2×6.5W Smart Audio Amplifier with Boost Converter, TFB and AGC

FEATURES

- Automatic Gain Control (AGC) with Battery Tracking and Limiter function
  - Battery Tracking: automatically reduce system gain to extend battery life when the battery voltage is low
  - Limiter: adjusts the amplifier gain to prevent heavy clipping
- Integrated Adaptive Sync Boost Converter
  - Increases efficiency at low output power
  - No need for external diode
- Integrated Thermal Foldback (TFB) function
  - Particularly apply to applications with a weak thermal system, significantly increase the peak audio power
- Power Supply/Output
  - V_{BAT} from 2.8V to 5.0V
  - Multiple Boost Output V_{POUT} Settings: 6.5V, 7.5V, 8.0V
- Output Power

  2×4.5 W (V_{BAT}=4.2V, V_{POUT} = 6.5V, R_L=4Ω, THD+N=1%)

  2×5.8W (V_{BAT}=4.2V, V_{POUT} = 7.5V, R_L=4Ω, THD+N=1%)

  2×6.5W (V_{BAT}=4.2V, V_{POUT} = 8.0V, R_L=4Ω, THD+N=1%)

  10.0W (V_{BAT}=4.2V, V_{POUT} = 8.0V, R_L=3Ω, THD+N=3%, PBTL)

  (Do contract and confirm with HT supplier before setting V_{POUT} = 8.0V, otherwise do not use this setting.)
- Gain: 25dB
- Quiescent current: 8.0mA (V_{BAT} = 3.6V)
- Efficiency: 88% (V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 2×0.6W)
- THD+N: 0.03% (V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 2×0.5W)
- Over Current /Thermal/Low voltage malfunction prevention function with auto recovery
- Pb-free Packages,TSSOP28L-PP

DESCRIPTION

The HT868 is a smart audio power amplifier with TFB, AGC technology and an integrated adaptive sync boost converter that enhances efficiency at low output power. It drives up to continuous 10W (3% THD+N, boosted to 8.0V) into 3ohm speaker, or instantaneous 2×6.5W (1% THD+N, boosted to 8.0V) into 4ohm speaker from a Li-battery voltage.

The built-in sync boost converter generates a supply voltage (6.5V, 7.5V, 8.0V optional to meet different out power demands) for the audio amplifier. The boost converter is adaptive and is automatically active only when the peak output audio signal exceeds a preset voltage threshold, which is optimized to prevent clipping while maximizing system efficiency. What more, there's no need for an external diode.

HT868 integrates Automatic Gain Control (AGC), including Limiter and Battery Tracking function. When Limiter function is active, the output music can be limited below a certain power and THD+N. When Battery Tracking function is active, HT868 monitors the battery voltage and the audio signal, automatically decreasing gain when battery is lower than preset voltage and the audio output power is high. It finds the optimal gain to maximize the loudness and minimize the battery current, providing louder audio and preventing early shutdown at end-of-charge battery voltages.

The HT868 Thermal Foldback (TFB) is designed to protect the HT868 from excessive die temperature in case of the device being operated beyond the recommended temperature or power limit, or with a weaker thermal system than recommended. The TFB works by reducing the on-die power dissipation by reducing Gain if the temperature trig point is exceeded, so that the peak audio power is significantly increased.

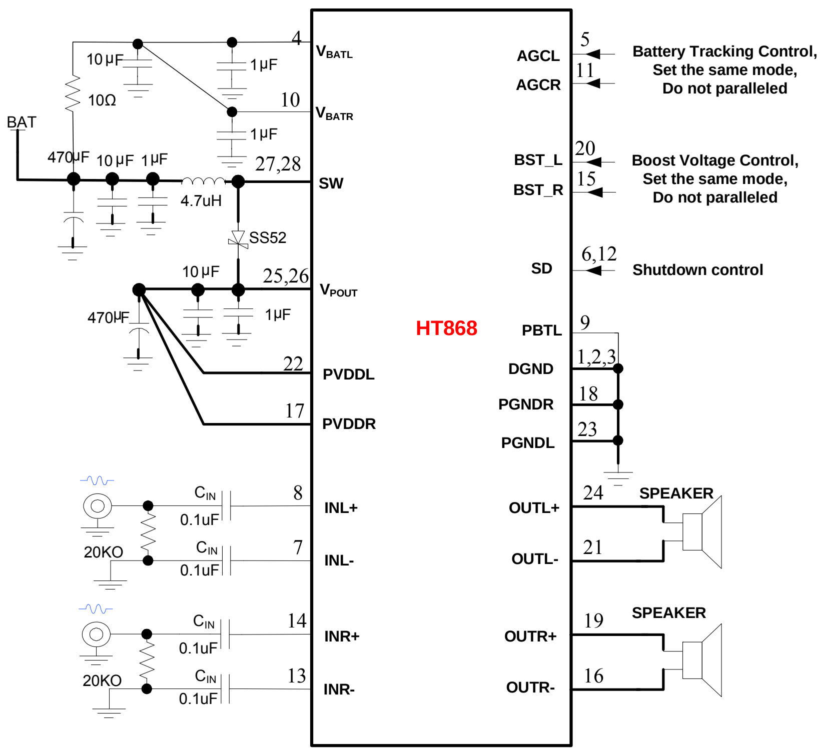
HT868 has a filter-less modulation circuit which can directly drive speakers. HT868 can be shut down so that the power consumption can be minimized. As for protection function, over current protection function for speaker output terminals, over temperature protection function and low supply voltage malfunction preventing function are also prepared.

APPLICATIONS

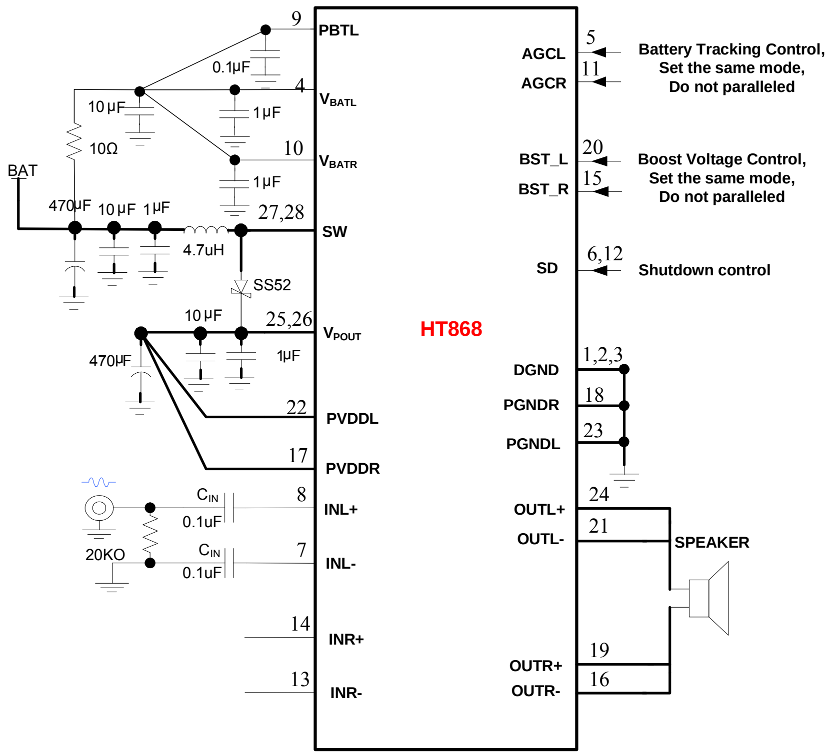
- Bluetooth/Wi-Fi Speakers
- Portable Speakers
- 2.1Channel Speakers
- Megaphone
- Portable Gamers
- MP4, GPS
- Tablet PC/Note Book
- LCD TV/Monitor

■ TYPICAL APPLICATION

1. HT868 BTL MODE

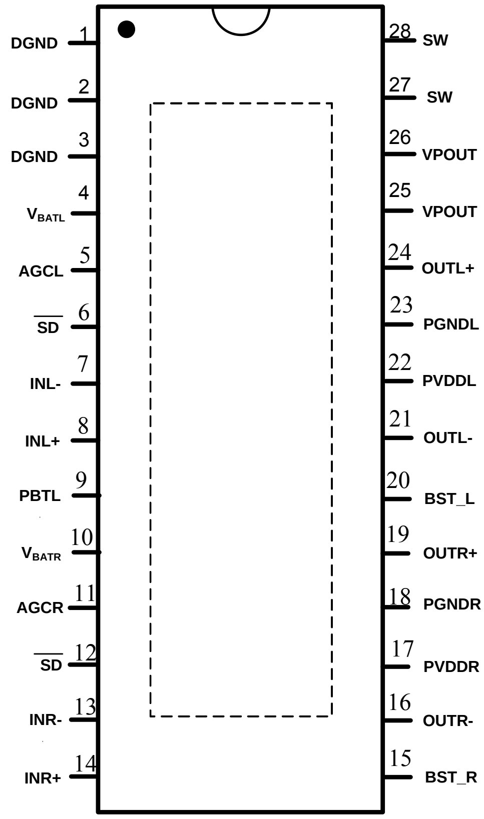


2. HT868 PBTL MODE



Contents

■ TERMINAL CONFIGURATION



HT868 Top View

■ TERMINAL FUNCTION

Terminal No.	NAME	I/O[*1]	Description
1,2,3	DGND	GND	Power ground for boost converter
4	V_{BATL}	Power	Power supply for left channel
5	AGCL	O	Terminal that enables and selects Battery Tracking Function for left channel
6	$\overline{SD}$	I	Shut-down terminal
7	INL-	I	Negative input (differential-) for audio amplifier of left channel
8	INL+	I	Positive input (differential+) for audio amplifier of left channel
9	PBTL	I	Parallel BTL mode switch
10	V_{BATR}	Power	Power supply for right channel
11	AGCR	O	Terminal that enables and selects Battery Tracking Function for right channel
12	$\overline{SD}$	I	Shut-down terminal
13	INR-	I	Negative input (differential-) for audio amplifier of right channel
14	INR+	I	Positive input (differential+) for audio amplifier of right channel
15	BST_R	O	Select boost converter output voltage V_{POUT} for right channel
16	OUTR-	O	Negative output (BTL-) for audio amplifier of right channel
17	PVDDR	Power	Power supply terminal for audio amplifier of right channel
18	PGNDR	GND	Power ground for audio amplifier of right channel
19	OUTR+	O	Positive output (BTL+) for audio amplifier of right channel
20	BST_L	O	Select boost converter output voltage V_{POUT} for left channel
21	OUTL-	O	Negative output (BTL-) for audio amplifier of left channel
22	PVDDL	Power	Power supply terminal for audio amplifier of left channel

23	PGNDL	GND	Power ground for audio amplifier of left channel
24	OUTL+	O	Positive output (BTL+) for audio amplifier of left channel
25,26	V_{POUT}	Power	Boost Converter output voltage
27,28	SW	I	Boost and rectifying switch input
-	PAD	GND	Connect to PGND

*1 I: input O: output

■ ORDERING INFORMATION

H T 8 6 8 xx

xx: Package type

Part Number	Package Type	Marking	Operating Temperature Range	MOQ/Shipping Package
HT868MTE	TSSOP28L-PP	HT868MTE UVWXYZ *2	-40℃～85℃	Tape 30 PCS

*2：WXYZ/UVWXYZ is production track code.

■ ELECTRICAL CHARACTERISTIC

● Absolute Maximum Ratings*3

PARAMETER	Symbol	MIN	MAX	UNIT
Supply voltage range	V_{BAT}	-0.3	V_{POUT}	V
Input voltage range	V_{IN}	-0.3	V_{POUT}+0.3	V
Operating temperature range	T_A	-40	85	℃
Operating junction temperature range	T_J	-40	170	℃
Storage temperature range	T_{STG}	-50	170	℃

*3: Stresses beyond those listed under absolute maximum ratings may 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–rated conditions for extended periods may affect device reliability.

