

18W内置升压单声道D类音频功放

18W Boosted Mono Class D Amplifier

■ FEATURES

- Anti-Clipping Function (ACF)
- Spread spectrum technology
- Output Power
18W ($V_{BAT}=3.7V$, $R_L=4\Omega$, THD+N=10%, $f_{IN} = 1kHz$)
16W ($V_{BAT}=3.7V$, $R_L=4\Omega$, THD+N=1%, $f_{IN} = 1kHz$)
- Power Supply V_{BAT} : 3.0V~12V
- High Efficiency Class H Boost Converter
 - Multiple boost voltages automatically adjust Class D audio amplifier (HT81293A)
 - Extends the playing time in battery supply applications
 - Adjustable switch peak current limit to avoid over-pulling on battery current
- Over Current Protection, Thermal Protection, over voltage protection function included
- Pb-Free Packages, ESOP16
- 防削顶失真功能(防破音, Anti-Clipping Function, ACF)
- 扩频技术
- 输出功率
18W ($V_{BAT}=3.7V$, $R_L=4\Omega$, THD+N=10%, $f_{IN} = 1kHz$)
16W ($V_{BAT}=3.7V$, $R_L=4\Omega$, THD+N=1%, $f_{IN} = 1kHz$)
- V_{BAT} 供电范围: 3.0V至12V
- 高效H类升压功能
- 自适应功放功率的升压轨, 延长电池播放时间 (HT81293A)
- 可调节最大限流值, 有效防止电池拉死
- 保护功能:过流/过热/过压保护功能
- 无铅封装, ESOP16

■ APPLICATIONS

- Bluetooth/Wi-Fi Speakers
- Portable Speakers
- Smart speakers
- Smart Home
- 蓝牙/ Wi-Fi音箱
- 智能音箱
- 便携式音箱
- 智能家居

■ DESCRIPTION

HT81293, integrated with a boost converter, is a mono Class D audio amplifier that drives up to continuous 18W (10% THD+N, 1kHz) into 4ohm speaker from a Li-battery voltage.

HT81293A integrates an adaptive boost converter that generates a Class D amplifier supply rail tracking the audio signal, which will significantly improve the efficiency and extends the playing time in battery supply applications. The output voltage of boost converter in HT81293F is forced into 9V or 12V and it provides to the class D amplifier. Configurable current limit is adopted to avoid accidental large peak current.

HT81293 features Anti-Clipping Function (ACF) which detects output signal clip due to the over input signal and suppresses the output signal clip automatically. Also, the ACF function can adapt the output clip caused by power supply voltage down with battery. It can significantly improve the sound quality, creating a very comfortable musical enjoyment, and to protect the speakers from overload damage. It supplies 2 different ACF mode with different audio experience, and also ACF OFF mode.

HT81293 integrates Spread Spectrum Control technology to achieve advanced EMI suppression. The Gain of HT81293 is 32dB .

As for protection function, over current protection function for speaker output terminals, over temperature protection function and over voltage protection for boost converter output are also prepared.

HT81293是一款内置升压的单声道D类音频功率放大器，由锂电池供电时，THD+N=10%，能连续输出18W功率（4Ω负载）。

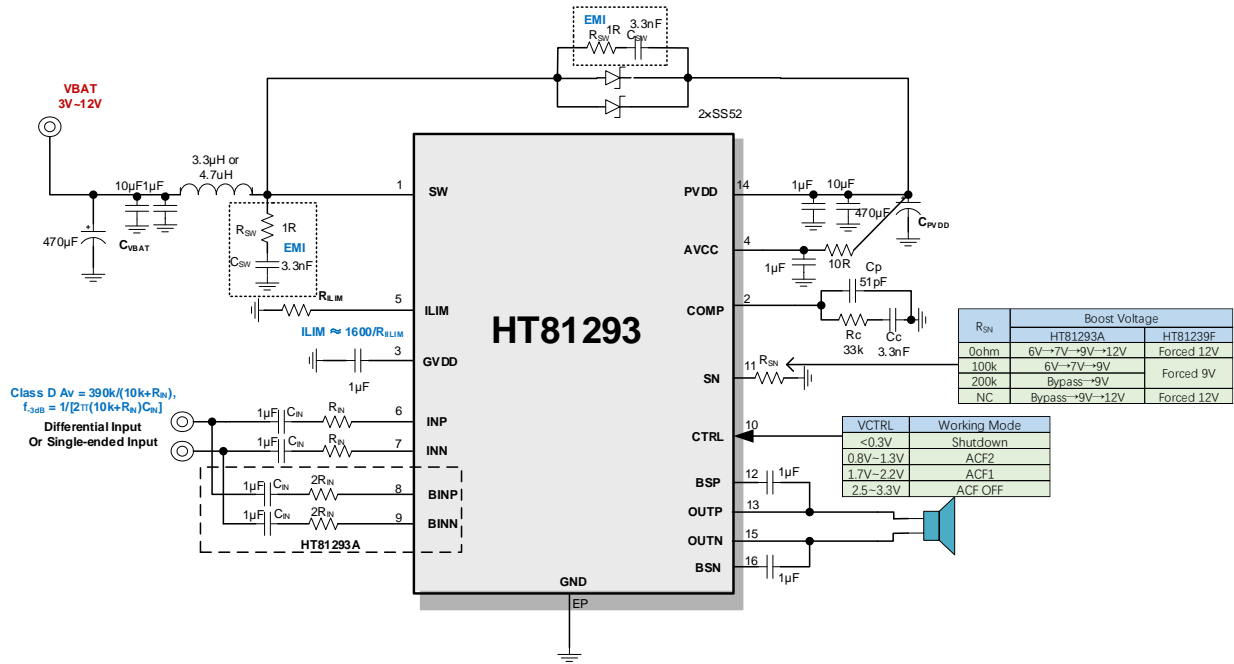
HT81293A内置可动态调节的升压，可以提供适应不同输出功率的电压给D类功放，其可大幅提高系统效率，延长电池续航时间。HT81293F则内置固定升压，提供一个固定9V或12V的升压给D类功放。HT81293可配置升压限流值，以防止过大的电流尖峰。

HT81293的最大特点是防削顶失真（ACF）输出控制功能，可检测并抑制由于输入音乐、语音信号幅度过大所引起的输出信号削顶失真（破音），也能自适应地防止在BOOST升压电压下降所造成的输出削顶，显著提高音质，创造非常舒适的听音享受，并保护扬声器免受过载损坏。HT81293提供两种不同音乐体验的ACF模式，以及ACF-Off模式。

HT81293具有先进的扩频功能来抑制EMI。HT81293的增益为32dB。

此外，HT81293集成了输出端过流保护、片内过温保护、升压过压保护等功能。

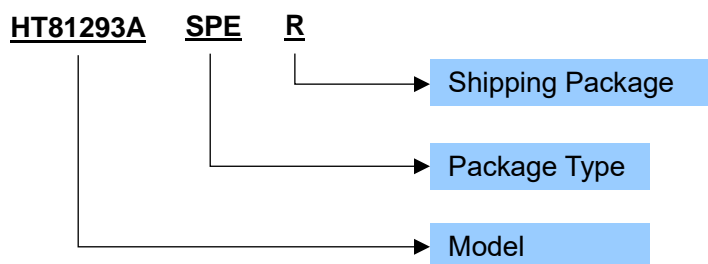
TYPICAL APPLICATION



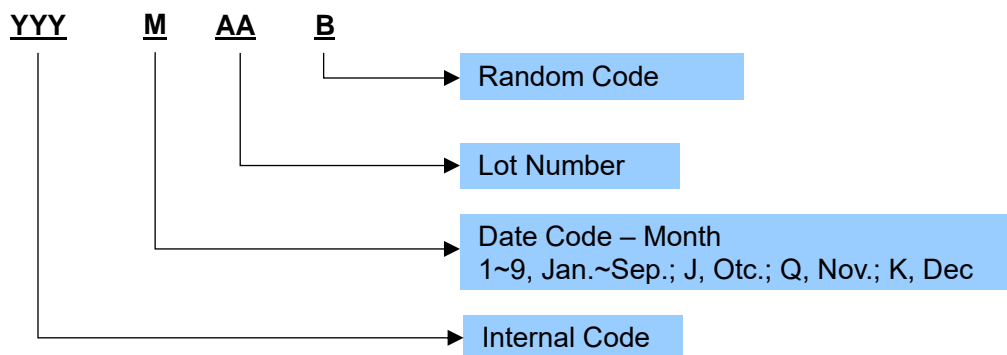
ORDERING INFORMATION

Part Number	Package Type	Marking	Operating Temperature Range	Shipping Package / MOQ
HT81293ASPER	ESOP16 (SPE)	HT81293A YYYMAAB ¹	-40℃~85℃	Tape and Reel (R) / 2500pcs
HT81293ASPET	ESOP16 (SPE)	HT81293A YYYMAAB	-40℃~85℃	Tube (T) / 50pcs
HT81293FSPER	ESOP16 (SPE)	HT81293F YYYMAAB	-40℃~85℃	Tape and Reel (R) / 2500pcs
HT81293FSPET	ESOP16 (SPE)	HT81293F YYYMAAB	-40℃~85℃	Tube (T) / 50pcs

