内置自适应升压/AGC/限温功能
7W单声道智能音频功率放大器

■ 特点

- 具有电池跟踪和限幅功能的自动增益控制（AGC）
  - 电池跟踪（Battery Tracking）功能：电池电压较低时，自动减小系统增益，延长电池续航时间
  - 限幅（Limiter）功能：自由选择音频限制幅度，使输出音频信号限制在固定失真水平内
- 内置自适应升压
  - 小音乐信号时不升压，可大幅提高系统效率，延长电池续航时间
- 内置自动限温控制功能
  - 特别适用于升压7.85V+D类，升压+AB类状态下及环境温度较高的情况，显著提升音乐峰值功率
- 静态电流：4.0mA, 3.6V
- 效率：88%（V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.6W）
- THD+N：0.02%（V_{BAT} = 3.6V, R_L = 4Ω+22uH, Po = 0.5W, Class D）
- 灵活配置：可选择硬件或I^2C控制模式
- 电源
  - 升压输入V_{BAT}：2.8V至5.0V
  - 升压输出V_{POUT}多种选择：5.45V, 6.45V, 7.45V, 7.85V
- 输出功率
  - 3.4 W (V_{BAT}=4.2V, V_{POUT} = 5.45V, R_L=4Ω, THD+N=1%)
  - 4.7 W (V_{BAT}=4.2V, V_{POUT} = 6.45V, R_L=4Ω, THD+N=1%)
  - 6.2 W (V_{BAT}=4.2V, V_{POUT} = 7.45V, R_L=4Ω, THD+N=1%)
  - 7.0 W (V_{BAT}=4.2V, V_{POUT} = 7.85V, R_L=4Ω, THD+N=1%)
- 二种增益选择：25dB, 30dB； I^2C控制模式下最大支持80阶音量调节
- 多种模式可选：升压+D类，升压+AB类，单独D类，单独AB类
- 保护功能：过流/过热/欠压异常保护功能
- 无铅无卤封装，TSSOP20L-PP

■ 概述

HT862是一款内置自适应升压/AGC/限温功能的单声道智能音频功率放大器。由锂电池供电升压至7.85V时， 4Ω负载条件下，能连续输出7W功率（1% THD+N）。

HT862内置的自适应升压可提供5.45V, 6.45V, 7.45V, 7.85V四种输出电压选择，以满足不同的输出功率需求。另外，该升压还具有自适应功能，小音乐信号时不升压，可大幅提高系统效率，延长电池续航时间。

HT862内置了丰富的自动增益控制（AGC）功能，包括限幅（Limiter）和电池跟踪（Battery Tracking）功能。限幅功能开启后，即使输入信号很大，音乐输出也能被限制在指定的功率和THD+N之内；电池跟踪功能开启后，当电池电压低于设定值，HT862能随电池电压降低而逐步减小增益以限制电池电流，此举能大幅延长电池续航时间，并且能防止破音和过大的电流需求，降低电池在低电量时提前进入锁死状态的风险。

HT862还具有自动限温控制（TFB）功能，在高功率输出、高环境温度等情况下导致芯片片内温度较高时，芯片能自动降低系统增益，避免芯片进入过温关断保护模式，在保证音乐品质的前提下显著提升音乐峰值功率。

HT862可在多种模式下自由切换，以满足更多的系统应用需求：升压+D类，升压+AB类，单独D类，单独AB类。

HT862支持硬件控制模式和I^2C控制模式。在I^2C控制模式下，提供了丰富的功能和参数配置。

此外，HT862内部集成免滤波器调制技术，能够直接驱动扬声器，内置的关断功能使待机电流最小化，还集成了输出端过流保护、片内过温保护和电源欠压异常保护等功能。

芯片料号	升压方式	可选升压值
HT862B3	同步升压	5.45V, 6.45V, 7.45V
HT862T3	非同步升压	5.45V, 6.45V, 7.45V, 7.85V

■ 应用

- 蓝牙音箱/Wi-Fi音箱
- 便携式音箱
- 2.1声道小音箱
- 拉杆音箱
- iphone/ipod/ipod docking
- MP4，导航仪
- 平板电脑，笔记本电脑
- 智能手机
- 小尺寸LCD电视/监视器
- 便携式游戏机

7W 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 Boost Converter
  - Increases efficiency at low output power
- Integrated Thermal Foldback (TFB) function
  - Particularly apply to applications of 7.85V+Class D, Boost + Class AB or one with a weak thermal system, significantly increase the peak audio power
- Low quiescent current of 4.0mA (V_{BAT} = 3.6V)
- Efficiency: 88% (V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.6W)
- THD+N: 0.02% (V_{BAT} = 3.6V, R_L = 4Ω+22uH, Po = 0.5W, Class D)
- Control Mode :Hardware or I^2C
- Power Supply/Output
  - V_{BAT} from 2.8V to 5.0V
  - Multiple Boost Output V_{POUT} Settings: 5.45V, 6.45V, 7.45V, 7.85V
- Output Power
  - 3.4 W (V_{BAT}=4.2V, V_{POUT} = 5.45V, R_L=4Ω, THD+N=1%)
  - 4.7 W (V_{BAT}=4.2V, V_{POUT} = 6.45V, R_L=4Ω, THD+N=1%)
  - 6.2 W (V_{BAT}=4.2V, V_{POUT} = 7.45V, R_L=4Ω, THD+N=1%)
  - 7.0 W (V_{BAT}=4.2V, V_{POUT} = 7.85V, R_L=4Ω, THD+N=1%)
- Two gain settings in hardware mode: 25dB, 30dB; 80-step volume control In I^2C Mode
- Optional multiple modes : Boost + Class D, Boost + Class AB, Class D only and Class AB only
- Over Current /Thermal/Low voltage malfunction prevention function with auto recovery
- Pb-free Packages,TSSOP20L-PP

APPLICATIONS

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

DESCRIPTION

The HT862 is a smart audio power amplifier with TFB, AGC technology and an integrated adaptive boost converter that enhances efficiency at low output power. It drives up to continuous 7W (1% THD+N, boosted to 7.85V) into 4ohm speaker from a Li-battery voltage.

The built-in boost converter generates a supply voltage (5.45V, 6.45V, 7.45V, 7.85V 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.

HT862 integrates Automatic Gain Control (AGC), including Limiter and Battery Tracking function. When Limiter function is active, the output music can be limited below the preset power and THD+N. When Battery Tracking function is active, HT862 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 HT862 Thermal Foldback (TFB) is designed to protect the HT862 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.

HT862 can be switched in various modes to adapt different system, such as boost + Class D, boost + Class AB, Class D only and Class AB only.

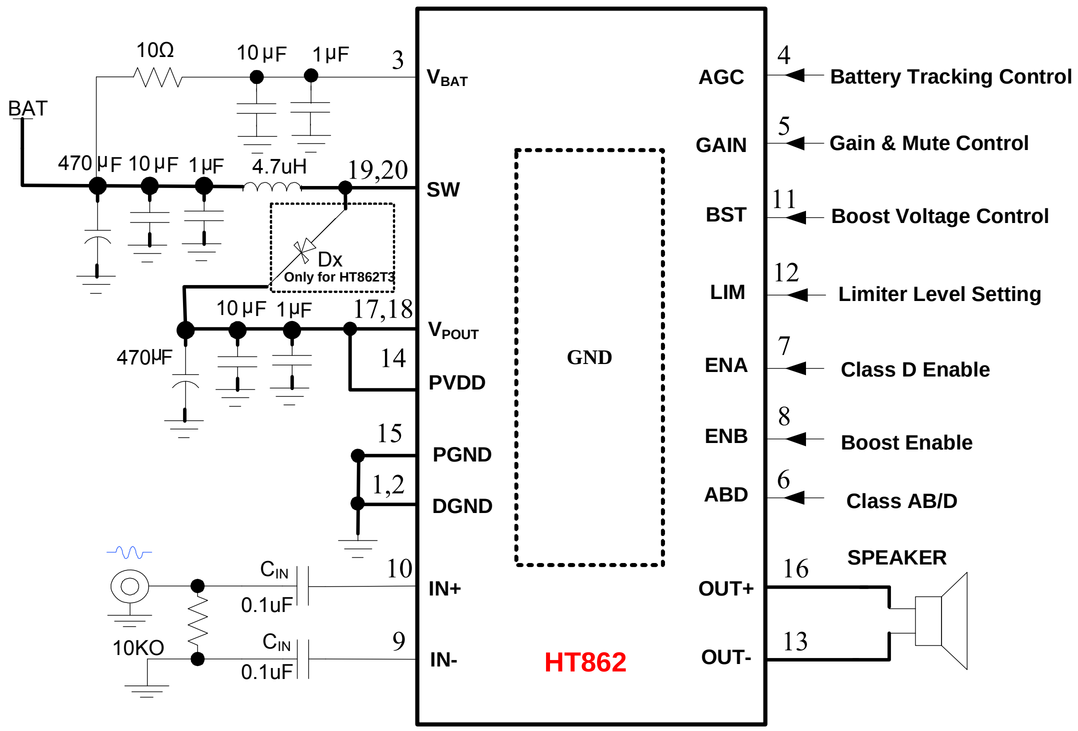
Both hardware and I^2C control mode are available for HT862. More functions and parameters can be configured in I^2C control mode.

HT862 has a filter-less modulation circuit which can directly drive speakers. HT862 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.

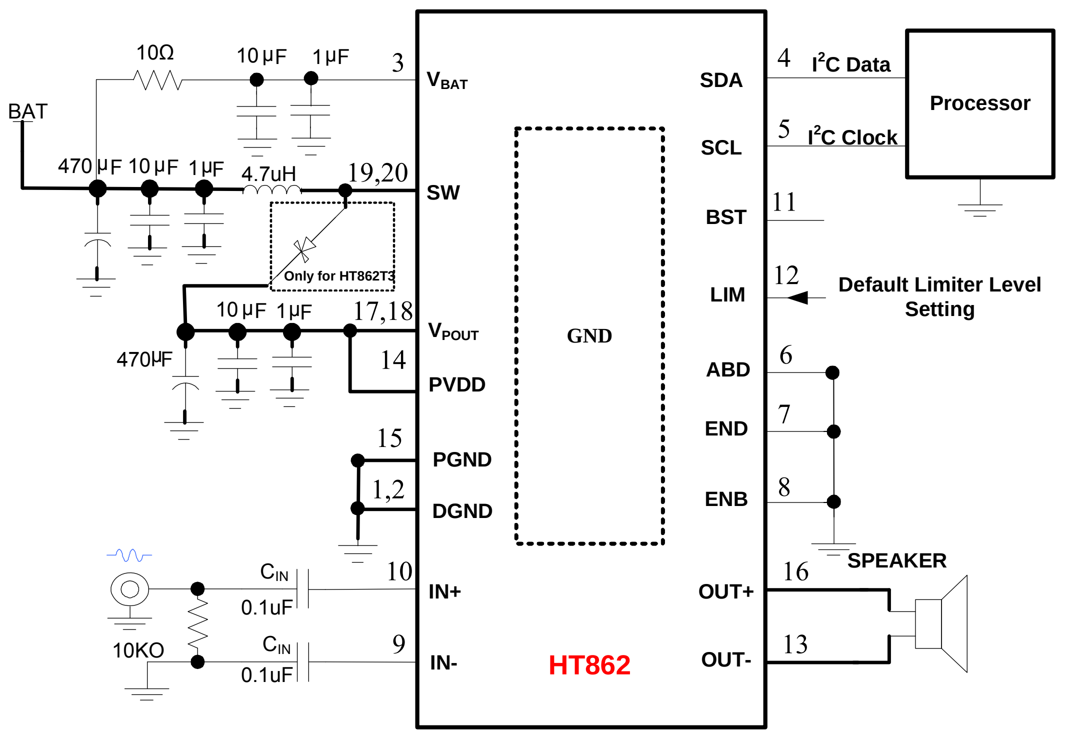
Part No.	Boost Converter	Available Boost Voltage
HT862B3	Sync	5.45V, 6.45V, 7.45V
HT862T3	Non-Sync	5.45V, 6.45V, 7.45V, 7.85V

■ TYPICAL APPLICATION

1. HARDWARE CONTRL MODE

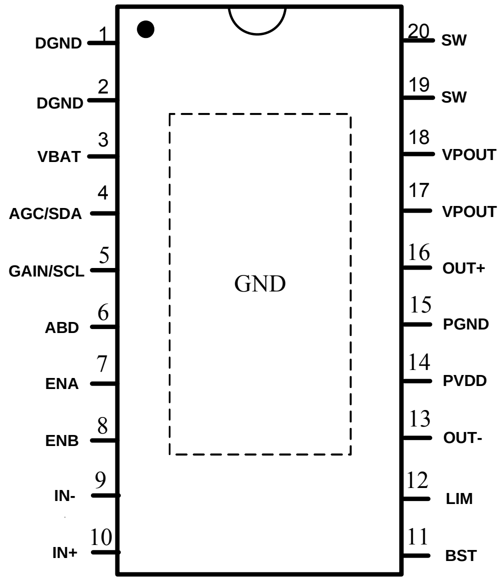


2. I²C CONTROL MODE



Contents

■ TERMINAL CONFIGURATION



TSSOP20L-PP 顶视图

■ TERMINAL FUNCTION

TSSOP Terminal No.	NAME	I/O*1	Description
1,2	DGND	GND	Power ground for boost converter
3	V_{BAT}	Power	Power supply
4	AGC/SDA	I/O	Dual function terminal that enables and selects Battery Tracking in Hardware Control Mode or functions as an I^2C data input/output terminal in I^2C Control Mode as ABD = ENA = ENB = L
5	GAIN/SCL	I	Dual function terminal that selects system gain or mute in Hardware Control Mode or functions as an I^2C clock input terminal in I^2C Control Mode as ABD = ENA = ENB = L
6	ABD	I/O	Choose different Audio Amplifier mode, set to logic high to be in Class AB, logic low to be in Class D
7	ENA	I	Enable for Audio amplifier, set to logic high to enable. Internal 300k resistor grounded
8	ENB	I	Enable for the boost converter; set to logic high to enable. Internal 300k resistor grounded
9	IN-	I	Negative input terminal (differential-)
10	IN+	I	Positive input terminal (differential+)
11	BST	O	Select boost converter output voltage V_{POUT}
12	LIM	O	Enable AGC and select limiter level
13	OUT-	O	Negative output terminal (BTL-)
14	PVDD	Power	Power supply terminal for audio amplifier
15	PGND	GND	Power ground for audio amplifier
16	OUT+	O	Positive output (BTL+)
17,18	V_{POUT}	Power	Boost Converter output voltage
19,20	SW	I	Boost and rectifying switch input

*1 I: input O: output

■ ORDERING INFORMATION

Part Number	Boost Converter	Available Boost Voltage	Package Type	Marking	Operating Temperature Range	MOQ/Shipping Package
HT862B3MTET	Sync	5.45V, 6.45V, 7.45V	TSSOP20L-PP	$HT862_{MTE}$	-40℃～85℃	Tube / 46 PCS
HT862B3MTER	Sync	5.45V, 6.45V, 7.45V	TSSOP20L-PP	$HT862_{MTE}$	-40℃～85℃	Tape and Reel 3000PCS
HT862T3MTET	Non-Sync	5.45V, 6.45V, 7.45V, 7.85V	TSSOP20L-PP	$HT862_{MTE}$	-40℃～85℃	Tube / 46 PCS
HT862T3MTER	Non-Sync	5.45V, 6.45V, 7.45V, 7.85V	TSSOP20L-PP	$HT862_{MTE}$	-40℃～85℃	Tape and Reel 3000PCS

■ 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 ENA, ENB, SDA, SCL, ABD	V_{IH}		1.5			V
Low-level input voltage of ENA, ENB, SDA, SCL, ABD	V_{IL}				0.4	V
Operating temperature	T_a		-40	25	85	℃
Load impedance	R_L			4		Ω

● Electrical Characteristics[*4]

Condition: Ta=25ºC, V_{BAT} = 3.6V, f_{IN} = 1 kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C, THD+N≈5%), Battery tracking disabled (Point off), Load = 4ohm + 22uH, unless otherwise specified.

