AXPA7388Q

4 x 45W MOSFET
Quad Bridge Power Amplifier

Datasheet — Jun 2023

Description

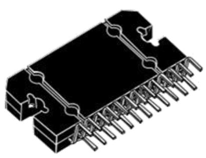
AXPA7388Q is an automotive AEC-Q100 certified quad bridge class AB car radio audio power amplifier designed in BCD (Bipolar, CMOS, DMOS) technology with a fully complementary P-Channel/N-Channel output structure. It has a rail to rail output voltage swing, high output current and low saturation losses, giving it an excellent distortion performance. AXPA7388Q can operate down to 6V for low voltage operation to achieve 'start-stop' battery profile during engine stop enabling reduction in overall emissions.

Features

- Automotive AEC-Q100 Certified
- Multipower BCD technology with DMOS MOSFET output power stage
- Hi-Fi class low distortion
- Low output noise
- High immunity to RF noise injection
- Standby function
- Mute function
- Auto-mute at min. supply voltage detection
- Low external component count
  - No external compensation
  - No bootstrap capacitors
- Internally fixed gain (26dB)
- Capable to operate down to 6V (e.g. “start-stop”)
- High output power capability:
  - 4 x 45W/4Ω Max.
  - 4 x 25W/4Ω @ 14.4V, 1kHz, 10%
- Protections:
  - Output short circuit to GND, to Vs, across the load
  - Very inductive loads
  - Overrating chip temperature with soft thermal limiter
  - Load dump
  - Fortuitous open GND
  - ESD

Table 1 Device Summary

Order code	Package	Packing	MOQ
AXPA7388Q	HZIP25	Tube	1360
	FZIP25	Tube	2040



HZIP25 / FZIP25

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1 Block Diagram and Application Circuits