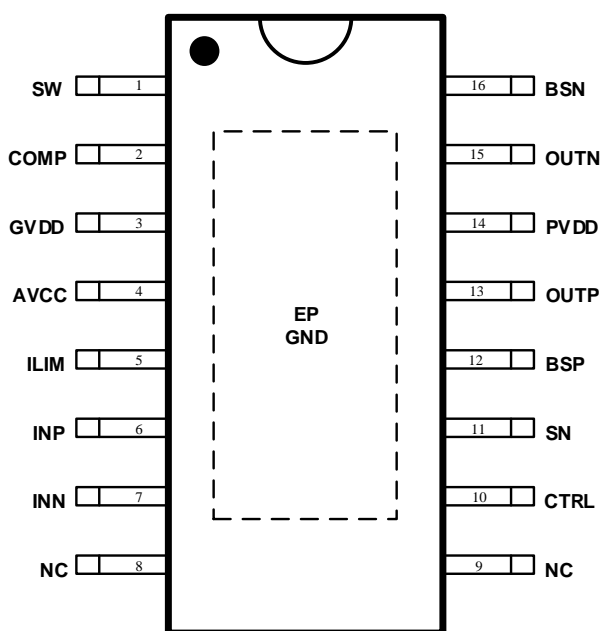
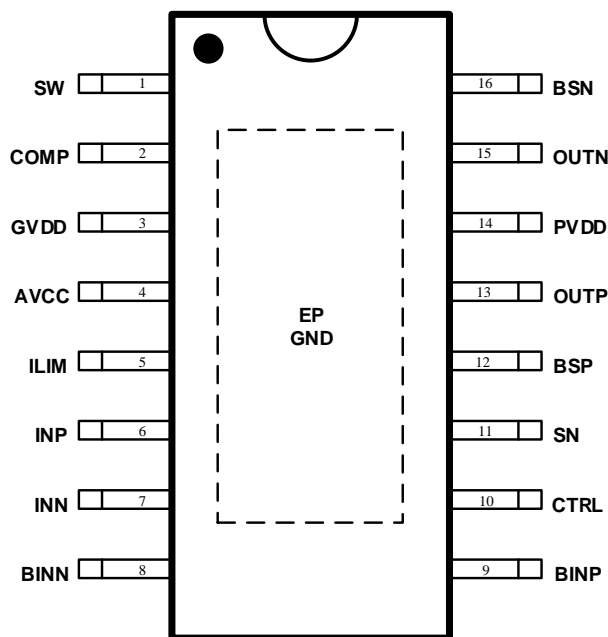
Part Number



Production Tracking Code



¹ YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION

HT81293F Top View

HT81293A Top View
■ TERMINAL FUNCTION

Terminal No.		Name	I/O ¹	Description
HT81293F	HT81293A			
1		SW	I	Boost and rectifying switch input. 升压整流开关输入端
2		COMP	O	Output of the internal error amplifier, the loop compensation network should be connected between this pin and the GND pin. 环路补偿脚, 接补偿电路到GND。
3		GVDD	O	Voltage regulator, connect 1uF to GND. 电压调节器, 接1uF到地。
4		AVCC	P	Analog power supply. 模拟供电
5		ILIM	I	Adjustable switch peak current limit. An external resistor should be connected between this pin and GND. 最大限流值设置端, 外部接电阻到地。
6		INP	I	Positive input (differential+) for audio amplifier. 功放输入正端
7		INN	I	Negative input (differential-) for audio amplifier. 功放输入负端
8, 9	/	NC	I	No connection. 内部无连接
/	8	BINN	I	Audio negative input (differential-) for adaptive boost converter. 自适应升压的音频输入负端
/	9	BINP	I	Audio positive input (differential+) for adaptive boost converter. 自适应升压的音频输入正端
10		CTRL	I	Mode Control Terminal. 模式控制脚
11		SN	I	Boost converter output voltage selection. 升压电压选择
12		BSP	BST	Connection point for the OUTP bootstrap capacitor, which is used to create a power supply for the high-side gate drive for OUTP. OUTP自举电容位
13		OUTP	O	Positive pin for differential speaker amplifier output. 输出正端
14		PVDD	P	Power Supply for internal power circuitry. 功率电源
15		OUTN	O	Negative pin for differential speaker amplifier. 输出负端
16		BSN	BST	Connection point for the OUTN bootstrap capacitor, which is used to create a power supply for the high-side gate drive for OUTN. OUTN自举电容位
EP		GND	G	Provides both electrical and thermal connection from the device to the board. A matching ground pad must be provided on the PCB and the device connected to it via solder. For proper electrical operation, this ground pad must be connected to the system ground. 既是地, 又是散热PAD

¹ I: Input; O: Output; G: Ground; P: Power; BST: BOOT Strap;

SPECIFICATIONS¹
Absolute Maximum Ratings²

PARAMETER	Symbol	MIN	TYP	MAX	UNIT
AVCC voltage	AVDD	-0.3		14	V
PVDD voltage	PVDD	-0.3		14	V
SW voltage	V _{SW}			16	V
Input Voltages (INP, INN, BINP, BINN, CTRL)	V _I	-0.3		5.8	V
Moisture Sensitivity Level (MSL)			MSL3		
Ambient Operating Temperature	T _A	-25		85	°C
Junction Temperature	T _J	-40		125	°C
Storage Temperature	T _{STG}	-40		125	°C

Recommended Operating Conditions

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Power supply voltage for V _{BAT}	V _{BAT}		3		12	V
Ambient Operating Temperature	T _a		-25	25	85	°C
Input Voltages (INP, INN, BINP, BINN, CTRL)	V _I		0		3.3	V
Minimum Speaker Load in PBTL Mode	R _L		2.8			Ω

Electrical Specification³

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
BOOST Converter						
Maximum Boost converter output voltage	PVDD			12		V
Boost converter frequency	f _{SW}			440		kHz
Boost on threshold voltage V _{RMS} (R _{SN} = 0R or 100k)	V _{B_TH1}	Vout from 6V to 7V		2.6		V
	V _{B_TH2}	Vout from 7V to 9V		4.2		V
	V _{B_TH3}	Vout from 9V to 12V		5.3		V
Boost on threshold voltage V _{RMS} (R _{SN} = 200k or NC)	V _{B_TH1}	Vout from bypass to 9V		4.8		V
	V _{B_TH2}	Vout from 9V to 12V		5.3		V
Boost shut off time	t _{BOOST_OFF}			5.4		ms
MOSFET on-resistance	R _{ds(on)}	Including wire bond		35		mohm
Peak switch current limit	I _{LIM}				10	A

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Class D Channel V _{SS} =0V, V _{BAT} =3.7V, T _a =25°C, C _{IN} =1uF, ACF-Off mode, unless otherwise specified						
Carrier clock frequency	f _{PWM}			360		kHz
Over current protection	I _{max}				6	A
System Gain	Gain	External R _{IN} =0Ω		32		dB
Start-up time (power-on or shutdown release)	t _{STUP}			45		ms
ACF attenuation gain	A _a		-16		0	dB
Consumption current in shutdown mode	I _{SD}	V _{BAT} = 3.7V		4.6		μA
		V _{BAT} = 7.4V		8		uA
Total Harmonic Distortion plus Noise	THD+N	P _O =1.0W, R _L =4Ω, f=1kHz		0.03		%
Output Noise	V _N	f=20Hz~20kHz, A weighted,		130		μV _{rms}

¹ Depending on parts and PCB layout, characteristics may be changed.

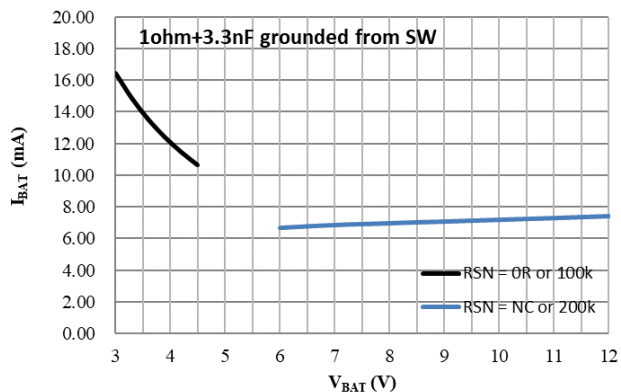
² Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

³ Depending on parts and pattern layout, characteristics may be changed.

