THE PAM8902H IS NOT RECOMMENDED FOR NEW DESIGNS.
PLEASE CONTACT US.

Lead-free Green

PAM8902H

30V$_{PP}$ MONO CLASS-D AUDIO AMPLIFIER FOR PIEZO/CERAMIC SPEAKERS

Description

The PAM8902H is a mono, Class-D audio amplifier with integrated boost converter designed for piezo and ceramic speakers. The PAM8902H is capable of driving a ceramic/piezo speaker with 30V$_{PP}$ (10.6Vrms) from a 3.6V power supply. The PAM8902H's boost converter operates at a fixed frequency of 1.5MHz and provides a 17.5V supply with a minimum number of external components. The PAM8902H features an integrated audio low pass filter that rejects high frequency noise thus improving audio fidelity. And there are three gain modes of 21dB, 26dB, and 32.5dB for easy use. The PAM8902H also provides thermal, short, under and overvoltage protection.

The PAM8902H is available in a 16-ball 1.95mm x 1.95mm CSP-16L package and 16-pin W-QFN4040-16 (Standard) package.

Features

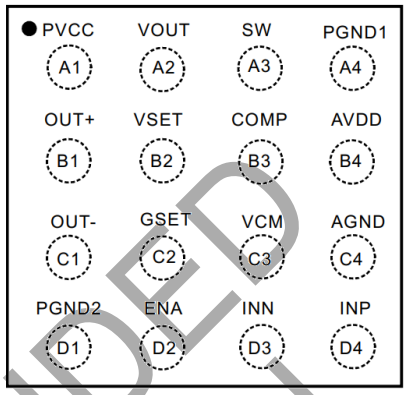
- Supply Voltage Range from 2.5V to 5.5V
- 30V$_{PP}$ Output Load Voltage from a 2.5V Supply
- Integrated Boost Converter Generates 17.5V Supply
- Programmable Soft-Start
- Small Boost Converter Inductor
- Selectable Gain of 21dB, 26dB, and 32.5dB
- Selectable Boost Output Voltage of 8V, 12V, and 17.5V
- Low Shutdown Current: < 1μA
- Built-in Thermal, OCP, OVP, Short Protection
- Available in Space Saving Packages:
  - 16-Ball 1.95mm x 1.95mm CSP-16L Package
  - 16-Pin W-QFN4040-16 (Standard) Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

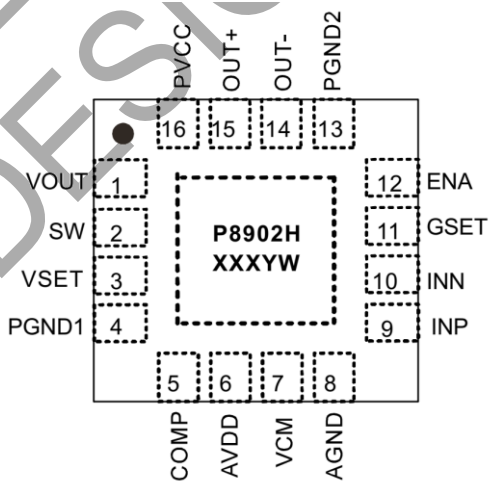
- Wireless or cellular handsets
- Portable DVD players
- Personal digital assistants (PDAs)
- Electronic dictionaries
- Digital still cameras

Pin Assignments

16 Ball CSP-16L
Top View



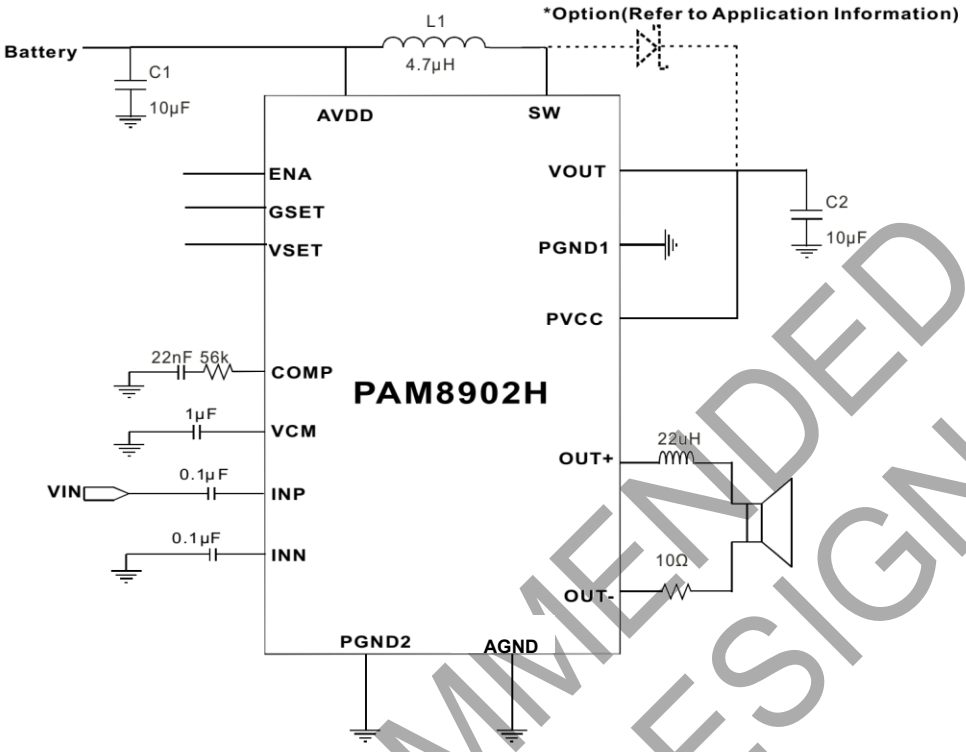
Top View
W-QFN4040-16 (Standard)