Figure 1 Block diagram

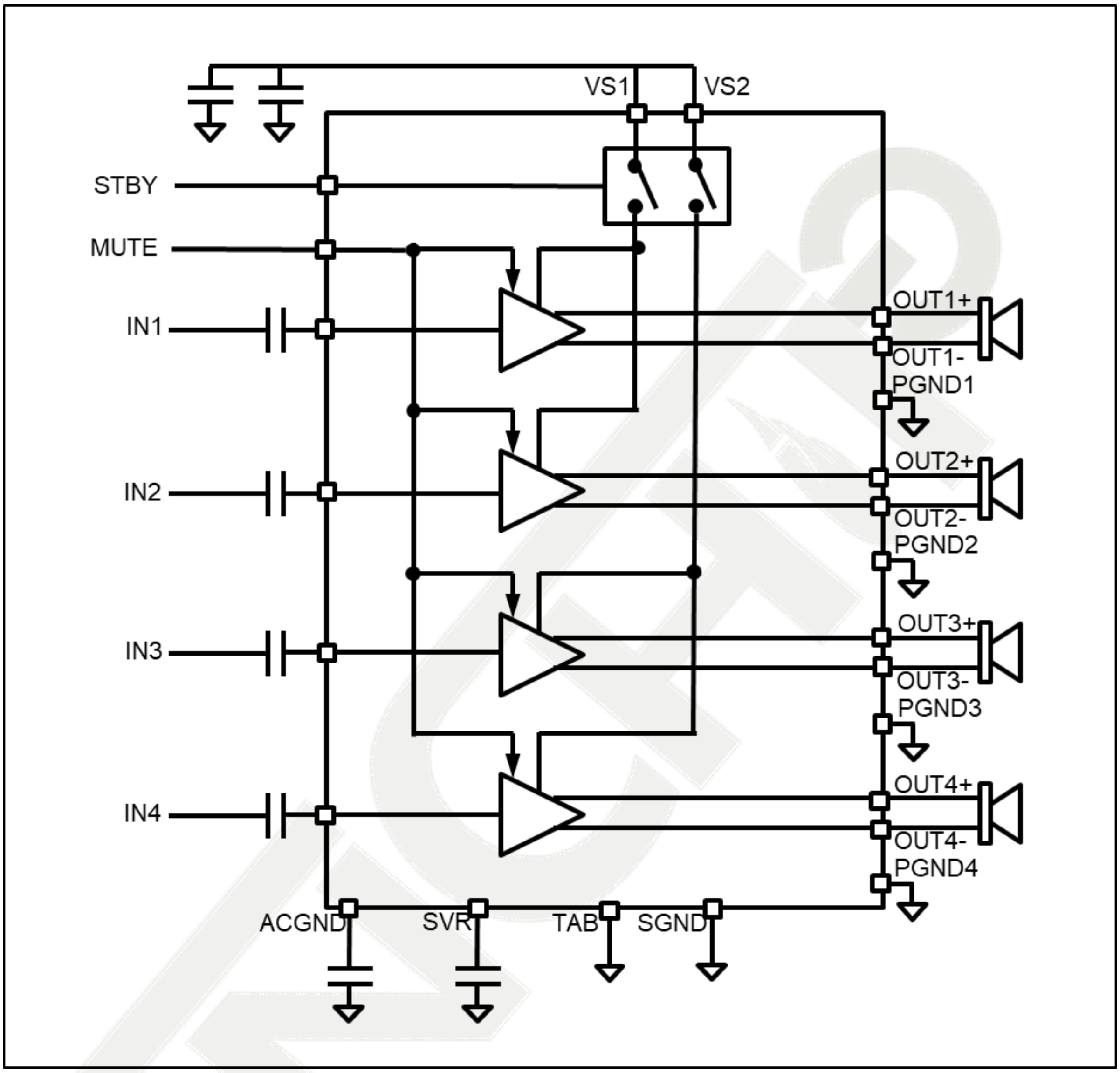
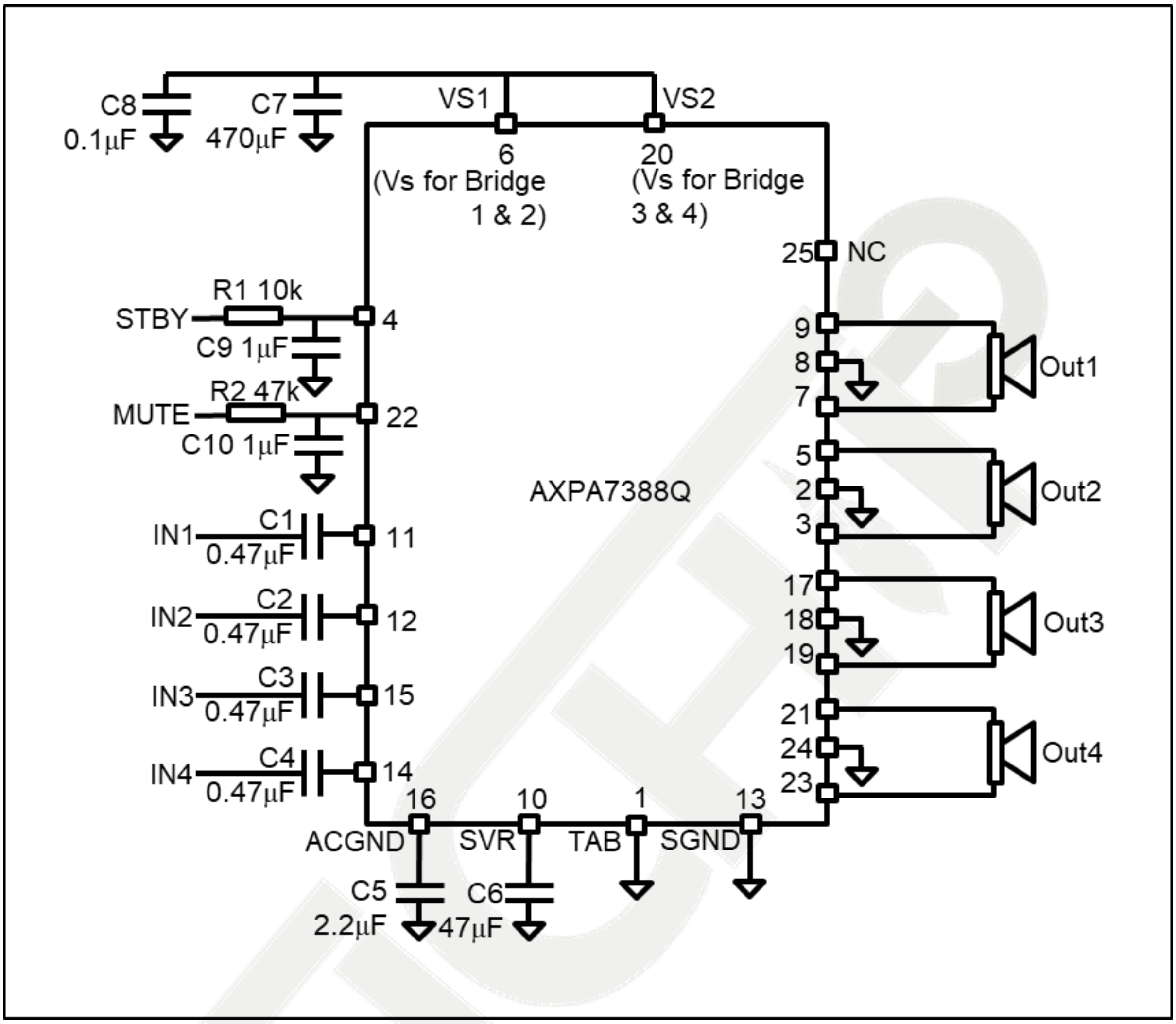