● Recommended Operating Conditions

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VBAT supply voltage range	V_{BAT}		2.8	3.6	V_{POUT} -0.5	V
High-level input voltage of $\overline{SD}$, PBTL	V_{IH}		1.5			V
Low-level input voltage of $\overline{SD}$, PBTL	V_{IL}				0.4	V
Operating temperature	T_a		-40	25	85	℃
Load impedance	R_L	BTL		4		Ω
		PBTL	2			

Electrical Characteristics[*4]

Condition: Ta=25ºC, V_{BAT} = 3.6V, f_{IN} = 1 kHz, Gain = 25dB, C_{IN} = 1uF, Battery tracking disabled (AGC floating, Point off), Load = 4ohm + 22uH, unless otherwise specified.

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VBAT supply voltage range	V_{BAT}	Boost + Amp work	2.8	3.6	V_{POUT} -0.5	V
Boost on threshold voltage	V_{B_TH}	Amplifier Output V_{RMS}		0.415×V_{BAT}		V
Start-up time	t_{ON}	t_{BOOST_ON}, Boost only		1.5		ms
		t_{AMP_ON}, Audio Amplifier only		60		
Closed-loop voltage gain	Av		23.5	25	26.5	dB
Input impedance (per input pin)	R_{IN}			31.4		KΩ
Boost Converter						
Boost converter output voltage range	V_{POUT}	R_{BOOST} = Floating	6.25	6.45	6.75	V
		R_{BOOST} = 33kΩ (±1%)	7.25	7.45	7.75	
		R_{BOOST} = 5.1kΩ (±1%)	7.65	7.85	8.15	
Boost shut off time	t_{BOOST_OFF}			208		ms
Boost converter input current limit	I_L			3.5		A
Boost converter frequency	f_{BOOST}			800		kHz
Boost Converter + Class D (BTL)						
Output power	P_O	V_{POUT} = 6.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		2×4.5		W
		V_{POUT} = 7.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		2×5.8		
		V_{POUT} = 8.0V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		2×6.5		
		V_{POUT} = 6.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 8ohm + 22uH		2×2.5		
		V_{POUT} = 7.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 8ohm + 22uH		2×3.5		
		V_{POUT} = 8.0V; THD+N=1%, V_{BAT} = 4.2V, Load = 8ohm + 22uH		2×3.8		
Total harmonic distortion plus noise	THD+N	P_O=0.4W; R_L=4Ω+22uH, f=1kHz		0.03		%
		P_O=1.0W; R_L=4Ω+22uH, f=1kHz		0.04		
Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB		45		μVrms
Efficiency (Class D + Boost)	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 2×0.6W		88		%
		V_{POUT} = 6.5V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 2×3.0W		74		
		V_{POUT} = 7.5V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 2×3.0W		72		
		V_{POUT} = 8.0V; V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 2×3.0W		70		
		V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2×0.3W		87		
		V_{POUT} = 6.5V; V_{BAT} = 4.2V, R_L =8Ω+33uH, Po = 2×2.0W		75		
		V_{POUT} = 7.5V; V_{BAT} = 4.2V, R_L =8Ω+33uH, Po = 2×2.0W		72		
		V_{POUT} = 8.0V; V_{BAT} = 4.2V, R_L =8Ω+33uH, Po = 2×2.0W		70		
Operating quiescent current	I_{BAT}	Input Grounded, With or without load		8		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load			1	μA
Class D switching frequency	$f_{ClassS-D}$			400		kHz
Boost Converter + Class D (PBTL)						
Output power	P_O	V_{POUT} = 6.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		5.0		W
		V_{POUT} = 7.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		6.5		
		V_{POUT} = 8.0V; THD+N=1%, V_{BAT} = 4.2V, Load = 4ohm + 22uH		7.3		
		V_{POUT} = 6.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 3ohm + 22uH		6.4		
		V_{POUT} = 7.5V; THD+N=1%, V_{BAT} = 4.2V, Load = 3ohm + 22uH		8.5		
		V_{POUT} = 8.0V; THD+N=1%, V_{BAT} = 4.2V, Load = 3ohm + 22uH		9.5		

		V_{POUT} = 8.0V	THD+N=3% V_{BAT} = 4.2V Load = 3ohm + 22uH		10		
Total harmonic distortion plus noise	THD+N	P_O=0.7W	R_L=3Ω+ 22uH, f=1kHz		0.02		%
		P_O=1.5W			0.05		
Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB			45		μV_{rms}
Efficiency	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 2×0.8W			88		%
		V_{POUT} = 6.5V	V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 2×3.0W		75		
		V_{POUT} = 7.5V			75		
		V_{POUT} = 8.0V			75		
		V_{BAT} = 4.2V, R_L = 3Ω+22uH, Po = 2×1.0W			88		
		V_{POUT} = 6.5V	V_{BAT} = 4.2V, R_L = 3Ω+22uH, Po = 2×2.0W		73		
		V_{POUT} = 7.5V			70		
		V_{POUT} = 8.0V			73		
Operating quiescent current	I_{BAT}	Input Grounded, With or without load			8		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load				1	μA
Class D switching frequency	$f_{ClassS-D}$				400		kHz
Automatic Gain Control (AGC)							
AGC gain range	Av_{AGC}				30		dB
AGC gain step	STP_{AGC}				80		/
AGC attack time	t_{A_AGC}				12		ms/dB
AGC release time	t_{R_AGC}				150		ms/dB
Limiter level (Peak)	V_{LIM_L}				0.95×V_{POUT}		V
VBAT vs. Limiter slope	S_{BAT}	V_{POUT} = 6.5V			3.1		V/V
		V_{POUT} = 7.5V			3.5		
		V_{POUT} = 8.0V			4.1		
AGC battery tracking point	Point2	R_{AGC} = 33kΩ (±5%)			3.5		V
	Point3	R_{AGC} = 5.1kΩ (±5%)			3.8		
Thermal Foldback (TFB)							
Over temperauture protection point	OTP				170		℃
Over temperature protection hysteresis	OTP_{hys}				30		℃
Over temperature protection recovery point	OTPR				140		
Thermal foldback trig point	TFB				150		℃
TFB attack time	t_{A_TFB}				1200		ms/dB
TFB release time	t_{R_TFB}				2400		ms/dB
Input/Output							
Battery tracking control pin (AGC) voltage	V_{AGC}	AGC without battery tracking (Floating)		2			V
		Point 2(3.5V), R_{AGC} = 33kΩ (±5%)		0.85		1.5	
		Point 3(3.8V), R_{AGC} = 5.1kΩ (±5%)		0		0.6	
Boost voltage control pin (BST) voltage	V_{BST}	V_{POUT} = 6.5V (Floating)		2			V
		V_{POUT} = 7.5V, R_{BST} = 33kΩ (±5%)		0.85		1.5	
		V_{POUT} = 8.0V, R_{BST} = 5.1kΩ (±5%)		0		0.6	
AGC control pin output	I_{AGC}				40		μA

current						
BOOST control pin output current	I_{BOOST}			40		μA
Internal pulldown resistor of PBTL	R_{DOWN}			300		kΩ
Internal pulldown resistor of $\overline{SD}$	R_{DOWN}			150		kΩ
High-level input voltage of $\overline{SD}$, PBTL	V_{IH}		1.5			V
Low level input voltage of $\overline{SD}$, PBTL	V_{IL}				0.4	V

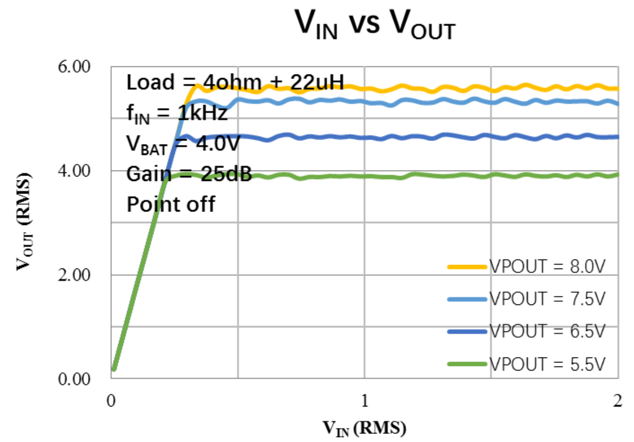
*4: Depending on parts and PCB layout, characteristics may be changed.

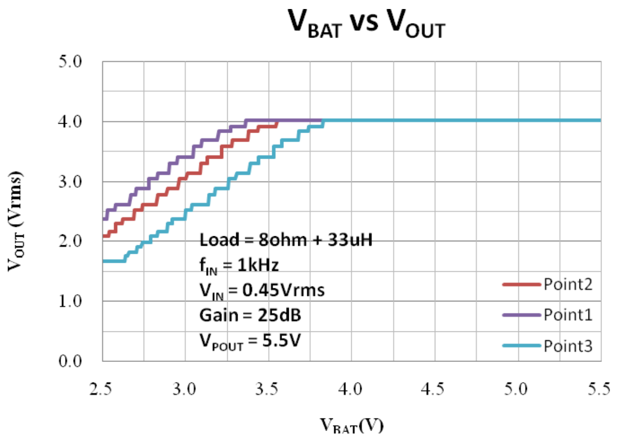
■ TYPICAL OPERATING CHARACTERISTICS

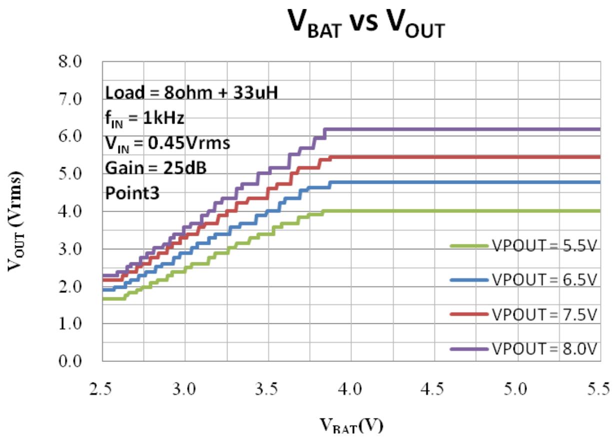
Condition: V_{BAT} = 4.2V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, unless otherwise specified.

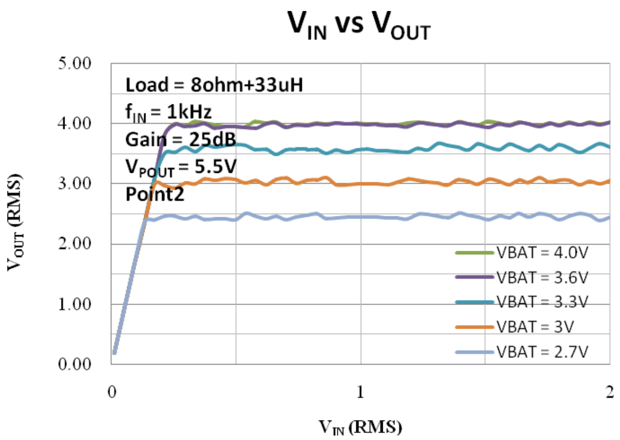
AGC

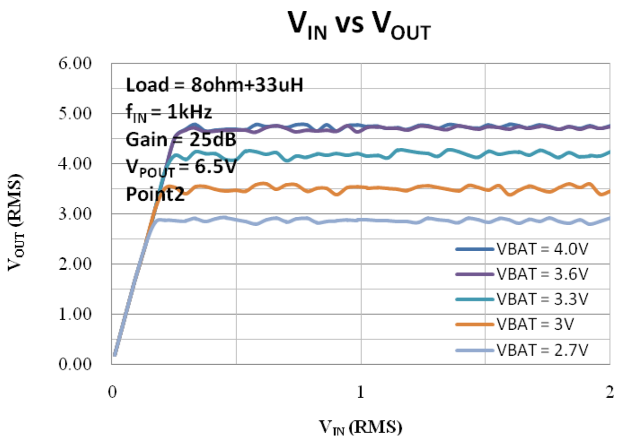
Characteristics below are measured in Class D mode, both BTL and PBTL mode are available.
Condition: V_{BAT} = 4.2V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter ON, Battery tracking enabled (Point 3), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.