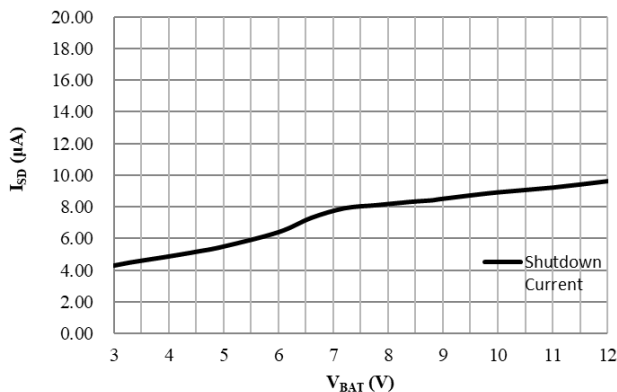
		Av=26dB				
Output offset voltage	V _{OS}			±2		mV
Quiescent current	I _{BAT}	VBAT = 3.7V, HT81293A, R _{SN} = 0R or 100k		13		mA
		VBAT = 7.4V, HT81293A, R _{SN} = NC or 200k		6		mA
		VBAT = 3.7V, HT81293F, R _{SN} = 100k or 200k, PVDD=9V		20		mA
		VBAT = 3.7V, HT81293F, R _{SN} = 0R or NC, PVDD=12V		25		mA
		VBAT = 7.4V, HT81293F, R _{SN} = 100k or 200k, PVDD=9V		10		mA
		VBAT = 7.4V, HT81293F, R _{SN} = 0R or NC, PVDD=12V		14		mA
Output Power	P _O	PVDD=12V	V _{BAT} =3.7V, f=1kHz, R _L =4Ω THD+N=10%	18		W
		PVDD=9V		11		
		PVDD=12V	V _{BAT} =3.7V, f=1kHz, R _L =4Ω THD+N=1%	16		
		PVDD=9V		9		
		PVDD=12V	V _{BAT} =7.4V, f=1kHz, R _L =4Ω THD+N=10%	18		
		PVDD=9V		11		
		PVDD=12V	V _{BAT} =7.4V, f=1kHz, R _L =4Ω THD+N=1%	16		
		PVDD=9V		9		
Efficiency (Class D + Boost)	η	V _{BAT} =3.7V, R _L =4Ω+22μH, THD+N = 10%, PVDD=9V		80		%
		V _{BAT} =3.7V, R _L =4Ω+22μH, THD+N = 10%, PVDD=12V		73		%
		V _{BAT} =7.4V, R _L =4Ω+22μH, THD+N = 10%, PVDD=9V		89		%
		V _{BAT} =7.4V, R _L =4Ω+22μH, THD+N = 10%, PVDD=12V		86		%

■ TYPICAL OPERATING CHARACTERISTICS

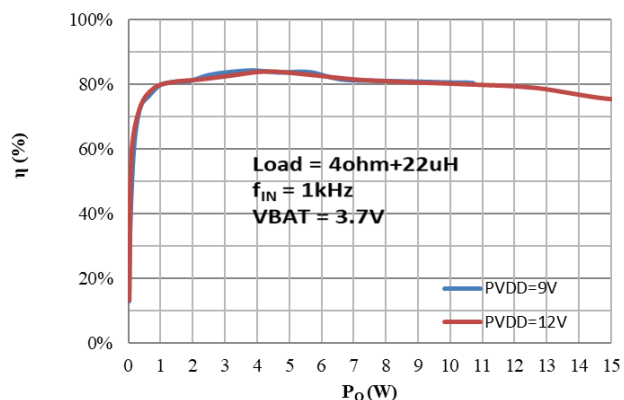
Quiescent Current



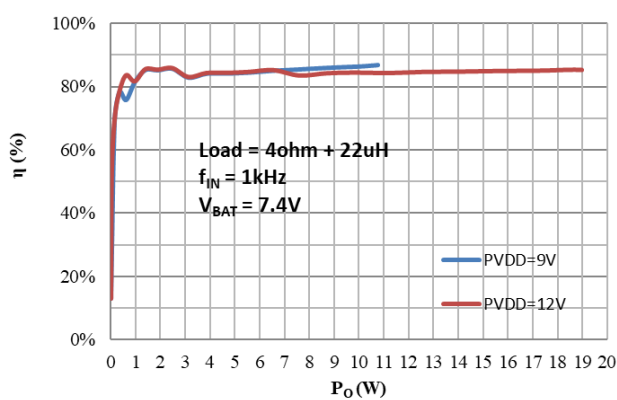
Shutdown Current



P_O vs η

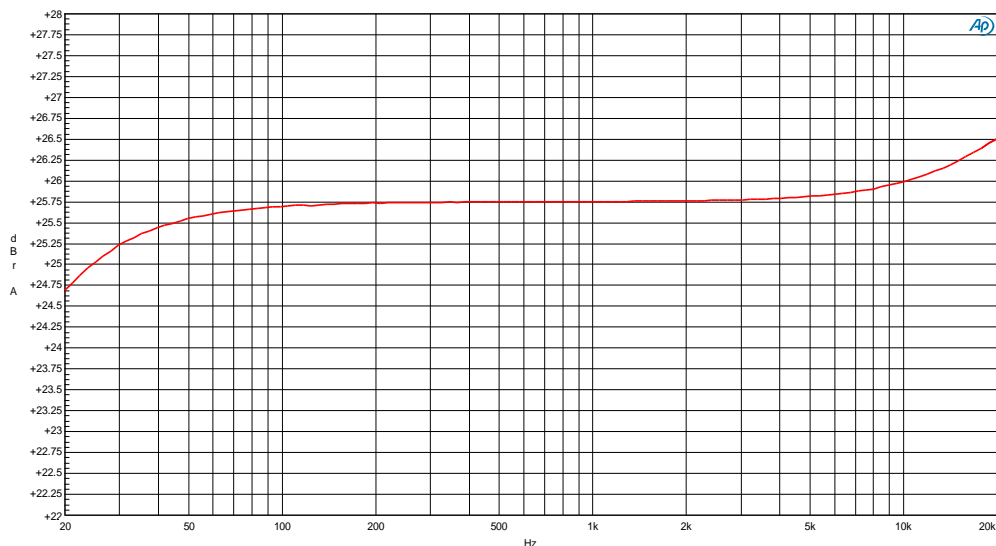


P_O vs η



Audio Precision

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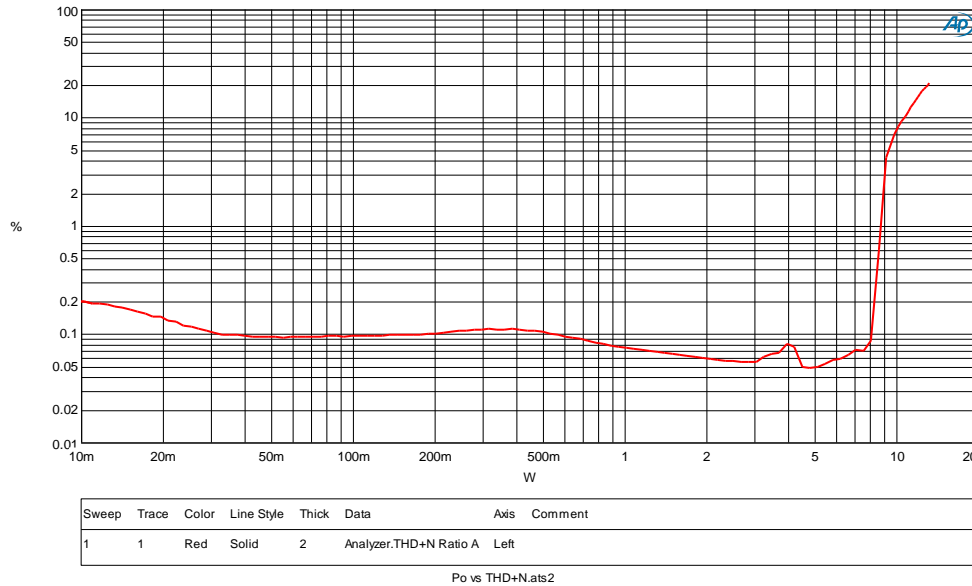
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer:Level A	Left	

Frequency Respon
C_{IN}=1uF, R_{EIN} = 9.1k

V_{BAT} = 3.7V, R_L = 4ohm, f_{IN} = 1kHz, R_{LIM} = 180k, unless otherwise specified

Audio Precision

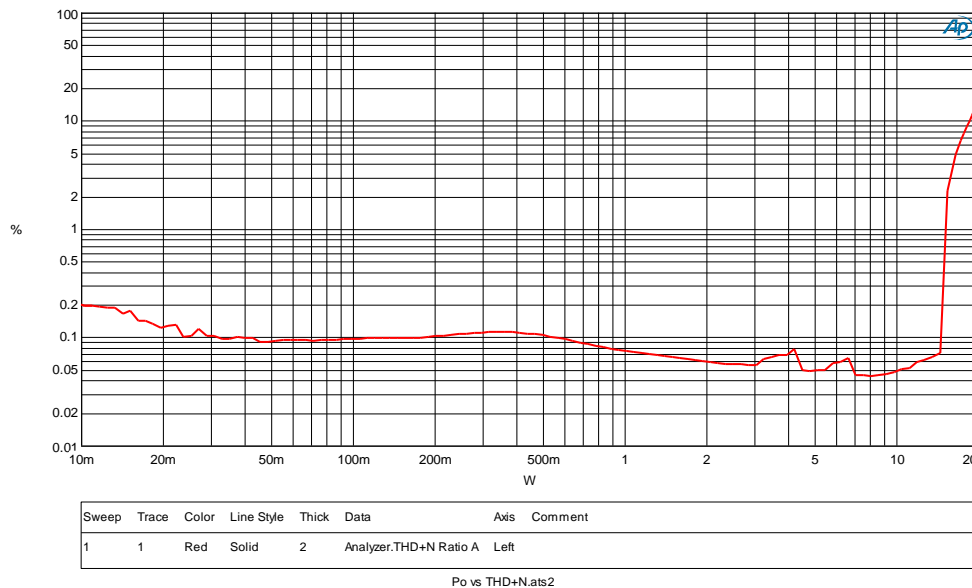
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Output power vs
THD+N, PVDD = 9V