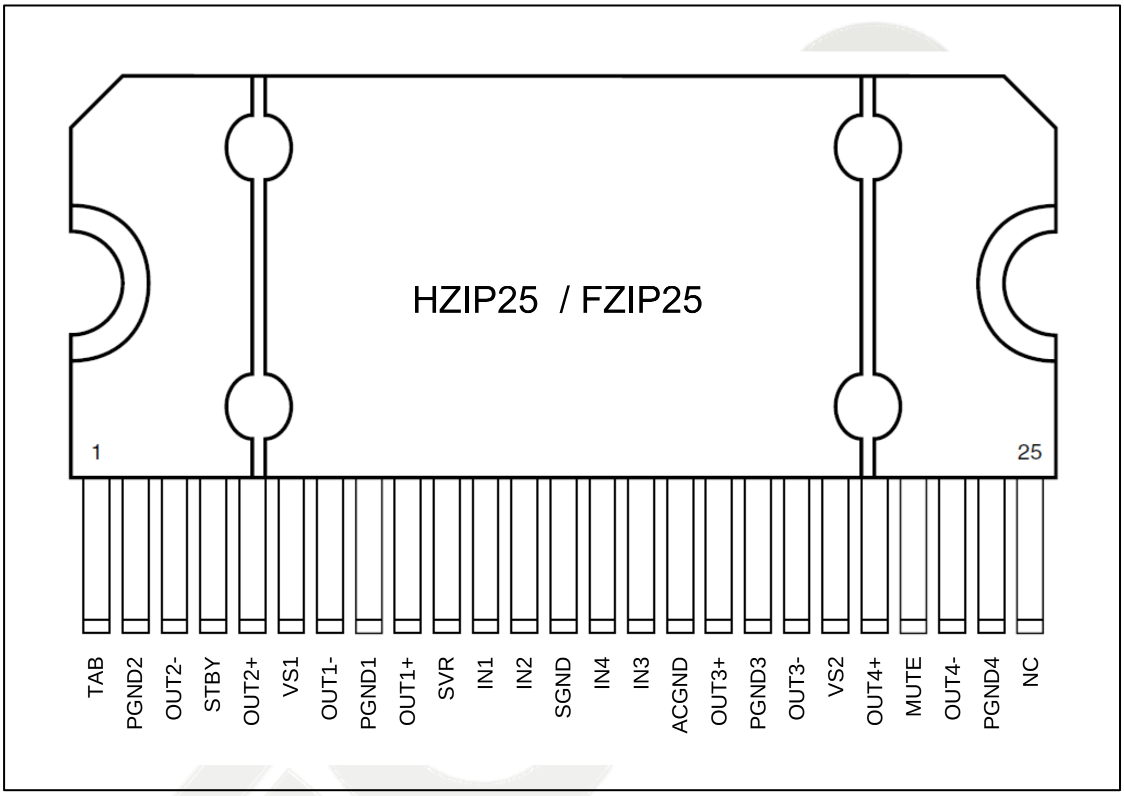
Figure 2 Application circuit



2 Pin Description

2.1 Pin Names

Figure 3 Pin connection



2.2 Pin Functions

Table 2 Pin Functions

Pin number	Pin name	Description
1	TAB	-
2	PGND2	Channel 2, output power ground
3	OUT2-	Channel 2, negative output
4	STBY	Stand-by
5	OUT2+	Channel 2, positive output
6	VS1	Supply voltage
7	OUT1-	Channel 1, negative output
8	PGND1	Channel 1, output power ground
9	OUT1+	Channel 1, positive output
10	SVR	Supply voltage rejection pin
11	IN1	Channel 1, input
12	IN2	Channel 2, input
13	SGND	Signal ground
14	IN4	Channel 4, input
15	IN3	Channel 3, input
16	ACGND	AC ground
17	OUT3+	Channel 3, positive output
18	PGND3	Channel 3, output power ground
19	OUT3-	Channel 3, negative output
20	VS2	Supply voltage
21	OUT4+	Channel 4, positive output
22	MUTE	Mute pin
23	OUT4-	Channel 4, negative output
24	PGND4	Channel 4, output power ground
25	NC	Not Connected

3 Electrical Specifications

3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
VS	Operating supply voltage	18	V
VS (DC)	DC supply voltage	28	V
VS (pk)	Peak supply voltage (for t = 50ms)	50	V
Io	Output peak current	4.5	A
Ptot	Power dissipation T_{case} = 70°C	80	W
Tj	Junction temperature	150	°C
Tstg	Storage temperature	-55 to 150	°C

3.2 Thermal Data

Table 4 Thermal Data

Symbol	Parameter	Value	Unit
Rth j-case	Thermal resistance junction-to-case Max.	1	°C/W

