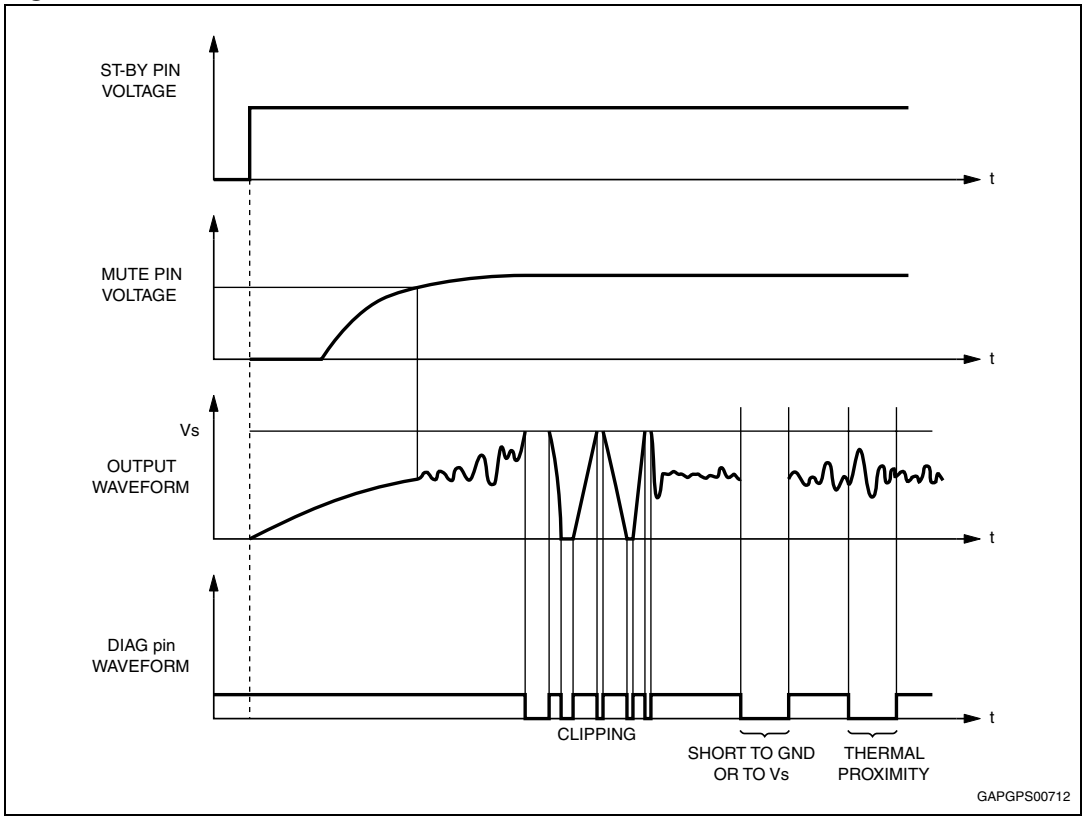
4.4.2 Clipping detection and diagnostics (CD-DIAG pin)

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 6.5 V.

A short to ground and short to Vcc is pointed out by CD-DIAG. This pin is pulled down to 6 V 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 °C, it is pulled down to notify this occurrence.

Figure 10. Audio section waveforms



4.5 Heat sink definition

Assume we have a maximum dissipated power of 26 W (e.g. in a worst case situation of frequent clipping occurrence). 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 °C/26 W = 3 °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.

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*.

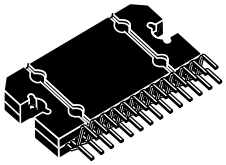
ECOPACK® is an ST trademark.

Figure 11. Flexiwatt27 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	25.75	26.00	26.25	1.014	1.023	1.033
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 protusion not included
(2): molding protusion included

OUTLINE AND MECHANICAL DATA



Flexiwatt27 (vertical)

