2W Class-K Audio Amplifier with RF-TDD Suppression and NCN

Features

- **Built-In RNS Function，Excellent TDD Suppression**
- **NCN Function Protects the Speaker**
- **EEE Function，Greatly reduces EMI over the full bandwidth**
- **2.0W into 8Ω at 4.2V(10% THD+N)**
- **4 Selectable Gain，12dB，16dB，24dB，27.5dB**
- **4 Mode selected by one-wire pulse**
- **Excellent Pop-Click Suppression**
- **Short-Circuit and Thermal Protection**
- **±7KV HBM ESD，±450mA Latch-up**
- **Small 3mm×3mm 20-Pin TQFN Package**

Applications

- Cellular Phones
- Portable Audio Devices
- Mini Speakers

General Description

The AW8733A is a powerful Class-K audio amplifier that features RNS (RF-TDD Noise Suppression), NCN (Non-Crack-Noise) and EEE (Enhanced Emission Elimination).

The AW8733A features the RNS function which greatly reduces RF-TDD Noise.

The AW8733A features a built-in charge pump converter generates a 6.3V supply voltage. This provides a louder audio output than a stand-alone amplifier directly connected to the battery. The AW8733A features 2W output power (10% THD+N) into 8Ω load at 4.2V battery voltage.

The AW8733A features the NCN function, which adjusts the system gain automatically while detecting the “Crack” distortion of output signal, protects the speaker from damage at high power levels and brings the most comfortable listening experience to the customers.

The AW8733A is available in a small 3mm×3mm 20-Pin TQFN Package. It is specified over the extended -40℃ to +85℃ temperature range.

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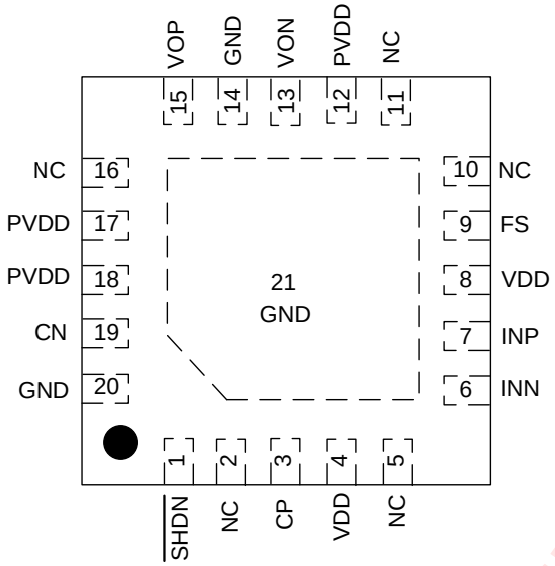
Pin Configuration and Top Mark

AW8733ATQR TOP VIEW



AW8733ATQR MARKING

8733A – AW8733ATQR
XXXX – Manufacture Date Code

Figure 1 Pin Configuration and Top Mark of AW8733ATQR

Pin Definition and Function

No.	Symbol	Description
1	$\overline{\text{SHDN}}$	Shutdown and one-wire control pin
3	CP	Positive Terminal of Flying capacitor
4，8	VDD	Supply Voltage.
6	INN	Negative Amplifier Input
7	INP	Positive Amplifier Input
9	FS	Test pin. No Connect
12，17，18	PVDD	Charge-Pump Output.
13	VON	Negative Amplifier output
14，20	GND	Ground
15	VOP	Positive Amplifier Output
19	CN	Negative Terminal of Flying capacitor.
21	GND	Exposed Pad. Connect to GND.
2，5，10，11，16	NC	No Connect