● : Pin 1 Indicator

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

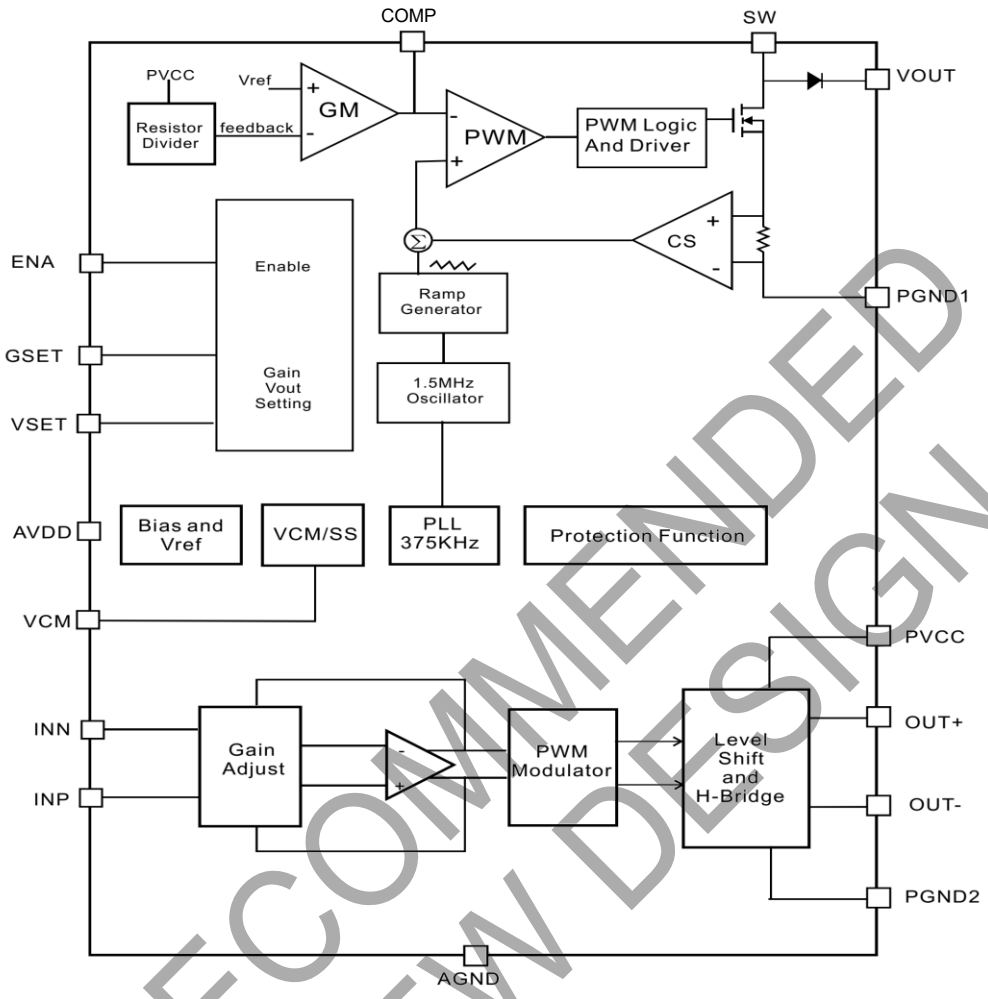
Typical Applications Circuit



Pin Descriptions

Pin Name	Bump CSP-16L	Pin Number W-QFN4040-16 (Standard)	Function
PVCC	A1	16	Audio Amplifier Power Supply
VOUT	A2	1	Boost Converter Output
SW	A3	2	Boost Converter Switching Node
PGND1	A4	4	Boost Converter Power Ground
OUT+	B1	15	Positive Differential Audio Output
VSET	B2	3	Boost Converter Output Voltage Setting (8V, 12V, 17.5V)
COMP	B3	5	Boost Converter Compensation
AVDD	B4	6	Power Supply
OUT-	C1	14	Negative Differential Audio Output
GSET	C2	11	Amplifier Gain Setting (21dB, 26dB, 32.5dB)
VCM	C3	7	Common Mode Bypass Cap
AGND	C4	8	Analog Ground
PGND2	D1	13	Class D Power Ground
ENA	D2	12	Whole Chip Enable
INN	D3	10	Negative Differential Audio Input
INP	D4	9	Positive Differential Audio Input

