Two Anti Burst Modes,Spread Spectrum Mode, Built–in Boost Module, Two Lithium Battery Series Power Supply, Constant 2 x 17W Output Power Class R Stereo Audio Power Amplifier

General Description

IU8373E is for two lithium battery series application, It has two anti burst modes, spread spectrum module, built-in boost module and class R stereo audio power amplifier. It can provide up to 2x17W constant power for 4Ω load. It provides greater convenience for the power amplifier design of audio subsystems and the cost reduction of terminal products.

IU8373E fully differential architecture and extremely high PSRR effectively improve the RF noise suppression ability of it. The filter free PWM modulation structure and built-in boost module, as well as the IU8373E adopt the proprietary AERC (Adaptive Edge Rate Control) technology, which greatly reduces EMI interference in the full audio bandwidth. For 60cm audio cable, it has more than 20dB margin under FCC standard. In addition, IU8373E has built-in over-current protection, short-circuit protection and overheating protection, It can effectively protect the chip from damage under abnormal working conditions.

Features

- Built-in Boost Module R Class Structure
- Output Power(D MODE NCN OFF)
  P_O at 1% THD+N, Vbat=7V, R_L=4Ω+47uH 2x17W
- Excellent "Pop Click" Noise Suppression
- Operating Voltage Range: 6~9V
- Built-in Two Anti Burst Modes
- Boost to 13V
- Class-D Structure without Filtering
- 88% Efficiency@Vbat=8.4V, P_O=2X17W
- High PSRR: - 72dB at 217Hz
- Start time (220ms)
- Quiescent Current(25mA)
- Low Turn off Current(10uA)
- Over Current Protection, Short Circuit Protection and Overheat Protection
- RoHS Compliant Lead Free Package

Applications

- Portable Audio Device

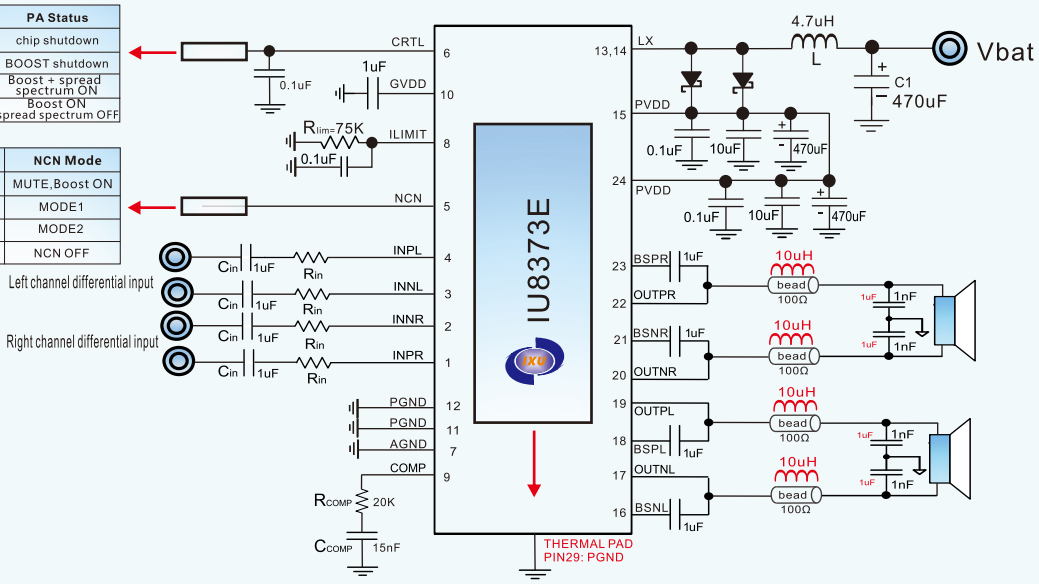
Package

- EQA28

Typical Applications

CTRL Status	PA Status
0~0.2V	chip shutdown
1.2~1.4V	BOOST shutdown
1.7V~1.9V	Boost + spread spectrum ON
2.2V~3.3V	Boost ON spread spectrum OFF

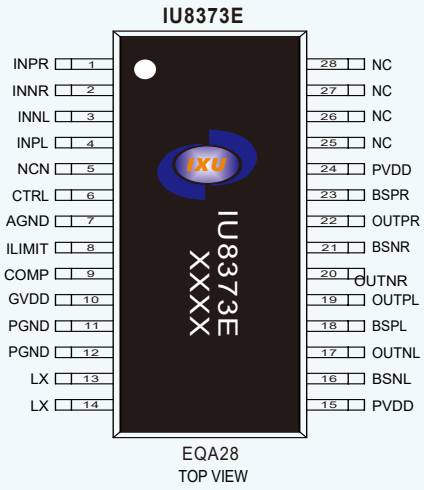
NCN Status	NCN Mode
Direct grounding	MUTE,Boost ON
39K R grounding	MODE1
82K R grounding	MODE2
FLOAT	NCN OFF



NOTES :

- L is 4.7uH and the saturation current is more than 15A, DCR is small enough.
- The Schottky model of D1 and D2 is SS54
- There are two matching methods for output filtering: magnetic bead+1nF and 10uH+1uF
- The maximum withstand voltage of the CTRL pin is 6V