3.3 Electrical Characteristics

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

Table 5 Electrical Characteristics

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
General characteristics						
Vs	Supply voltage range	-	6	-	18	V
Iq	Quiescent current	$R_L = \infty$	100	180	300	mA
Vos	Output offset voltage	Play mode / Mute mode	-90	-	+90	mV
dVOS	During mute ON/OFF output offset voltage	ITU R-ARM weighted	-10	-	+10	mV
	During standby ON/OFF output offset voltage		-15	-	+15	mV
Ri	Input impedance	-	40	55	70	kΩ
ISB	Standby current consumption	Vstby = 0	-	-	1	μA
Audio performances						
Po	Output power	THD = 10%	22	25	-	W
Po max	Maximum output power	Square wave input (2Vrms) Vs = 14.4V; R_L = 4Ω	37	41	-	W
		V_S = 15.2V; R_L = 4Ω		45	-	W
THD	Distortion	P_o = 4W	-	0.005	0.05	%
Gv	Voltage gain	-	25	26	27	dB
dGv	Channel gain unbalance	-	-1	-	+1	dB
eNo	Output Noise	"A" Weighted	-	45	-	μV
		Bw = 20Hz to 20kHz	-	70	100	μV
SVR	Supply voltage rejection	f = 100Hz; V_r = 1Vrms	50	65	-	dB
fch	High cut-off frequency	Po = 0.5W	100	200	-	kHz
CT	Cross talk	f = 1kHz Po = 4W	65	80	-	dB

		f = 10kHz Po = 4W	-	65	-	dB
AM	Mute attenuation	Po ref = 4W	80	100	-	dB
Control pin characteristics						
ISTBY	Standby pin current	Vstby = 1.2V to 2.6V	-	-	1	μA
VSB out	Standby out threshold voltage	(Amp: ON)	2.6	-	-	V
VSB in	Standby in threshold voltage	(Amp: OFF)	-	-	1.2	V
VM out	Mute out threshold voltage	(Amp: Play)	3.5	-	-	V
VM in	Mute in threshold voltage	(Amp: Mute)	-	-	1.2	V
VAM in	Vs auto-mute threshold	(Amp: Mute) Att 80dB; P_O = 4W	5	5.4	5.8	V
		(Amp: Play) Att <0.1dB; P_O = 0.5W	-	-	6	V
Imute	Muting pin current	V_{MUTE} = 1.2V (Sourced current)	5	9	15	μA

4 Functional Description

4.1 Overview

AXPA7388Q is a complementary quad audio power amplifier designed in BCD Technology and it is automotive AEC-Q100 certified. Integrated within the AXPA7388Q are:

- 4 dependent class AB amplifiers with DMOS Mosfet output stages
- Standby function with STBY pin
- Mute function with MUTE pin
- Circuits fully operational down to 6V, with no pop noise and uninterrupted play during battery transitions.
- Protection circuits for
  - short circuit
  - open circuit
  - over voltage
  - over temperature

It is available in package HZIP25 / FZIP25.

4.2 Inputs

AXPA7388Q's channel inputs are ground-compatible with reference to ACGND. Referring to application circuit (Figure 2), input capacitors of 0.47μF will attain a low frequency cut-off of around 16Hz. For best pop noise minimization, input capacitors should be 1/4 of the capacitor connected to ACGND pin.

4.3 Standby and Mute

Standby and Mute functions are controlled by CMOS compatible STBY and MUTE pins.

Control signals for these functions should be coupled to AXPA7388Q using a RC circuit (refer to Figure 2 Application Diagram) to damp any sharp transition, preventing unwanted audible transient noise. If not used, an external resistive pull up to V_S should be connected.

4.4 SVR – Supply Voltage Rejection

The SVR pin is set internally to Vs/4 and serves as the input voltage reference as well as to generate the Vs/2 output reference.

An external capacitor connected to the SVR help in supply voltage ripple rejection and serves 3 functions:

1. Start-up time
2. Shut-down time
3. Pop noise free transitions.

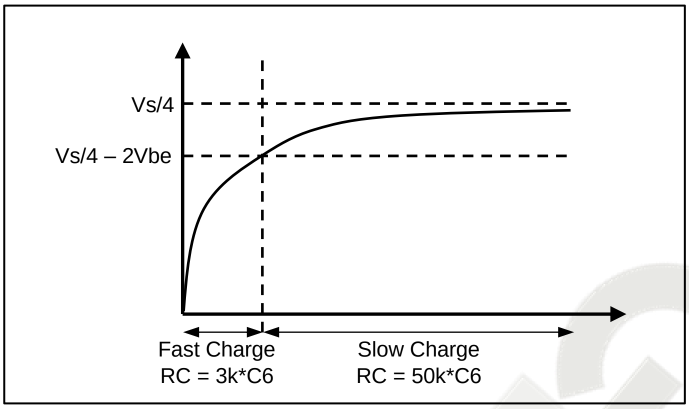
A minimum capacitance value of 10μF is recommended.