Audio Precision

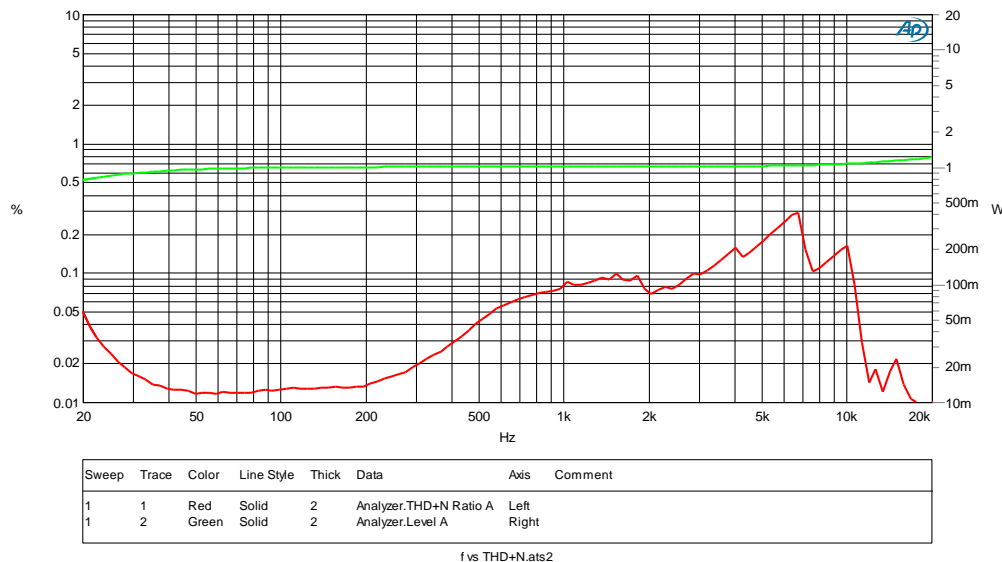
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Output power vs
THD+N, PVDD =
12V

Audio Precision

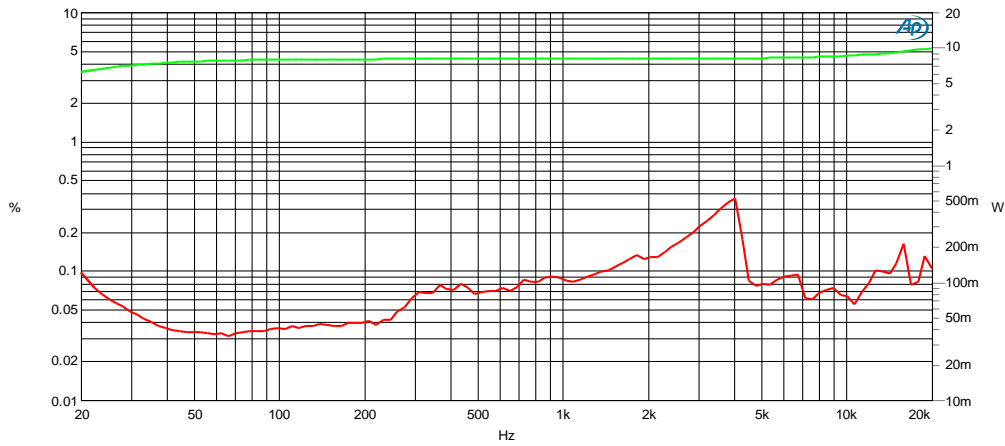
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frequency vs
THD+N, Po ≈ 1W

Audio Precision

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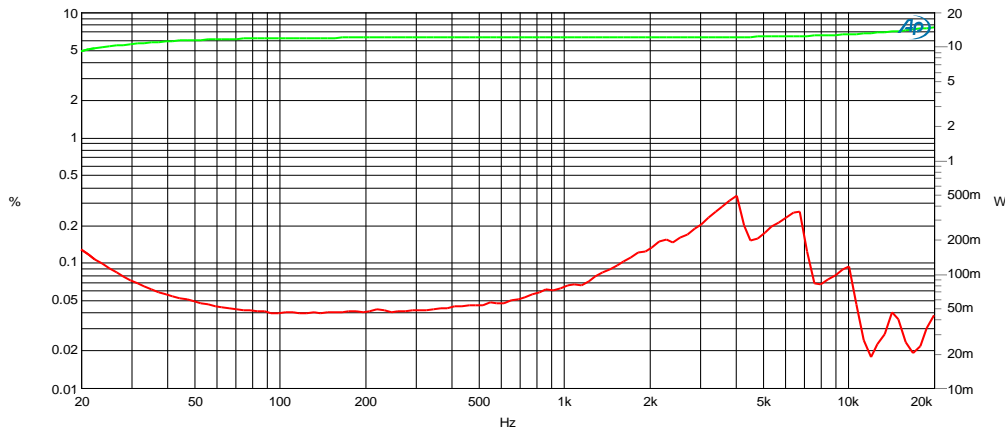
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.TH+N Ratio A	Left	
1	2	Green	Solid	2	Analyzer.Level A	Right	

f vs THD+N.ats2

frequency vs
THD+N, $P_o \approx 8W$

Audio Precision

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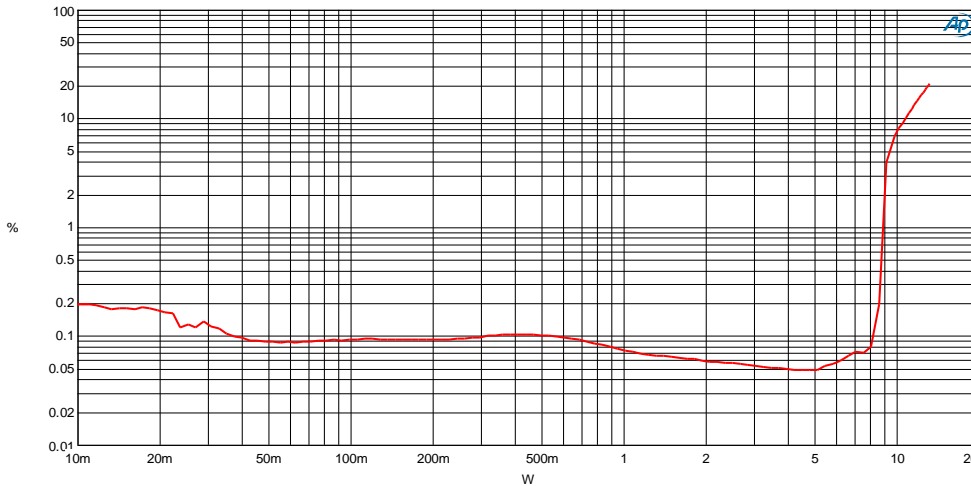
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer.TH+N Ratio A	Left	
1	2	Green	Solid	2	Analyzer.Level A	Right	

f vs THD+N.ats2

frequency vs
THD+N, $P_o \approx 12W$,
PVDD=12V

V_{BAT} = 7.4V, R_L = 4ohm, f_{IN} = 1kHz, R_{LIM} = 180k
 Audio Precision

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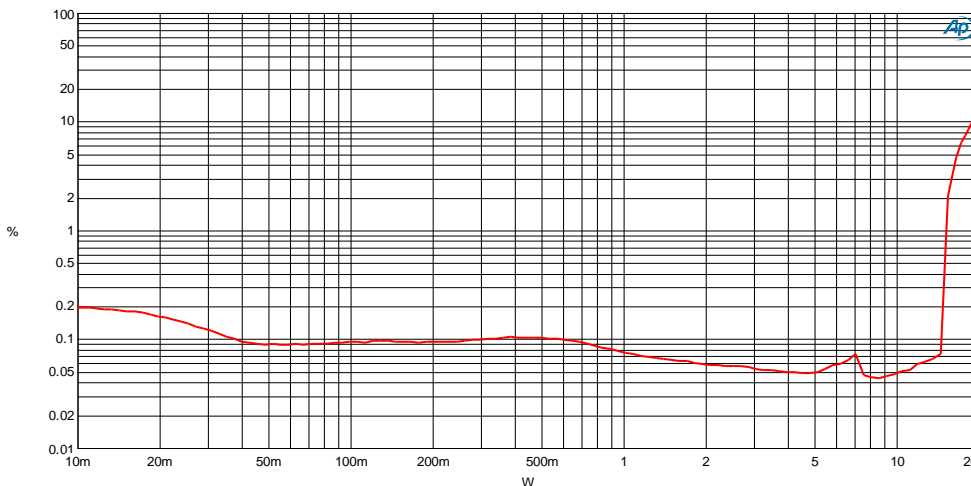
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
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Po vs THD+N.ats2