PIN Configuration and Functions



EQA28
TOP VIEW

NO.	NAME	I/O	DESCRIPTION	NO.	NAME	I/O	DESCRIPTION
1	INPR	I	Right channel audio input positive end				
2	INNR	I	Right channel audio input negative end	16	BSNL	I	Left channel negative output upper tube bootstrap
3	INNL	I	Left channel audio input negative end	17	OUTNL	O	Left channel audio output negative end
4	INPL	I	Left channel audio input positive end	18	BSPL	I	Left channel positive output upper tube bootstrap
5	NCN	I	Anti burst control pin	19	OUTPL	O	Left channel audio output positive end
6	CTRL	I	Turn off control, boost and spread spectrum module control	20	OUTNR	O	Right channel audio output negative end
7	AGND	P	Analog ground	21	BSNR	I	Right channel negative output upper tube bootstrap
8	ILIMIT	I	Current limiting pin	22	OUTPR	O	Right channel audio output positive end
9	COMP	I	External compensation pin	23	BSPR	I	Right channel positive output upper tube bootstrap
10	GVDD	P	Upper gate drive voltage	24	PVDD	P	Power supply terminal
11	PGND	P	Power ground	25	NC	—	Empty
12	PGND	P	Power ground	26	NC	—	Empty
13	LX	I	Switch pin, connect external inductor	27	NC	—	Empty
14	LX	I	Switch pin, connect external inductor	28	NC	—	Empty
15	PVDD	P	Power supply terminal	29	PGND	P	Power ground(Heat sink)

Absolute Maximum Ratings [1]

SYMBOL	PARAMETER	VALUE	UNIT
V_{IN}	Power supply when there is no signal input	13	V
T_J	Junction operating temperature range	-40~150	℃
T_{STG}	Storage temperature range	-55~150	℃
T_{SDR}	Lead temperature (Soldering, 10 sec.)	260	℃

Recommended Operating Conditions

SYMBOL	PARAMETER	VALUE	UNIT
V_{IN}	Input power supply voltage	6~9	V
T_J	Junction operating temperature range	-40~125	℃
T_A	Ambient temperature range	-40~85	℃

Thermal Information [2]

SYMBOL	PARAMETER	VALUE	UNIT
θ_{JA}	Package thermal resistance - chip to environment thermal resistance	45	℃/W
θ_{JC}	Package thermal resistance - chip to package surface thermal resistance	10	℃/W

Ordering Information

Product Name	Package Type	Device Marking	Reel Size	Tape width	Quantity
IU8373E	EQA28		13″	16mm	3000
			Tube		50

ESD Range

HBM (Human Body Model) ---------- ±2kV

MM (Machine model) ---------- ±200V

1. The above parameters are only the limit values of device operation. It is not recommended that the working conditions of the device exceed the limit values. Otherwise, the reliability and life of the device will be affected, and even permanent damage will be caused.
2. Where the PCB board is placed in IU8373E, a heat dissipation design is needed. The heat sink at the bottom of IU8373E is connected with the heat sink area of PCB board.

Electrical Characteristics (T_A=25℃, unless otherwise specified)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$\|V_{OO}\|$	Output offset voltage	Vbat=0V, Av=2V/V Vbat=6.0V to 9.0V		5	25	mV
PSRR	Power supply ripple rejection ratio	Vbat=6V to 9V,217Hz		-70		dB
CMRR	Common mode rejection ratio	Input pins are shorted together Vbat =6V to 9V		-72		dB
I_{DD}	Quiescent current	Vbat=7.0V,No load, No filter		25		mA
I_{SD}	Turn off current	Vbat=8.0V		10		μA
$r_{DS(ON)}$	On resistance of power amplifier module	Vbat=7.4V		110		mΩ
		Vbat=10V		100		
$f_{(SW)}$	Class D modulation frequency	Vbat=6V to 9V		310		KHz
Rf	Built in feedback resistor			640		KΩ

Electrical Parameters of BOOST Module (T_A=25℃ , unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
input voltage		6.0		10.0	V
Under voltage protection threshold	V_{IN} Rising		5.0		V
switching frequency			310		KHZ
Maximum duty cycle		85			%
On current of switch tube	Vbat= 7.4V,Duty cycle= 70%		12		A
On resistance of switch tube			20		mΩ
Conduction leakage current of switch tube	V_{LX}= 7.5V, EN = 0			5	uA
Thermal protection temperature			160		°C
Thermal protection hysteresis			40		°C

Working characteristics T_A =25°C, R_L = 4Ω+47uH

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_O	NCNOFF	Vbat=7V,THD=1%,f=1KHz		17		W
		Vbat=8V,THD=1%,f=1KHz		17		
	BOOST OFF	PV_{DD}=12V,THD=10%,f=1KHz		18.0		
		PV_{DD}=12V,THD=1%,f=1KHz		14.5		
THD+N	Total harmonic distortion + noise	Vbat=8.0V,Po=1.0W, f=1KHz		0.1		%
η	efficiency	Vbat=8.4V,THD@Po=2X8W, f=1KHz		88		%
		Vbat=8.4V,Po=2X8W, f=1KHz		88		
t_{ST}	Chip start time			220		ms
Vn	Output background noise	Differential input floating,f=20~20K,A-Weighted		85		uV