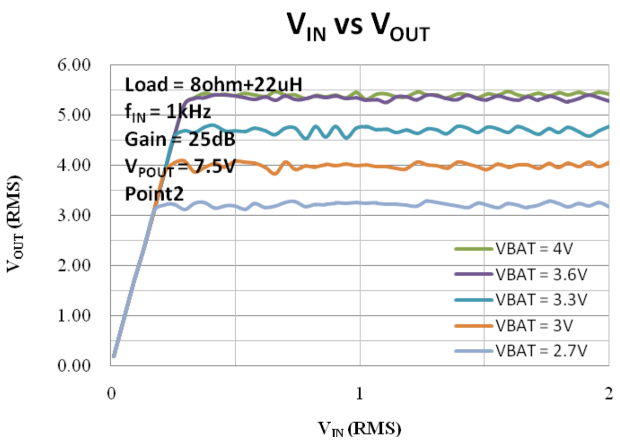


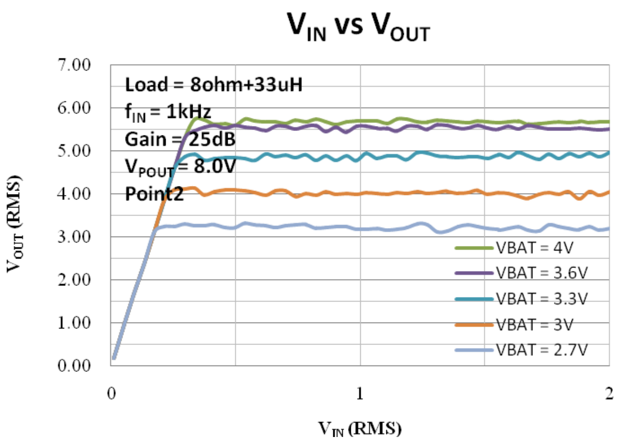






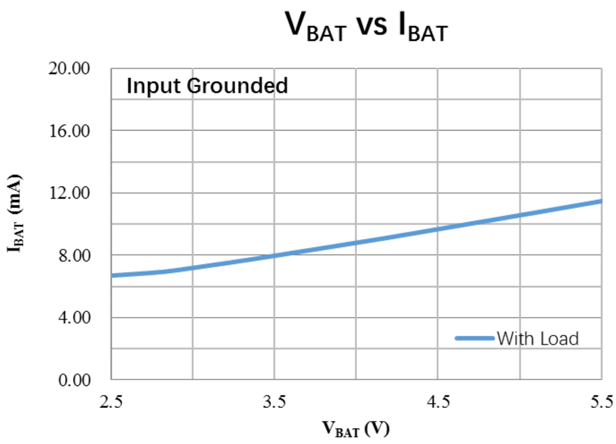


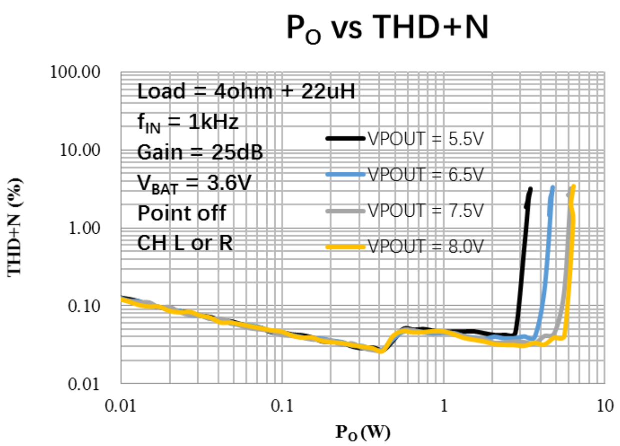

V_{IN} vs V_{OUT}
Load = 8ohm+22uH
f_{IN} = 1kHz
Gain = 25dB
V_{POUT} = 7.5V
Point2
VBAT = 4V
VBAT = 3.6V
VBAT = 3.3V
VBAT = 3V
VBAT = 2.7V
V_{OUT} (RMS)
V_{IN} (RMS)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
1
2

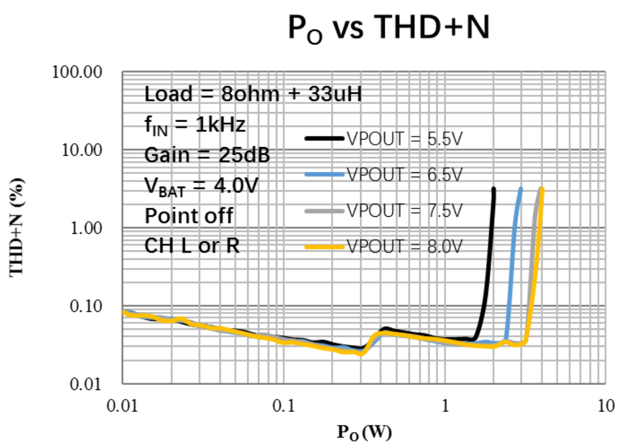

V_{IN} vs V_{OUT}
Load = 8ohm+33uH
f_{IN} = 1kHz
Gain = 25dB
V_{POUT} = 8.0V
Point2
VBAT = 4V
VBAT = 3.6V
VBAT = 3.3V
VBAT = 3V
VBAT = 2.7V
V_{OUT} (RMS)
V_{IN} (RMS)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
1
2

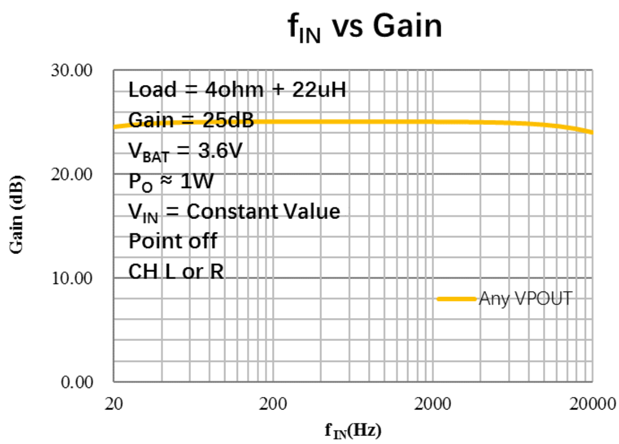
BOOST + Class D (BTL)

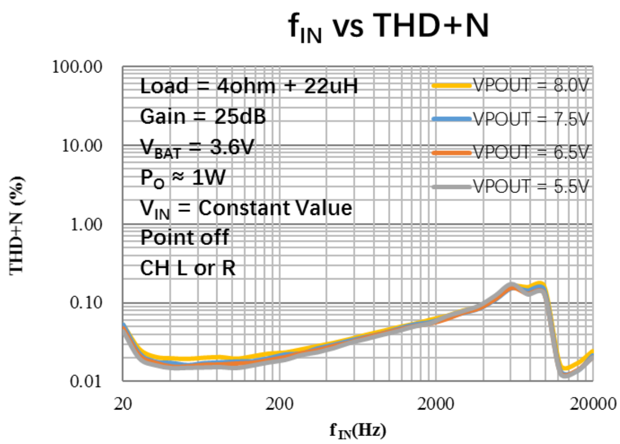
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter ON, Battery tracking disabled (Point off), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.