Upon STBY going beyond the 2.6V threshold, the SVR pin is charged for normal operation.

The Start-up profile time constant is determined by an internal R coupled with the external capacitor. A 2-step profile is designed with a fast charge of 3kΩ from 0 to VS/4-2Vbe voltage and thereafter a slower charge through 50kΩ to Vs/4 voltage.

A time constant slower than 2.5V/ms is recommended for pop-free transitions.

Figure 4 SVR charge diagram



Proper sequencing of the MUTE and STBY can ensure no audible noise during transition. Placing the amplifier in Mute prior to the device going into or coming out from Standby will ensure no audible noise in the transition.

4.5 Operation Modes

4.5.1 Low Voltage Operation

In the effort to reduce emissions of polluting substances, OEM specifications dictates that the car engine automatically stops when the car is stopping at traffic lights. AXPA7388Q can meet this operation requirement.

It provides for continuous operation when the battery falls as low as 6V, remaining fully operational. The output power is however reduced accordingly to the available voltage supply. Upon battery voltage dropping below 6V, a proper sequencing is performed with amplifier first fast muted and then the SVR capacitor discharged. On returning to above 6V, the amplifier restarts.

4.5.2 Cranks

AXPA7388Q has excellent performance on worst case cranks profile from 16V to 6V, continuing to play and without producing any pop noise. It can sustain operation for battery cranking curves shown below:

Figure 5 Battery cranking curve example 1

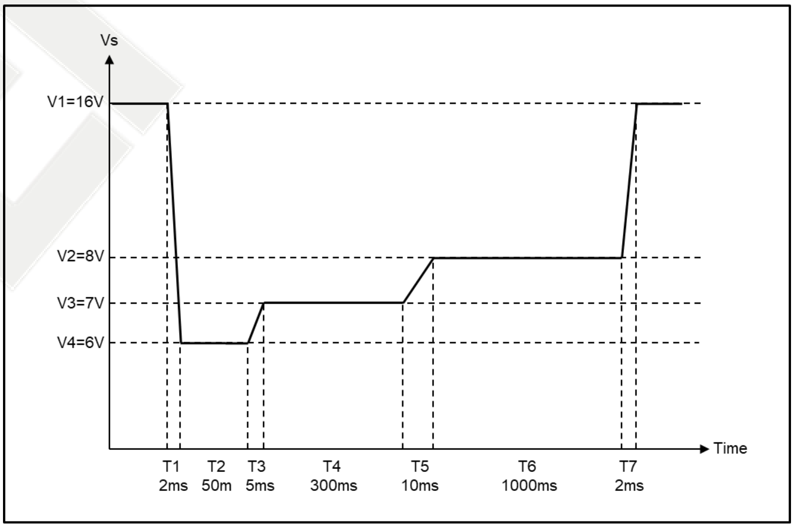
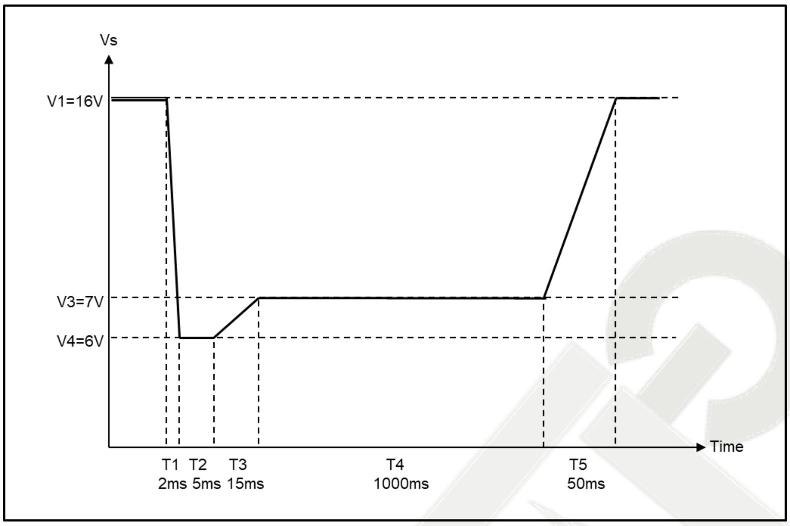