Working characteristics

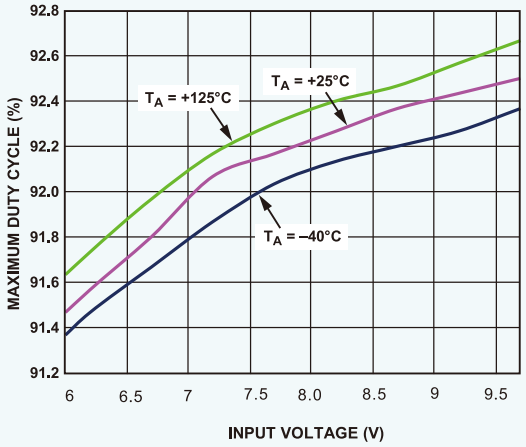
T_A=25°C, RL = 4 Ω+47uH,The NCN is grounded through a 39K Ω resistor (NCN MODE1)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_O	output power	Vbat=8.4V,NCN MODE1		11.0		W
		Vbat=7.2V,NCN MODE1		11.0		
THD+N	Total harmonic distortion + noise	Vbat=8.4V,NCN MODE1		0.7		%
		Vbat=7.2V,NCN MODE1		0.7		
T_{at}	Anti breaking			50		ms
T_{rl}	Anti breaking			400		ms

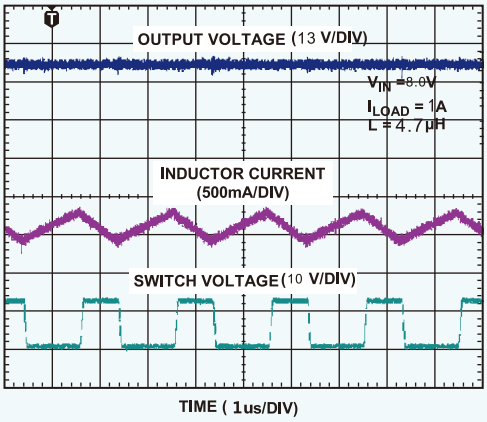
T_A=25°C, RL = 4 Ω+47uH,The NCN is grounded through a 82K Ω resistor (NCN MODE2)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_O	output power	Vbat=8.4V,NCN MODE1		15		W
		Vbat=7.2V,NCN MODE1		15		
THD+N	Total harmonic distortion + noise	Vbat=8.4V,NCN MODE1		0.7		%
		Vbat=7.2V,NCN MODE1		0.7		
T_{at}	Anti breaking			50		ms
T_{rl}	Anti breaking			100		ms

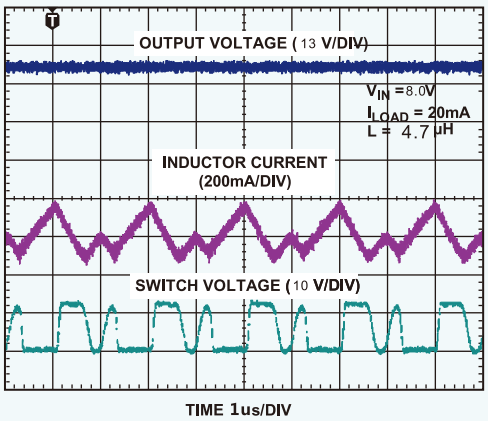
Boost Typical Characteristics T_A=25°C, RL = 4 Ω



Maximum Duty Cycle vs. Input Voltage, f_{SW} = 310KHz



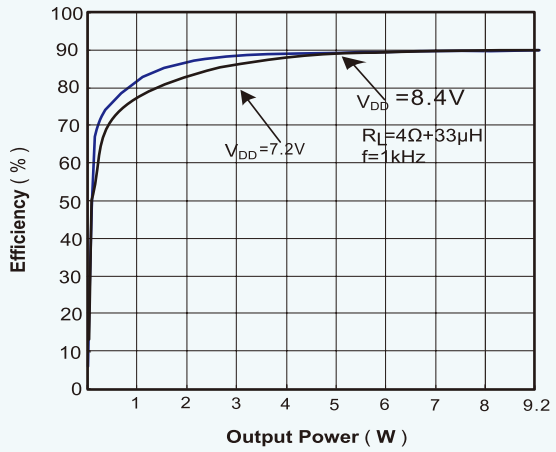
Switching Waveform in Continuous Conduction Mode



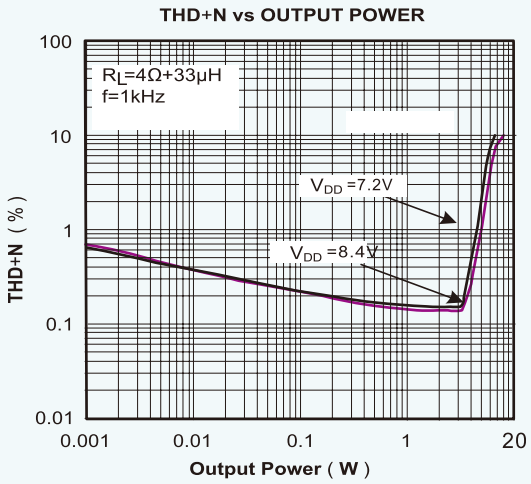
Switching Waveform in Discontinuous Conduction Mode