Functional Block Diagram



Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Parameter	Rating	Unit
Supply Voltage	6.0	V
Input Voltage	-0.3 to V_{DD} +0.3	
Storage Temperature	-65 to +150	°C
Maximum Junction Temperature	+150	
Soldering Temperature	+250, 10s	

Notes: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability. All voltages are with respect to ground.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Parameter	Rating	Unit
Supply Voltage Range	2.5 to 5.5	V
Ambient Temperature Range	-40 to +85	°C
Junction Temperature Range	-40 to +125	

Thermal Information

Parameter	Symbol	Package	Maximum	Unit
Thermal Resistance (Junction to Ambient)	θ_{JA}	CSP-16L	90	°C/W
		W-QFN4040-16 (Standard)	52	
Thermal Resistance (Junction to Case)	θ_{JC}	CSP-16L	72	°C/W
		W-QFN4040-16 (Standard)	30	

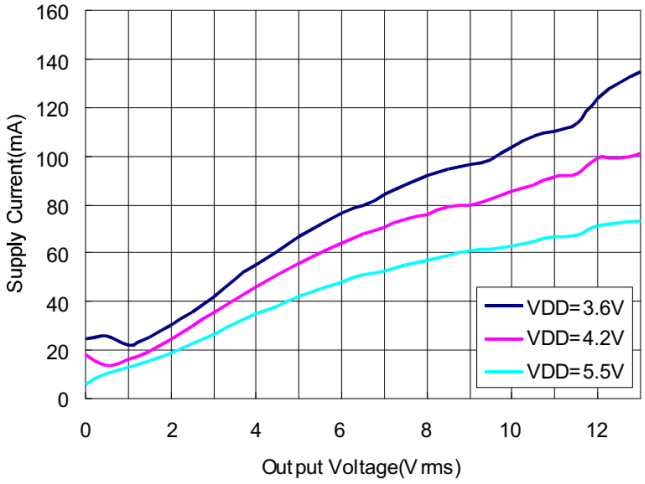
Electrical Characteristics (@T_A = +25°C, V_{DD} = 3.6V, C_L = 1μF, V_{SET} Float, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DD}	Input Voltage	—	2.5	—	5.5	V
I_Q	Quiescent Current	V_{EN} > 1.2V, V_{SET} = High	—	30	48	mA
		V_{EN} > 1.2V, V_{SET} = Floating	—	10	18	
		V_{EN} > 1.2V, V_{SET} = GND	—	5	12	
I_{SD}	Shutdown Current	V_{EN} = 0	—	0.1	1.0	μA
t_{WU}	Wake-up Time	V_{EN} from Low to High	—	40	—	ms
V_{EH}	Chip Enable	—	1.2	—	—	V
V_{EL}	Chip Disable	—	—	—	0.4	
V_H	GSET/VSET High	—	V_{DD} -0.5	—	V_{DD}	V
V_F	GSET/VSET Floating	—	1	—	V_{DD} -1	
V_L	GSET/VSET Low	—	0	—	0.5	
UVLO	Undervoltage Lockout Threshold	V_{DD} from High to Low	—	2.2	—	V
$UVLO_H$	Undervoltage Lockout Hysteresis	V_{DD} from Low to High	—	0.2	—	
OTP	Thermal Shutdown Threshold	—	—	+150	—	°C
OTP_H	Thermal Shutdown Lockout Hysteresis	—	—	+30	—	°C
Boost Converter						
V_O1	Output Voltage	V_{SET} = GND, No Load	7.2	8.0	8.8	V
V_O2		V_{SET} = NC, No Load	10.8	12.0	13.2	V
V_O3		V_{SET} = AVDD, No Load	16	17.5	19	V
C_L	Current Limit	Average Input Current	—	1.0	—	A
R_{LS}	Low Side MOSFET $R_{DS(ON)}$	I_O = 50mA	—	0.5	—	Ω
f_{OSCB}	Boost Switching Frequency	—	1.1	1.5	1.9	MHz
Class D						
f_{OSCD}	Class-D Amplifier Switching Frequency	Input AC-GND	225	375	475	kHz
CMRR	Common Mode Reject Ratio	V_{IN} = ±100mV, V_{DD} = 3.6V	—	60	—	dB
V_{OS}	Output Offset Voltage	Output Offset Voltage	—	5	50	mV
R_P	$R_{DS(ON)}$	High Side	—	1.5	—	Ω
		Low Side	—	0.6	—	Ω
A_V1	Closed-Loop Voltage Gain	G_{SET} = AVDD, V_O = 1V_{RMS}	—	32.5	—	dB
A_V2		G_{SET} = AVDD, V_O = 1V_{RMS}	—	26	—	
A_V3		G_{SET} = AVDD, V_O = 1V_{RMS}	—	21	—	
PSRR	Power Supply Reject Ratio	200m V_{PP} Supply Ripple @ 217Hz	—	70	—	dB
THD+N	Total Harmonious Distortion Plus Noise	V_O = 5V_{RMS}	—	0.3	—	%
SNR	Signal to Noise Ratio	Input AC Ground, A-Weighting	—	90	—	dB