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VBAT supply voltage range	V_{BAT}	I²C read/write	3.0	3.6	V_{POUT} -0.5	V
		Boost + Amp work	2.8			
Boost on threshold voltage Δ	V_{B_TH}	Amplifier Output V_{RMS}		0.415× V_{BAT}		V
Start-up time Δ	t_{ON}	t_{BOOST_ON}, Boost only		6		ms
		t_{AMP_ON}, Audio Amplifier only		60		
Closed-loop voltage gain Δ	Av	GAIN = Floating	23.5	25	26.5	dB
		GAIN = L (30dB)	28	29.5	31	
Input impedance (per input pin)	R_{IN}	GAIN = Floating		31.4		KΩ
		GAIN = L		19.2		
Boost Converter						
Boost converter output voltage range Δ	V_{POUT}	(V_{POUT} = 5.45V) Δ Only in I²C mode	5.25	5.45	5.75	V
		BST Floating (V_{POUT} = 6.45V)	6.25	6.45	6.75	
		R_{BST} = 33kΩ (±5%), (V_{POUT} = 7.45V)	7.25	7.45	7.75	
		R_{BST} = 5.1kΩ (±5%), (V_{POUT} = 7.85V, HT862T3)	7.65	7.85	8.15	
Boost shut off time Δ	t_{BOOST_OFF}			208		ms
Boost converter input current limit Δ	I_L			3.5		A
Boost converter frequency	f_{BOOST}			800		kHz
Boost Converter + Class D						
Output power	Po	THD+N=1%, f=1kHz, V_{POUT} = 5.45V R_L=4Ω + 22uH		3.4		W
		THD+N≈5%, f=1kHz, V_{POUT} = 5.45V R_L=4Ω + 22uH		3.7		
		THD+N=10%, f=1kHz, V_{POUT} = 5.45V R_L=4Ω + 22uH		4.0		
		THD+N=1%, f=1kHz, V_{POUT} = 6.45V R_L=4Ω + 22uH		4.7		
		THD+N≈5%, f=1kHz, V_{POUT} = 6.45V R_L=4Ω + 22uH		5.0		
		THD+N=10%, f=1kHz, V_{POUT} = 6.45V R_L=4Ω + 22uH		5.7		
		THD+N=1%, f=1kHz, V_{POUT} = 7.45V R_L=4Ω + 22uH		6.2		
		THD+N≈5%, f=1kHz, V_{POUT} = 7.45V R_L=4Ω + 22uH		6.8		
		THD+N=10%, f=1kHz, V_{POUT} = 7.45V R_L=4Ω + 22uH		7.3		
		THD+N=1%, f=1kHz, V_{POUT} = 7.85V R_L=4Ω + 22uH, HT862T3		7.0		
		THD+N≈5%, f=1kHz, V_{POUT} = 7.85V R_L=4Ω + 22uH, HT862T3		7.8 (Instantaneous)		
		THD+N=10%, f=1kHz, V_{POUT} = 7.85V R_L=4Ω + 22uH, HT862T3		8.5 (Instantaneous)		
		THD+N=1%, f=1kHz, V_{POUT} = 5.45V R_L=8Ω + 33uH		1.7		
		THD+N≈5%, f=1kHz, V_{POUT} = 5.45V R_L=8Ω + 33uH		1.85		
		THD+N=10%, f=1kHz, V_{POUT} = 5.45V R_L=8Ω + 33uH		2.1		
		THD+N=1%, f=1kHz, V_{POUT} = 6.45V R_L=8Ω + 33uH		2.4		
		THD+N≈5%, f=1kHz, V_{POUT} = 6.45V R_L=8Ω + 33uH		2.6		
		THD+N=10%, f=1kHz, V_{POUT} = 6.45V R_L=8Ω + 33uH		2.9		
		THD+N=1%, f=1kHz, V_{POUT} = 7.45V R_L=8Ω + 33uH		3.1		
		THD+N≈5%, f=1kHz, V_{POUT} = 7.45V R_L=8Ω + 33uH		3.5		
		THD+N=10%, f=1kHz, V_{POUT} = 7.45V R_L=8Ω + 33uH		3.8		
		THD+N=1%, f=1kHz, V_{POUT} = 7.85V		3.7		
		THD+N≈5%, f=1kHz, V_{POUT} = 7.85V		4.0		

		THD+N=10%	R_L=8Ω + 33uH, HT862T3		4.5		
Total harmonic distortion plus noise	THD+N	P_O=0.5W	R_L=4Ω+22uH, f=1kHz		0.02		%
		P_O=1.0W			0.04		
Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB			45		μV_{rms}
Efficiency (Class D + Boost)	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.6W			88		%
		V_{POUT} = 5.45V	V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		80		
		V_{POUT} = 6.45V			75		
		V_{POUT} = 7.45V			74		
		V_{POUT} = 7.85V, HT862T3			71		
		V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 0.3W			85		
		V_{POUT} = 5.45V	V_{BAT} = 4.2V, R_L =8Ω+33uH, Po = 2.0W		85		
		V_{POUT} = 6.45V			80		
		V_{POUT} = 7.45V			77		
		V_{POUT} = 7.85V, HT862T3			74		
Operating quiescent current	I_{BAT}	Input Grounded, With or without load			4		mA
Quiescent current in mute mode	I_{MUTE}	Input Grounded, With or without load			1.5		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load			1		μA
Class D switching frequency	$f_{ClasS-D}$				400		kHz
Boost Converter + Class AB							
Output power	P_O	THD+N=1%	f=1kHz, V_{POUT} = 5.45V R_L=4Ω + 22uH		2.9		W
		THD+N≈5%			3.4		
		THD+N=10%			3.65		
		THD+N=1%	f=1kHz, V_{POUT} = 6.45V R_L=4Ω + 22uH		4		
		THD+N≈5%			4.75		
		THD+N=10%			5.1		
		THD+N=1%	f=1kHz, V_{POUT} = 7.45V R_L=4Ω + 22uH		5.4 (Instantaneous)		
		THD+N≈5%			6.0 (Instantaneous)		
		THD+N=10%			6.25 (Instantaneous)		
		THD+N=1%	f=1kHz, V_{POUT} = 7.85V R_L=4Ω + 22uH, HT862T3		5.4 (Instantaneous)		
		THD+N≈5%			6.0 (Instantaneous)		
		THD+N=10%			6.25 (Instantaneous)		
		THD+N=1%	f=1kHz, V_{POUT} = 5.45V R_L=8Ω + 33uH		1.65		
		THD+N≈5%			1.85		
		THD+N=10%			2.1		
		THD+N=1%	f=1kHz, V_{POUT} = 6.45V R_L=8Ω + 33uH		2.35		
		THD+N≈5%			2.7		
		THD+N=10%			2.95		
		THD+N=1%	f=1kHz,		3.1		

		THD+N≈5%	V_{POUT} = 7.45V R_L=8Ω + 33uH		3.5		
		THD+N=10%			3.9		
		THD+N=1%	f=1kHz, V_{POUT} = 7.85V R_L=8Ω + 33uH, HT862T3		3.7		
		THD+N≈5%			4.35		
		THD+N=10%			4.6		
Total harmonic distortion plus noise	THD+N	P_O=0.5W	R_L=4Ω, f=1kHz		0.04		%
		P_O=1.0W			0.05		
Noise output voltage	V_N	Differential input floating, f=20Hz~20kHz, A-weighted, Av=25dB			45		μV_{rms}
Efficiency (Class AB + Boost)	η	V_{BAT} = 4.2V, R_L = 4Ω+22uH, Po = 0.5W			40		%
		V_{POUT} = 5.45V	V_{BAT} = 4.2V, R_L =4Ω+22uH, Po = 3.0W		65		
		V_{POUT} = 6.45V			50		
		V_{POUT} = 7.45V			40		
		V_{POUT} = 7.85V, HT862T3			35		
		V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 0.3W			40		
		V_{POUT} = 5.45V	V_{BAT} = 4.2V, R_L = 8Ω+22uH, Po = 2.0W		75		
		V_{POUT} = 6.45V			60		
		V_{POUT} = 7.45V			50		
		V_{POUT} = 7.85V, HT862T3			46		
Operating quiescent current	I_{BAT}	Input Grounded, With or without load			30		mA
Quiescent current in mute mode	I_{MUTE}	Input Grounded, With or without load			0.6		mA
Shutdown quiescent current	I_{SD}	Input Grounded, With or without load			1		μA
Automatic Gain Control (AGC)							
AGC gain range	Av_{AGC}				30		dB
AGC gain step ᐞ	STP_{AGC}			40	80		/
AGC attack time ᐞ	t_{A_AGC}				12		ms/dB
AGC release time ᐞ	t_{R_AGC}				150		ms/dB
Limiter level (Peak)ᐞ	V_{LIM_L}	LIM Floating, 10h = 0x3C			0.95×V_{POUT}		V
VBAT vs. Limiter slope ᐞ	S_{BAT}	V_{POUT} = 5.45V			2.6		V/V
		V_{POUT} = 6.45V			3.1		
		V_{POUT} = 7.45V			3.5		
		V_{POUT} = 7.85V, HT862T3			4.1		
AGC battery tracking point ᐞ	Point1	Only I^2C mode			3.3		V
	Point2	R_{AGC} = 33kΩ (±5%)			3.5		
	Point3	R_{AGC} = 5.1kΩ (±5%)			3.8		
Thermal Foldback (TFB)							
Over temperaure protection point ᐞ	OTP				170		℃
Over temperature protection hysteresis	OTP_{hys}				30		℃
Over temperature protection recovery point	OTPR				140		

Thermal foldback trig point Δ	TFB			150		℃
TFB attack time Δ	t_{A_TFB}			1200		ms/dB
TFB release time Δ	t_{R_TFB}			2400		ms/dB
Input/Output						
Gain control pin voltage	V_{GAIN}	Gain = 30dB	0		0.25× V_{BAT}	V
		Gain = 25dB	0.45× V_{BAT}		0.55× V_{BAT}	
		MUTE	0.75× V_{BAT}		V_{BAT}	
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} = 6.45V (Floating)	2			V
		V_{POUT} = 7.45V, R_{BST} = 33kΩ (±5%)	0.85		1.5	
		V_{POUT} = 7.85V, R_{BST} = 5.1kΩ (±5%)	0		0.6	
AGC control pin output current	I_{AGC}			40		μA
BOOST control pin output current	I_{BOOST}			40		μA
Internal pulldown resistor of ENA, ENB, ABD	R_{DOWN}			300		kΩ
High-level input voltage of ENA, ENB, ABD, SDA, SCL	V_{IH}		1.5			V
Low level input voltage of ENA, ENB, ABD, SDA, SCL	V_{IL}				0.4	V

*4: Depending on parts and PCB layout, characteristics may be changed.
Δ: Parameters configurable in I^2C Control Mode

I²C Timing Characteristics

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Frequency, SCL	f_{SCL}				400	kHz
Pulse duration, SCL high	$t_{W(H)}$		0.6			µs
Pulse duration, SCL low	$t_{W(L)}$		1.3			µs
Setup time, SDA to SCL	t_{SU1}		100			ns
Hold time, SCL to SDA	t_{h1}		10			ns
Bus free time between stop and start condition	$t_{(buf)}$		1.3			µs
Setup time, SCL t start condition	t_{SU2}		0.6			µs
Hold time, start condition to SCL	t_{h2}		0.6			µs
Setup time, SCL to stop condition	t_{SU3}		0.6			µs

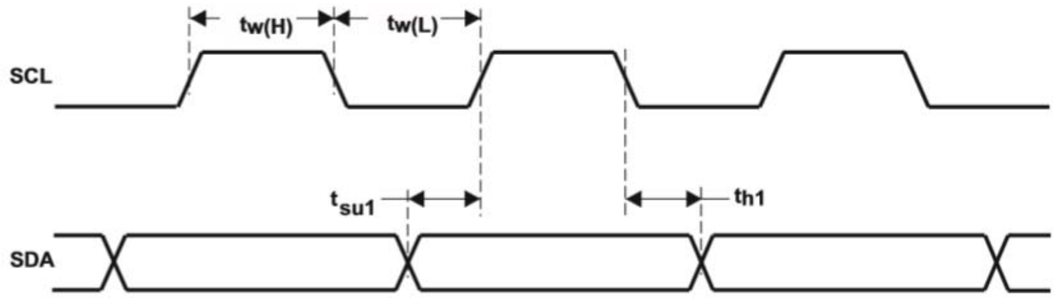


Fig. 1 I²C SCL and SDA Timing

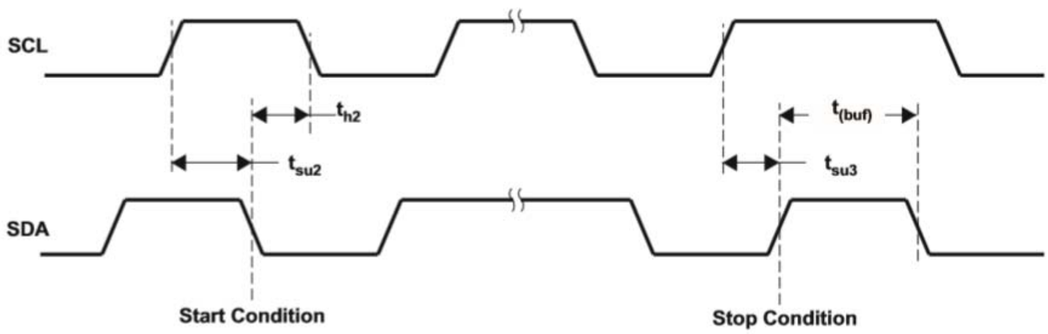


Fig. 2 I²C Start and Stop Conditions Timing

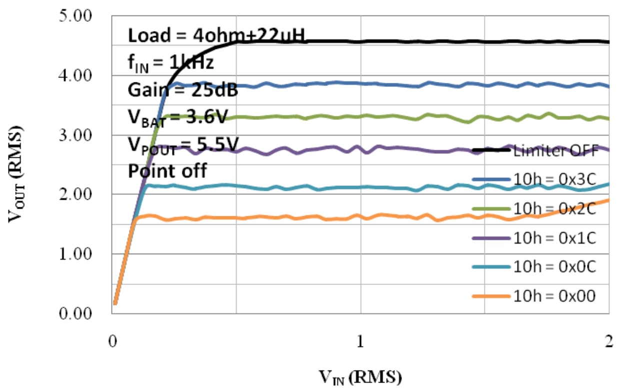
■ TYPICAL OPERATING CHARACTERISTICS

Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, unless otherwise specified.
In the graph, V_{POUT} = 5.5V refers to V_{POUT} = 5.45V that can only be available in I^2C mode , V_{POUT} = 6.5V refers to V_{POUT} = 6.45V, V_{POUT} = 7.5V refers to V_{POUT} = 7.45V, and V_{POUT} = 8.0V refers to V_{POUT} = 7.85V that can only be available for HT862T3

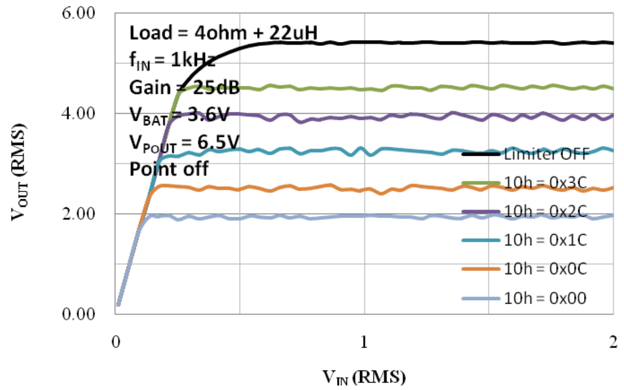
AGC

Characteristics below are measured in Class D mode, but Class AB mode is also available.
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter ON (LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking enabled (Point 3), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.