Typical Characteristics T_A=25°C, RL = 4 Ω

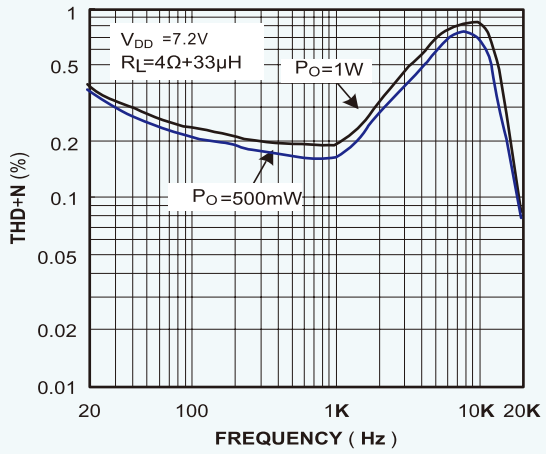
EFFICIENCY vs OUTPUT POWER



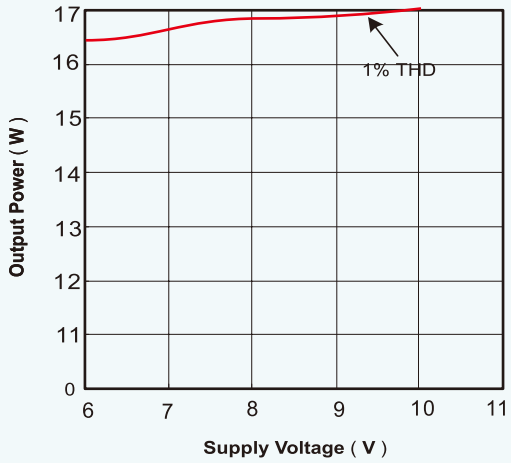
THD+N vs OUTPUT POWER



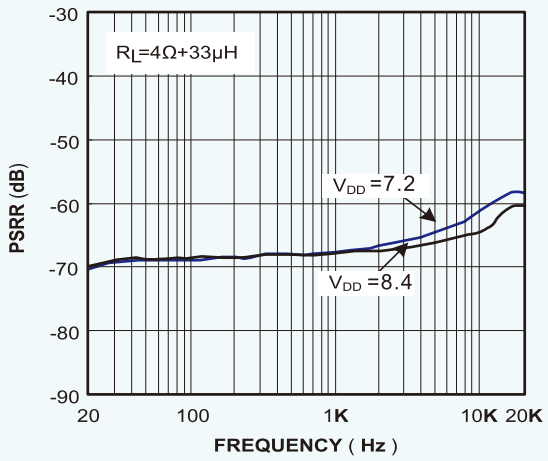
THD+N vs FREQUENCY



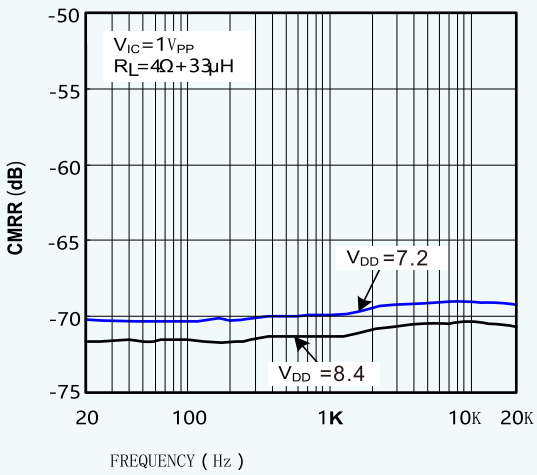
OUTPUT POWER vs SUPPLY VOLTAGE



PSRR vs FREQUENCY



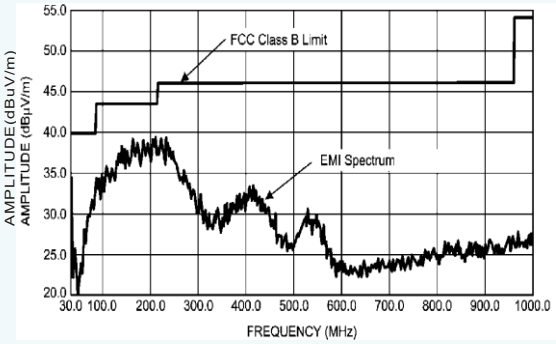
CMRR vs FREQUENCY



IU8373E Application Points

1. Function Introduction

IU8373E is for two lithium battery series applications, with two anti burst modes, spread spectrum module, built-in BOOST boost module, and R-class stereo audio power amplifier. It can provide a constant power of up to 2X17W for a load of 4Ω. IU8373E provides considerable power margin and maximum convenience for the design of audio subsystem amplifiers and the upgrading and replacement of terminal products. The fully differential architecture and extremely high PSRR of IU8373E effectively improve its ability to suppress RF noise. The PWM modulation structure without a filter and the built-in BOOST boost module, as well as the use of proprietary AERC (Adaptive Edge Rate Control) technology in the IU8373E, greatly reduce EMI interference within the full audio bandwidth range, and have a margin of over 20dB under FCC standards for 60cm audio lines.