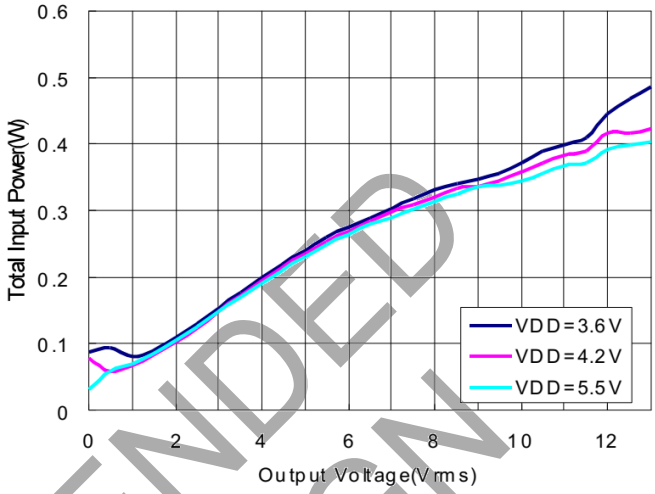
Typical Operating Characteristics

(@T_A = +25°C, V_{DD} = 4.2V, Gain = 26dB, C_{IN} = 1µF, C_{LOAD} = 1µF, unless otherwise specified.)

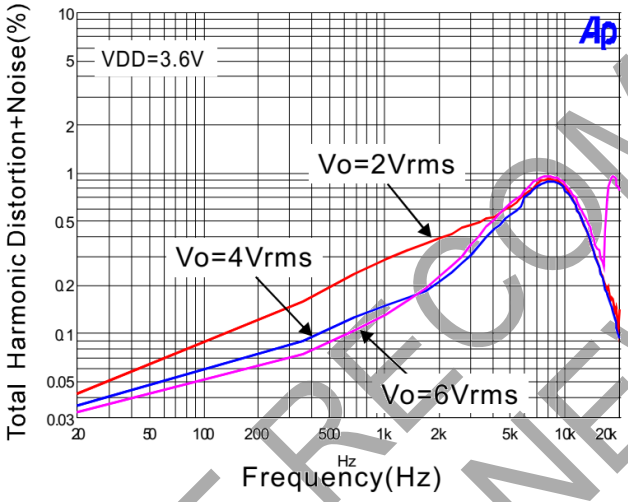
1. Total Supply Current VS Output Voltage