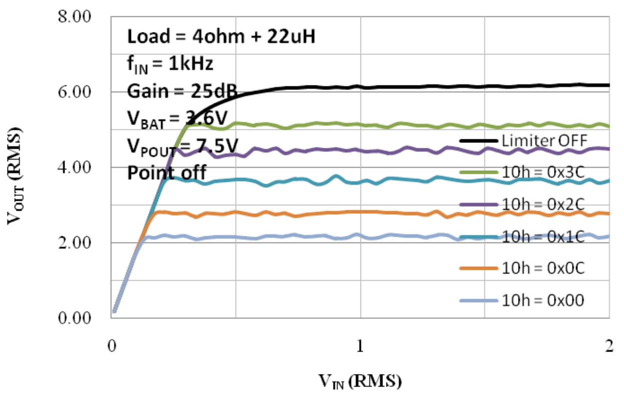
V_{IN} vs V_{OUT}



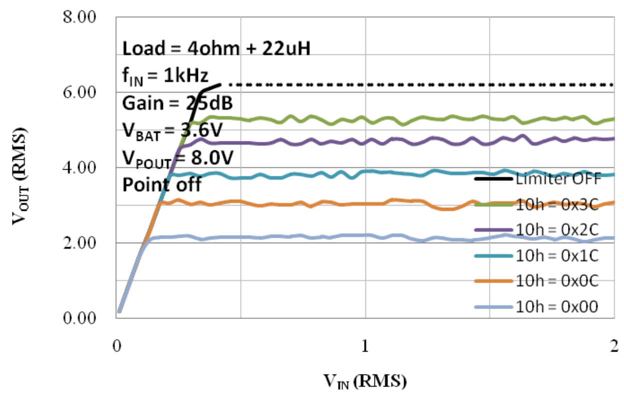
V_{IN} vs V_{OUT}



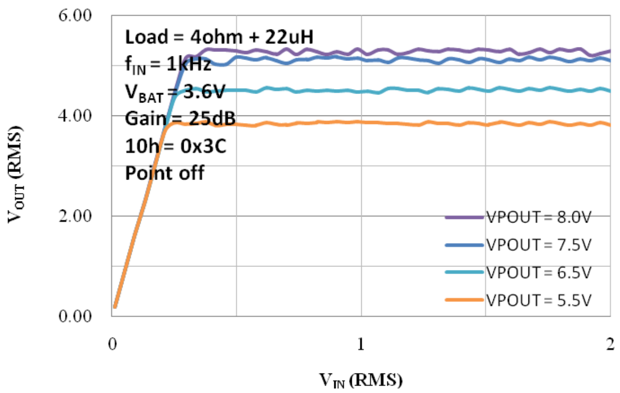
V_{IN} vs V_{OUT}



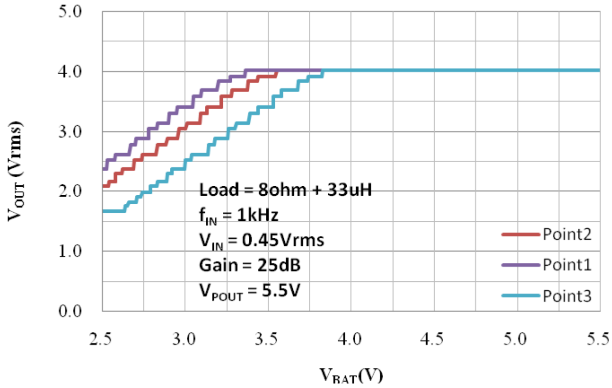
V_{IN} vs V_{OUT}



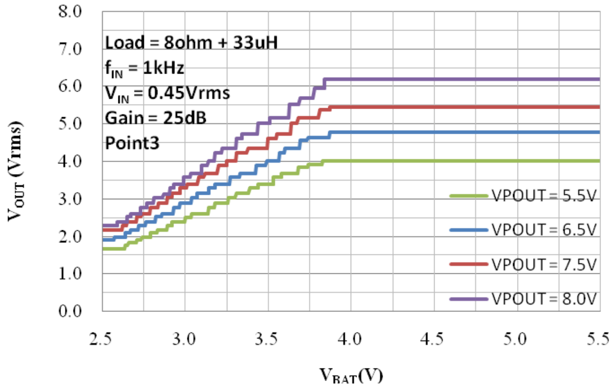
V_{IN} vs V_{OUT}



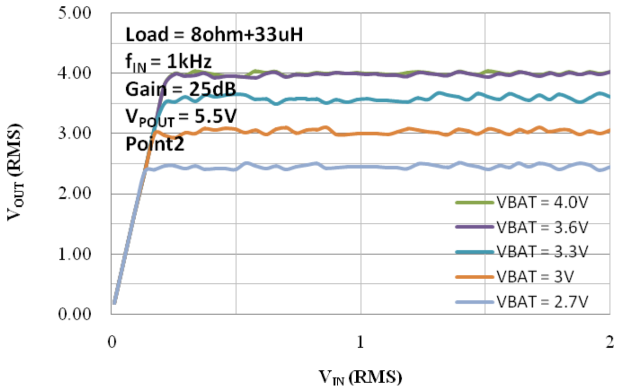
V_{BAT} vs V_{OUT}



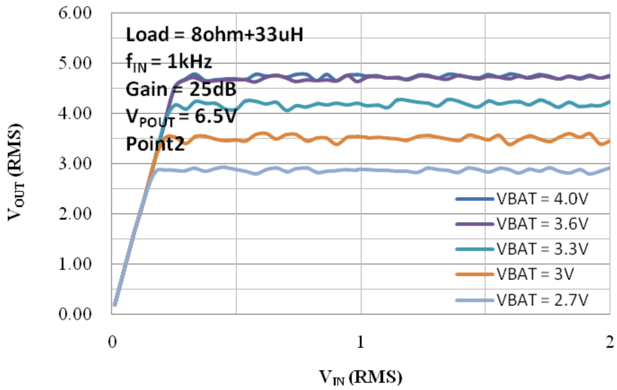
V_{BAT} vs V_{OUT}



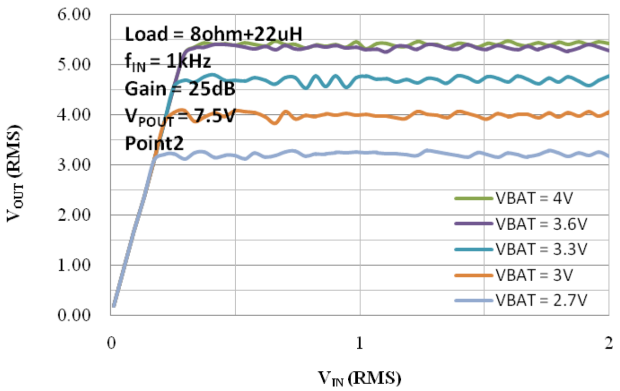
V_{IN} vs V_{OUT}



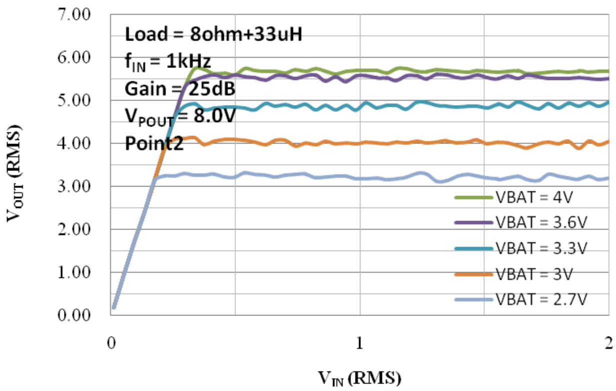
V_{IN} vs V_{OUT}



V_{IN} vs V_{OUT}

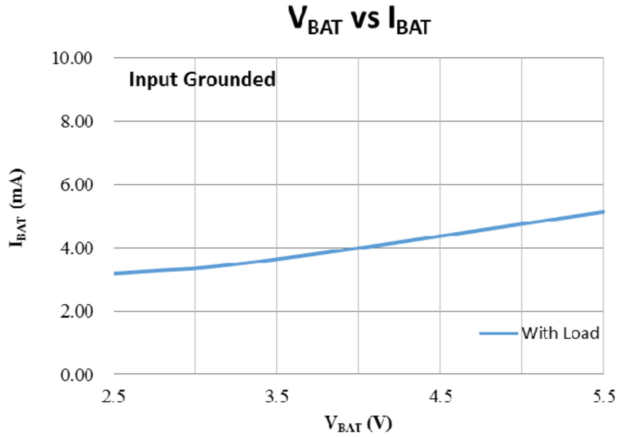


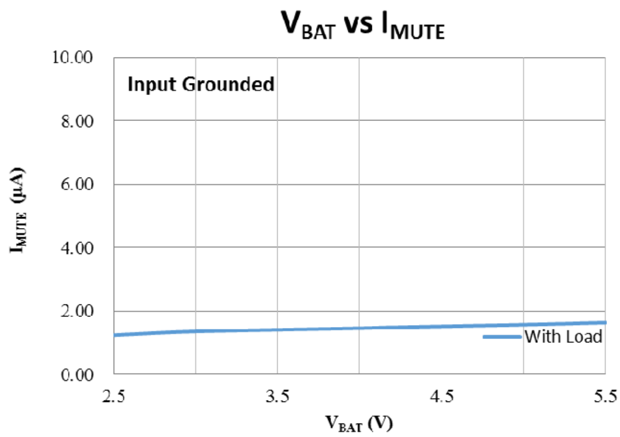
V_{IN} vs V_{OUT}

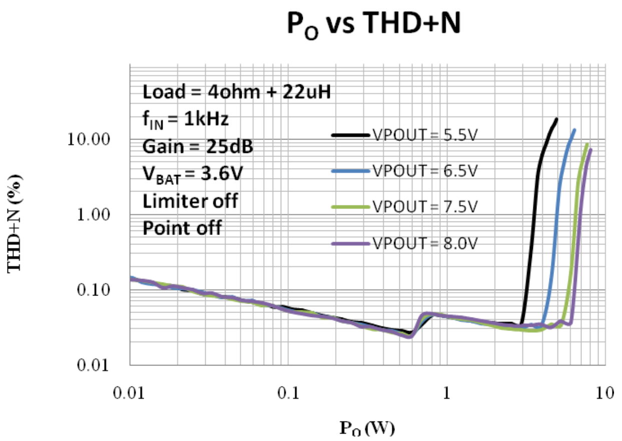


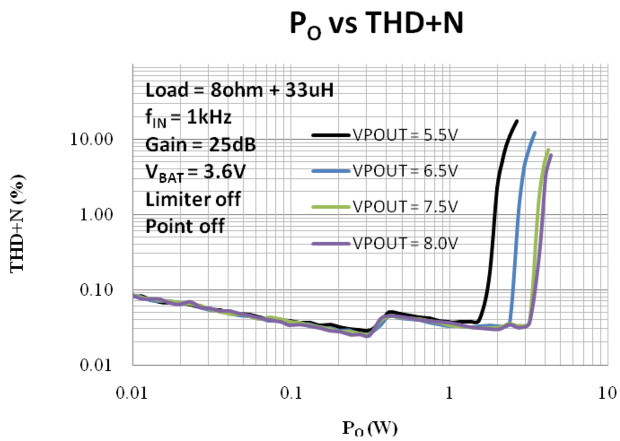
BOOST + Class D

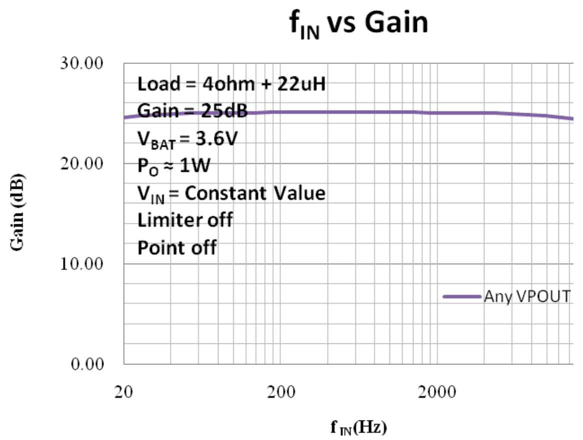
Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking disabled (Point off), Output = Load + Filter, Load = 4ohm + 22uH, Filter = 100ohm + 47nF, unless otherwise specified.