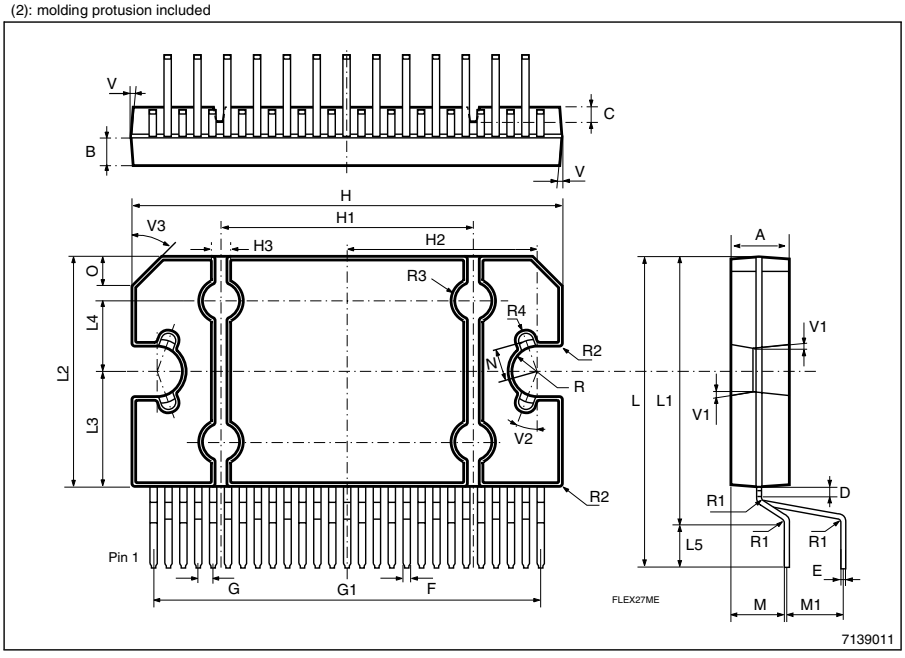


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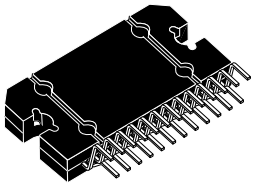
Figure 12. Flexiwatt25 mechanical data and package dimensions

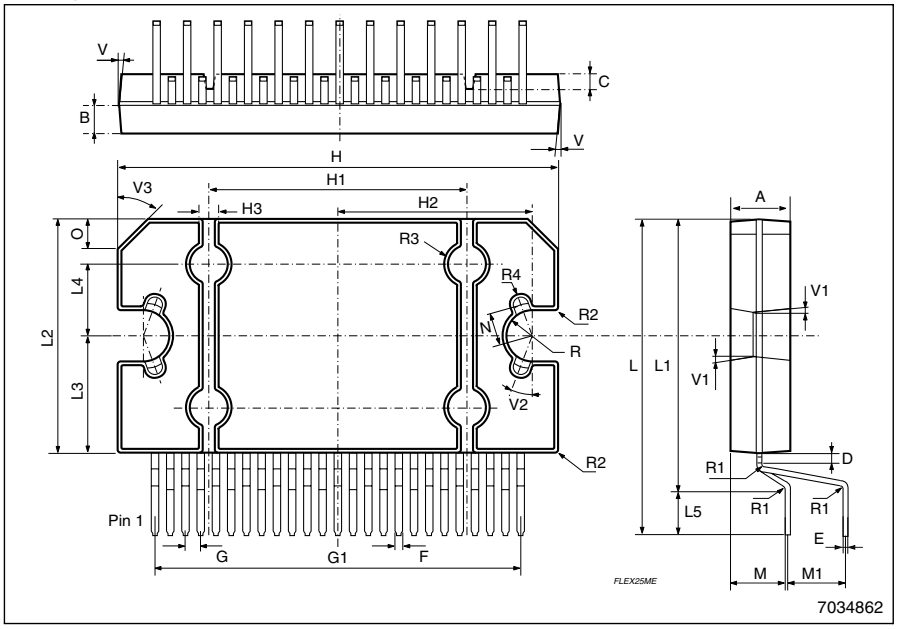
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.45	4.50	4.65	0.175	0.177	0.183
B	1.80	1.90	2.00	0.070	0.074	0.079
C		1.40			0.055	
D	0.75	0.90	1.05	0.029	0.035	0.041
E	0.37	0.39	0.42	0.014	0.015	0.016
F (1)			0.57			0.022
G	0.80	1.00	1.20	0.031	0.040	0.047
G1	23.75	24.00	24.25	0.935	0.945	0.955
H (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 protusion not included
(2): molding protusion included

OUTLINE AND MECHANICAL DATA



Flexiwatt25 (vertical)



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6 Revision history

Table 6. Document revision history

Date	Revision	Changes
03-Apr-2012	1	Initial release.