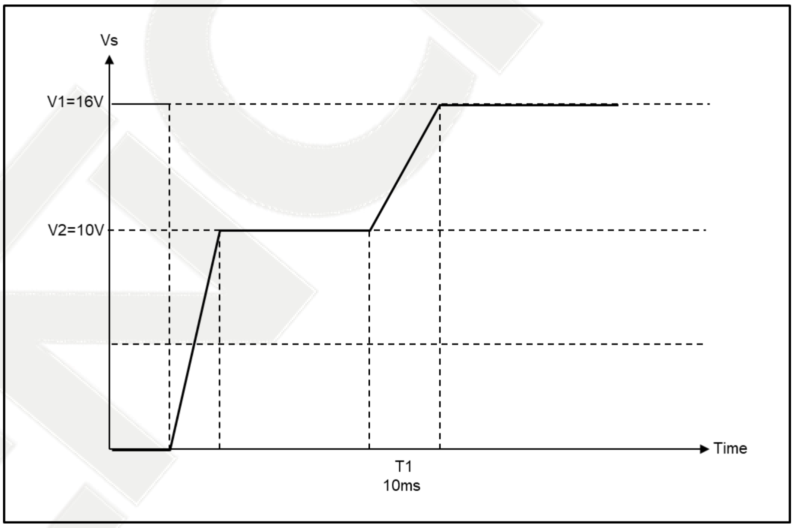
Figure 6 Battery cranking curve example 2



4.5.3 Advanced battery management (hybrid vehicles)

For sudden spikes in battery voltage, as in the case of Hybrid vehicles engine ignition, AXPA7388Q can handle such situations of 16V in 10ms spikes without any pop noise and interruptions.

Figure 7 Upwards fast battery transitions diagram



4.6 Protection

4.6.1 Short circuits

AXPA7388Q detects for short circuit under the conditions of:

1. Short to ground
   When detected, the outputs are put into tristate high impedance. The device will only revert to normal operation when short is removed. This is determined by detecting the output voltage returning to internally set limits.

2. Short to Vs
   When detected, the outputs are put into tri-state high impedance. The device will only revert to normal operation when the short is removed. This is determined by detecting the output voltage returning to internally set limits.

3. Short across the load
   This is determined by sensing an over current at the outputs. The outputs are then put into a high impedance protection mode for 100μs. The short is repeated checked every 100μs, If the short is removed, the amplifier returns to normal operation, otherwise high impedance state is maintained.

4.6.2 Open circuit Operation

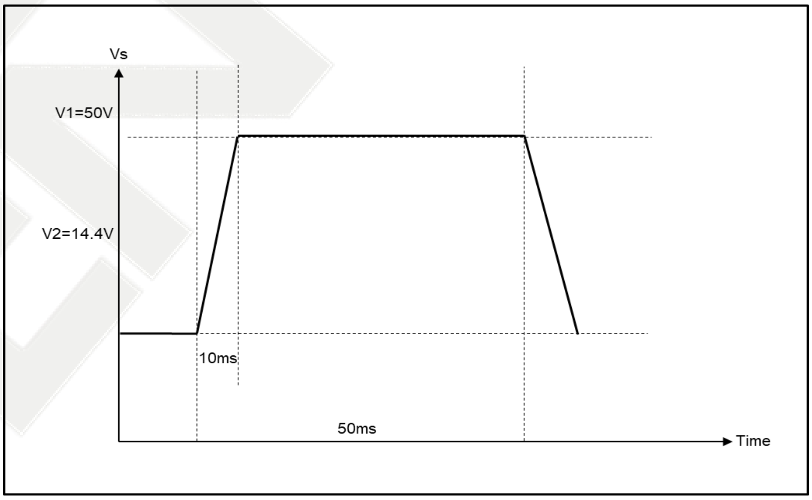
When there is an open load condition, no damage will occur. AXPA7388Q will continue to play.

4.6.3 Over-voltage and load dump

AXPA7388Q is designed to detect over voltage of beyond 19V. When detected, the amplifier outputs go into a high impedance state preventing damage. Normal play operations are reverted when Vs returns to the acceptable range.

The robustness of the design allows for protection against load dumps surges of as high as 50V with 5ms rise time and 50ms duration.

Figure 8 Load dump protection diagram



4.6.4 Thermal protection

Thermal warning is activated at Tj of 140ºC. If Tj rise continues and reaches 150ºC, a slow mute is then activated to reduce output power and dissipation. On reaching Tj of 170ºC, the amplifier will be shutdown to prevent damage.

4.7 Heat sink definition

The power dissipation and temperature generated by the heat dissipation is governed by the following equation.

$$\mathrm{Pd} * (\mathrm{Rthj{\sim}case} + \mathrm{Rthc{\sim}amb}) = \mathrm{Tj} - \mathrm{Ta}$$

Pd = Power dissipation of amplifier (W)
Rthj~case = Thermal resistance from silicon junction to the package casing. (^{o}C/W)
Rthc~amb = Thermal resistance from case to ambient (^{o}C/W)
Tj = Silicon junction operating temperature (^{o}C)
Tamb = Ambient Temperature. (^{o}C)

Example:
Pd= 25W
Rthj~case = 1^{o}C/W
Tj = 150^{o}C
Tamb = 70^{o}C

Rthc~amb = 2.2^{o}C/W

The heatsink need to be designed to have thermal resistance of 2.2^{o}C/W or lower to avoid overheating and thermal shutdown.