IU8373E EMI Spectrum

2. Pop&Click Suppression

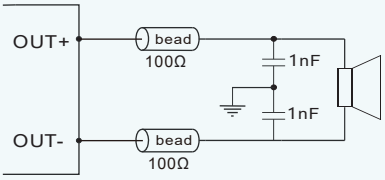
IU8373E has a proprietary timing control circuit built-in to achieve comprehensive Pop&Click suppression, which can effectively eliminate transient noise that may occur during system power on and off, Wake up, and Shutdown operations.

3. Protection Circuit

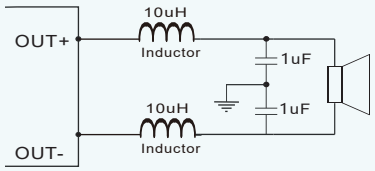
During the application process of IU8373E, when the chip experiences a short circuit between the output pin and the power or ground, or a short circuit fault between the outputs, the overcurrent protection circuit will turn off the chip to prevent damage. After the short circuit fault is eliminated, IU8373E automatically resumes operation. When the chip temperature is too high, the chip will also be turned off. After the temperature drops, IU8373E can continue to operate normally. When the power supply voltage is too low, the chip will also be turned off. After the power supply voltage is restored, the chip will start again.

4. Inductor, Magnetic Beads, Capacitors

The IU8373E module can pass FCC B-level testing with magnetic bead filters under various conditions such as high power and long output load lines. The type and specifications of magnetic beads can be selected based on actual use. As shown in the following figure:



If the amplifier is applied to a system with strict noise requirements, a series LC filter can be considered for output. The relevant parameters of the filter are shown in the following figure:



5. Selection of Schottky

The Boost section of IU8373E adopts asynchronous rectification and requires an external Schottky diode for continuous current. The Schottky diode has a significant impact on the overall performance of the IC, and improper selection may lead to low overall efficiency, and even generate a large reverse overshoot voltage at the LX end of the IC, causing the IC to burn out. We recommend using two 5A, 40V Schottky diodes (such as SS54) in parallel. It should be noted that the wiring from Schottky to the inductor to the output filter capacitor to the PVDD end should be as short as possible. Improper wiring can cause the LX end to overshoot and ringing to increase, affecting EMI, and even burning the IC.

6. Selection of Inductor

Inductance has a great impact on the performance of the IU8373E. According to many considerations such as ripple stability, 4.7uH inductance is recommended and its DCR should be small enough, and the Saturation current should be above 10A.

7. Efficiency

The switching mode of the output transistor determines the high efficiency of the R-class amplifier. In R-class amplifiers, the output transistor is like a current adjustment switch, and the additional power consumed during the switching process can be basically ignored. The power loss related to the output stage is mainly caused by the IR generated by the MOSFET conduction resistance and the power supply current. After boosting, the efficiency of IU8373E can reach over 88%.

8. Magnification

The built-in feedback resistor of IU8373E is 640K, so the calculation of amplification factor is: Gain=640K/R_{IN}.

IU8373E Application Points

9. Input Capacitance C_{in}

A high pass filter is formed between the input resistor and input capacitor, and its cutoff frequency is as follows:

$$f_c = \frac{1}{2\pi * R_{in} * C_{in}}$$

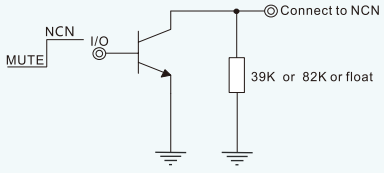
The value of the input capacitance is very important, and it is generally believed to directly affect the low-frequency performance of the circuit. The speakers in wireless phones usually do not respond well to low-frequency signals, and larger fc can be selected in applications to filter out the interference introduced by 217HZ noise. A good matching between capacitors is helpful for improving the overall performance of the chip and suppressing Pop&Click, therefore it is required to select capacitors with an accuracy of 10% or less.

10. NCN, MUTE Functions

In audio applications, factors such as excessive input signals or a decrease in battery voltage can lead to audio amplifier output signal distortion, and overloaded signals can cause permanent damage to the speaker. The unique No Break (NCN) function of IU8373E can automatically adjust the system gain by detecting the distortion of the amplifier output signal, ensuring that the output audio signal remains smooth and round. This not only effectively avoids damage to the speaker caused by high-power overload output, but also brings more comfortable auditory enjoyment. IU8373E provides two NCN working modes and can set the mute MUTE function through this pin. The control methods are shown in the table below:

NCN Status	NCN Mode	Start Time	Release Time
Direct grounding	MUTE,Boost ON	——	——
39K R grounding	MODE1	50ms	400ms
82K R grounding	MODE2	50ms	100ms
FLOAT	NCN OFF	——	——

In the MUTE state, IU8373E only turns off the output stage of the power amplifier. The MUTE and anti burst state of IU8373E can be controlled through IO, as shown in the following figure:



11. Current limiting Function

By setting a pull-down resistor and a pull-down capacitor to the ground through the ILIMIT pin, the peak current of the BOOST inductor can be limited and the power supply soft start function can be achieved. The following table lists the effective values of soft start time and inductance current under different resistance and capacitance conditions for reference.