Output power vs
 THD+N, PVDD = 9V

Audio Precision

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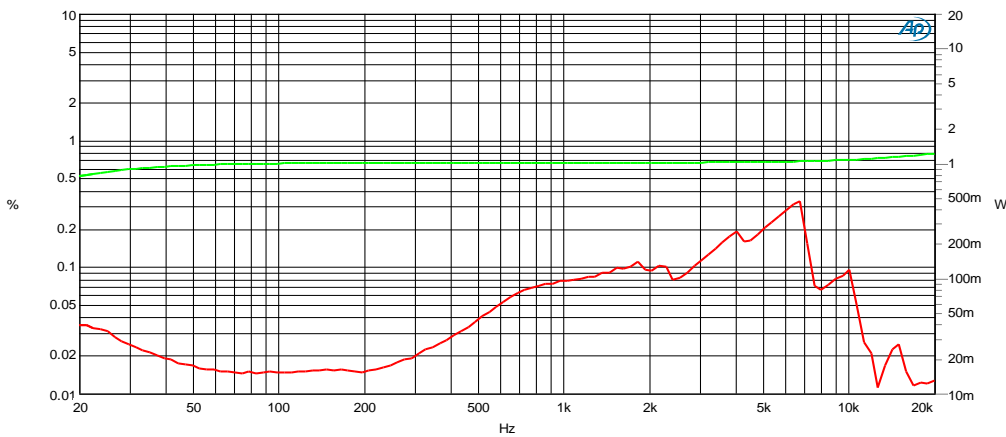
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
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Po vs THD+N.ats2

Output power vs
 THD+N, PVDD =
 12V

Audio Precision

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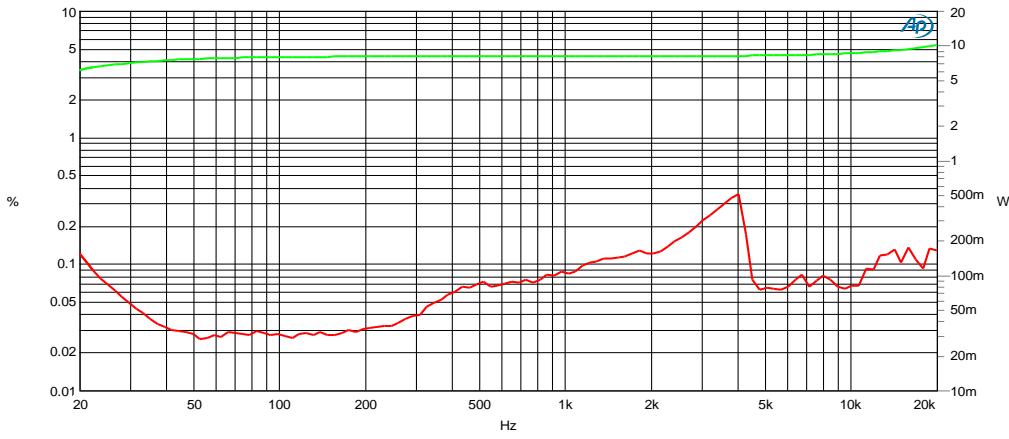
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
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1	2	Green	Solid	2	Analyzer.Level A	Right	

f vs THD+N.ats2

frequency vs
 THD+N, Po ≈ 1W

Audio Precision

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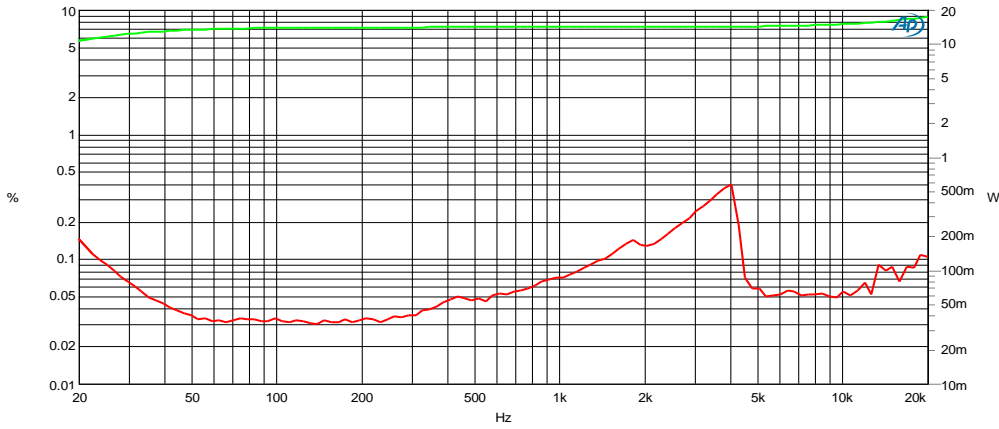
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
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1	2	Green	Solid	2	Analyzer:Level A	Right	

f vs THD+N.ats2

frequency vs
 THD+N, Po≈8W

Audio Precision

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Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Analyzer:THD+N Ratio A	Left	
1	2	Green	Solid	2	Analyzer:Level A	Right	

f vs THD+N.ats2

frequency vs
 THD+N, Po≈14W,
 PVDD=12V

APPLICATION INFORMATION

1 Boost Converter

HT81293 consists of a boost converter and an audio amplifier. The boost converter takes the supply voltage, VBAT, and increases it to a higher output voltage to drives the audio amplifier. This improves loudness over non-boosted solutions. An external inductor and diode should be added for the boost converter.

For HT81293A, the boost converter is adaptive and generates a Class D amplifier supply rail tracking the audio signal, which will significantly improve the efficiency and extends the playing time in battery supply applications. When the output audio signal exceeds a preset voltage threshold (Boost on Threshold Voltage V_{B_TH}), the output voltage of boost converter jumped into the higher preset voltage. When the audio output voltage is lower than the threshold voltage, the output voltage of boost converter drops to the lower preset voltage automatically. For HT81293F, the output voltage of boost converter is forced into 9V or 12V. The output voltage is selected by SN terminal, see as the following table, where R_{SN} represents the resistor connected from SN terminal to GND.

HT81293 包含一个升压和一个音频功放。其中升压电路将输入的电池电压 VBAT 升压至更高的电压，以提供给功放。该方法可提升功放的输出功率。该升压需要外部放置电感和二极管。

对于 HT81293A, 其升压是自适应的跟随音乐信号的, 以有效提升电池应用下的播放时间。当输出信号超过一个阈值时, 升压跳转至一个更高的预设电压 (V_{B_TH}); 当输出信号小于该阈值时, 升压下降到低档位的预设电压。对于 HT81293F, 输出电压被强制升压到 9V 或 12V。输出电压的选择是通过 SN 脚设置的, 如下表, 其中, R_{SN} 为 SN 脚到地的电阻。

Table 1 Mode Selection for Boost Converter

R_{SN}	Boost Voltage	
	HT81293A	HT81293F
0ohm	6V→7V→9V→12V	Forced 12V
100k	6V→7V→9V	Forced 9V
200k	Bypass→9V	
NC	Bypass→9V→12V	Forced 12V

1.1 ILIM

To avoid an accidental large peak current, an internal cycle-by-cycle current limit is adopted. The low-side switch is turned off immediately as soon as the switch current touches the limit (I_{LIM}). The peak switch current limit can be set by a resistor (R_{ILIM}) at the ILIM pin to ground. The following figure details the R_{ILIM} settings.

在 ILIM 脚外接电阻(R_{ILIM})到地, 可设置升压的输入最大峰值电流。具体设置如下图。

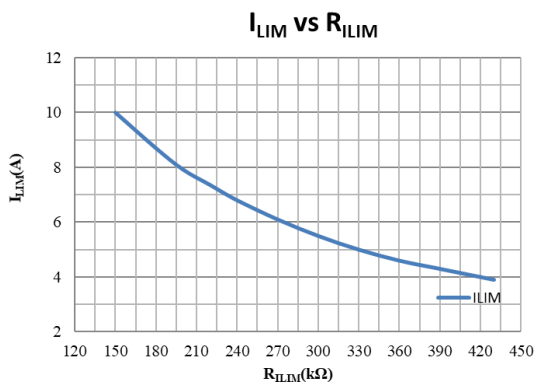


Figure 1 Switch Current Limit Setting

1.2 COMP

The HT81293 requires external compensation for the stability of boost converter. The COMP pin is the output of the internal error amplifier. An external resistor 33k in serial with a ceramic capacitor 3.3nF connected from the COMP pin to GND can be applied in most cases.

1.3 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 HT81293 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.

1.4 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. $L \geq 2.2\mu\text{H}$, $\text{DCR} < 0.1\text{ohm}$ is recommended for general application circuit. The inductor should be placed as close to the SW pin as possible with direct and wide traces. The saturation current (I_{SAT}) of the inductor should be larger than the switch current limit (I_{LIM}).

1.5 Schottky Diode Selection and Placement

A Schottky Diode with $V_{RRM} > 16\text{V}$, $V_{FM} < 0.5\text{V}$ is recommended for general application circuit. The diode should be placed as close to the SW and PVDD capacitor as possible with direct and wide traces. The I_F of the diode should be larger than the maximum output current from PVDD.

1.6 RC

Adding an RC snubber across the SW pin and the power ground can help reduce the radiation EMI levels. The RC snubber should be placed as close as possible to the switching node and the power ground.