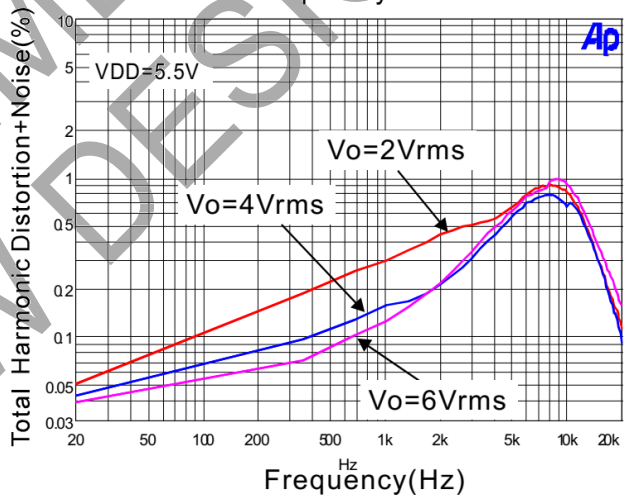
2. Total Input Power VS Output Voltage



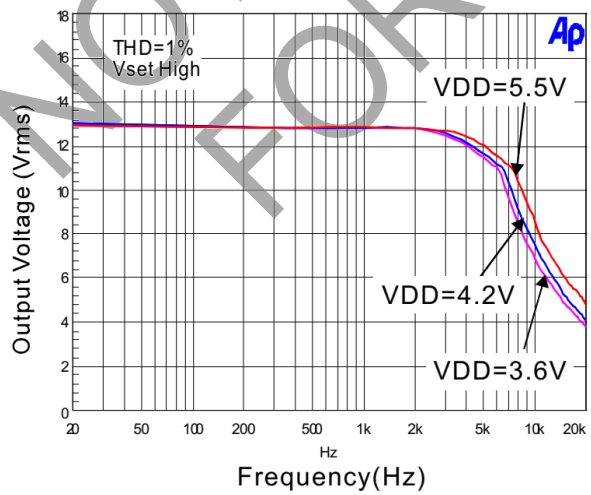
3. THD+N VS Frequency



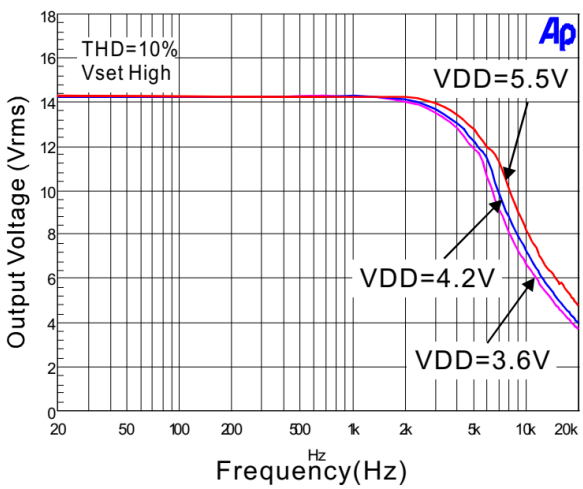
4. THD+N VS Frequency



5. Output Voltage RMS VS Frequency

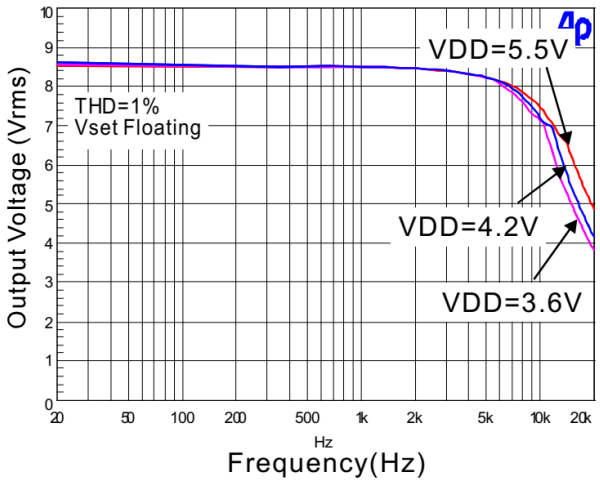


6. Output Voltage RMS VS Frequency

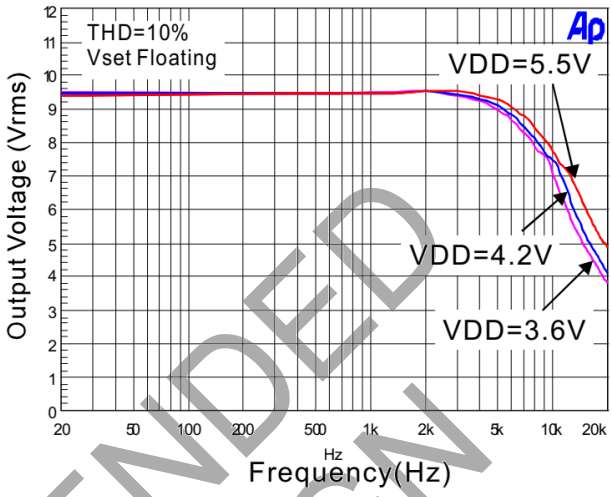


Typical Operating Characteristics (@T_A = +25°C, V_{DD} = 5V, Gain = 18dB, unless otherwise specified.)