Inductance	Rlim	Power soft start time	Effective value of inductor current
		100nF capacitor	
4.7uH	82K	16ms	8.0A
	75K	16ms	7.5A
	62K	16ms	5.3A

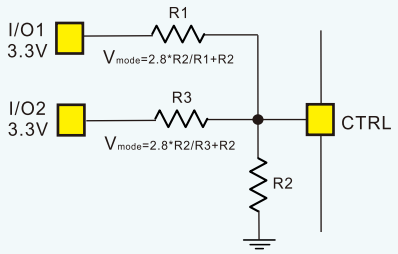
12. CTRL Working Mode Setting

There are four working modes for IU8373E: chip off, BOOST module off, BOOST module on+spread spectrum function on, and BOOST module on+spread spectrum mode off. By simply setting the hardware for the CTRL foot, you can switch between the four modes.

CTRL Status	PA Status
0~0.2V	chip shutdown
1.2~1.4V	BOOST shutdown
1.7V~1.9V	Boost + spread spectrum ON
2.2V~3.3V	Boost ON spread spectrum OFF

13. CTRL Pin IO Control

If the IO control voltage of the main control is 3.3V, as shown in the figure, the switching of three working states is achieved through two IO ports and a voltage divider line. When both IO1 and IO2 are at low levels, IU8373E enters the shutdown mode; When IO1 is high and IO2 is suspended, as long as the appropriate R1 and R2 resistance ratio are selected to make the VCTRL voltage between 1.2 and 1.4V, IU8373E will turn off the BOOST module and the power amplifier module will work normally; When IO1 is suspended and IO2 is at a high level, as long as the appropriate R3 and R2 resistance ratio are selected to ensure that the VCTRL voltage is between 1.7 and 1.9V, IU8373E enters the mode where the power amplifier, BOOST module, and spread spectrum function are both turned on; When IO1 is high, IO2 is suspended, and IU8373E enters the mode where the power amplifier and BOOST module are turned on and the spread spectrum function is turned off. Special attention should be paid to the maximum withstand voltage of the CTRL pin being 6V, and excessive voltage should not be used to connect to the CTRL.

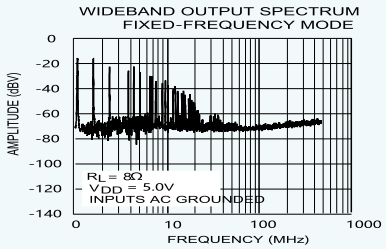


IU8373E Application Points

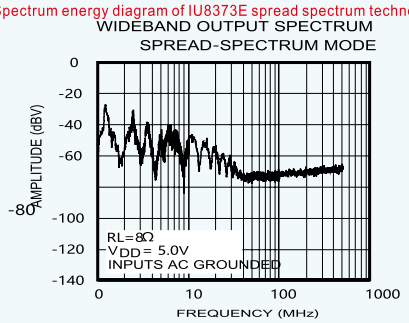
14. Spread Spectrum Mode Setting

When the CTRL pin voltage is between 1.7V and 1.9V, IU8373E enters a unique spread spectrum modulation mode. In this mode, the spectral components are spread out over a wide frequency range, which can effectively reduce EMI (see fixed frequency spectrum energy diagram and spread spectrum technology spectrum energy diagram for details). The proprietary technology ensures that the switching frequency does not decrease audio reconstruction performance or efficiency with periodic changes. The switching frequency varies randomly within the range of ± 25K around the center frequency of 310K. The modulation mode remains the same, but the frequency of the Sawtooth wave wave changes with the period. In this way, the energy is distributed to the entire frequency band that grows with the frequency, rather than concentrating a large amount of spectral energy on the companion frequency of the switching frequency. In the frequency band up to several MHZ, EMI is equivalent to the white noise of the broadband frequency (see the EMI spectrum diagram).

IU8373E fixed frequency spectrum energy diagram



Spectrum energy diagram of IU8373E spread spectrum technology



Recommendation for improving interference in FM situations

In the presence of FM, the following actions can be taken during system design to improve the interference of switch signals with FM:

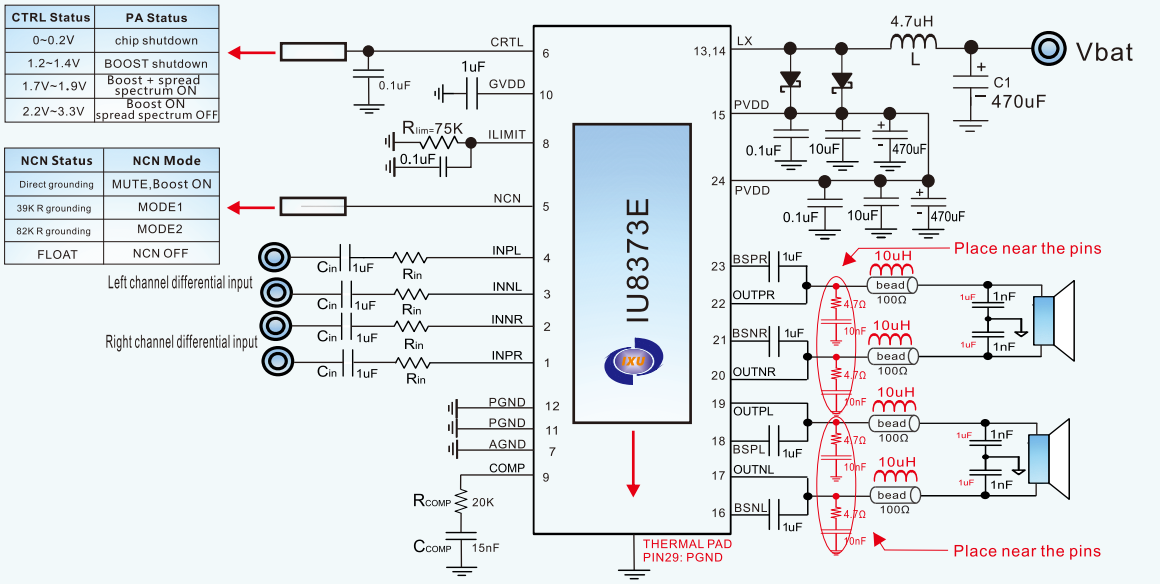
- Turn off the spread spectrum function of IU8373E
- Close the BOOST module of IU8373E