HT81293 升压需要外部补偿电路以维持升压稳定性。对于大多数应用，COMP 外部需要接电阻 33k 串联 3.3nF 电容到地。

对于储能电容，电容值由应用中稳定所需的最小工作电容值和 PVDD 上允许的最大电压纹波决定。较大的储能电容有助于防止电源电压下降。

对于滤波电容器，低等效串联电阻(ESR)的陶瓷电容器较为合适。这种电容的选择和布局有助于提高线路上的瞬态尖峰和噪声。此外，将这种滤波电容靠近 HT81293 非常重要，因为芯片和电容之间的任何寄生电阻或电感都会导致效率损失。

我们建议，在 VBAT 和 PVDD 端至少放置一组 1uF 和 10uF 滤波电容到地，用于吸收纹波和稳定电压，并尽可能靠近芯片引脚。另外，VBAT 和 PVDD 端需各放置一个不小于 470uF 的储能电容。这些电容应以最短的路径连接至安静可靠的地，以有效滤波。

电感的电流参数由功放的最大功率决定；而电感的感值则由可允许的最大峰值电流决定。通常而言，为保证芯片的正常工作，建议使用 $L \geq 2.2\mu\text{H}$, $\text{DCR} < 0.1\text{ohm}$ 。

电感需要尽可能靠近 SW 引脚，并且与 SW 在同一 PCB 层尽可能短的直接相连。

电感的建议饱和电流应大于输入最大峰值电流 (I_{LIM})。

肖特基二极管的建议参数： $V_{RRM} > 16\text{V}$, $V_{FM} < 0.5\text{V}$ ，并依据不同功率选择不同 I_F ，并需要大于 PVDD 最大输出电流。该肖特基二极管应尽可能靠近电感和 PVDD 端电解电容放置。

SW 端加 RC 到地，可有效减少辐射干扰，RC 电路需尽可能靠近 SW 和 GND。

2 Analog Signal Input Configuration

HT81293 is an amplifier with analog input (single-ended or differential).

For a differential operation, input signals into INP and INN pins via DC-cut capacitors (C_{IN}) and external input resistors R_{EIN} . See as figure 2. The system gain can be calculated by $Gain \approx 20 \times \log\left(\frac{R_F}{R_{IIN} + R_{EIN}}\right)$, where $R_F = 390k$, $R_{IIN} = 10k$. And the high pass cut-off frequency of input signal can be calculated by $f_c = \frac{1}{2\pi(R_{IIN} + R_{EIN}) \times C_{IN}}$.

For a single-ended operation, input signals to INP pin via a DC-cut capacitor (C_{IN}) and external input resistor (R_{EIN}). INN pin should be connected to ground via a DC-cut capacitor and external input resistor (R_{EIN}) (with the same value of C_{IN} and R_{IN}). See as figure 3. The Gain and high pass Cut-off frequency are the same as the above case.

2.1 BINP and BINN pin

For HT81293A, BINP and BINN terminals are designed to receive audio signals to determine the output voltage of adaptive boost converter. Input signals to BINP and BINN (or only BINP if in single-ended operation) with C_{IN} and R_{BIN} , where $R_{BIN} = 2R_{EIN}$.

HT81293 接受模拟差分或单端音频信号输入，产生 PWM 脉冲输出信号驱动扬声器。

对差分输入，通过隔直电容 C_{IN} 和输入电阻 R_{EIN} 分别输入到 INP 和 INN 端，见图 2。系统增益 $Gain \approx 20 \times \log\left(\frac{R_F}{R_{IIN} + R_{EIN}}\right)$ ， $R_F = 390k$ ， $R_{IIN} = 10k$ 。高通滤波器截止频率为 $f_c = \frac{1}{2\pi(R_{IIN} + R_{EIN}) \times C_{IN}}$ 。

对单端输入，则通过 C_{IN} 耦合到 INP 端。INN 端必须通过输入电阻和电容（与 C_{IN} 、 R_{EIN} 值相同）接地，见图 3。增益 Gain 和截止频率 f_c 与差分输入时相同。

对于 HT81293A，BINP 和 BINN 用来接收音频信号以决定动态升压值。将音频信号同时接入 BINP 和 BINN（或仅 BINP，如果是单端输入），如下图，其中 $R_{BIN} = 2R_{EIN}$ 。

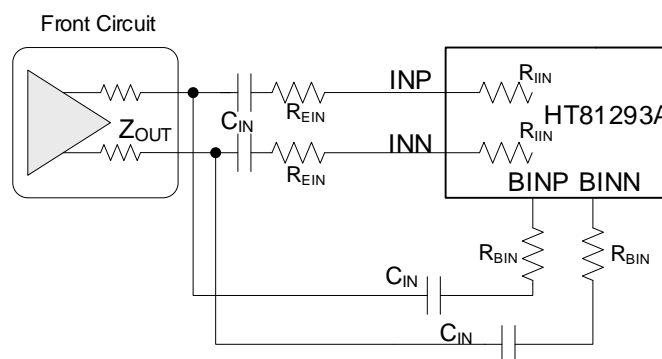


Figure 2 Differential Input configuration

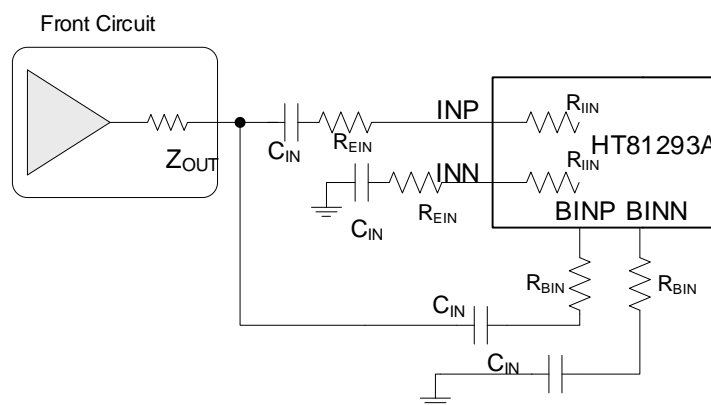


Figure 3 Single-ended Input configuration

3 Output Configuration

HT81293 can directly drive speakers without any other components. But if EMI is highly concerned, ferrite beads or L-C filter is needed.

一般而言，输出端可直接连接负载喇叭。如对 EMI 的要求较高，则可选择添置铁氧体磁珠或 LC 滤波器。

4 Speaker Amplifier Operating Modes

HT81293 can work in different modes by setting the CTRL terminal, shown as follow.

HT81293 在 CTRL 端输入不同电压值，能实现 4 种工作模式，详见下表。

Table 2 CTRL Terminal Configuration

VCTRL	Working Mode
<0.3V	Shutdown
0.8V~1.3V	ACF2
1.7V~2.2V	ACF1
2.5~3.3V	ACF OFF

In ACF modes (ACF1 or ACF2), HT81293 attenuates system gain to an appropriate value when an excessive input is applied, so as not to cause the clipping at the differential signal output. In this way, the output audio signal is controlled in order to obtain a maximum output level without distortion. And HT81293 also follows to the clips of the output waveform due to the decrease in the power-supply voltage.

在 ACF 模式 (ACF1 或者 ACF2) 下，当电路检测到输入信号幅度过大而产生输出削顶时，HT81293 通过自动调整系统增益，控制输出达到一种最大限度的无削顶失真功率水平，由此大大改善了音质效果。此外，当电源电压下降时，HT81293 也能自动衰减输出增益，实现与 PVDD 下降值相匹配的最大限度无削顶输出水平。

The Attack time of ACF Function is a time interval until system gain falls to target attenuation gain -3dB when a big enough signal input. And, the Release Time is a time from target attenuation gain to not working of ACF. The maximum attenuation gain is 16dB.

ACF 模式下的启动时间 (Attack time) 指在突然输入足够大信号而产生输出削顶的条件下，ACF 启动对放大器的增益调整速率，以 ms/dB 为单位；释放时间 (Release time) 指产生削顶的输入条件消失，增益退出衰减状态的速率，以 ms/dB 为单位。HT81293 的最大衰减增益为 16dB。