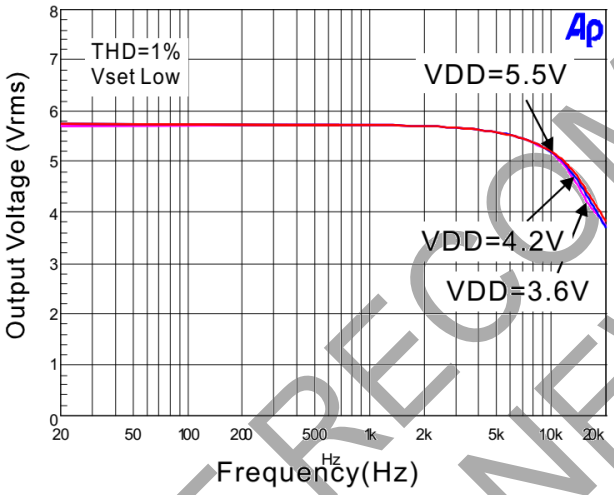
7. Output Voltage RMS VS Frequency



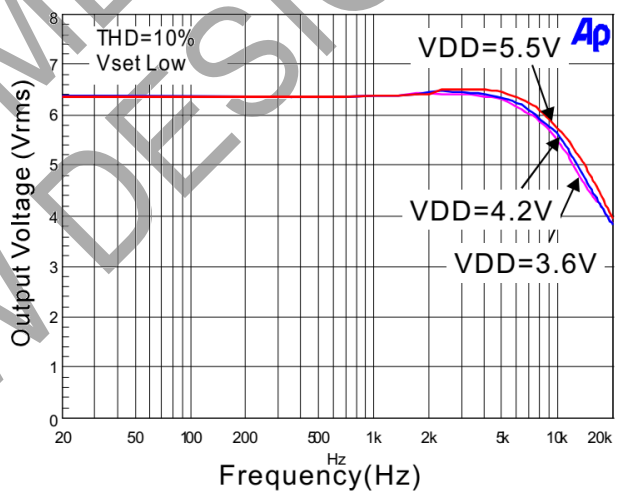
8. Output Voltage RMS VS Frequency



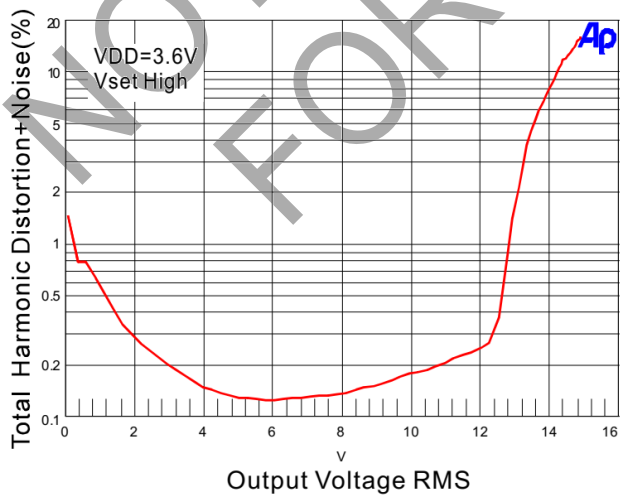
9. Output Voltage RMS VS Frequency



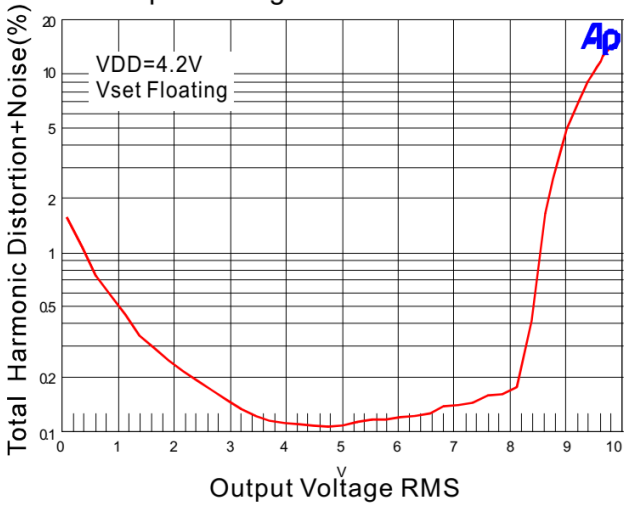
10. Output Voltage RMS VS Frequency



11. Output Voltage RMS VS THD+N



12. Output Voltage RMS VS THD+N



Application Information

Select Boost Converter Output Voltage

Customer can use V_{SET} pin to set boost converter output voltage between 8V, 12V and 17.5V. V_{SET} pin configuration table as below:

V_{SET} Pin Configuration	Min	Max	PVCC Voltage	Audio Amplifier Maximum Output Voltage
Connect to AVDD	AVDD – 0.5V	AVDD	17.5V	$11V_{RMS}$ (V_{PP} = 31.1V)
Floating	1V	AVDD – 1V	12V	$8V_{RMS}$ (V_{PP} = 22.6V)
Connect to GND	GND	0.5V	8V	$5V_{RMS}$ (V_{PP} = 14.1V)

Input Resistance (R_I)

The input resistors ($R_I = R_{IN} + R_{EX}$) set the gain of the amplifier according to Equation 1 when anti-saturation is inactive.

$$G = 20 \text{ Log } [12.8 \times R_F/(R_{IN} + R_{EX})] \text{ (dB)}$$

G_{SET}	R_{IN}	R_F
$G_{SET} = V_{DD}$	36.5kΩ	122.6kΩ
G_{SET} = Floating	59kΩ	100kΩ
G_{SET} = GND	82kΩ	77.4kΩ

Where R_{IN} is a 77.4kΩ internal resistor, R_{EX} is the external input resistor, R_F is a 122.6kΩ internal resistor. Resistor matching is very important in fully differential amplifiers. The balance of the output on the reference voltage depends on matched ratios of the resistors. CMRR, PSRR, and cancellation of the second harmonic distortion diminish if resistor mismatch occurs. Therefore, it is recommended to use 1% tolerance resistors or better to keep the performance optimized. Matching is more important than overall tolerance. Resistor arrays with 1% matching can be used with a tolerance greater than 1%.

Place the input resistors very close to the PAM8902H to limit noise injection on the high-impedance nodes. For optimal performance the gain should be set to lower. Lower gain allows the PAM8902H to operate at its best, and keeps a high voltage at the input making the inputs less susceptible to noise. In addition to these features, higher value of R_I minimizes pop noise.

Input Capacitors (C_I)

In the typical application, an input capacitor, C_I, is required to allow the amplifier to bias the input signal to the proper DC level for optimum operation. In this case, C_I and the minimum input impedance R_I form is a high-pass filter with the corner frequency determined in the following equation:

$$f_C = \frac{1}{2\pi R_I C_I}$$

It is important to consider the value of C_I as it directly affects the low frequency performance of the circuit. For example, when R_I is 150kΩ and the specification calls for a flat bass response are down to 150Hz. Equation is reconfigured as follows:

$$C_I = \frac{1}{2\pi R_{IFC}}$$

When input resistance variation is considered, the C_I is 7nF, so one would likely choose a value of 10nF. A further consideration for this capacitor is the leakage path from the input source through the input network (C_I, $R_I + R_F$) to the load. This leakage current creates a DC offset voltage at the input to the amplifier that reduces useful headroom, especially in high gain applications. For this reason, a low-leakage tantalum or ceramic capacitor is the best choice. When polarized capacitors are used, the positive side of the capacitor should face the amplifier input in most applications as the DC level is held at $V_{DD}/2$, which is likely higher than the source DC level. Please note that it is important to confirm the capacitor polarity in the application.