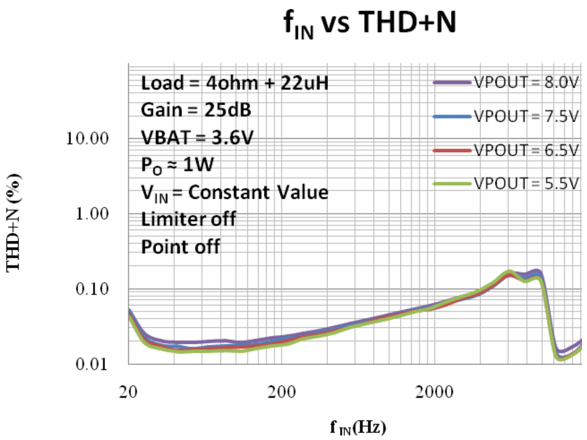




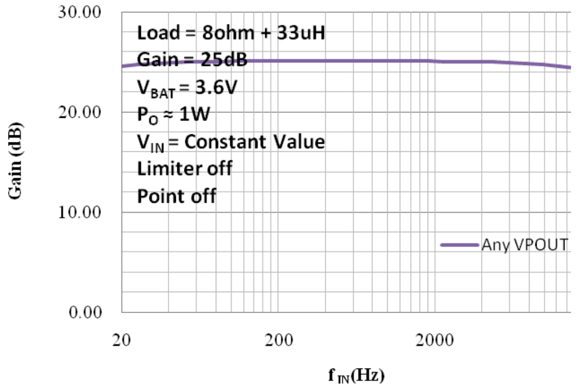




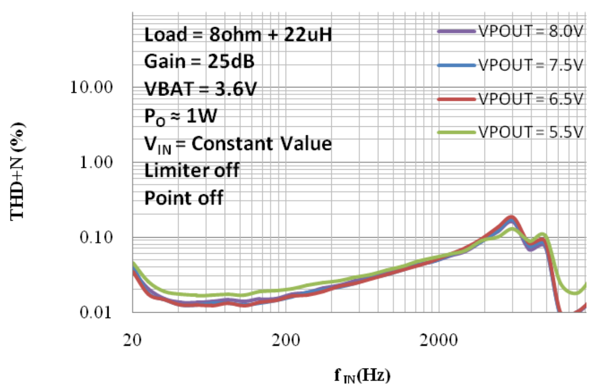




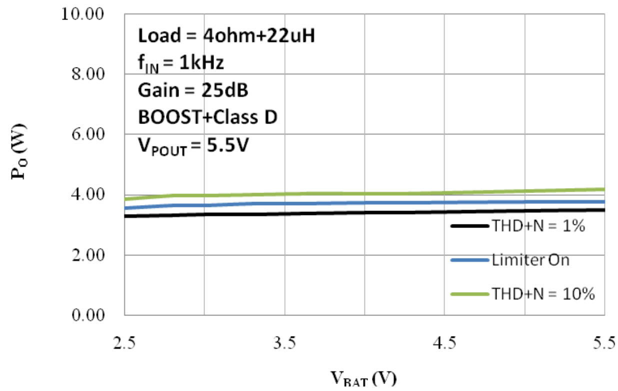
f_{IN} vs Gain



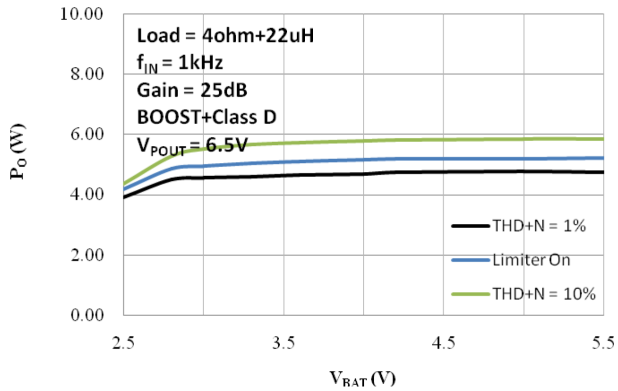
f_{IN} vs THD+N



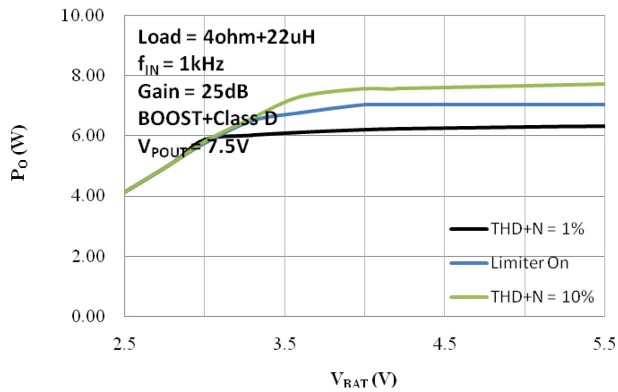
V_{BAT} vs P_O



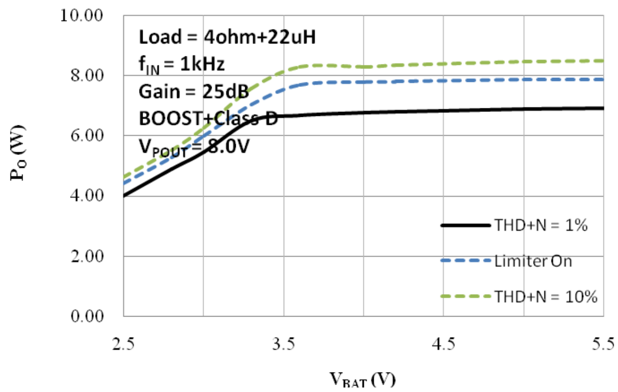
V_{BAT} vs P_O



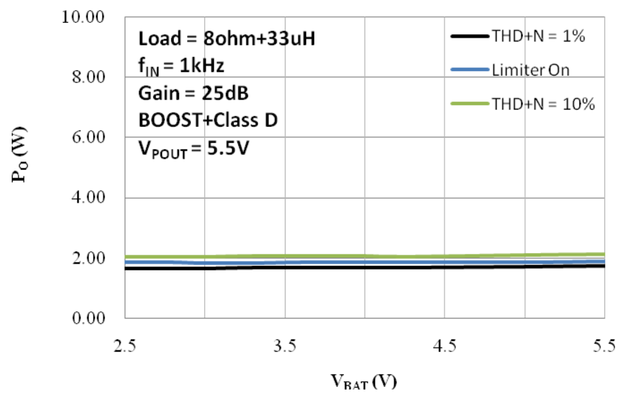
V_{BAT} vs P_O



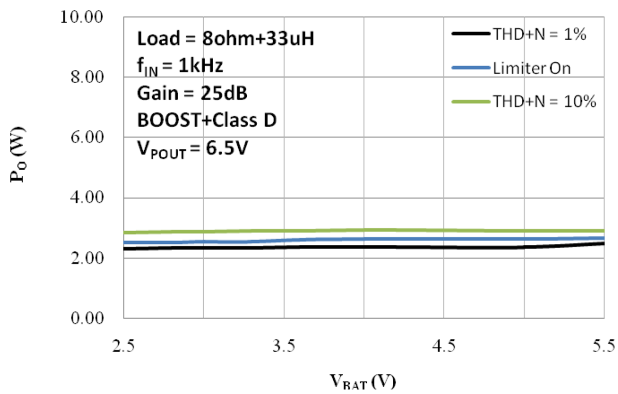
V_{BAT} vs P_O



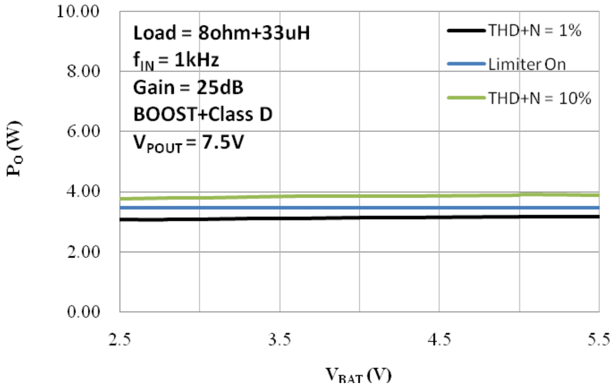
V_{BAT} vs P_O



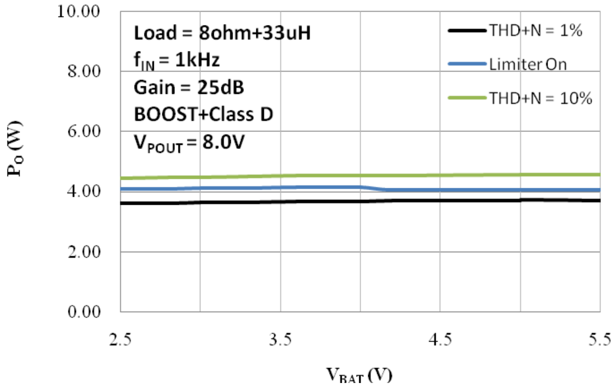
V_{BAT} vs P_O



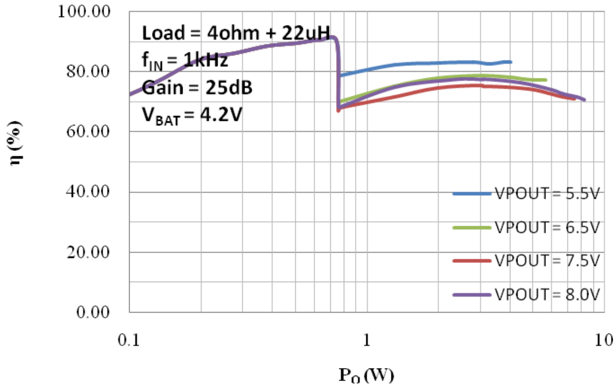
V_{BAT} vs P_O



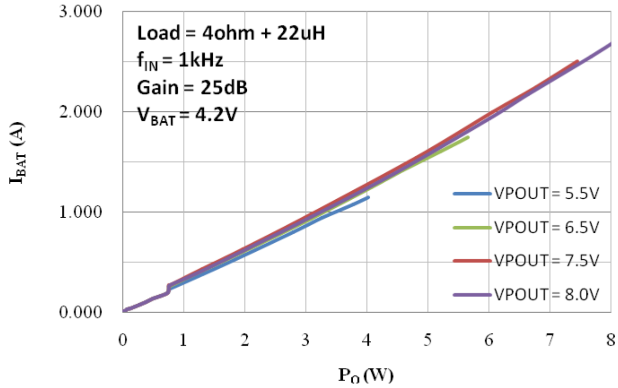
V_{BAT} vs P_O



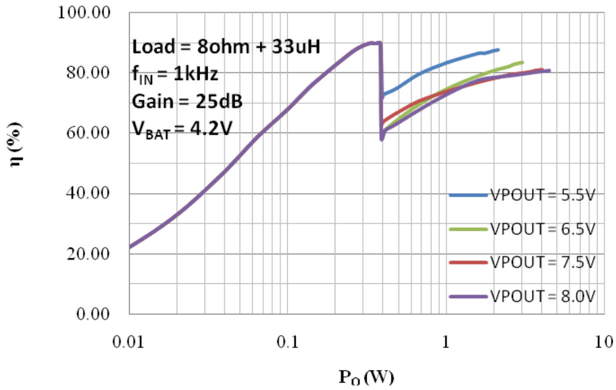
P_O vs η



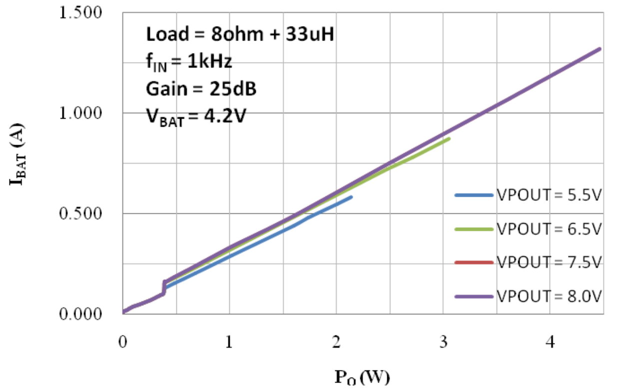
P_O vs I_{BAT}



P_O vs η



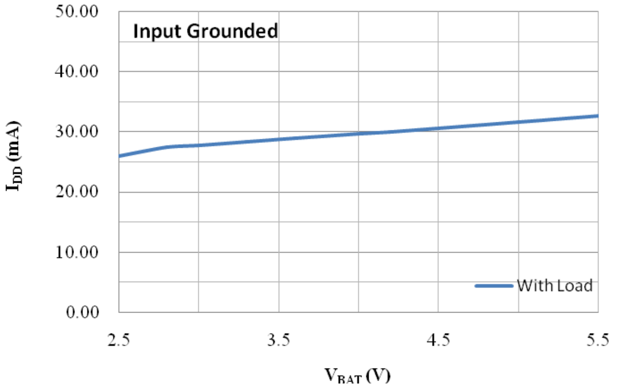
P_O vs I_{BAT}



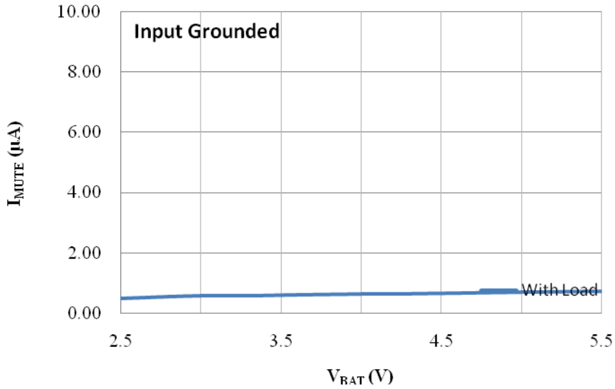
BOOST + Class AB

Condition: V_{BAT} = 3.6V, f_{IN} = 1kHz, Gain = 25dB, C_{IN} = 1uF, Limiter Off (if Limiter On, LIM terminal with 6M resistor grounded, 10h = 0x3C), Battery tracking disabled (Point off), Output = Load = 4ohm + 22uH, unless otherwise specified.