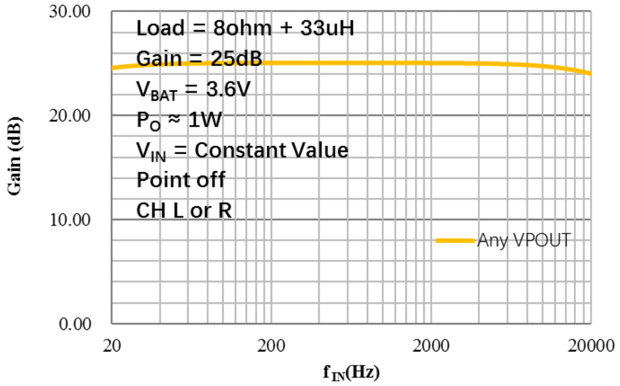




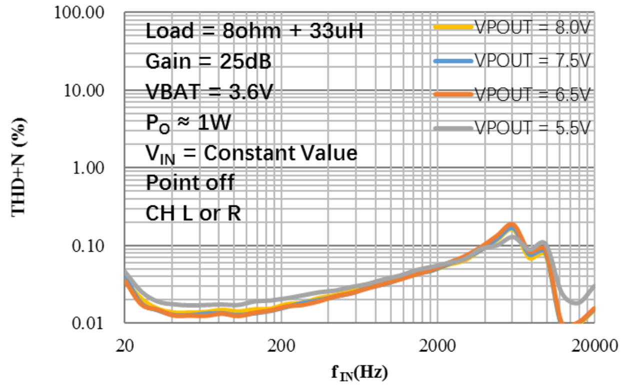




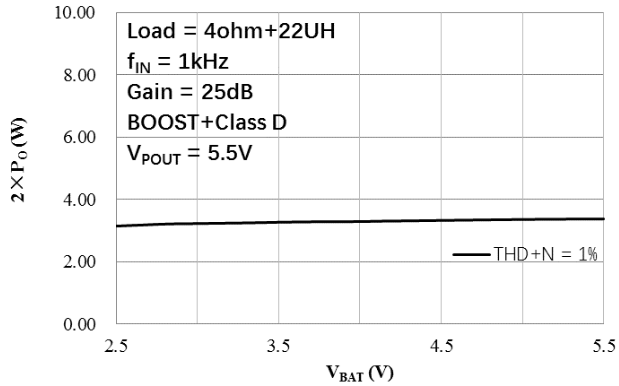
f_{IN} vs Gain



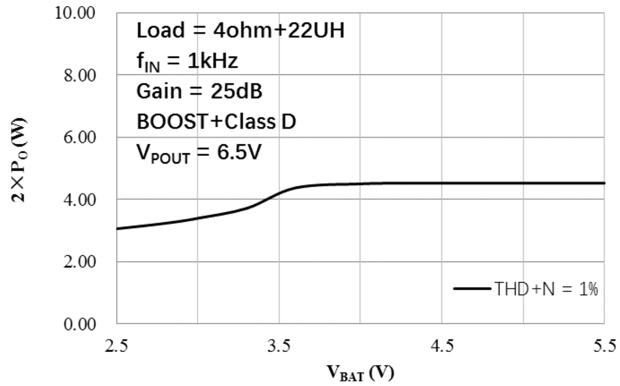
f_{IN} vs THD+N



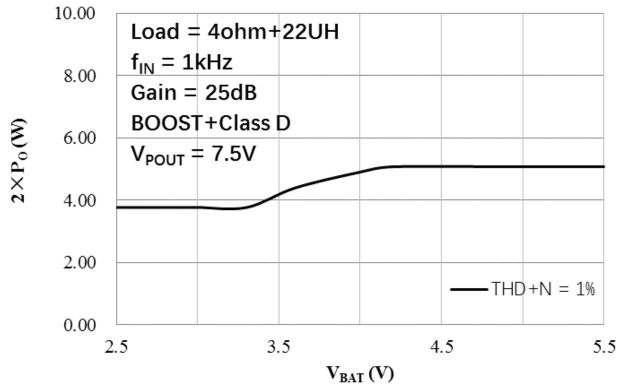
V_{BAT} vs $2\times P_O$



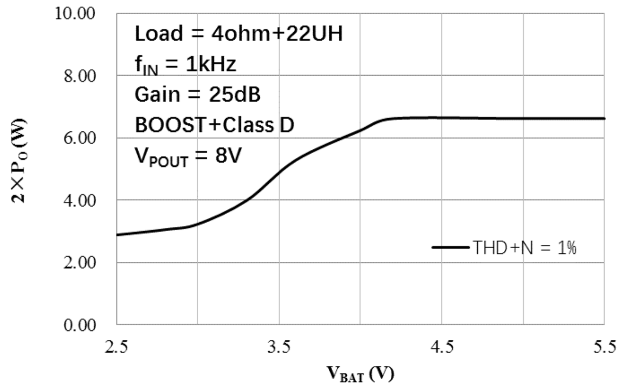
V_{BAT} vs $2\times P_O$



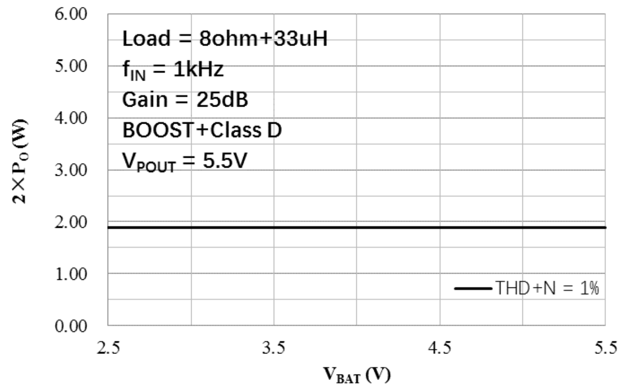
V_{BAT} vs $2\times P_O$



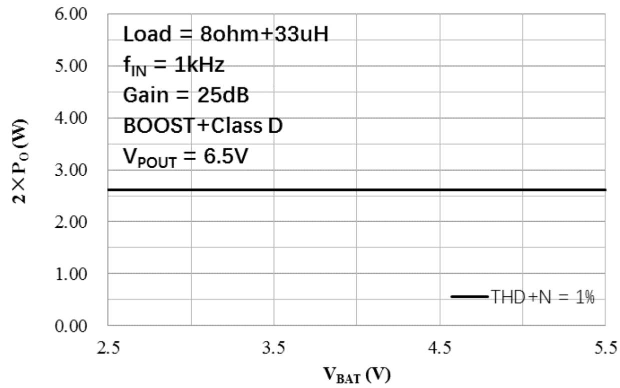
V_{BAT} vs $2\times P_O$



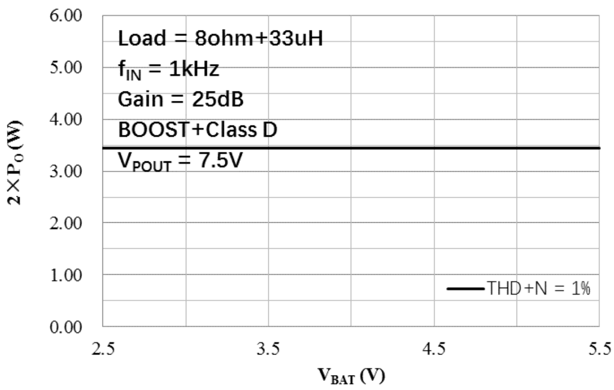
V_{BAT} vs $2\times P_O$



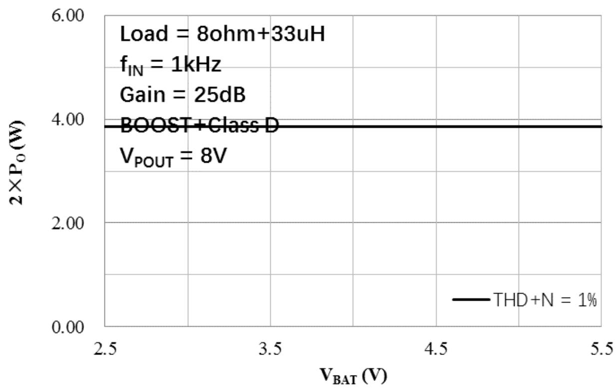
V_{BAT} vs $2\times P_O$



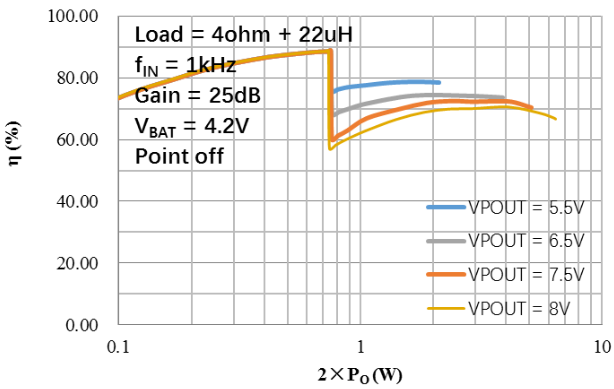
V_{BAT} vs $2\times P_O$



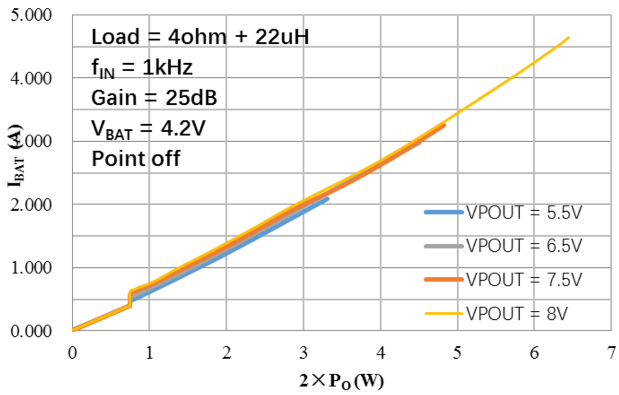
V_{BAT} vs $2\times P_O$



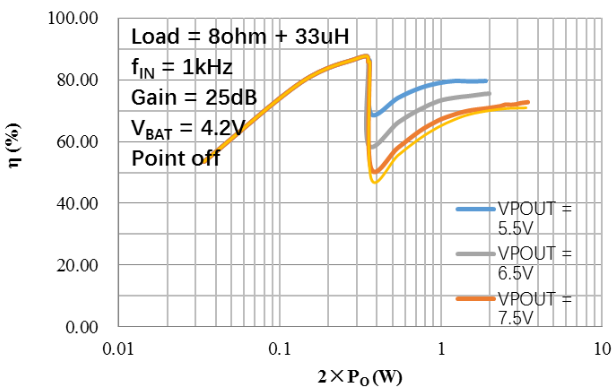
$2\times P_O$ vs η



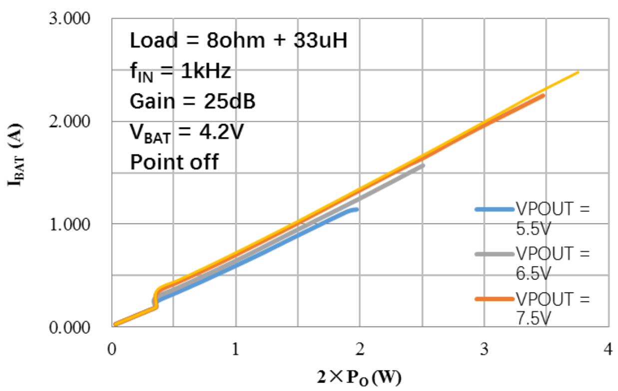
$2\times P_O$ vs I_{BAT}



$2\times P_O$ vs η



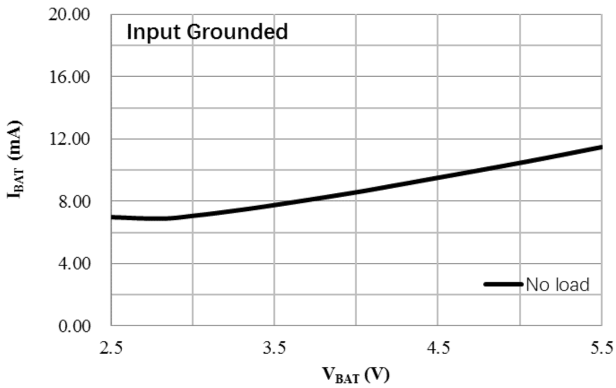
$2\times P_O$ vs I_{BAT}



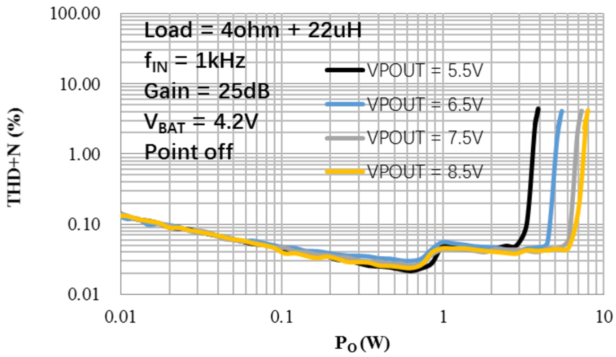
BOOST + Class D (PBTL)

Condition: V_{BAT} = 4.2V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Battery tracking disabled (Point off), Output = Load = 4ohm + 22uH, unless otherwise specified.