Application Information (continued)

Decoupling Capacitor

The PAM8902H is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output Total Harmonic Distortion (THD) as low as possible.

The optimum decoupling is achieved by using two different types of capacitors that target on different types of noise on the power supply leads. For higher frequency transients, spikes or digital hash on the line, a good low Equivalent Series Resistance (ESR) ceramic capacitor, typically 1μF, is placed as close as possible to the device AVDD pin for the best operation. For filtering lower frequency noise signals, a large ceramic capacitor of 10μF or greater placed near the AVDD supply trace is recommended.

External Schottky Diode

Using external Schottky diode can get the best driving capability and efficiency. Since internal power diode has limited driving capability, only in the following conditions can customer remove the external Schottky diode to reduce the cost.

1. V_{SET} = GND or Floating and C_L less than 1μF.
2. The signal frequency less than 4kHz.
3. Haptic application (50 to 500Hz)

Shutdown Operation

In order to reduce power consumption while not in use, the PAM8902H contains shutdown circuitry amplifier off when a logic low is placed on the ENA pin. By switching the ENA pin connected to GND, the PAM8902H supply current draw will be minimized in idle mode.

Undervoltage Lockout (UVLO)

The PAM8902H incorporates circuitry designed to detect supply voltage. When the supply voltage drops to 2.2V or below, the PAM8902H goes into a state of shutdown, and the device comes out of its shutdown state and restore to normal function only when resetting the power supply or ENA pin.

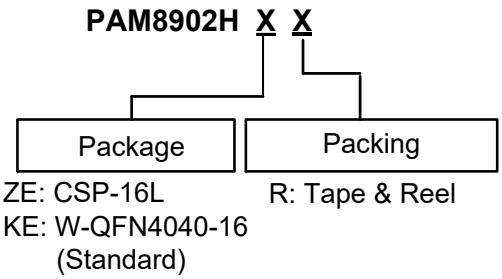
Short-Circuit Protection (SCP)

The PAM8902H has short circuit protection circuitry on the outputs to prevent the device from damage when output-to-output shorted or output-to-GND shorted occurs. When a short circuit occurs, the device goes into a latch state and must be reset by cycling the voltage on the ENA pin to a logic low and then back to the logic high state for normal operation. This will clear the short-circuit flag and allow for normal operation if the short was removed. If the short was not removed, the protection circuitry will again be activated.

Overtemperature Protection (OTP)

Thermal protection on the PAM8902H prevents the device from damage when the internal die temperature exceeds +150°C. There is a +15°C tolerance on this trip point from device to device. Once the die temperature exceeds the set point, the device will enter the shutdown state and the outputs are disabled, in this condition both OUT+ and OUT- will become high impedance. This is not a latched fault. The thermal fault is cleared once the temperature of the die decreased by +30°C. This large hysteresis will prevent motor boating sound well and the device begins normal operation at this point with no external system interaction.

Ordering Information (Note 5)

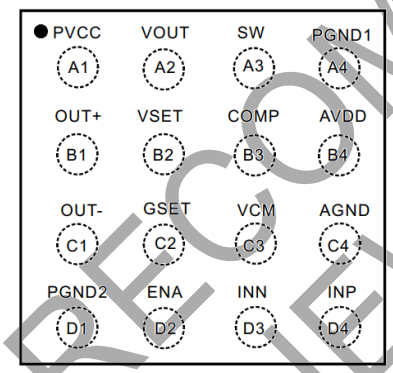


Orderable Part Number	Part Marking	Package	Packing	
			Qty.	Carrier
PAM8902HZER	BT YW	CSP-16L	3000 Units	Tape and Reel
PAM8902HKER	P8902H XXXYW	W-QFN4040-16 (Standard)	3000 Units	Tape and Reel

Note: 5. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

16 Ball CSP-16L
Top View

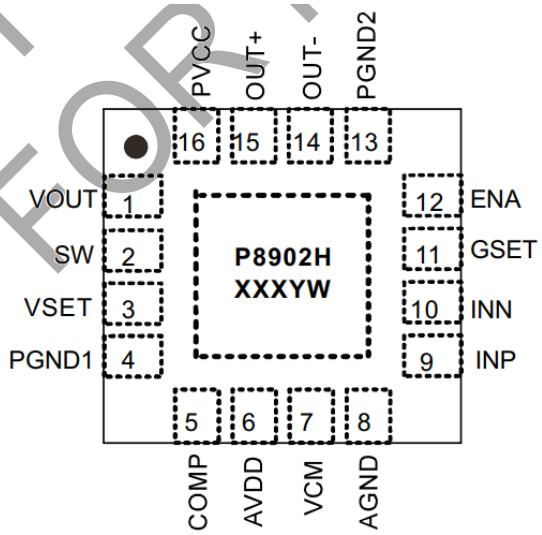


Marking

BT
YW

BT: Product Code of PAM8902H
Y: Year 0 to 9 (ex: 6 = 2026)
W: Week : A to Z : week 1 to 26
a to z : week 27 to 52; z represents week 52 and 53