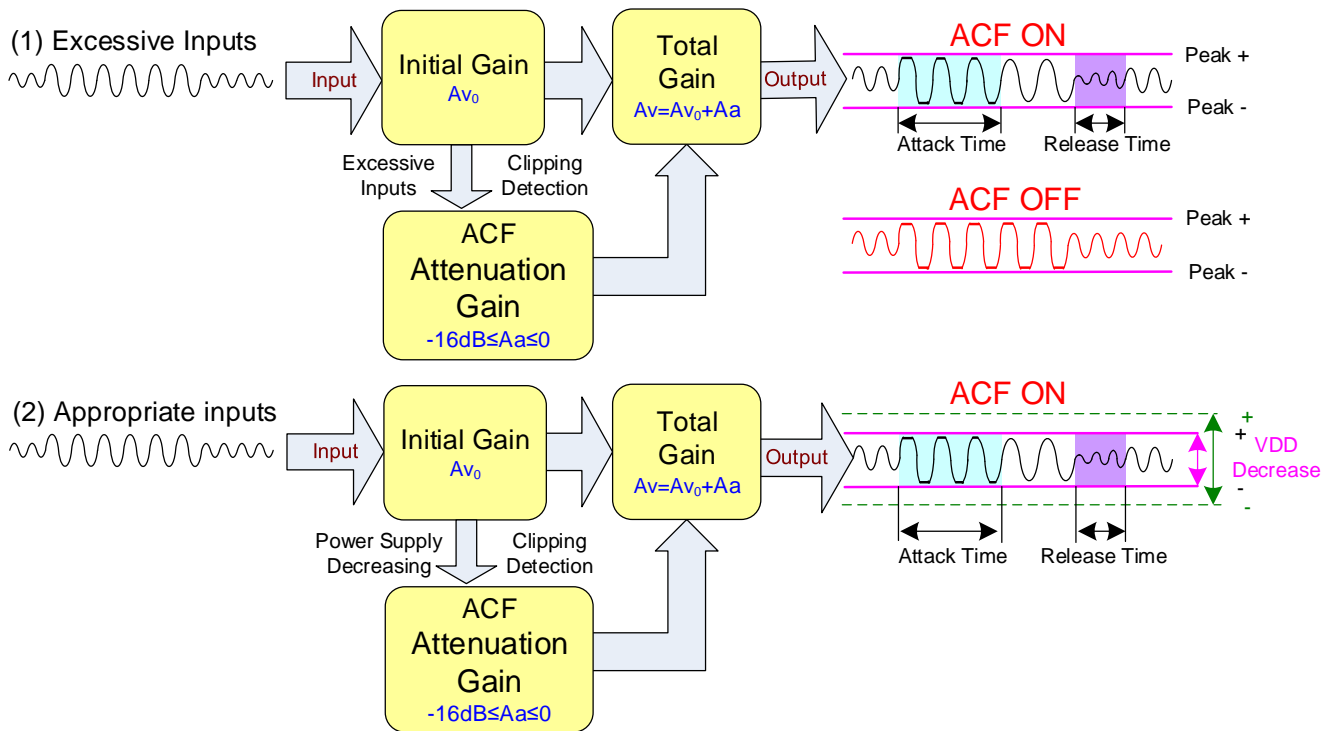


Figure 4 the ACF Function Operation Outline

Table 3 Attack time and Release time

ACF mode	Attack time	Release time
ACF-1	50ms	64ms
ACF-2	2.5ms	1200ms

In shutdown mode, HT81293 shuts all circuit down and minimizes the power consumption. And, the output terminals become Weak Low (A high resistance grounded state).

在关断模式（低功耗待机）下，芯片关闭所有功能并将功耗降低到最小，输出端为弱低电平状态（内部通过电阻接地）。

5 Spread Spectrum

The HT81293 device has built-in spread spectrum control of the oscillator frequency to improve EMI performance. The spread spectrum scheme is internally fixed.

HT81293 内置了输出频率的扩频功能，以提升 EMI 性能。

6 GVDD Supply

The GVDD Supply is used to power the gates of the output full bridge transistors. Decouple GVDD with a X5R ceramic 1 μF capacitor to GND. The GVDD supply is not intended to be used for external supply.

GVDD 电源用于为输出全桥晶体管的栅极供电。使用 X5R 陶瓷 1 μF 电容器将 GVDD 与 GND 连接。GVDD 电源不用于外部电源。

7 BSP and BSN Capacitors

The full H-bridge output stages use only NMOS transistors. Therefore, they require bootstrap capacitors for the high side of each output to turn on correctly. A 1 μ F ceramic capacitor of quality X5R or better, rated for at least 16 V, must be connected from each output to its corresponding bootstrap input. The bootstrap capacitors connected between the BSx pins and corresponding output function as a floating power supply for the high-side N-channel power MOSFET gate drive circuitry. During each high-side switching cycle, the bootstrap capacitors hold the gate-to-source voltage high enough to keep the high-side MOSFETs turned on.

8 Protection Function

HT81293 has the protection functions such as Over-Current Protection function, Thermal Protection function, and over voltage protection.

(1) Over-current Protection function

When a short circuit occurs between one output terminal and Ground, PVDD, 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 HT81293 (150 $^{\circ}$ C) 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) Over-voltage Protection function

The HT81293 device monitors the voltage on PVDD voltage. When the voltage on PVDD pin exceeds the over-voltage threshold (13V typ), the OVP circuit puts the device into shutdown mode. The device recovers automatically once the over-voltage condition has been removed.

(4) DC Detect Protection.

The HT81293 has circuitry which will protect the speakers from DC current which might occur due to an internal amplifier error. The DC Detect fault will cause the amplifier to shutdown by changing the state of the outputs to Hi-Z.

A DCE event occurs when the output differential duty-cycle of either channel exceeds 60% for more than 420 msec at the same polarity. This feature protects the speaker from large DC currents or AC currents less than 2 Hz.

全 H 桥输出级仅使用 NMOS 晶体管。因此，它们需要引导电容器，以使每个输出的高端正确开启。必须从每个输出端将额定电压至少为 16 V、质量为 X5R 或更高的 1 μ F 陶瓷电容器连接到相应的自举输入端。连接在 BSx 引脚和相应输出之间的自举电容器，用作高端 NMOS 栅极驱动电路的电源。在每个高端开关周期中，自举电容器保持栅极至源极电压足够高，以保持高端 MOSFET 导通。

HT81293 具有以下几种保护功能：输出端过流保护、片内过温保护、升压过压保护。

(1) 过流保护

当检测到一输出端对电源、对地、或对另一输出端短路时，过流保护启动，输出端切换至高阻态，防止芯片烧毁损坏。短路情况消除后，通过关断、唤醒一次芯片，或重新上电均能使芯片退出保护模式。

(2) 过温保护

当检测到芯片内温度超过 150 $^{\circ}$ C 时，过温保护启动，正负输出端切换至弱低电平状态（内部通过高阻接地），防止芯片被热击穿损坏。

(3) 过压保护

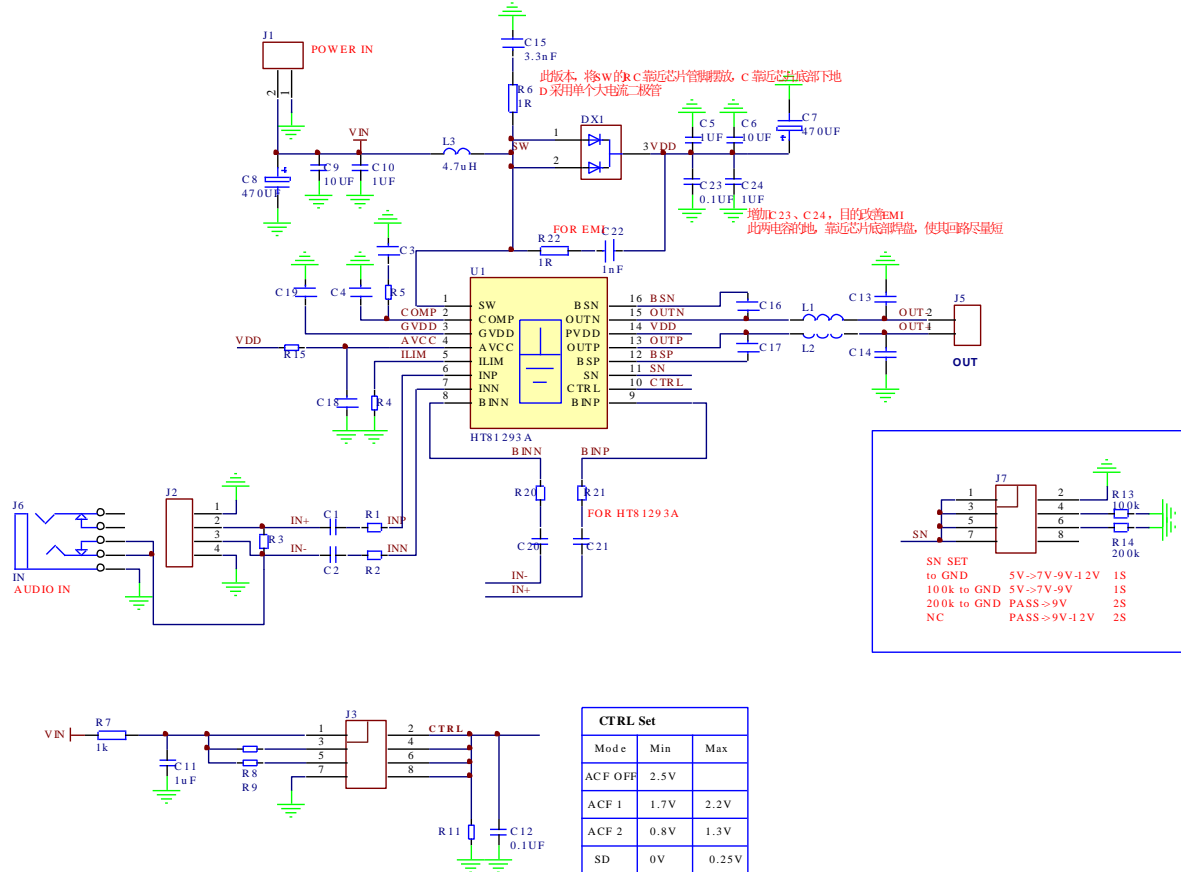
HT81293 监控 PVDD 电压上的电压。当 PVDD 引脚上的电压超过过电压阈值（13V 典型值）时，OVP 电路将 HT81293 置于关机模式。一旦消除过电压情况，设备将自动恢复。