} → Set the voltage value of the CTRL pin to 1.2V~1.4V

- Add a ground RC combination to the output pin, as shown in the following figure

CTRL Status	PA Status
0~0.2V	chip shutdown
1.2~1.4V	BOOST shutdown
1.7V~1.9V	Boost + spread spectrum ON
2.2V~3.3V	Boost ON spread spectrum OFF

NCN Status	NCN Mode
Direct grounding	MUTE,Boost ON
39K R grounding	MODE1
82K R grounding	MODE2
FLOAT	NCN OFF



Design Steps and Key Points of IU8373E PCB

- **Vbat Terminal Capacitor**

The IU8373E is internally integrated with a voltage stabilizing circuit, so it does not need to supply power to the IU8373E through Vbat, so it does not need a chip Decoupling capacitor, and it can be directly connected to the inductance. However, we generally recommend that at least one energy storage Electrolytic capacitor be added to Vbat, because both the boost power supply and power amplifier obtain current from Vbat. A 470uF Electrolytic capacitor helps to make the battery voltage more stable, reduce the interference to other ICs on the system, improve the low-frequency transient response of the IU8373E, and reduce EMI.

- **PVDD Terminal Capacitor**

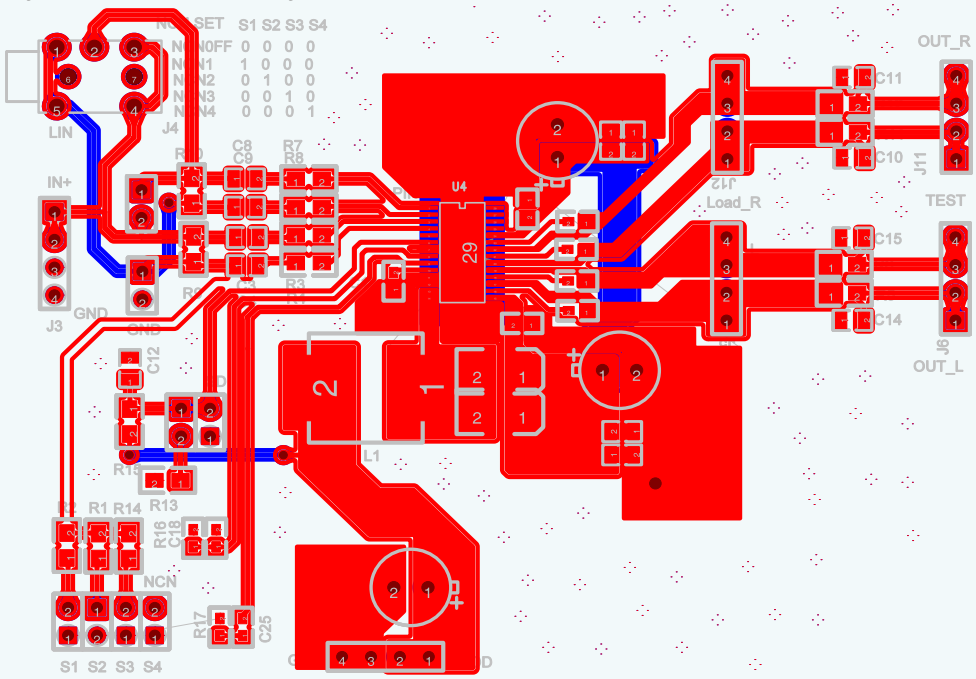
The PVDD of IU8373E is actually the output of the boost power supply and also the power input of the built-in power amplifier module. Therefore, filtering Decoupling capacitor is necessary. We require to use two groups of capacitors, one is a 10uF Decoupling capacitor and one is a 470uF filtering Electrolytic capacitor, which should be placed as close to Schottky as possible. Another set of 0.1uF chip capacitors should be placed as close to the chip pins as possible. 470uF filter capacitor is also necessary (it is recommended to use high-frequency low resistance series Electrolytic capacitor, which can effectively improve efficiency and reduce voltage ripple). Too small capacitance will cause output voltage oscillation of BOOST module. The PVDD terminal capacitance has a significant impact on the performance of IU8373E. For specific details, please refer to the PCB design guide or contact the original factory engineer.

- **Chip GND**

IU8373E has two sets of GNDs, PGND and AGND. PGND is a power ground, with transient currents exceeding 9A flowing through it, and also serves as a heat sink for the chip. Be sure to directly connect to the copper layer and ensure sufficient through-holes are connected to the bottom layer of copper layer. AGND is the analog reference ground for the chip, and we suggest connecting it directly to the copper substrate.