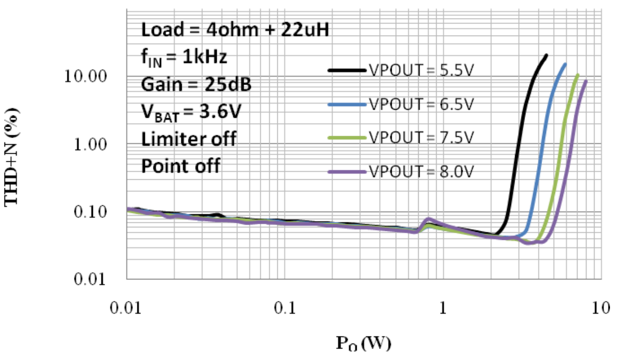
V_{BAT} vs I_{DD}



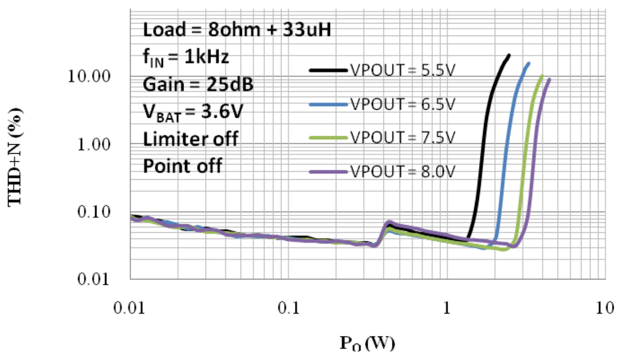
V_{BAT} vs I_{MUTE}



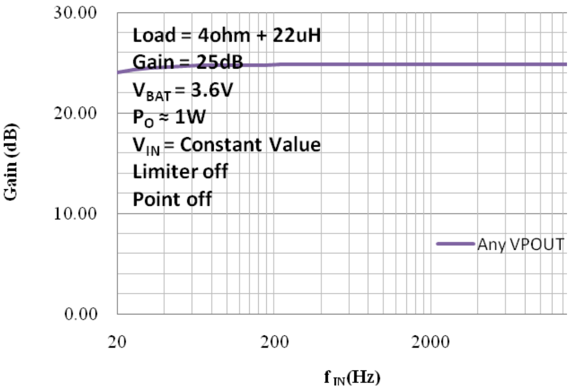
P_O vs THD+N



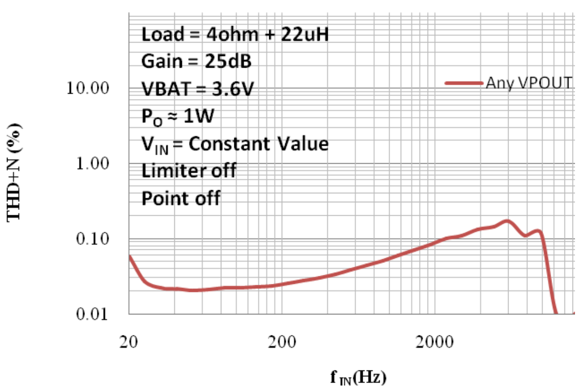
P_O vs THD+N



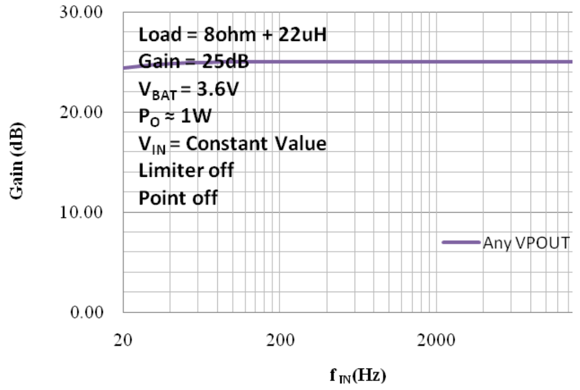
f_{IN} vs Gain



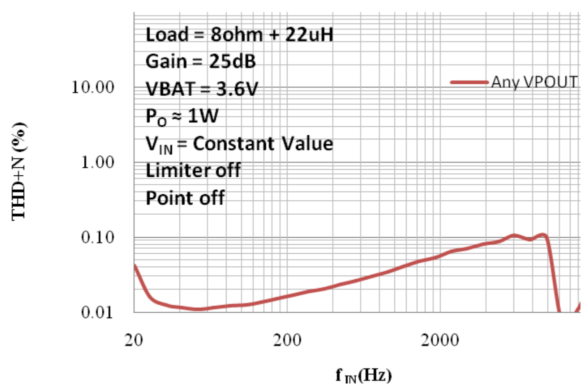
f_{IN} vs THD+N



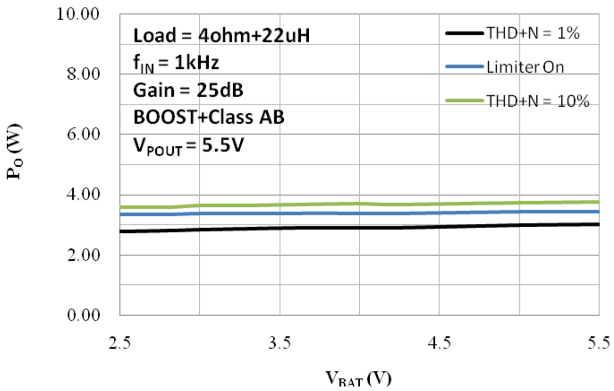
f_{IN} vs Gain



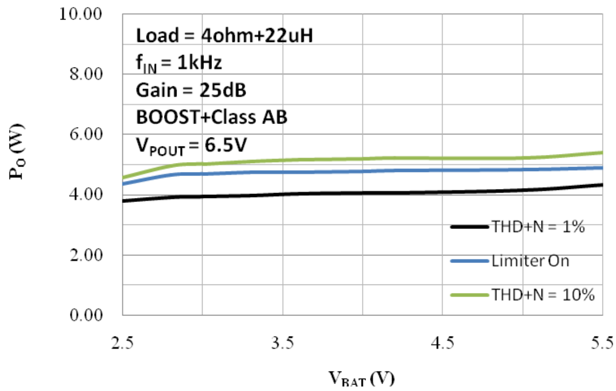
f_{IN} vs THD+N



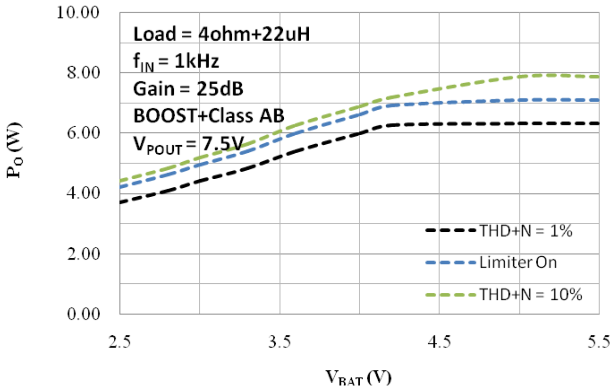
V_{BAT} vs P_O



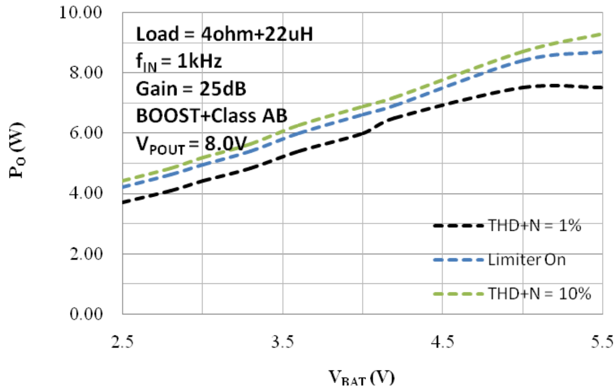
V_{BAT} vs P_O



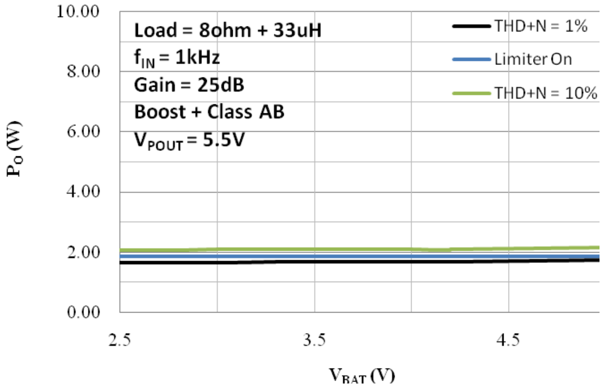
V_{BAT} vs P_O



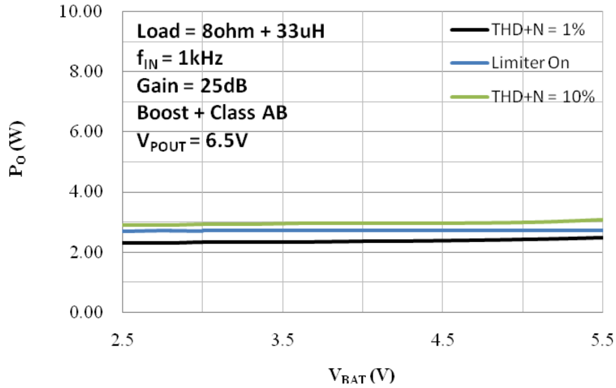
V_{BAT} vs P_O

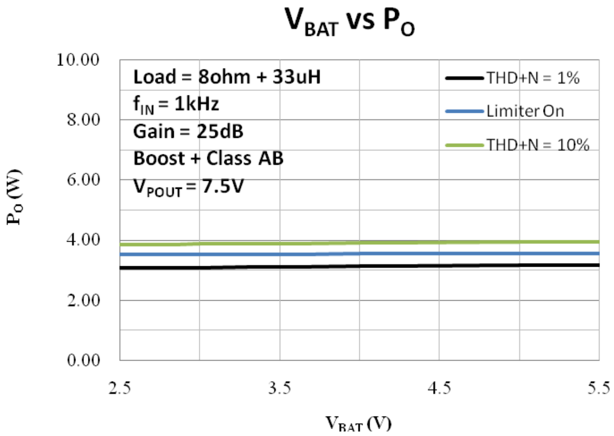


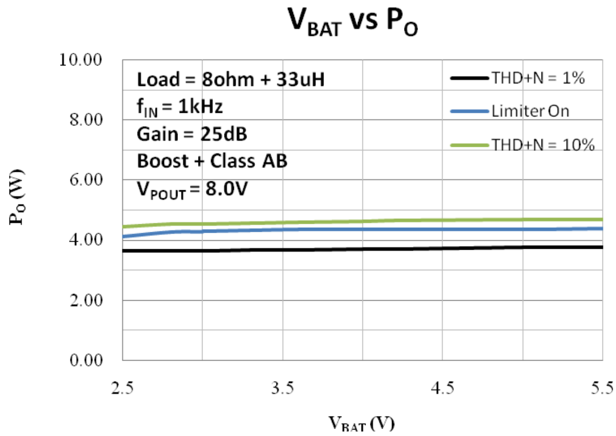
V_{BAT} vs P_O

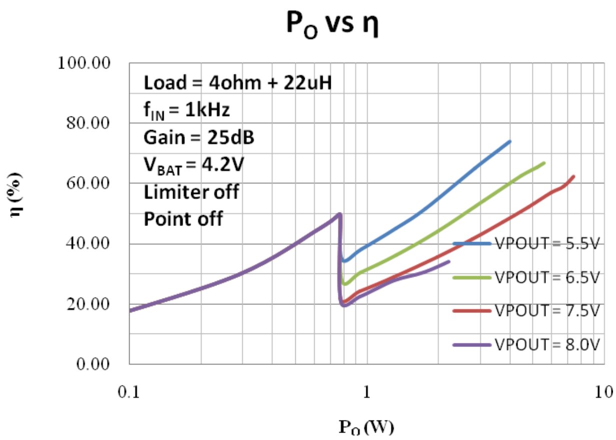


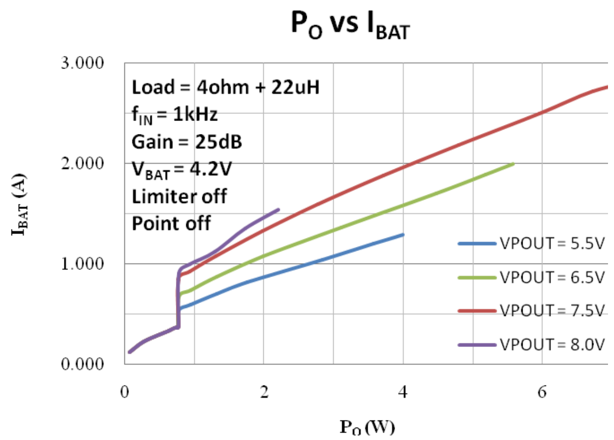
V_{BAT} vs P_O

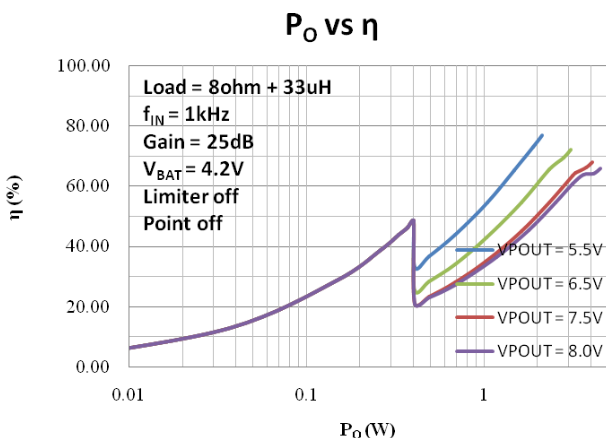


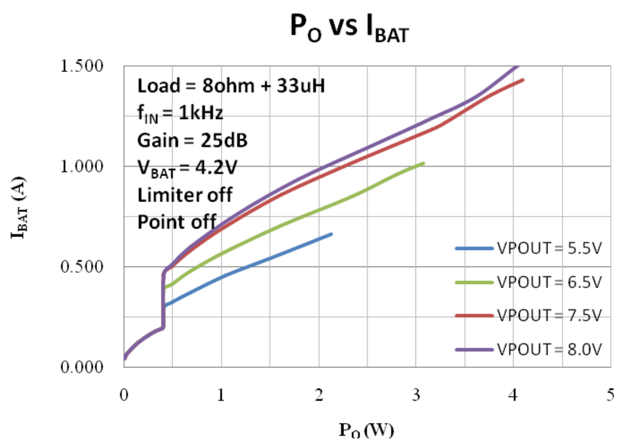

VBAT vs PO
Load = 8ohm + 33uH
fIN = 1kHz
Gain = 25dB
Boost + Class AB
VPOUT = 7.5V
THD+N = 1%
Limiter On
THD+N = 10%
PO (W)
10.00
8.00
6.00
4.00
2.00
0.00
2.5
3.5
4.5
5.5
VBAT (V)


VBAT vs PO
Load = 8ohm + 33uH
fIN = 1kHz
Gain = 25dB
Boost + Class AB
VPOUT = 8.0V
THD+N = 1%
Limiter On
THD+N = 10%
PO (W)
10.00
8.00
6.00
4.00
2.00
0.00
2.5
3.5
4.5
5.5
VBAT (V)


PO vs η
Load = 4ohm + 22uH
fIN = 1kHz
Gain = 25dB
VBAT = 4.2V
Limiter off
Point off
VPOUT = 5.5V
VPOUT = 6.5V
VPOUT = 7.5V
VPOUT = 8.0V
η (%)
100.00
80.00
60.00
40.00
20.00
0.00
0.1
1
10
PO (W)


PO vs IBAT
Load = 4ohm + 22uH
fIN = 1kHz
Gain = 25dB
VBAT = 4.2V
Limiter off
Point off
VPOUT = 5.5V
VPOUT = 6.5V
VPOUT = 7.5V
VPOUT = 8.0V
IBAT (A)
3.000
2.000
1.000
0.000
0
2
4
6
PO (W)


PO vs η
Load = 8ohm + 33uH
fIN = 1kHz
Gain = 25dB
VBAT = 4.2V
Limiter off
Point off
VPOUT = 5.5V
VPOUT = 6.5V
VPOUT = 7.5V
VPOUT = 8.0V
η (%)
100.00
80.00
60.00
40.00
20.00
0.00
0.01
0.1
1
PO (W)


PO vs IBAT
Load = 8ohm + 33uH
fIN = 1kHz
Gain = 25dB
VBAT = 4.2V
Limiter off
Point off
VPOUT = 5.5V
VPOUT = 6.5V
VPOUT = 7.5V
VPOUT = 8.0V
IBAT (A)
1.500
1.000
0.500
0.000
0
1
2
3
4
5
PO (W)

■ 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 preset Limiter Level.

Limiter Level: V_{LIM_L} for short. The maximum output voltage allowed before amplifier gain is automatically reduced. It can be configured both in hardware and I^2C control modes.

Battery Tracking: Point for short, when this function is active, HT862 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 both in hardware and I^2C control modes.

V_{BAT} vs Limiter Slope: Slope for short. The slope that Limiter Level followed while the battery voltage drops (VBAT< Battery Tracking Point). It can be only configured in I^2C control mode.

Thermal Foldback: TFB for short. When this function is active, HT862 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. It can be only configured in I^2C control mode.

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. Both can be only configured in I^2C control mode.

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 of TFB Release Time is 2400ms /dB. Both can be only configured in I^2C control mode.

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 preset Limiter Level (can be modified in register address ox10). If the output audio signal exceeds the Limiter Level, HT862 decreases amplifier gain by the rate of attack time (default value 12ms/dB, can be modified in register address 0x0B), 0.375dB per step (or 0.75dB per step, which can be modified in register address 0x0A). HT862 increases the gain by the rate release time (default value 150ms/dB, can be modified in register address 0x0C), 0.375 per step(or 0.75dB per step, which can be modified in register address 0x0A), once the output audio is below the limiter level. Figure 3 shows this relationship.