W-QFN4040-16 (Standard)

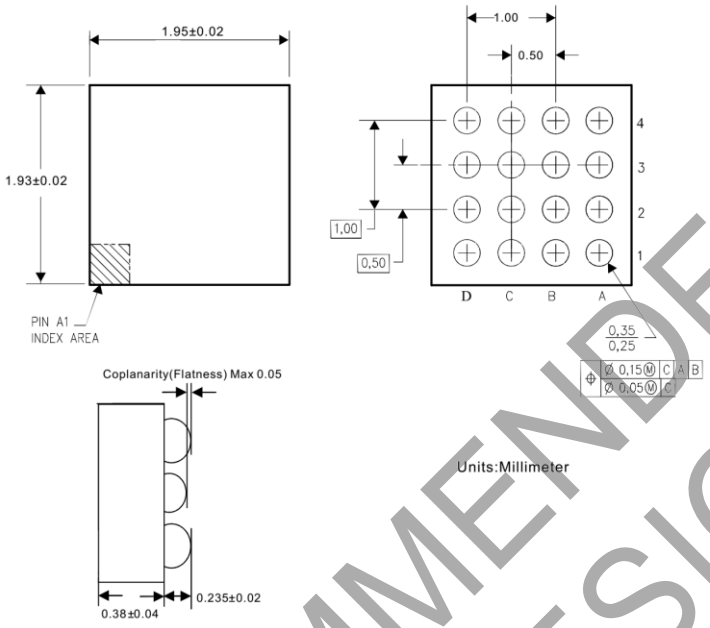


XXX: Internal Code
Y: Year 0 to 9 (ex: 6 = 2026)
W: Week : A to Z : week 1 to 26
a to z : week 27 to 52; z represents week 52 and 53

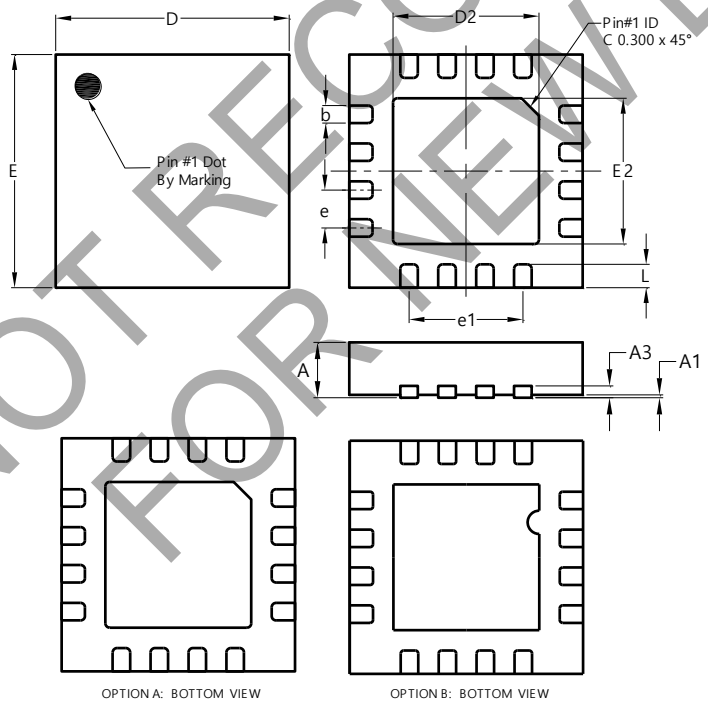
Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

CSP-16L



W-QFN4040-16 (Standard)

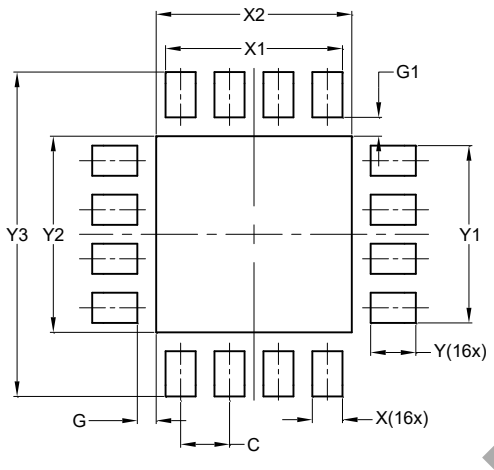


W-QFN4040-16 (Type Standard)			
Dim	**Min**	**Max**	**Typ**
A	0.55	0.80	0.75
A1	0.00	0.05	--
A3	--	--	0.203
b	0.25	0.35	0.30
D	3.95	4.05	4.00
D2	2.45	2.55	2.50
E	3.95	4.05	4.00
E2	2.45	2.55	2.50
e	0.65 BSC		
e1	1.950 REF		
L	0.35	0.45	0.40
z	--	--	0.875
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

W-QFN4040-16 (Type Standard)



Dimensions	Value (in mm)
C	0.650
G	0.250
G1	0.250
X	0.400
X1	2.350
X2	2.600
Y	0.600
Y1	2.350
Y2	2.600
Y3	4.300

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.042 grams (Approximate)

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