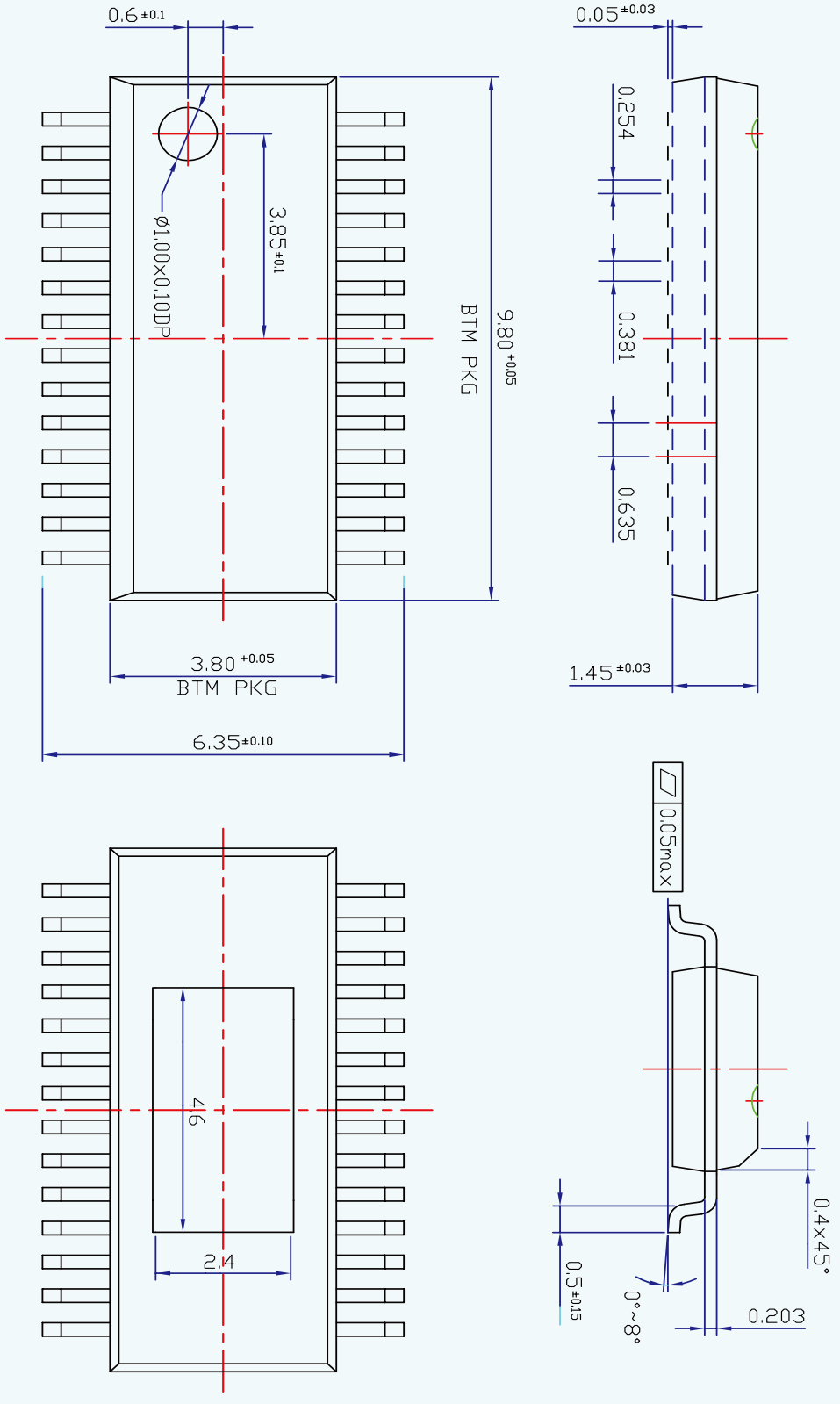
- **Input audio GND**

IU8373E is a differential input, and when the sound source is also a differential output, IU8373E can effectively shield interference without worrying too much about the introduction of ground circuit noise. But when the sound source is single ended output, attention should be paid to the introduction of shielding ground circuit noise. Due to the different characteristics of each system and the main control or DAC, we generally can only recommend ensuring that there is no potential difference between the reference ground of the audio signal and the reference ground of the pin pin pin through the capacitor grounding of IU8373E, or as much as possible, one ground. The following figure shows the actual diagram of the recommended DEMO board:



Package Information

IU8373E EQA28 PACKAGE OUTLINE DIMENSIONS (units:mm)





Precautions for MOS Circuit Operation:

Static electricity can be generated in many places. The following precautions can effectively prevent MOS circuit from being damaged due to the sound of electrostatic discharge:

- Operators shall be grounded through anti-static wrist strap.
- The equipment enclosure must be grounded.
- Tools used during assembly must be grounded.
- Conductor packaging or anti-static materials must be used for packaging or transportation.

Declaration:

•Shanghai IXU Semiconductor Co., Ltd. reserves the right to make changes to the manual without prior notice! Customers should obtain the latest version of the material before use and verify whether the relevant information is complete and up-to-date.

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