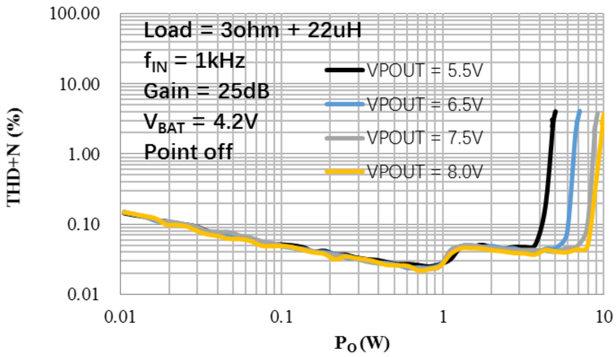
V_{BAT} vs I_{BAT}



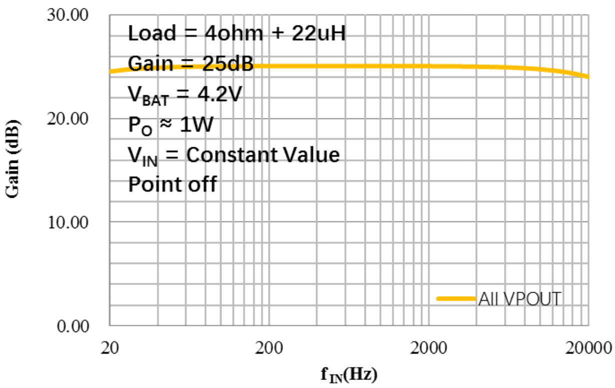
P_O vs THD+N



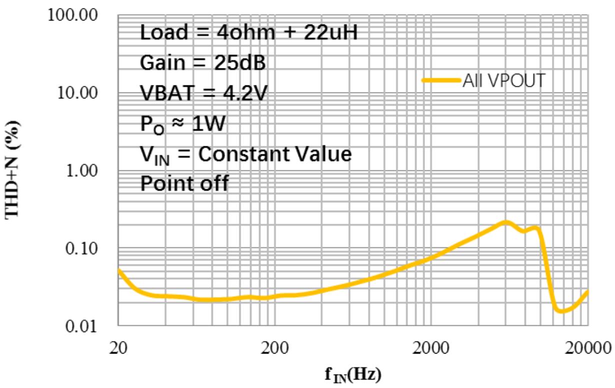
P_O vs THD+N



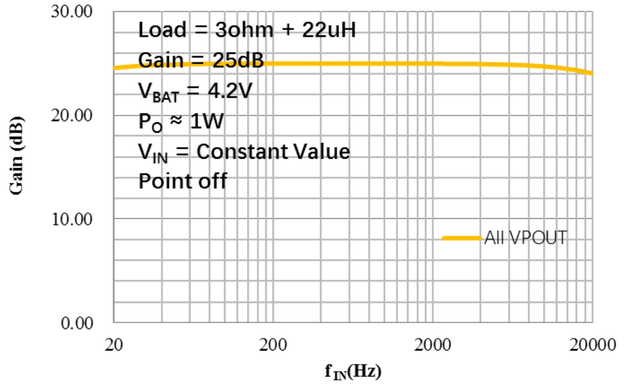
f_{IN} vs Gain



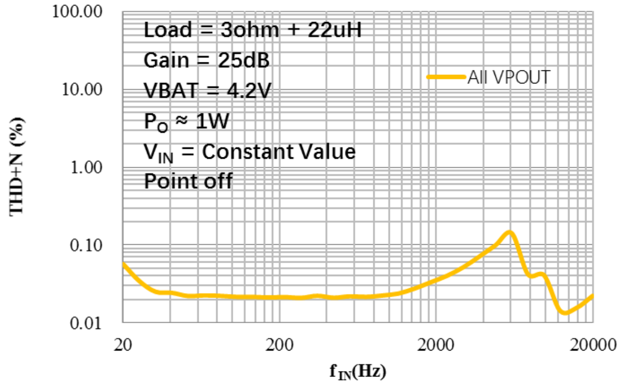
f_{IN} vs THD+N



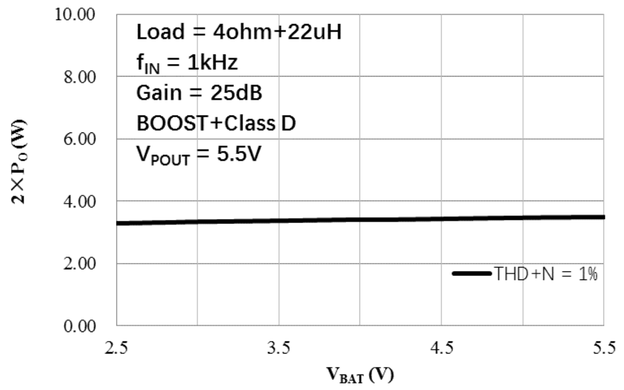
f_{IN} vs Gain



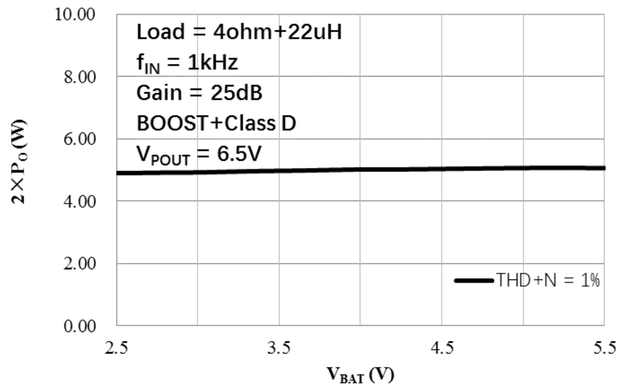
f_{IN} vs THD+N



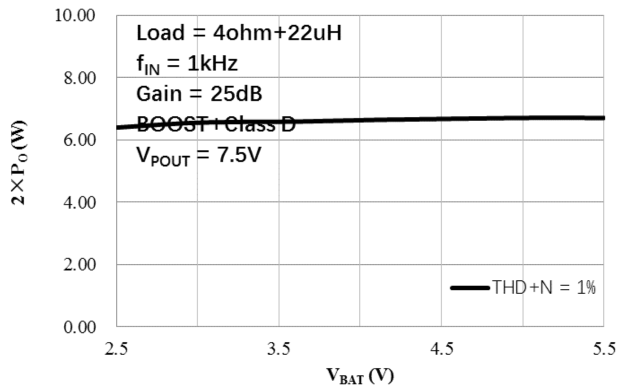
V_{BAT} vs $2\times P_O$



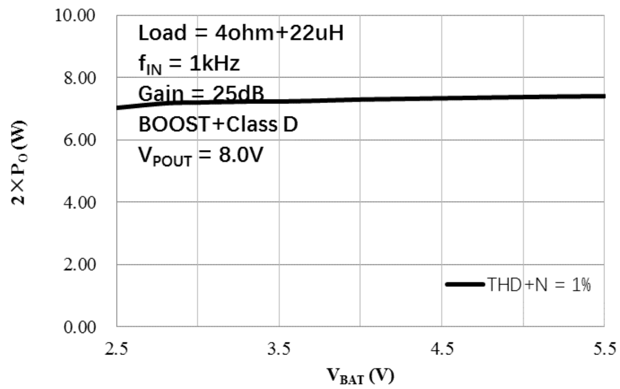
V_{BAT} vs $2\times P_O$



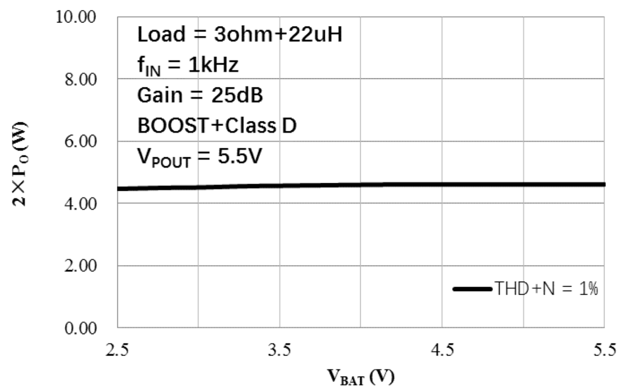
V_{BAT} vs $2\times P_O$



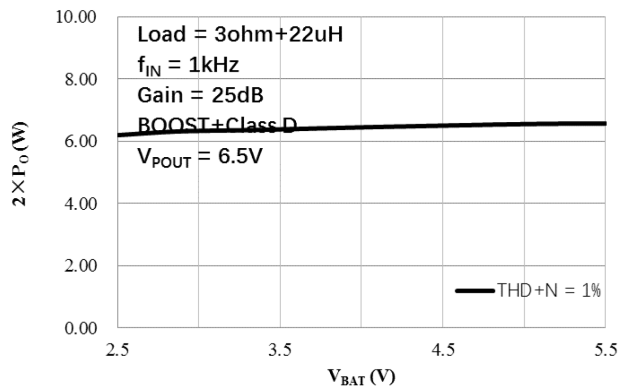
V_{BAT} vs $2\times P_O$



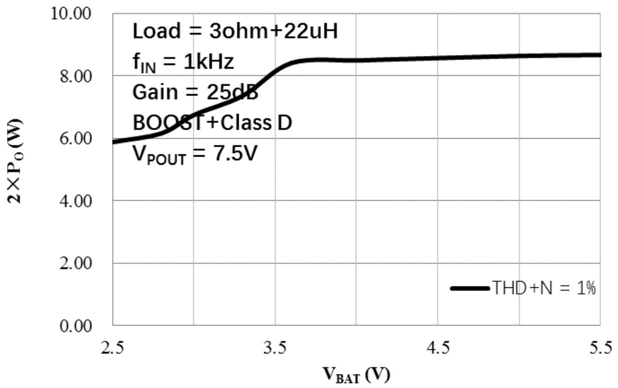
V_{BAT} vs $2\times P_O$



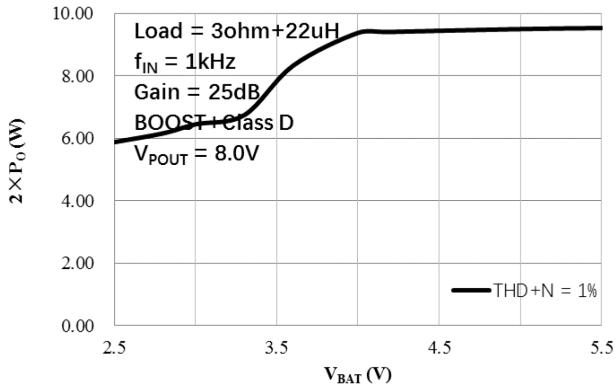
V_{BAT} vs $2\times P_O$



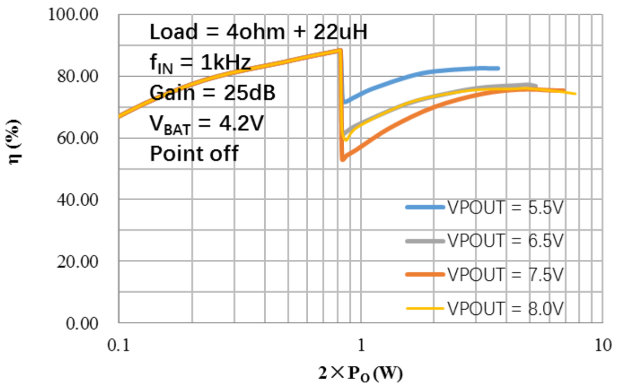
V_{BAT} vs $2\times P_O$



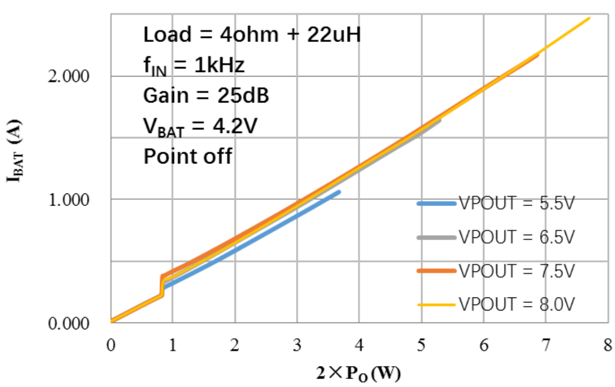
V_{BAT} vs $2\times P_O$



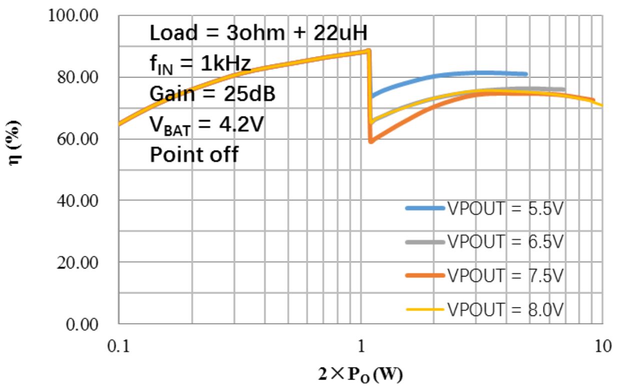
$2\times P_O$ vs η



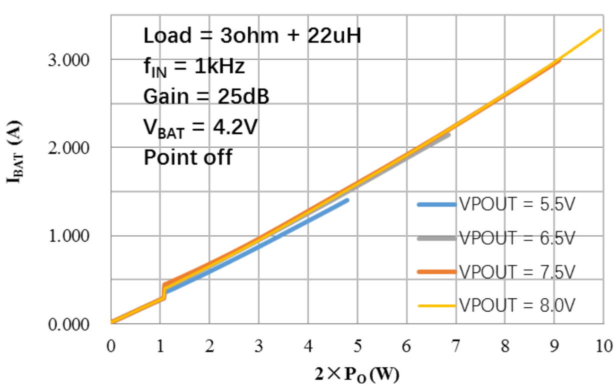
$2\times P_O$ vs I_{BAT}



$2\times P_O$ vs η



$2\times P_O$ vs I_{BAT}



■ APPLICATION INFORMATION

1. Glossary

The application section may use the following terms.