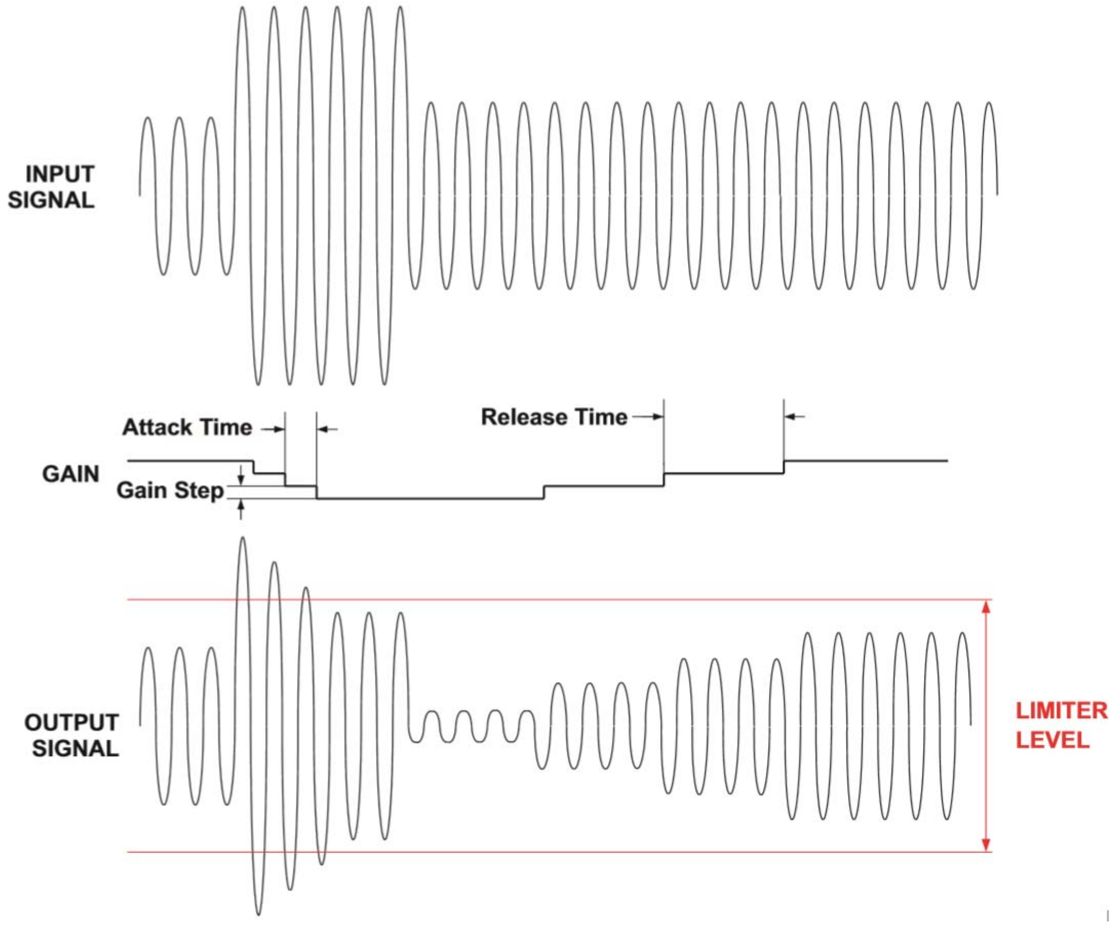


Fig. 3 AGC Limiter Function

The Limiter Level (also as the default Limiter Level in I²C Control Mode) can also be modified in Hardware Control Mode through LIM terminal. The internal circuit of LIM terminal shows in Fig 4, in which R1 ≈ 615kohm, R2 ≈ 227kohm, R3 ≈ 380kohm. If the LIM terminal is directly grounded, AGC function disabled. To obtain a different Limiter Level, the LIM terminal can be floating, connect a resistor to V_{POUT}, or connect a resistor to Ground. The Limiter Level can be calculated by $V_{LM\_L\ (Peak)} \approx (0.5V_{POUT} – V_{LIM\_COM}) \times 5$.Typical configurations are shown in the following table.

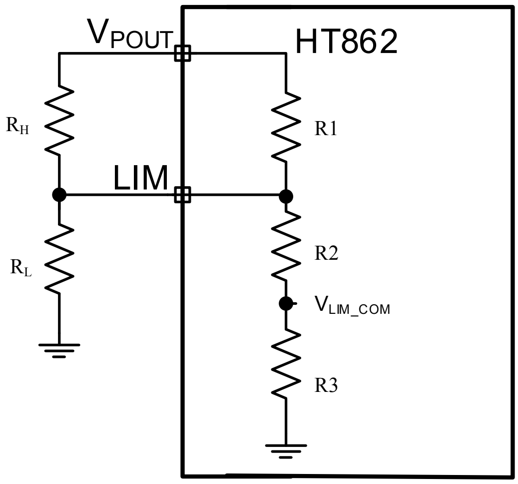


Fig. 4 LIM Terminal Configuration

Table. 1 Typical AGC Limiter Level Configuration in Hardware Mode

R_L(Ω)	R_H(Ω)	Limiter level (Peak)	THD+N(Class D)	THD+N(Class AB)
NC	NC	≈0.95×V_{POUT}	≈3%	≈5%
NC	6M	≈0.87×V_{POUT}	≈1%	≈3%
6M	NC	≈1.0×V_{POUT}	≈5%	≈7%
Short	NC	AGC Disabled		

2.1.2 Battery Tracking Function

The HT862 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 5 shows a plot of the limiter level as a function of the supply voltage.

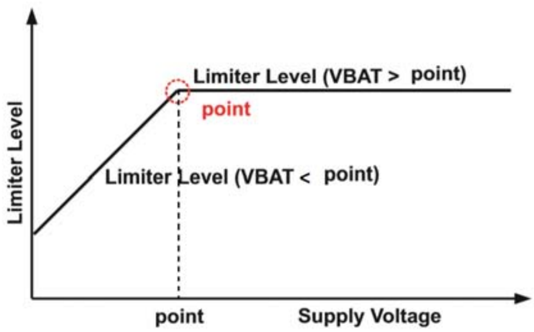


Fig. 5 Limiter Level vs Supply Voltage

In Hardware Control mode, connect a resistor between the AGC pin and Ground to set the Battery Tracking Point, as shown in Table 2. In I^2C control mode, the Battery Tracking Point can be programmed in register address 0x09. (Point1 can only be set in I^2C control mode)

The slope of the limiter level versus supply voltage (Battery Tracking Slope) can only be modified in I^2C Control Mode, located in register 0x14, 0x15, 0x16.

Table. 2 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 in IIC Control mode	3.3V
Battery tracking point2	33kΩ	3.5V

Battery tracking point3	5.1kΩ	3.8V

Figure 6 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. HT862 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.

HT862 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;

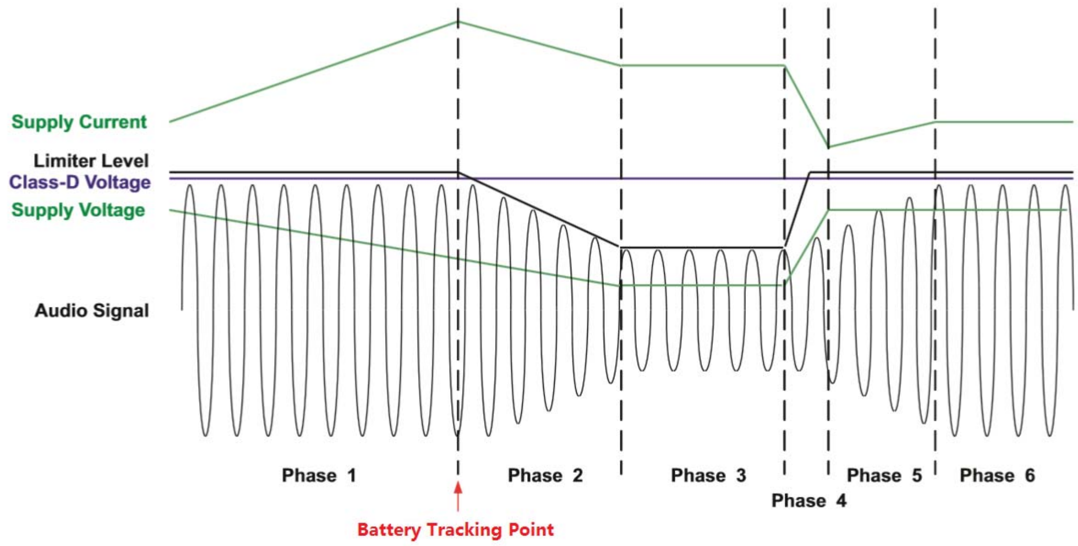


Fig. 6 Battery Tracking Function Operation Example

2.2. Adaptive Boost Converter

The HT862 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. Meanwhile, an external diode can be saved for the boost converter.

In Hardware Control mode, connect a resistor between the BST pin and Ground, 3 choices of the boost converter output voltage V_{POUT} can be set, as shown in Table 3. In I²C control mode, the V_{POUT} can be programmed in register address 0x09 with 4 choices (Choice of V_{POUT} = 5.45V is added). V_{POUT} = 7.85V is only available for HT862T3.

Table. 3 BOOST Terminal Configuration in Hardware Mode

Resistor on BST pin to GND	V_{POUT}	Supported Part
Available in IIC control mode	5.45V	HT862B3, HT862T3
Floating	6.45V	HT862B3, HT862T3
33kΩ	7.45V	HT862B3, HT862T3
5.1kΩ	7.85V	HT862T3

The boost converter of HT862B3 is working in synchronous mode, so that no external diode is needed.

The boost converter of HT862T3 is working in non-synchronous mode, so a Schottky Diode (V_{RRM} > 12V, V_{FM} < 0.5V, $I_F \geq 3$ A, SS54 is recommended) is needed to be connected between SW and V_{POUT}, as the pic shows in the following.

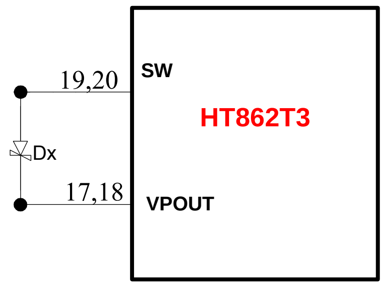


Fig. 7 Schottky diode for 7.85V boost converter

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} can be programmed only in I²C control mode in register address 0x19, the default value is optimized to prevent clipping while maximizing system efficiency.

The boost converter can be forcibly deactivated by setting the ENB pin to logic-low in Hardware Control Mode. In I²C Control Mode, it can be programed in register address 0x09. When the boost is deactivated, V_{POUT} is equal to the supply voltage (V_{BAT}) minus the I x R drop across the inductor and boost converter pass transistor.

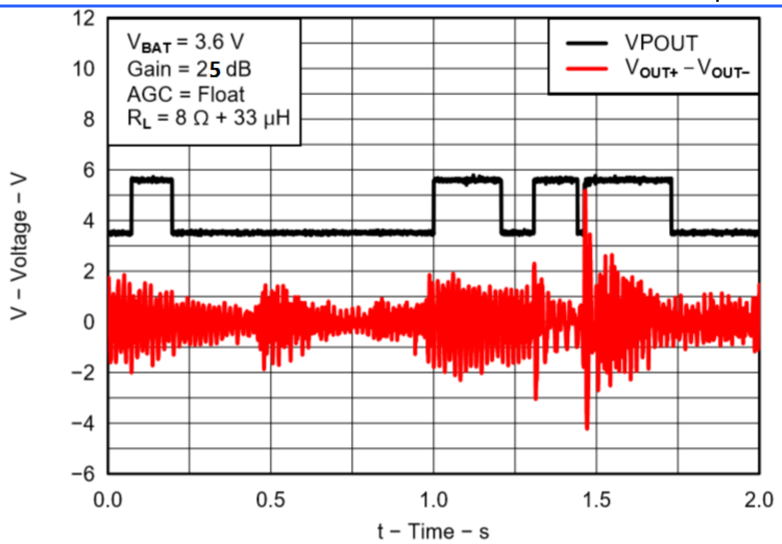


Fig. 8 Adaptive Boost Converter with Typical Music Playback

Figure 8 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 HT862 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 HT862 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.

(3) 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 HT862, C_{IN} and C_{OUT} should be connected close together directly to ground plane.

2.3. Thermal Foldback

The HT862 Thermal Foldback, TFB, is designed to protect the HT862 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 HT862 system gain by the rate of attack time (default value 1200ms/dB, can be modified in register address 0x0B) in steps of 0.375dB (or 0.75dB, can be modified in register address 0x0A) if the TFB trig point (default value 150℃, can be modified in register address 0x1C) is exceeded. Once the die temperature drops below the TFB trig point, the HT862 gain is increased by a single or by the rate of release time (default value 2400ms/dB, 0.375dB per step, can be modified in register address 0x0C) 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.

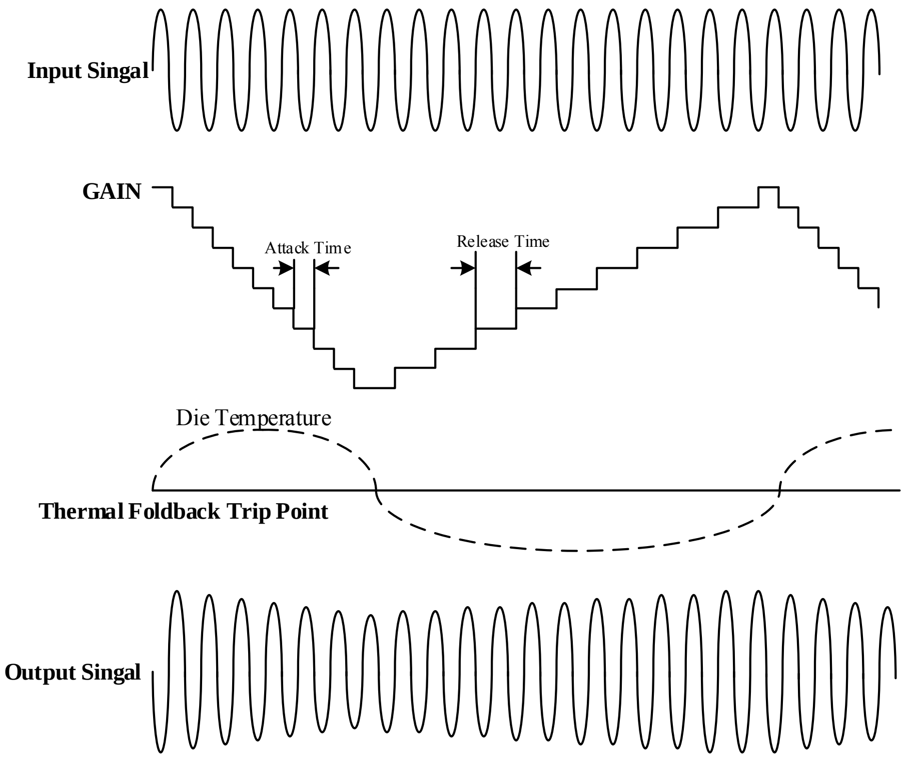


Fig. 9 Thermal Foldback Operation

2.4. Audio Amplifier Input Configuration

HT862 is an amplifier (Class AB or Class D, optional in both hardware and I²C Control Mode) 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.

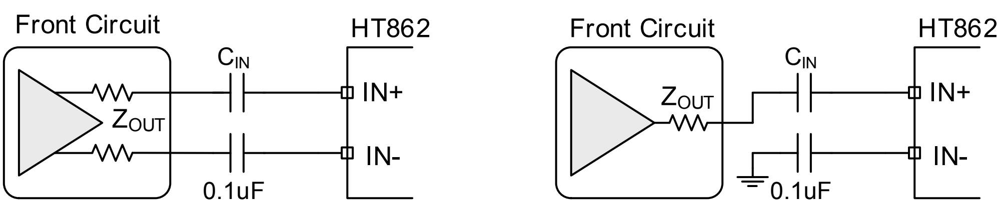


Fig. 10 (1) Differential Input; (1) Single-ended Input

Table. 4 R_{IN} vs GAIN

GAIN	R_{IN}
25dB	31.4 KΩ
30dB	19.1 KΩ

2.5. Amplifier Output

As mentioned before, HT862 can directly drive speakers without any other components. But there are exceptions. Once HT862 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.

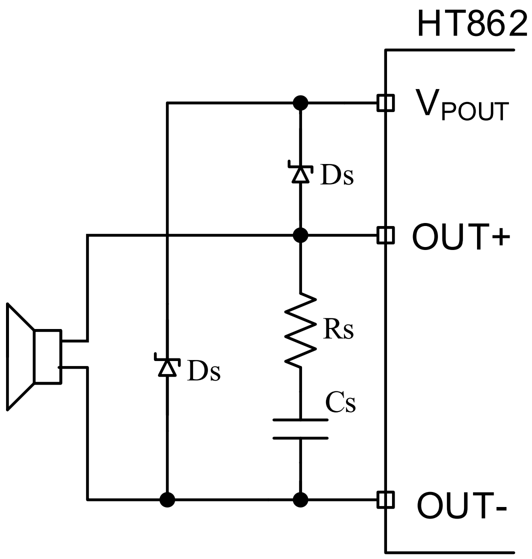


Fig. 11 Amplifier Output Configuration

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

HT862 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 is eliminated, the over current protection mode can be cancelled automatically.