5 Package Information

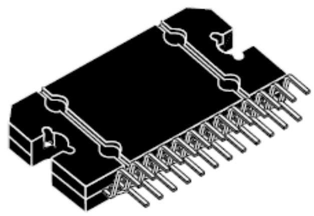
5.1 Package Dimension

Figure 9 HZIP25 / FZIP25 vertical mechanical data and package dimensions

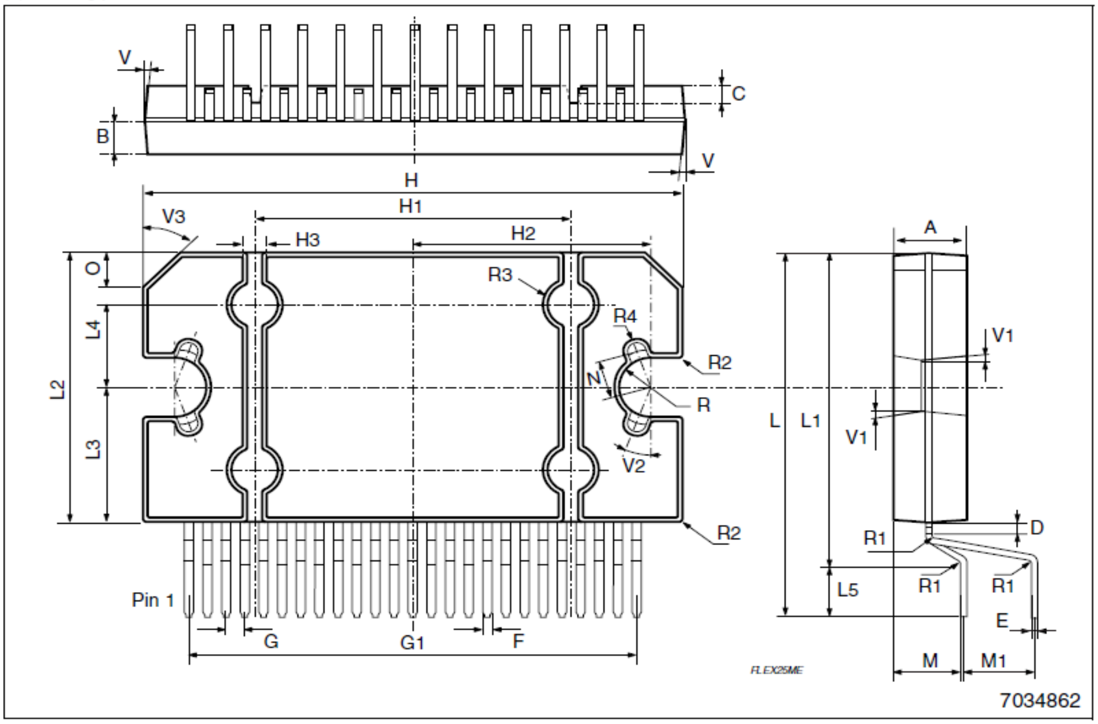
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.45	4.50	4.65	0.175	0.177	0.183
B	1.80	1.90	2.00	0.070	0.074	0.079
C		1.40			0.055	
D	0.75	0.90	1.05	0.029	0.035	0.041
E	0.37	0.39	0.42	0.014	0.015	0.016
F (1)			0.57			0.022
G	0.80	1.00	1.20	0.031	0.040	0.047
G1	23.75	24.00	24.25	0.935	0.945	0.955
H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

OUTLINE AND MECHANICAL DATA

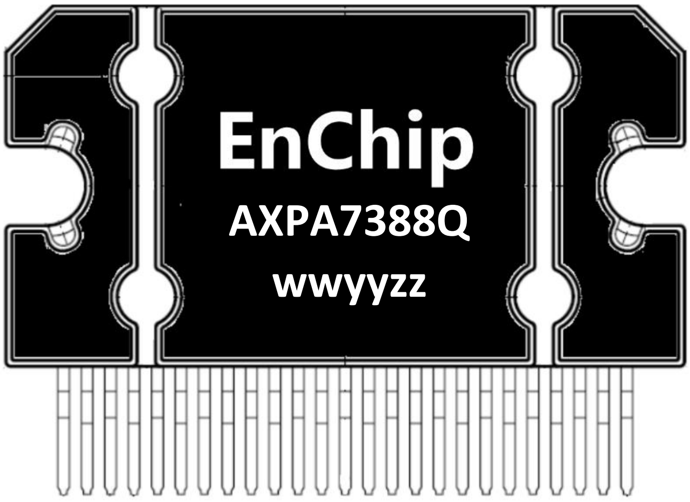


FZIP25



5.2 Marking Information

Figure 10 HZIP25 / FZIP25 Marking Information



3 lines of alphanumeric coding:

Line 1: "EnChip" characters to indicate company name

Line 2: "AXPA7388Q" to indicate part number

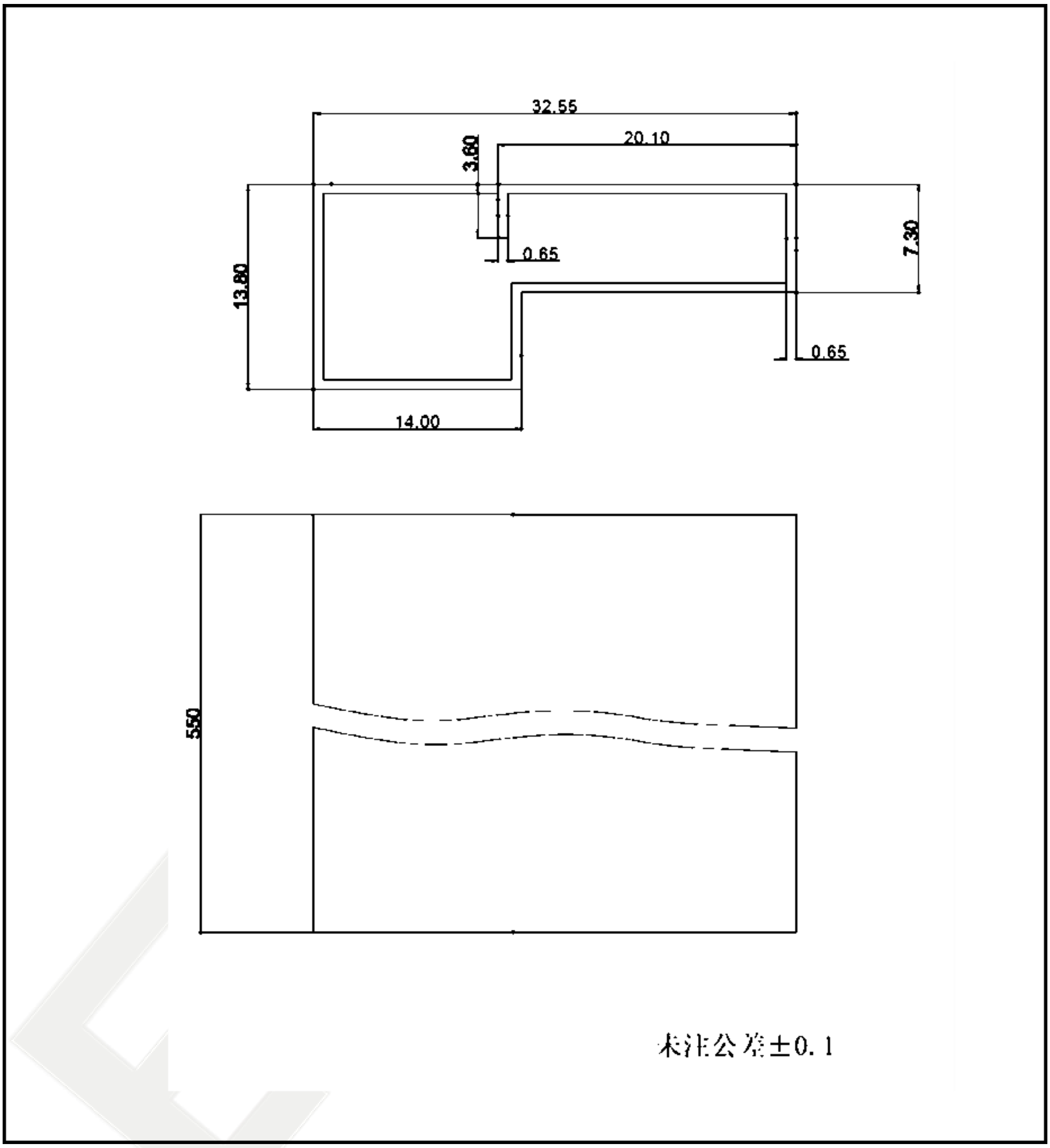
Line 3: "ww" to indicate week of production

"yy" to indicate year of production

"zz" reserve for internal use

6 Packing Information

Figure 11 Tube Packing Information



7 Revision History

Table 6 Document Revision History

Date	Version	Description
Jun 2023	1.00	First Version.