AGC: Automatic gain control function, including Limiter function and Battery Tracking function.

Limiter: When Limiter function is active, the output music can be limited below the Limiter Level.

Limiter Level: V_{LIM_L} for short. The maximum output voltage allowed before amplifier gain is automatically reduced.

Battery Tracking: Point for short, when this function is active, HT868 monitors the battery voltage and the audio signal, automatically decreasing gain when battery is lower than preset voltage (Battery Tracking Point) and the audio output power is high. It finds the optimal gain to maximize the loudness and minimize the battery current, providing louder audio and preventing early shutdown at end-of-charge battery voltages.

Battery Tracking Point: Point for short. The battery voltage threshold for reducing the limiter level. If the battery voltage drops below the Battery Tracking Point, the limiter level automatically reduces. Although it lowers the maximum output power, it prevents high battery currents at end-of-charge low battery voltages. It can be configured in AGC terminal.

V_{BAT} vs Limiter Slope: Slope for short. The slope that Limiter Level followed while the battery voltage drops (VBAT< Battery Tracking Point).

Thermal Foldback: TFB for short. When this function is active, HT868 reduces the on-die power dissipation by reducing system gain if the on-die temperature exceeds the Thermal Foldback Trig Point in case of the device being operated beyond the recommended temperature or power limit, or with a weaker thermal system than recommended. Once the die temperature drops below the TFB trig point, the system gain is increased until the TFB trig point is reached.

Thermal Foldback Trig Point: TFB for short. The on-die temperature trig point for reducing system gain.
Attack Time: t_A for short. The rate of AGC or TFB gain decrease. The default value for AGC Attack Time is 12ms /dB, and the default value of TFB Attack Time is 1200ms/dB.

Release Time: t_R for short. The rate of AGC or TFB gain increase. The default value for AGC release time is 150ms/dB, and the default value for TFB Release Time is 2400ms /dB.

Adaptive Boost: Only when the output audio signal exceeds a preset voltage threshold (Boost on Threshold Voltage), the boost converter is enabled. When the audio output voltage is lower than the threshold voltage, the boost deactivates automatically. This technology can improve the system efficiency and extend the battery life.

Boost on Threshold Voltage: V_{B_TH} for short. The output audio signal voltage threshold for enabling boost converter.

2. Feature Description

2.1. Automatic Gain Control

The Automatic Gain Control function includes Limiter function and Battery Tracking function, it protects speakers, improves loudness, smooths the music, limits peak supply current, extends battery life, prevents early shutdown at end-of-charge battery voltages.

2.1.1 Limiter

When Limiter function activates, the output music can be limited below the Limiter Level ($0.95\times V_{POUT}$, below THD+N = 3%). If the output audio signal exceeds the Limiter Level, HT868 decreases amplifier gain by the rate of attack time (12ms/dB), 0.375dB per step. HT868 increases the gain by the rate release time (150ms/dB), 0.375 per step, once the output audio is below the limiter level. Figure 3 shows this relationship.

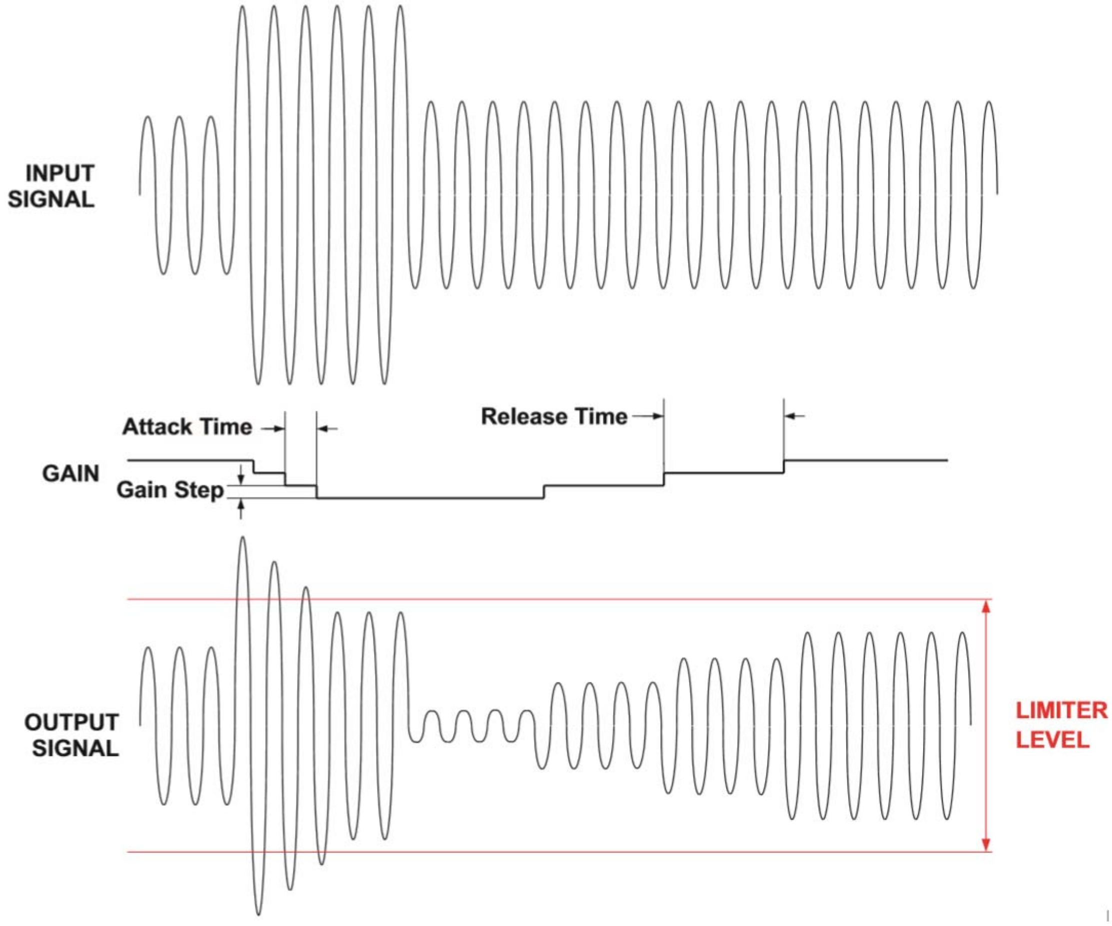


Fig. 1 AGC Limiter Function

The Limiter Level is fixed as 0.95×V_{POUT} (Peak Value), around THD+N = 1-3%.

2.1.2 Battery Tracking Function

The HT868 monitors the battery voltage and audio signal, automatically decreasing gain when battery voltage is low and audio output power is high. It finds the optimal gain to maximize loudness and minimize battery current, providing louder audio and preventing early shutdown at end-of-charge battery voltages. The Limiter Level automatically decreases when the supply voltage (V_{BAT}) is below the Battery Tracking Point. Figure 2 shows a plot of the limiter level as a function of the supply voltage.

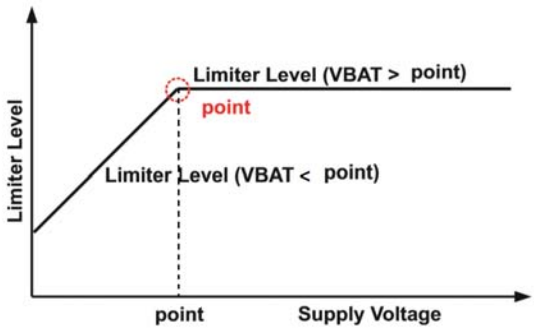


Fig. 2 Limiter Level vs Supply Voltage

To set the Battery Tracking Point, connect a resistor between the AGC pin and Ground, as shown in Table 1.

Table. 1 AGC Battery Tracking Configuration in Hardware Mode

Function	Resistor on AGC pin to GND	Battery tracking point
Battery tracking disabled	Floating	Disabled
Battery tracking point1	Available if customized	3.3V
Battery tracking point2	33kΩ	3.5V
Battery tracking point3	5.1kΩ	3.8V

Figure 3 shows the relationship between the audio signal, limiter level, supply voltage, and the supply current.

Battery Tracking Function Example:

Phase 1 Battery discharging normally; supply voltage is above point; audio output remains below limiter level.

The limiter level remains constant because the supply voltage is greater than the point. Amplifier gain is constant at preset gain. The audio remains at a constant loudness. The boost converter allows the audio output to swing above the battery supply voltage. Battery supply current increases as supply voltage decreases.

Phase 2 Battery continues to discharge normally; supply voltage decreases below Battery Tracking Point; limiter level decreases below audio output.

The limiter level decreases as the battery supply voltage continues to decrease. HT868 lowers amplifier gain, reducing the audio output below the new limiter level. The supply current decreases due to reduced output power.

Phase 3 Battery supply voltage is constant; audio output remains below limiter level.

The audio output, limiter level, and supply current remain constant as well.

Phase 4 Battery re-charges; supply voltage increases.

The limiter level, amplifier gain and audio output increase as the supply voltage increases, until the battery voltage is greater than the Battery Tracking Point.

Phase 5 Battery supply voltage is constant and higher than the Battery Tracking Point; audio output is below limiter level.

HT868 continues to increase amplifier gain to the preset gain, the audio output signal increases to original value, by the rate of Release Time.

Phase 6 Battery supply voltage is constant and higher than the Battery Tracking Point; audio output remains below limiter level.

Amplifier gain increased to the preset gain or audio output increased to the Limiter Level, and then both remain constant, as well as supply current;

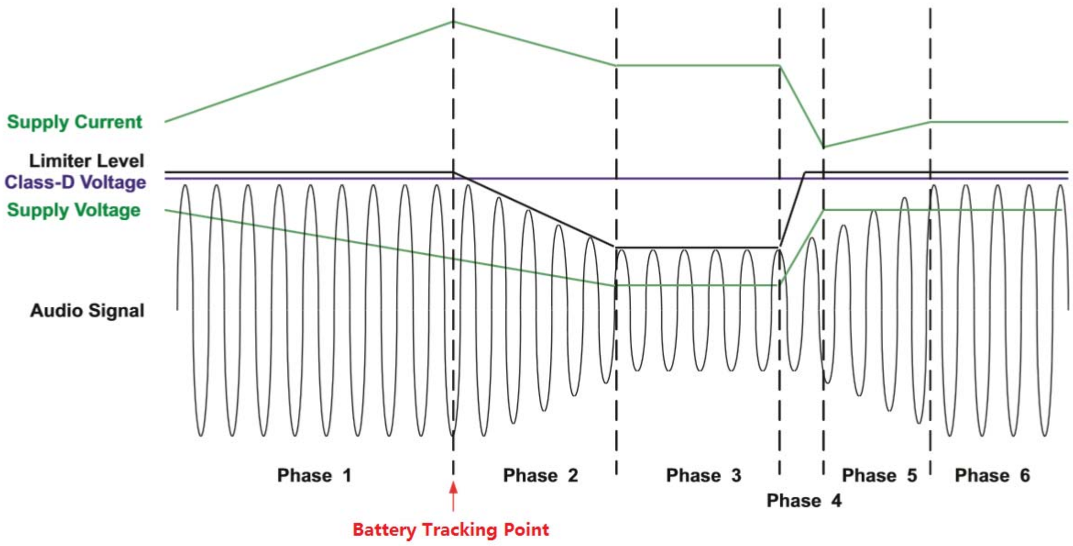


Fig. 3 Battery Tracking Function Operation Example

2.2. Adaptive Boost Converter

The HT868 consists of an adaptive boost converter and an audio amplifier. The boost converter takes the supply voltage, V_{BAT}, and increases it to a higher output voltage, V_{POUT}. V_{POUT} drives the supply voltage of the audio amplifier, PVDD. This improves loudness over non-boosted solutions. An external inductor and diode should be added for the boost converter.