(2) Thermal Protection function

When excessive high temperature of HT862 (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). HT862 will start up within the start-up time when the low voltage protection mode is cancelled.

3. Control Mode

3.1. I²C Control Mode

When ABD, ENB and ENA connected to ground, HT862 enters into I²C Control Mode, AGC/SDA is the I²C data input/output terminal, GAIN/SCL is the I²C clock input terminal.

The HT862 I²C address is 0x31(00110001) for reading and 0x30(00110000) for writing. Once ENB and ENA connected to ground, HT862 enters into I²C Control Mode, HT862 is in shutdown mode. Before reading and writing though I²C, wake up the chip first by writing either of Bit7 (ENB) or Bit6 (ENA) in register 0x09 to a 1.

I²C read and write timing shows as follows.

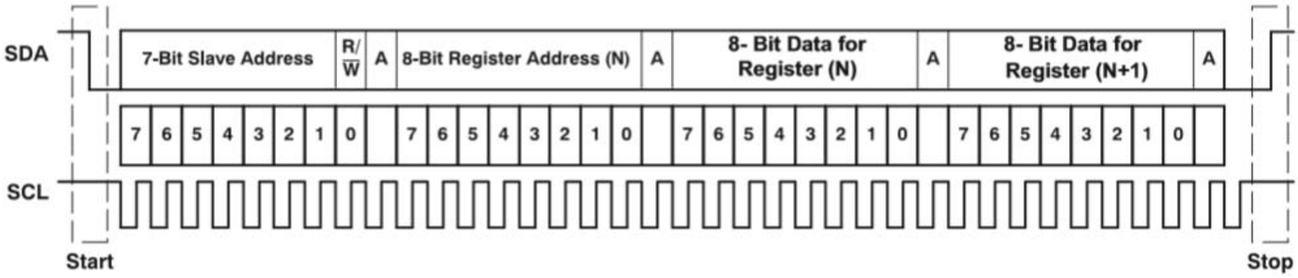


Fig. 12 Typical I²C Sequence

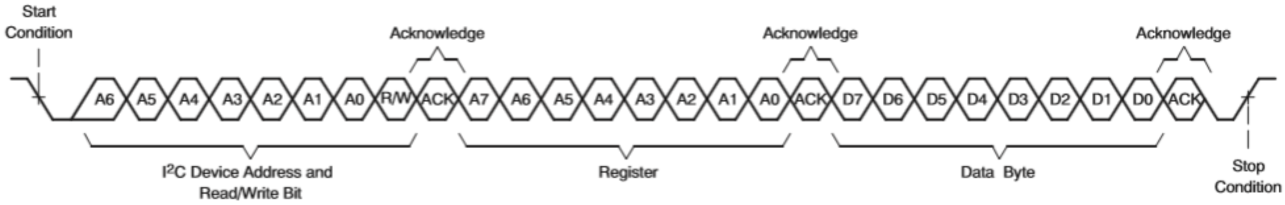


Fig. 13 Single-Byte Write Transfer

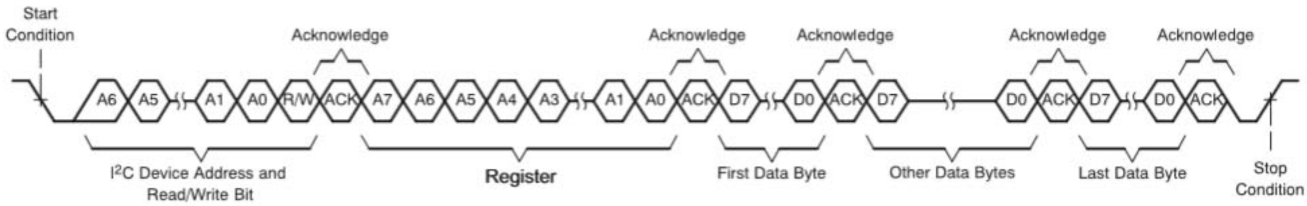


Fig. 14 Multiple-Byte Write Transfer

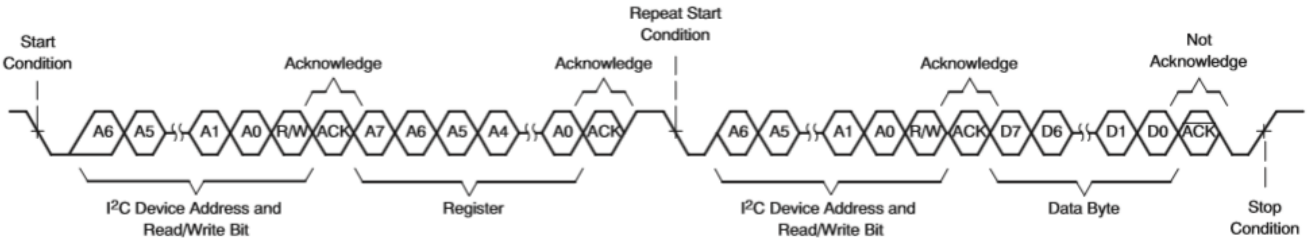


Fig. 15 Single-Byte Read Transfer

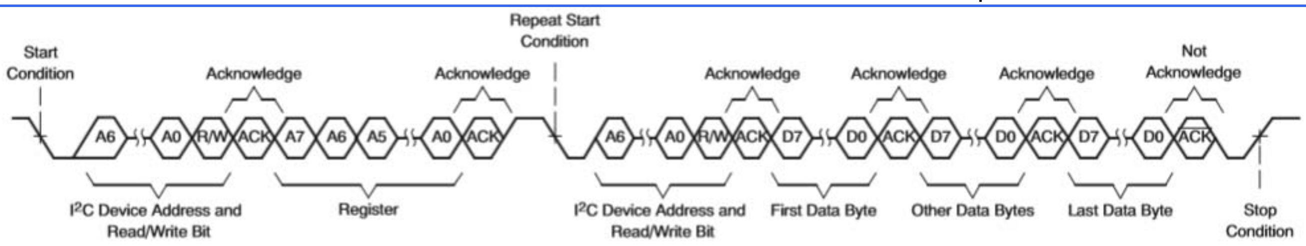


Fig. 16 Multiple-Byte Read Transfer

3.2. Hardware Control Mode

Either of ENA and ENB terminal is connected to logic high, HT862 enters into Hardware Control Mode.

3.2.1 ABD

By pulling ABD into logic low, HT862 enters into Class D mode. By pulling ABD into logic high, HT862 enters into Class AB mode. Note that an internal 300kohm pulldown resistor is connected to ABD.

3.2.2 ENA, ENB

By pulling ENA, ENB terminal into logic low or high, HT862 can enter into different modes, shown as follows.

Table. 5 ENA, ENB Terminal Configuration

ENA	ENB	Mode	
H	H	Hardware Control Mode	Adaptive Boost +Audio Amplifier
H	L		Audio Amplifier On, Boost disabled
L	H		Boost On, Audio Amplifier disabled
L	L	Shutdown	

Note that an internal 300kohm pulldown resistor is connected to ENA, ENB separately.

3.2.3 AGC/SDA

In I²C Control mode, it is the I²C data input/output terminal. In Hardware Control Mode, it is the terminal to enable and select Battery Tracking function. Detailed as follows.

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

3.2.4 GAIN/SCL

In I²C Control mode, it is the I²C clock input terminal. In Hardware Control Mode, it is the terminal to select system gain or mute system. Detailed as follows.

Table. 6 GAIN Terminal Configuration

GAIN	Mode	R_{IN}
H	Audio Amplifier Mute	/
Floating	Audio Amplifier Gain = 25dB	31.4KΩ
L	Audio Amplifier Gain = 30dB	19.1 KΩ

3.2.5 BST

In Hardware Control Mode, it is the terminal to select the Boost Converter output voltage. Detailed as follows.

Resistor on BST pin to GND	V_{POUT}
Floating	6.45V
33kΩ	7.45V
5.1kΩ	7.85V

3.2.6 AGC LIM

In Hardware Control Mode, it is the terminal to enable and select Limiter Level. The internal circuit structure can be seen in Figure 2. If the LIM terminal is directly grounded, AGC function disabled. To obtain a different Limiter Level, it can be calculated by $V_{LM\_L\,(Peak)} = (0.5V_{POUT} - V_{LIM\_COM}) \times 5$, typical configurations shown as follows.

$R_L(\Omega)$	$R_H(\Omega)$	Limiter level (VRMS)	THD+N(Class D)	THD+N(Class AB)
NC	NC	$0.95\times V_{POUT}$	3%	5%
NC	6M	$0.87\times V_{POUT}$	1%	3%
6M	NC	$1.0\times V_{POUT}$	5%	7%
Short	NC	AGC disabled		

4. Register description

Register Map

Table. 7 Register Map

Register	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default Value
0x00~0x07	Reserved								00h
0x08	Reserved					OCP Flag	OTP Flag	TFB Flag	00h
0x09	ENB	ENA	Boost Voltage		Battery Tracking Point		Gain		00h
0x0A	MUTE	ABD	AGC EN	AGC Step	TFB	Adaptive	Modulation Mode		74h
0x0B	TFB Attack Time			AGC Attack Time					9Eh
0x0C	TFB Release Time			AGC Release Time					80h
0x0D	Unused	Gain1							30h
0x0E	Unused	Gain2							24h
0x0F	Unused	Gain3							30h
0x10	Unused		Limiter Level						3Ch
0x11	Battery Tracking Point3								BCh
0x12	Battery Tracking Point2								ADh
0x13	Battery Tracking Point1								A4h
0x14	Unused	Unused	Battery Tracking Slope3						20h
0x15	Unused	Unused	Battery Tracking Slope2						20h
0x16	Unused	Unused	Battery Tracking Slope1						20h
0x17	Boost on Delay Time		Boost Off Delay Time		Amplifier Start-up Time		PWM Delay Time		19h
0x18	Reserved								xx
0x19	Boost on threshold voltage		Unused	Unused	Unused	Unused	Unused	Unused	40h
0x1A~0x1B	Reserved								xx
0x1C	OTP EN	OTP, TFB		Reserved		OTP, TFB			A4h

The HT862 register map is shown in Table 7. Any register below address 0x08 and above address 0x1C is reserved for testing and should not be written to because it may change the function of the device. If read, these bits may assume any value

The HT862 I^2C address is 0x31(00110001) or reading and 0x30(00110000) for writing. If a different I^2C address is required, please contact us.

The following tables show the details of the registers, the default values, and the values that can be programmed through the I2C interface.

Register Address: 0x08

Bit	R/W	Label	Default	Description
7:3	R	Reserved	0	Reserved, do not write.
2	R	OCP Flag	0	changes to a 1 when OCP happened; back to 0 when OCP evacuated
1	R	OTP Flag	0	Changes to a 1 when die temperature is above OTP point; back to 0 when that is below OTP - OTP_{hys}

0	R	TFB Flag	0	Changes to a 1 when die temperature is above TFB point; back to 0 when that is below TFB - TFB_{hys}

Register Address: 0x09

Bit	R/W	Label	Default	Description
7:6	R/W	ENB, ENA	00	Mode Setting: 00: Shutdown mode; 01: Pass through mode, Audio Amplifier only; 10: Boost only; 11: Adaptive boost + Audio Amplifier
5:4	R/W	BST	00	Boost Voltage V_{POUT} Setting: 00: V_{POUT} = 7.85V; 01: V_{POUT} = 7.45V; 10: V_{POUT} = 6.45V; 11: V_{POUT} = 5.45V.
3:2	R/W	Point	00	Battery Tracking Point Setting: 00: Point3, value of reg 0x11, default = 3.8V; 01: Point2, value of reg 0x12, default = 3.5V; 10: Point1, value of reg 0x13, default = 3.3V; 11: Battery tracking function disabled
1:0	R/W	GAIN	00	Amplifier Gain Setting: 00: Gain2, value of reg 0x0E, default = 25dB; 01: Gain1, value of reg 0x0D, default = 30dB; 10: Gain3, value of reg 0x0F, default = 30dB; 11: Gain2, value of reg 0x0E, default = 25dB

Register Address: 0x0A

Bit	R/W	Label	Default	Description
7	R/W	MUTE	0	0: Amplifier enabled; 1: Amplifier mute
6	R/W	ABD	1	0: Class AB; 1: Class D
5	R/W	AGC EN	1	0: AGC disabled; 1: AGC enabled
4	R/W	AGC Step	1	0: 40 steps, 0.75dB/step; 1: 80 steps, 0.375dB/step
3	R/W	TFB	0	0: TFB enabled; 1: TFB disabled
2	R	Reserved	1	Reserved, do not write.
1:0	R/W	Modulation	00	Modulation Mode Setting: 00: 4-state mode; 01: 3-state mode; 10: 3-state mode, OUT+ constantly high in positive sine-wave, not recommended to use this mode. If has to, line LC filter between OUT and speaker

Register Address: 0x0B

<table>
<tr><th>Bit</th><th>R/W</th><th>Label</th><th>Default</th><th colspan="8">Description</th></tr>
<tr><td rowspan="5">7:5</td><td rowspan="5">R/W</td><td rowspan="5">t_{A_TFB}</td><td rowspan="5">100</td><td colspan="8">Thermal Foldback Attack Time Setting</td></tr>
<tr><td>000</td><td colspan="3">150ms/dB</td><td>100</td><td colspan="3">1200ms/dB</td></tr>
<tr><td>001</td><td colspan="3">300ms/dB</td><td>101</td><td colspan="3">1800ms/dB</td></tr>
<tr><td>010</td><td colspan="3">450ms/dB</td><td>110</td><td colspan="3">2400ms/dB</td></tr>
<tr><td>011</td><td colspan="3">600ms/dB</td><td>111</td><td colspan="3">4800ms/dB</td></tr>
<tr><td rowspan="6">4:0</td><td rowspan="6">R/W</td><td rowspan="6">t_{A_AGC}</td><td rowspan="6">11110</td><td colspan="8">AGC Attack Time Setting</td></tr>
<tr><td>00000</td><td>13.33μs/dB</td><td>01000</td><td>226.6μs/dB</td><td>10000</td><td>440.0μs/dB</td><td>11000</td><td>840.0μs/dB</td></tr>
<tr><td>00001</td><td>39.9μs/dB</td><td>01001</td><td>253.3μs/dB</td><td>10001</td><td>466.6μs/dB</td><td>11001</td><td>900.0μs/dB</td></tr>
<tr><td>00010</td><td>66.6μs/dB</td><td>01010</td><td>280.0μs/dB</td><td>10010</td><td>480.0μs/dB</td><td>11010</td><td>1.2ms/dB</td></tr>
<tr><td>00011</td><td>93.3μs/dB</td><td>01011</td><td>306.6μs/dB</td><td>10011</td><td>540.0μs/dB</td><td>11011</td><td>1.5ms/dB</td></tr>
<tr><td>00100</td><td>120μs/dB</td><td>01100</td><td>333.3μs/dB</td><td>10100</td><td>600.0μs/dB</td><td>11100</td><td>3ms/dB</td></tr>
</table>

				00101	146.7μs/dB	01101	360.0μs/dB	10101	660.0μs/dB	11101	6ms/dB
				00110	173.4μs/dB	01110	386.7μs/dB	10110	720.0μs/dB	**11110**	**12ms/dB**
				00111	200.0μs/dB	01111	413.3μs/dB	10111	780.0μs/dB	11111	24ms/dB

Register Address: 0x0C

Bit	R/W	Label	Default	Description							
7:5	R/W	t_{A_TFB}	100	Thermal Foldback Release Time Setting							
				000	300ms/dB			**100**	**2400ms/dB**		
				001	600ms/dB			101	3600ms/dB		
				010	900ms/dB			110	4800ms/dB		
				011	1200ms/dB			111	9600ms/dB		
4:0	R/W	t_{A_AGC}	0000	AGC Release Time Setting							
				00000	**150ms/dB**	01000	1350ms/dB	10000	2250ms/dB	11000	5400ms/dB
				00001	300ms/dB	01001	1500ms/dB	10001	2700ms/dB	11001	6000ms/dB
				00010	450ms/dB	01010	1650ms/dB	10010	3000ms/dB	11010	6600ms/dB
				00011	600ms/dB	01011	1800ms/dB	10011	3600ms/dB	11011	7200ms/dB
				00100	750ms/dB	01100	1950ms/dB	10100	3900ms/dB	11100	7800ms/dB
				00101	900ms/dB	01101	2100ms/dB	10101	4200ms/dB	11101	8400ms/dB
				00110	1050ms/dB	01110	2250ms/dB	10110	4500ms/dB	11110	9000ms/dB
				00111	1200ms/dB	01111	2400ms/dB	10111	4800ms/dB	11111	9600ms/dB

Register Address: 0x0D

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain1	30h	Set gain1, detail followed.