(4) 直流监测保护

HT81293 具有保护扬声器免受由于内部放大器错误而产生的直流电流影响的电路。直流检测故障时，输出状态更改为 Hi-Z，致放大器关闭。

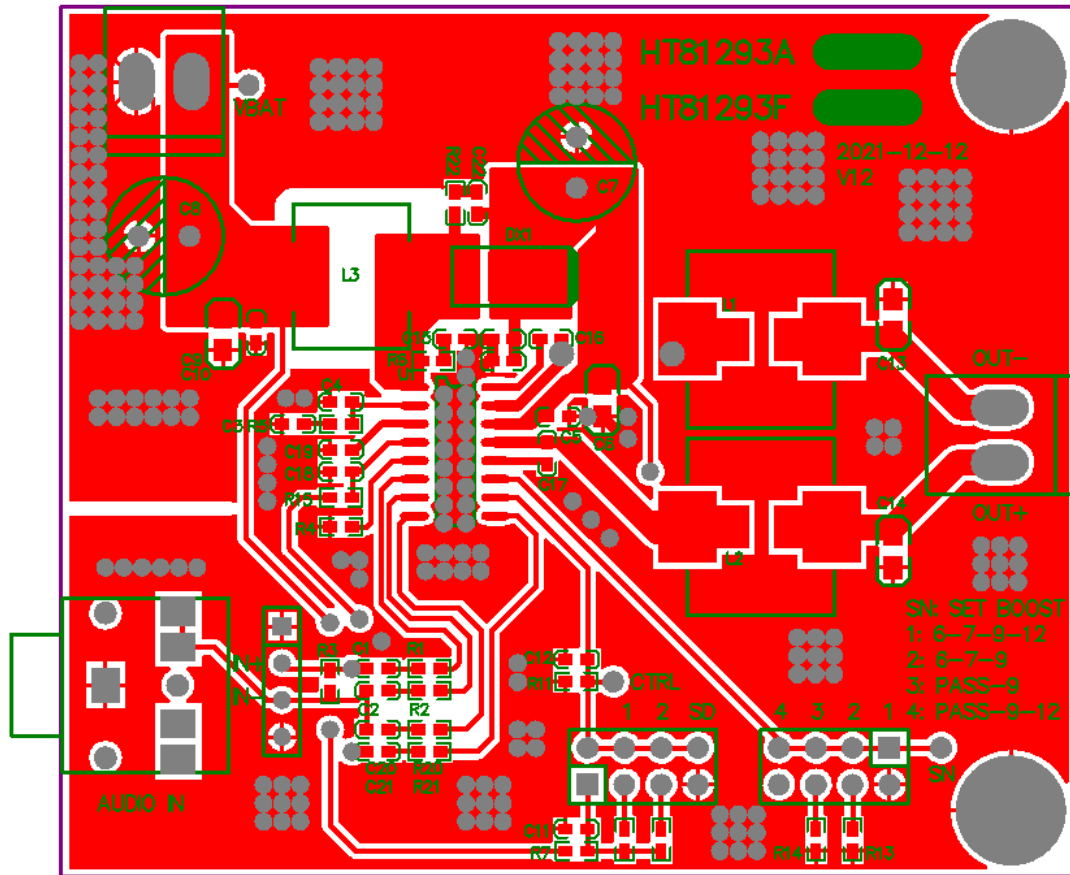
当任一通道在相同极性下的输出差占空比超过 60% 超过 420 毫秒时，就会发生 DCE 事件。此功能可保护扬声器免受大直流电流或小于 2 Hz 的交流电流的影响

8.1 Typical Circuit Diagram

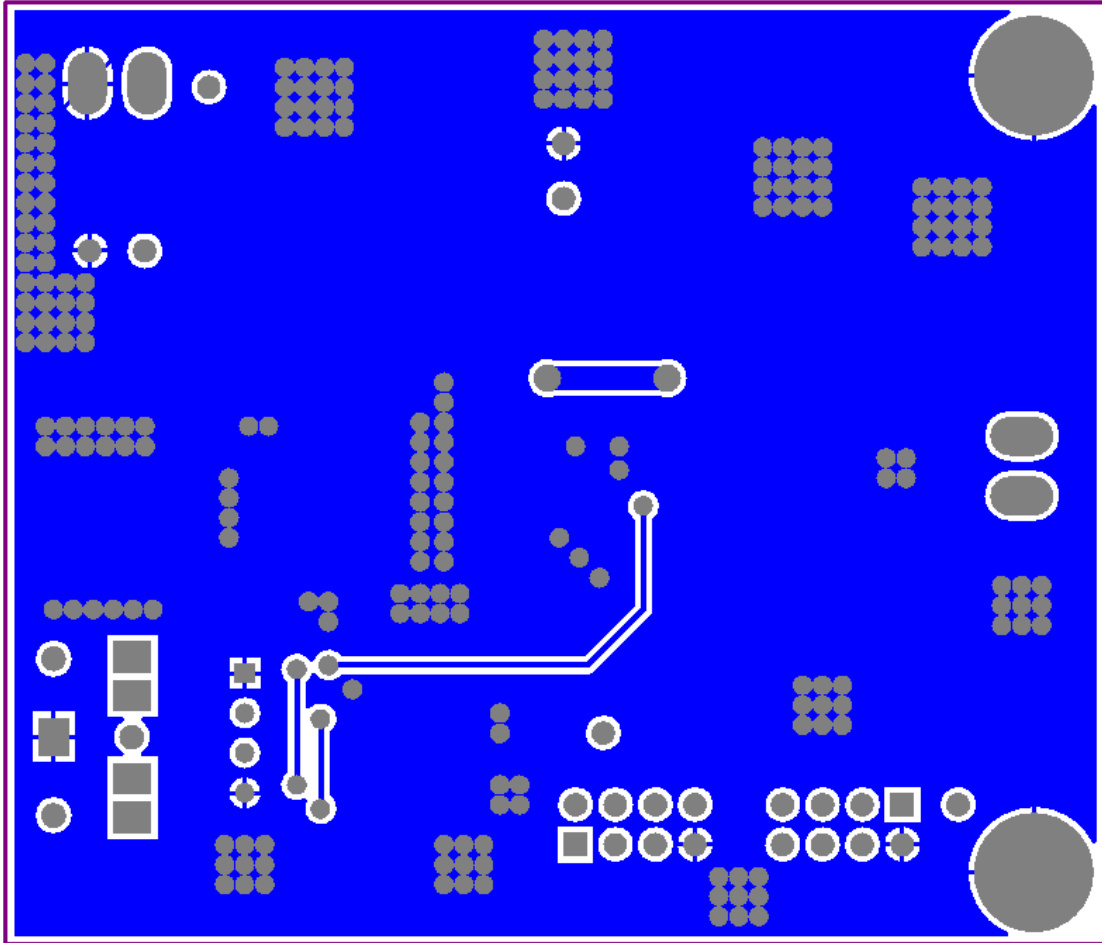


9 PCB Layout

9.1 Top Layer

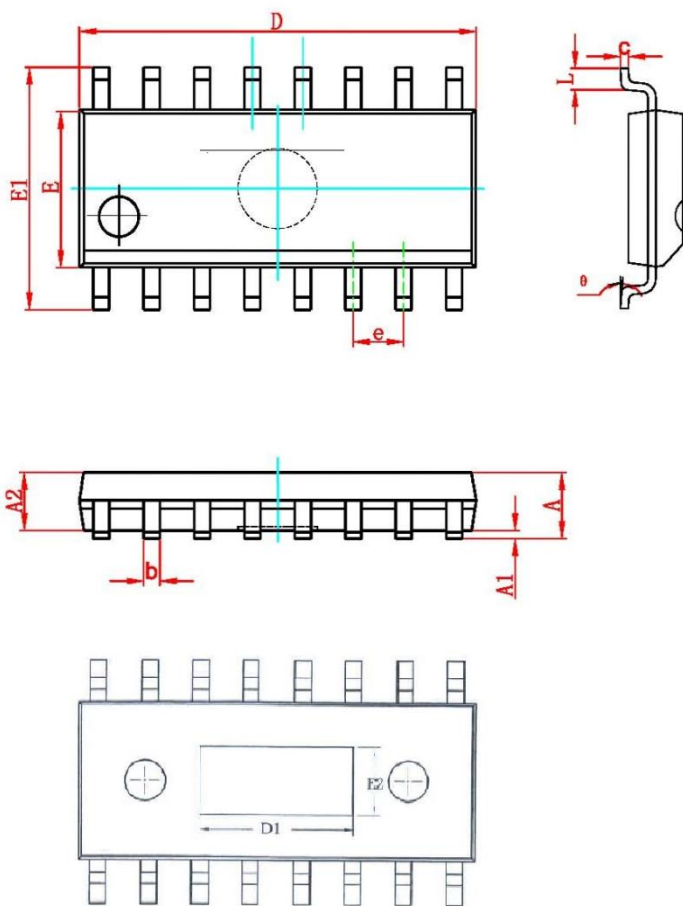


9.2 Bottom Layer



PACKAGE OUTLINE

SPE (ESOP16)



Symbol	Size (mm)	
	MIN	MAX
A	-	1.75
A1	0.05	0.15
A2	1.30	1.50
b	0.39	0.48
c	0.21	0.26
D	9.70	10.10
D1	4.57(REF)	
E	3.70	4.10
E1	5.80	6.20
E2	2.41(REF)	
e	1.27(BSC)	
L	0.50	0.80
θ	0°	8°

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