4 choices of the boost converter output voltage V_{POUT} can be set by connecting a resistor between the BST pin and Ground, as shown in Table 2.

Table. 2 BOOST Terminal Configuration in Hardware Mode

Resistor on BST pin to GND	V_{POUT}
Available if customized	5.5V
floating	6.5V
33kΩ	7.5V
5.1kΩ	8.0V

The boost converter is adaptive and activates automatically depending on the output audio signal amplitude. When the output audio signal exceeds a preset voltage threshold (Boost on Threshold Voltage V_{B_TH}), the boost converter is enabled, and the voltage at V_{POUT} is the preset voltage. When the audio output voltage is lower than the threshold voltage, the boost deactivates automatically. The Boost on Threshold Voltage V_{B_TH} is fixed as $0.415 \times V_{BAT}$.

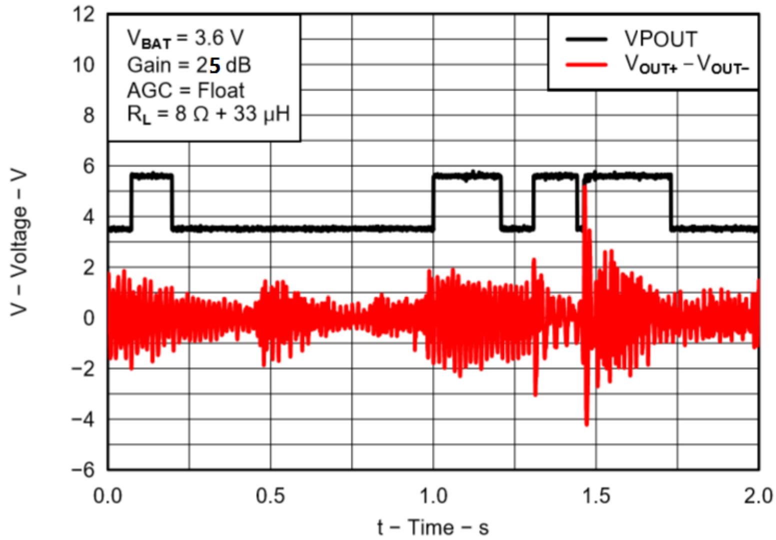


Fig. 3 Adaptive Boost Converter with Typical Music Playback

Figure 3 shows how the adaptive boost modulates with a typical audio signal. By automatically deactivating the boost converter and passing V_{BAT} to V_{POUT}, the HT868 efficiency is improved at low output power and extend the battery life.

2.2.1 Component Selection

(1) BOOST Converter Input and Output Capacitor C_{IN}, C_{OUT}

For the capacitor maintaining the supply voltage, the value of the boost capacitor is determined by the minimum value of working capacitance required for stability and the maximum voltage ripple allowed on PVDD in the application. It acts as a charge reservoir, providing energy faster than the board supply, thus helping to prevent any droop in the supply voltage.

For the decoupling capacitor, a low equivalent-series-resistance (ESR) ceramic capacitor is needed. This choice of capacitor and placement helps with higher frequency transients, spikes, or digital hash on the line. Additionally, placing this decoupling capacitor close to the HT868 is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss.

Over all, 1uF//10uF//470uF (paralleled) is highly recommended to be placed in both input and output terminal as closely to the pin as possible.

(2) Inductor selection and placement

Inductor current rating is determined by the requirements of the load. The inductance is determined by two factors: the minimum value required for stability and the maximum ripple current permitted in the application.

L ≥ 4.7uH, DCR < 0.5ohm, I_{SAT} ≥ 3.5A is recommended for general application circuit. The inductor should be placed as close to the SW pin as possible with direct and wide traces.

(3) Schottky Diode selection and placement

A Schottky Diode with V_{RRM} > 12V, V_{FM} < 0.5V, I_F ≥ 4 A, SS54 is recommended for general application circuit. The diode should be placed as close to the SW and VPOUT pin as possible with direct and wide traces.

(4) Layout Considerations

The power traces, consisting of the GND, SW, V_{BAT}, V_{POUT} and PVDD should be kept short, direct, wide, and be placed as closely to the pin as possible. The switching mode SW should be paid more attention for EMI and reliability consideration.

Place C_{IN} and C_{OUT} near V_{BAT} and V_{POUT} as closely as possible to maintain voltage steady and filter out the pulsing current.

The GND of the HT868, C_{IN} and C_{OUT} should be connected close together directly to ground plane.

2.3. Thermal Foldback

The HT868 Thermal Foldback, TFB, is designed to protect the HT868 from excessive die temperature in case of the device being operated beyond the recommended temperature or power limit, or with a weaker thermal system than recommended. The TFB works by reducing the on-die power dissipation by reducing the HT868 system gain by the rate of attack time (1200ms/dB) in steps of 0.375dB if the TFB trig point is exceeded. Once the die temperature drops below the TFB trig point, the HT868 gain is increased by a single or by the rate of release time (2400ms/dB) in steps of 0.375dB (or 0.75dB) until the TFB trig point, or a maximum of 30dB attenuation is reached, and the system gain will be decreased again, or the system gain is at its nominal gain level. The procedure shows as follows.

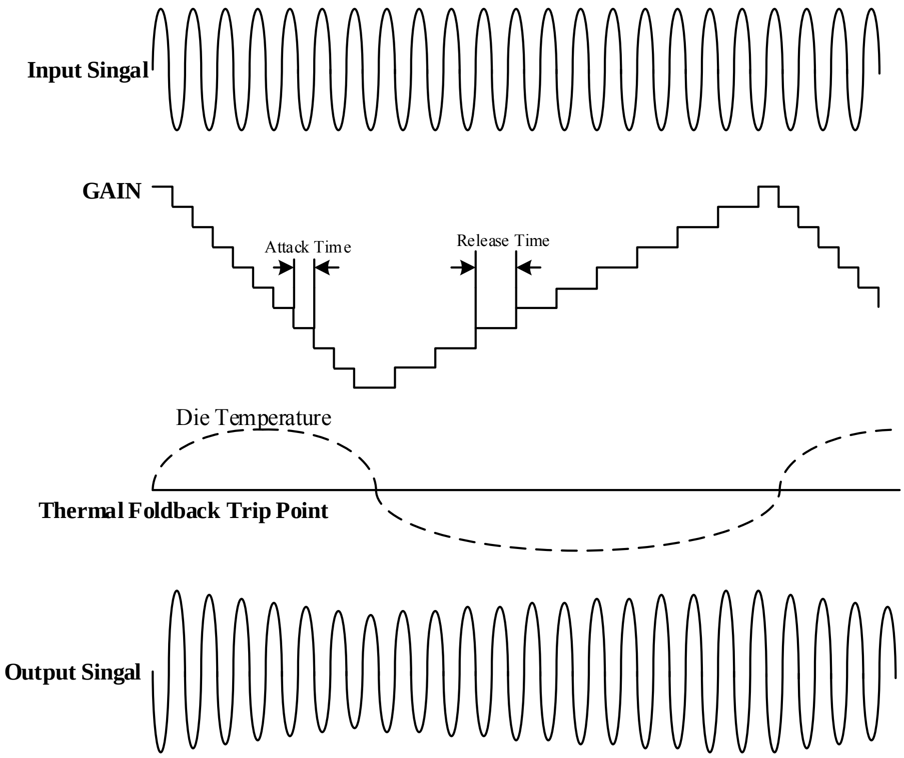


Fig. 4 Thermal Foldback Operation

2.4. Audio Amplifier Input Configuration

HT868 is a Class D amplifier with analog input (single-ended or differential), that can directly drive a speaker. For a differential input between IN+ and IN- pins, signals input via DC-cut capacitors (C_{IN}). And the high pass cut-off frequency of input signal can be calculated by $f_c = 1/(2\pi R_{IN} C_{IN})$.

For a single-ended input at IN+ pin, signal input via a DC-cut capacitor (C_{IN}). IN- should be connected to ground via a DC-cut capacitor (with the same value of C_{IN}). The gain and high pass cut-off frequency are the same as above case.

The relationship between the Input resistance (R_{IN}) and amplifier gain show as the following table.

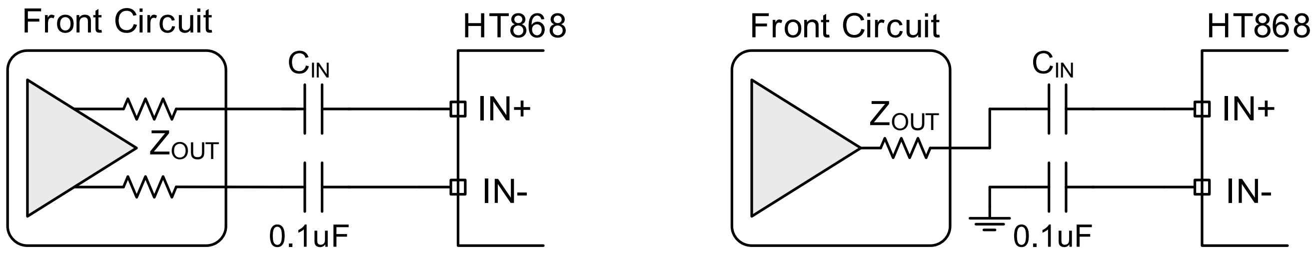


Fig. 5 (1) Differential Input; (1) Single-ended Input

Table. 3 R_{IN} vs GAIN

GAIN	R_{IN}
25dB	31.4 KΩ

2.5. Amplifier Output

As mentioned before, HT868 can directly drive speakers without any other components. But there are exceptions. Once HT868 works in Class D mode, the cable lined to the speaker is very long, and EMI is concerned, ferrite beads or L-C filter is needed.

If the Boost output voltage is high, the power supply ripple for amplifier is high, the voltage level of input signals is high (≥1.0Vrms) and AGC is disabled, or the impedance of the load speaker is low (≤4Ω), a bigger value of capacitance in the terminal of PVDD should to be placed, and a snubber circuit and two schottky diodes placed in the output terminal can be a choice to protect the chip from damage.

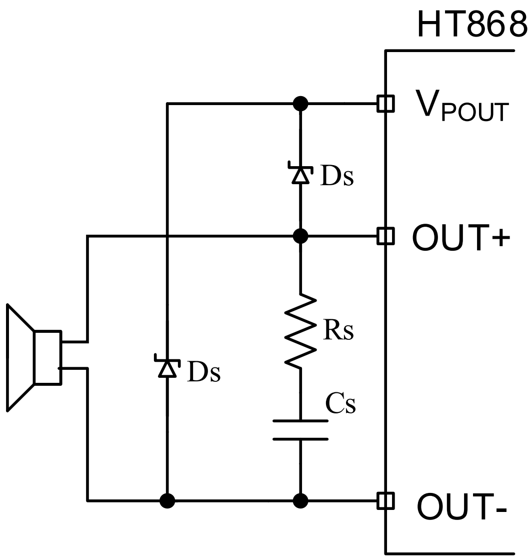


Fig. 6 Amplifier Output Configuration

Recommended component selection:

Rs: 1.5 ~ 2Ω;

Cs: 330pF~680pF;

Ds: Maximum Average Forward Rectified Current I_{AV}≥3A; Maximum Instantaneous Forward Voltage ≤0.5V; Peak Forward Surge Current I_{FSM} ≥6A.

2.6. Protection Function

HT868 has the protection functions such as Over-Current Protection function, Thermal Protection function, and Low Voltage Malfunction Prevention function.

(1) Over-current Protection function

When a short circuit occurs between one output terminal and Ground, Power, or the other output, the over-current protection mode starts up. In the over current protection mode, the differential output terminal becomes a high impedance state. Once the short circuit conditions are eliminated, the over current protection mode can be cancelled automatically.