Register Address: 0x0E

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain2	24h	Set gain2, detail followed.

Register Address: 0x0F

Bit	R/W	Label	Default	Description
7	R	Unused	0	Unused, make it always 0
6:0	R/W	Gain3	30h	Set gain3, detail followed.

Gain1, Gain2, Gain3 can be changed by programming register 0x0D, 0x0E, 0x0F separately, so that:

(1) the system gain can be set

Writing 0x0D, 0x0E, 0x0F value first, and then set the system gain by writing Bit1:0 of register 0x09.

(2) Volume control can be achieved

Choose the system gain by writing Bit1:0 of register 0x09 (Gain2 for instance) first, and then writing the corresponding register (0x0E for Gain2) step by step (follow the table below) to achieve volume control.

Note that the gain increases by the rate of t_{R_AGC} and decreases by the rate of t_{A_AGC}, to realize volume fading. Set t_{R_AGC} and t_{A_AGC} before volume control and recover after volume control finished.

Relationship between input resistor (R_{IN}) and system gain are shown as follows.

0x0D or 0x0E or 0x0F	Gain1 or Gain2 or Gain3	R_{IN}
0110,0000	0dB	193.4k
0110,0001	0.375dB	190.7k

0110,0010	0.750dB	188.0k
Gain increased by 0.375dB every step		R_{IN} decreased by 2.7k every step
0111,1111	11.625dB	104.3k
0000,0000	12dB	107.0k
0000,0001	12.375dB	109.7k
Gain increased by 0.375dB every step		R_{IN} decreased by 1.9117k every step
0011,0000	30dB	19.85k

Register Address: 0x10

Bit	R/W	Label	Default	Description	
7:6	R	Unused	00	Unused, make it always 0	
5:0	R/W	V_{LIM_L}	3Ch	Limiter Level $V_{LM\_L\ (Peak)}$ Setting:	
				11,1111	Biggest limiter level can be set in I²C mode
				Decreased by $0.0095\times V_{POUT}$ every step	
				11,1100	$V_{LM\_L\ (Peak)} = (V_{POUT}/2 - V_{LIM\_COM})\times 5$, if LIM floating, $V_{LIM\_L(Peak)} = 0.95\times V_{POUT}$
				Decreased by $0.0095\times V_{POUT}$ every step	
				00,0000	Smallest limiter level can be set in I²C mode.

Register Address: 0x11

Bit	R/W	Label	Default	Description
7:0	R/W	Point3	BCh	Set battery tracking point 3, default ≈ 3.8V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x12

Bit	R/W	Label	Default	Description
7:0	R/W	Point2	ADh	Set battery tracking point 2, default ≈ 3.5V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x13

Bit	R/W	Label	Default	Description
7:0	R/W	Point1	A4h	Set battery tracking point 1, default ≈ 3.3V, can be calculated by: DEC(Reg0x11) ×0.0202

Register Address: 0x14

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope3	20h	Set battery tracking slope3, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x15

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope2	20h	Set battery tracking slope2, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x16

Bit	R/W	Label	Default	Description
7:6	R	Unused	00	Unused, make it always 0
5:0	R/W	Slope1	20h	Set battery tracking slope1, default ≈ 3V/V, can be calculated by: $3\times(bit5+\frac{1}{2}\times bit4+\frac{1}{4}\times bit3+\frac{1}{8}\times bit2+\frac{1}{16}\times bit1+\frac{1}{32}\times bit0)$

Register Address: 0x17

Bit	R/W	Label	Default	Description
7:6	R/W	t_{BOOST_ON}	10	Boost Converter Start On Time t_{BOOST_ON} Setting: 00: 1.5ms; 01: 3ms; **10: 6ms;** 11: 24ms
5:4	R/W	t_{BOOST_OFF}	01	Boost Converter Shut Off Time t_{BOOST_OFF} Setting: 00: 57ms; **01: 209ms;** 10: 243ms; 11: 527ms
3:2	R/W	t_{AMP_ON}	10	Audio Amplifier (Class D or Class AB) Start On Time t_{AMP_ON} Setting: 00: 7.5ms; 01: 30ms; **10: 60ms;** 11: 120ms
1:0	R/W	t_{AMP_OFF}	01	PWM Delay Time Setting: 00: 186ns; **01: 0ns, default for 4-state modulation;** 10: 82ns, recommended for 3-state modulation; 11: 15ns

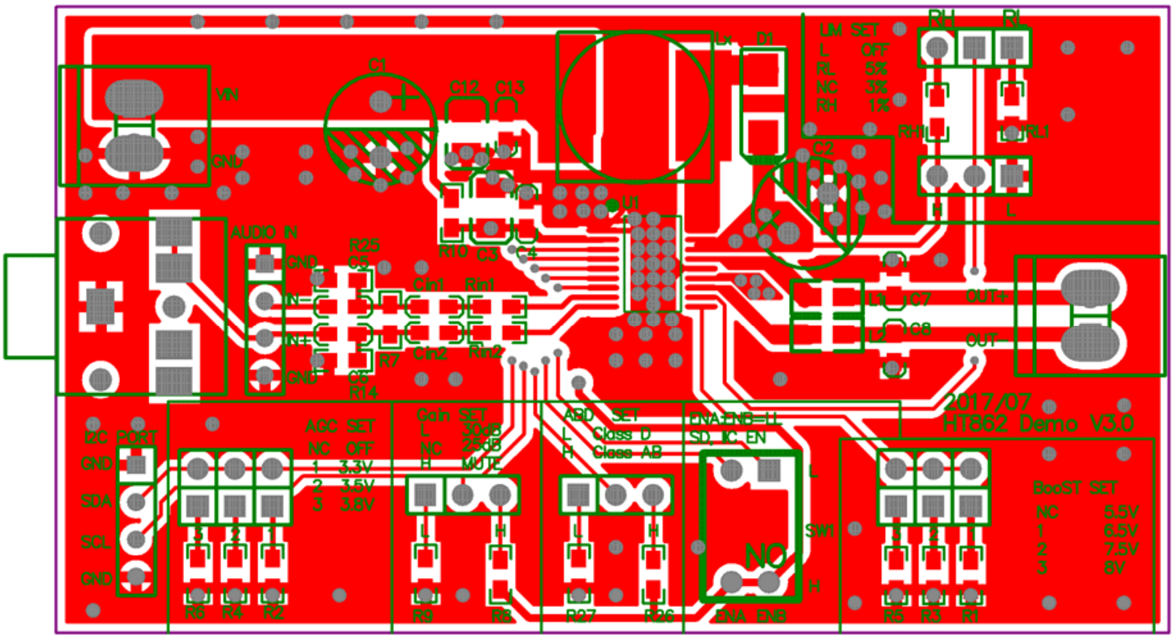
Register Address: 0x19

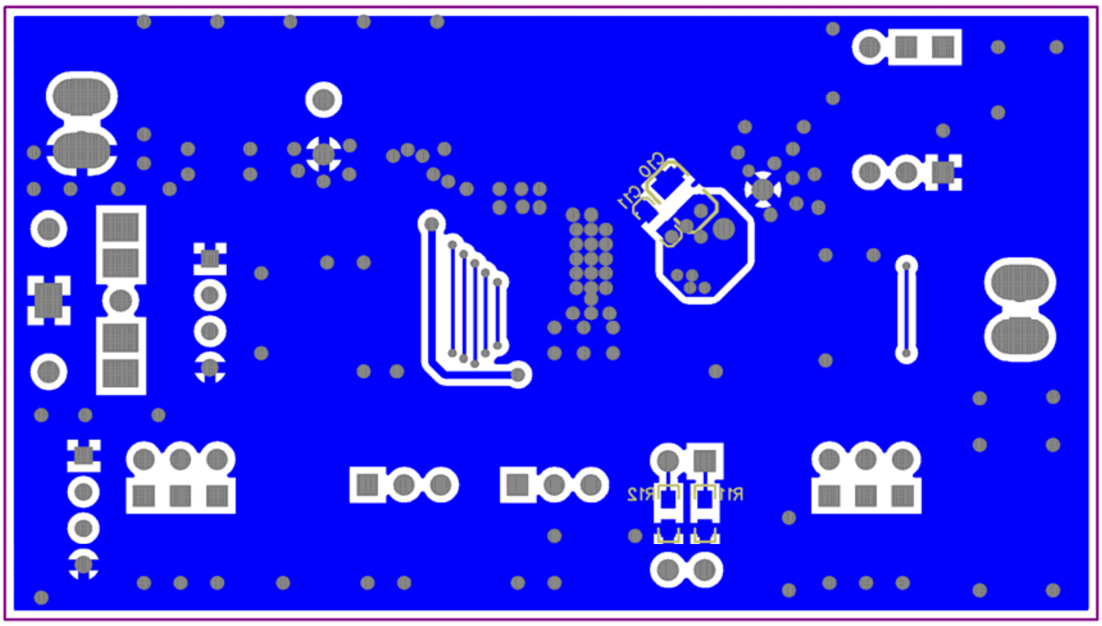
Bit	R/W	Label	Default	Description
7:6	R/W	V_{B_TH}	01	Boost On Threshold Voltage Setting: 00: 0.51V_{BAT}; **01: 0.415V_{BAT};** 10: 1.7V_{RMS}; 11: 1.38 V_{RMS}.
5:0	R	Unused	00,0000	Unused, make it always 0

Register Address: 0x1C

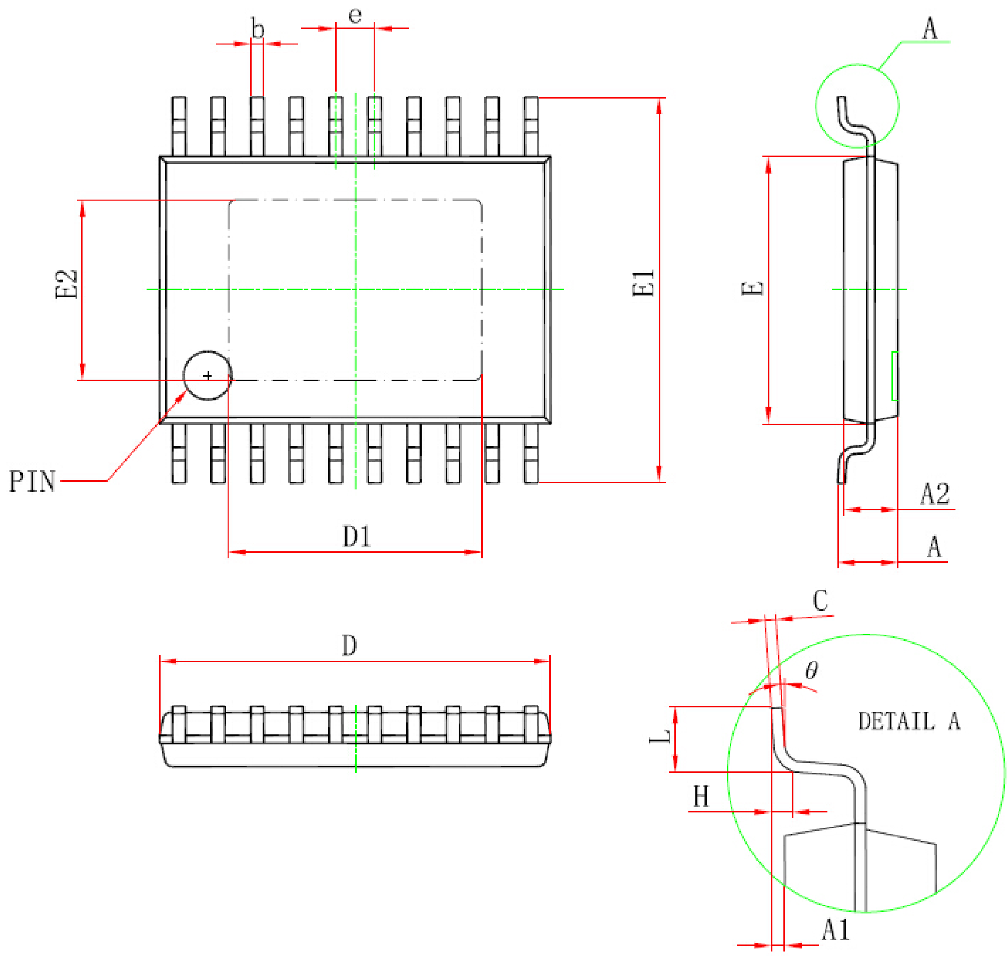
Bit	R/W	Label	Default	Description
7	R/W	OTP EN	1	0: Over temperature protection disabled, may cause permanent damage; **1: Over temperature protection enabled;**
6:5	R/W		01	OTPR reference, TFB reference Setting: 00: TFB = 130℃,OTPR = 115℃; **01: TFB = 150℃,OTPR = 140℃;** 10: TFB = 140℃,OTPR = 130℃; 11: TFB = 160℃,OTPR = 150℃
4:3	R	Reserved	00	Reserved, do not write.
2:0	R/W		100	OTP, TFB, OTPR Setting: 000: OTP = 136℃, TFB = TFB reference -32℃, OTPR = OTPR reference -32℃; 001: OTP = 145℃, TFB = TFB reference -24℃, OTPR = OTPR reference -24℃; 010: OTP = 154℃, TFB = TFB reference -16℃, OTPR = OTPR reference -16℃; 011: OTP = 163℃, TFB = TFB reference -8℃, OTPR = OTPR reference -8℃; **100: OTP = 170℃, TFB = TFB reference, OTPR = OTPR reference;** 101: OTP = 180℃, TFB = TFB reference +10℃, OTPR = OTPR reference+10℃; 110: OTP = 190℃, TFB = TFB reference +20℃, OTPR = OTPR reference+20℃; 111: OTP = 200℃, TFB = TFB reference +30℃, OTPR = OTPR reference+30℃ **DO NOT WRITE OTP OVER 170℃, OR IT MAY CAUSE PERMANENT DAMAGE!!!**

5. PCB Layout


2017/07
HT862 Demo V3.0
AUDIO IN
I2C PORT
AGC SET
Gain SET
ADD SET
BooST SET



■ PACKAGE OUTLINE



TSSOP20-PP Package

Symbol	size (mm)		size (inch)	
	min	max	min	max
D	6.400	6.600	0.252	0.259
D1	4.100	4.500	0.165	0.169
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
E2	2.900	3.100	0.114	0.122
A		1.100		0.043
A2	0.800	1.000	0.031	0.039
A1	0.020	0.150	0.001	0.006
e	0.65(BSC)		0.026(BSC)	
L	0.500	0.700	0.02	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°