(2) Thermal Protection function

When excessive high temperature of HT868 (OTP) is detected, the thermal protection mode starts up. In the thermal protection mode, the differential output terminal becomes Weak Low state (a state grounded through high impedance).

(3) Low voltage Malfunction Prevention function

This is the function to establish the low voltage protection mode when V_{BAT} terminal voltage becomes lower than the detection voltage (V_{UVLL}) for the low voltage malfunction prevention. And the protection mode is canceled when V_{BAT} terminal voltage becomes higher than the threshold voltage (V_{UVLH}). In the low voltage protection mode, the differential output pin becomes Weak Low state (a state grounded through high impedance). HT868 will start up within the start-up time when the low voltage protection mode is cancelled.

3. Terminal Configuration

3.1. AGCL, AGCR

It is the terminal to enable and select Battery Tracking function. Detailed as follows.

Function	Resistor on AGCL & AGCR pin to GND	Battery tracking point
Battery tracking disabled	Floating	Disabled
Battery tracking point1	Available if customized	3.3V
Battery tracking point2	33kΩ	3.5V
Battery tracking point3	5.1kΩ	3.8V

Note that AGCL and AGCR cannot be paralleled and must set as the same point.

3.2. $\overline{SD}$

It is the terminal to enable or shutdown HT868. While $\overline{SD}$ is connected to the ground, HT868 goes into shutdown mode. The 2 $\overline{SD}$ terminal can be paralleled and note that each of the terminal has a pull-down resistor of 150kΩ.

3.3. BST_L, BST_R

It is the terminal to select the Boost Converter output voltage. Detailed as follows.

Note that BST_L and BST_R cannot be paralleled and must set as the same V_{POUT}.

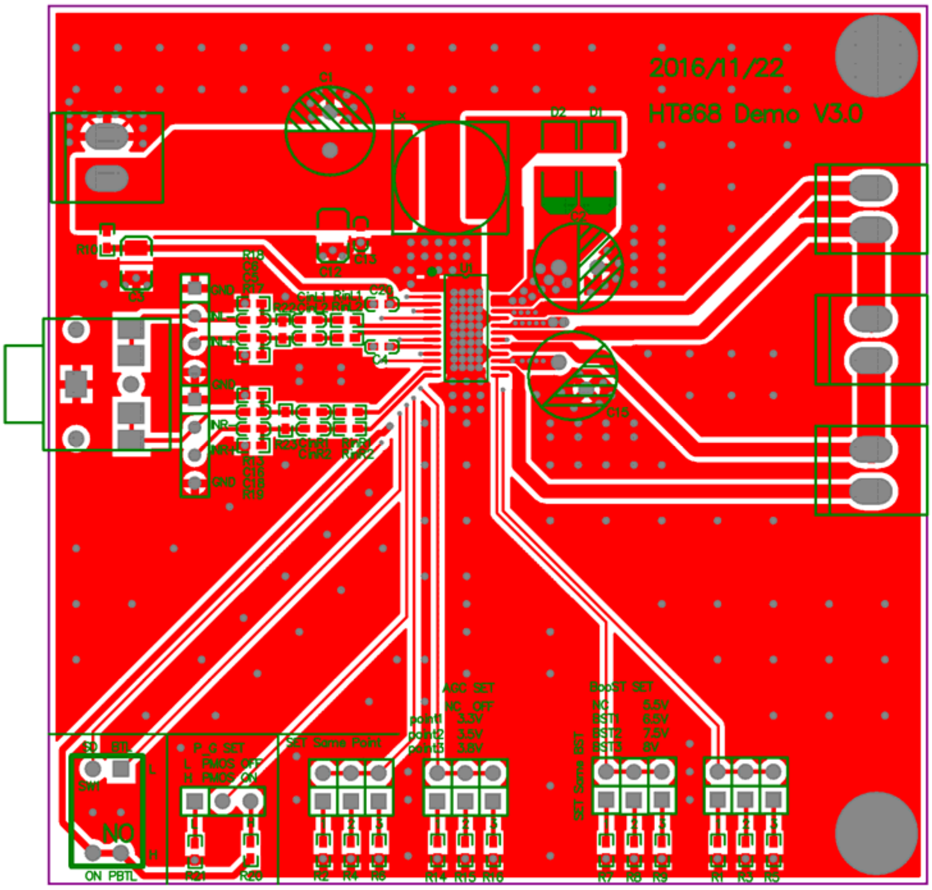
Resistor on BST_L & BST_R pin to GND	V_{POUT}
Available if customized	5.5V
Floating	6.5V
33kΩ	7.5V
5.1kΩ	8.0V

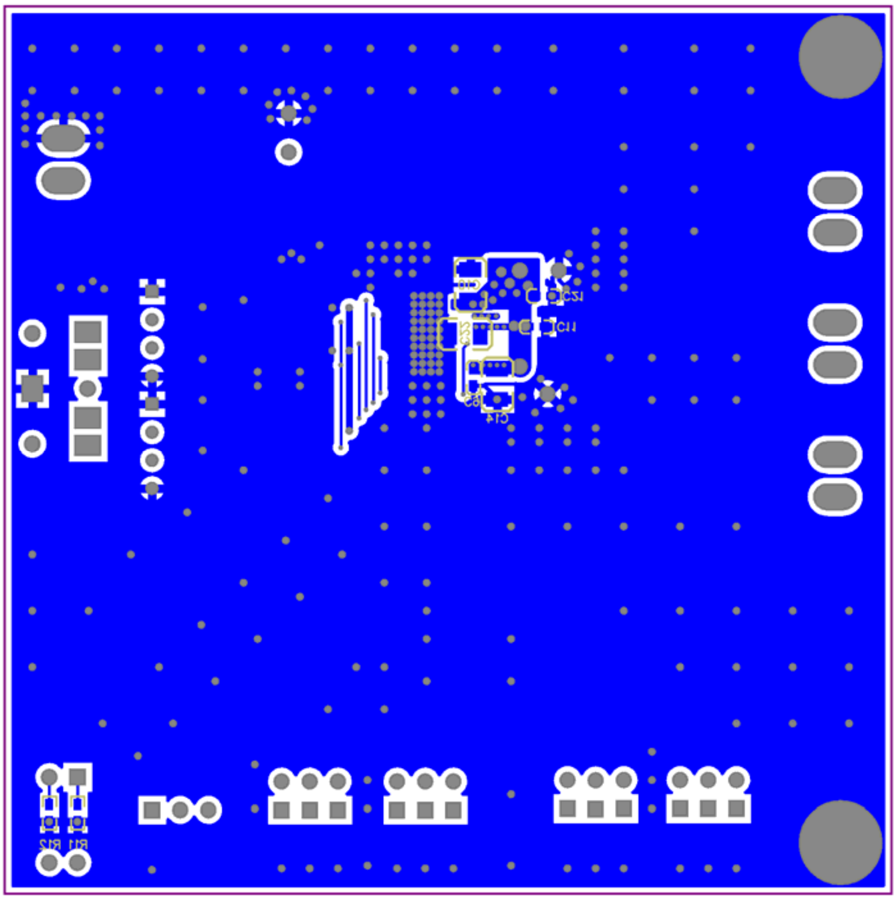
3.4. PBTL

HT868 offers the feature of parallel BTL operation with two outputs of each channel connected directly. If the PBTL pin is tied high, the positive and negative outputs of each channel (left and right) are synchronized and in phase. To operate in this PBTL (mono) mode, apply the input signal to LEFT input and place the speaker between the LEFT and RIGHT outputs. Connect the positive and negative output together for best efficiency. Note that there's a pull-down resistor of 300kΩ. For an example of the PBTL connection, see the diagram in the TYPICAL APPLICATION section.

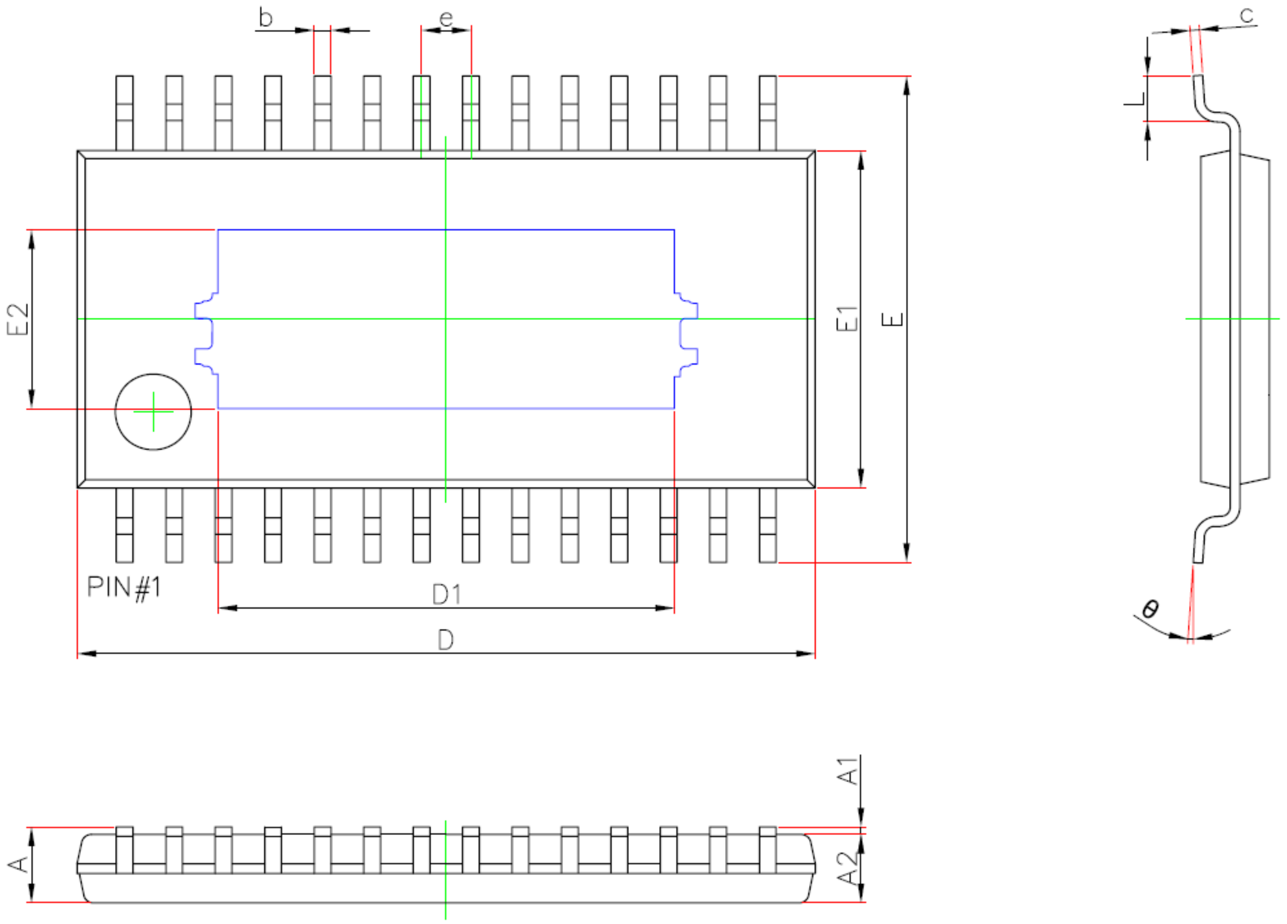
For normal BTL operation, connect the PBTL pin to local ground.

4. PCB Layout


2016/11/22
HT868 Demo V3.0
AGC SET
BOOST SET
SET Same Point
P_G SET
ON PBTL



■ PACKAGE OUTLINE



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	—	1.200	—	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
D1	5.908	6.108	0.233	0.240
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
E2	2.253	2.453	0.089	0.097
e	0.650(BSC)		0.026(BSC)	
L	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

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