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Typical Application

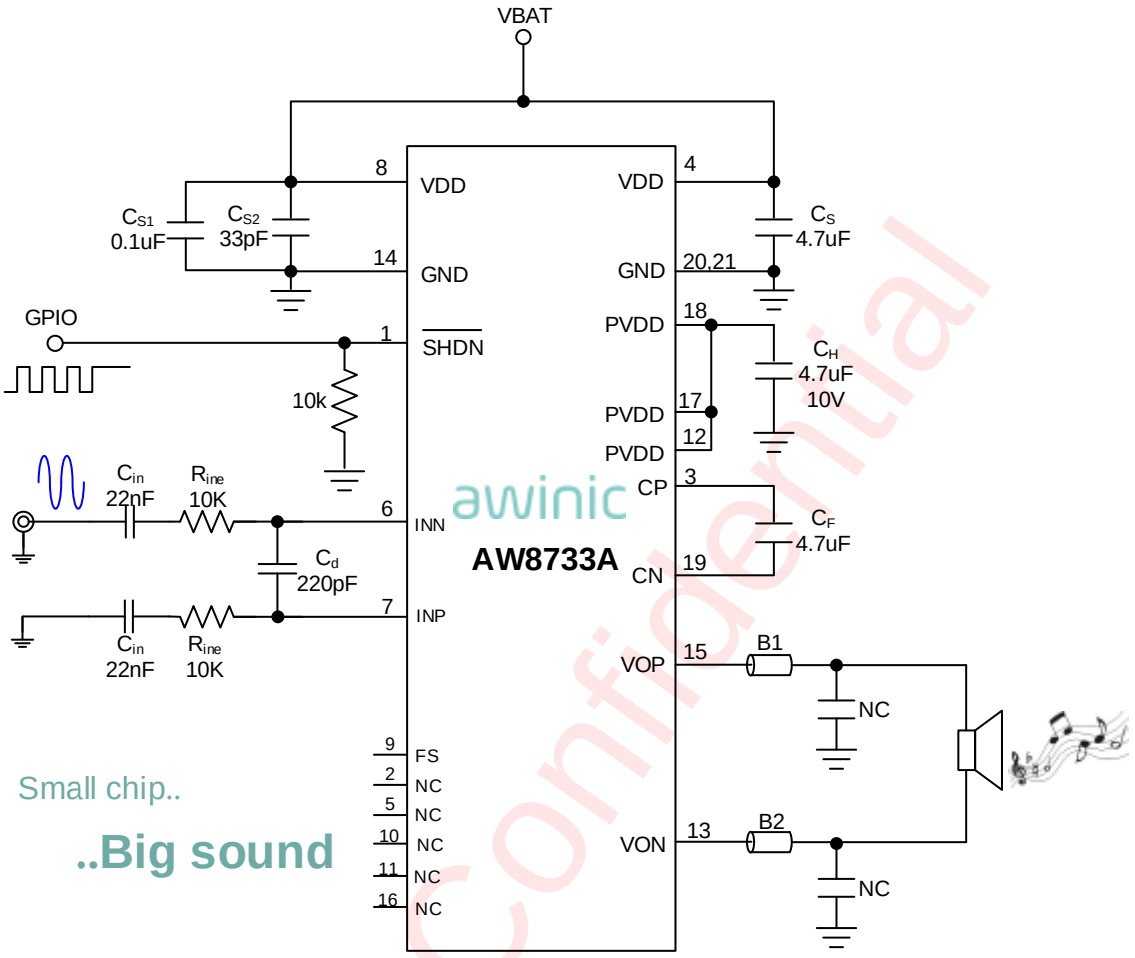

Figure 2 AW8733A Application Schematic With Single-Ended Input

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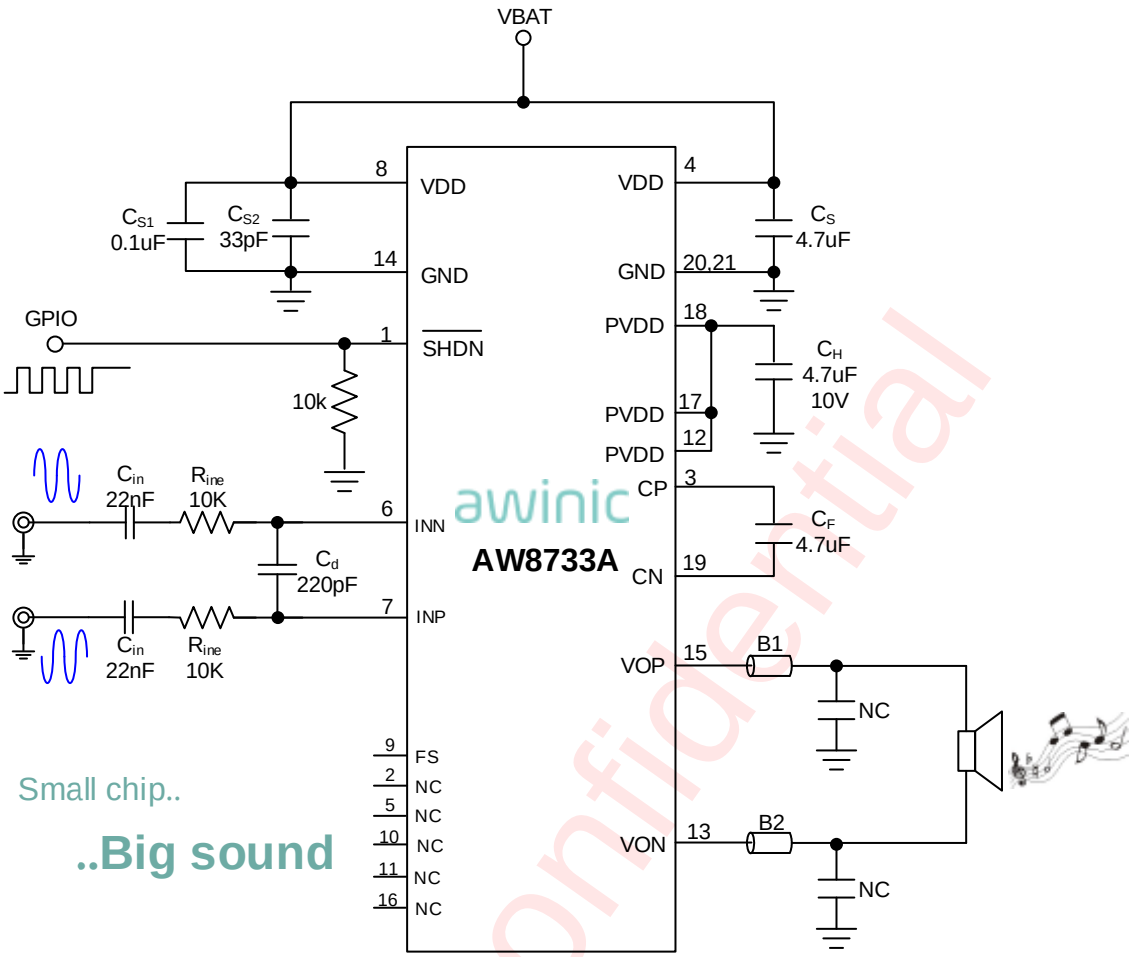
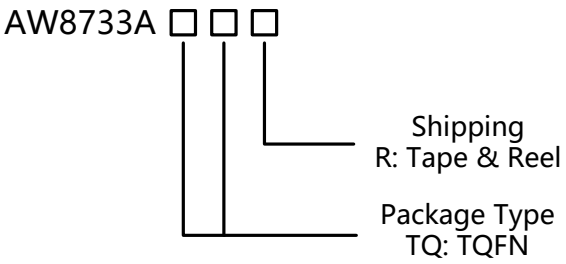


Figure 3 AW8733A Application Schematic With Differential Input

Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Packing Type
AW8733ATQR	-40℃～85℃	3mmX3mm 20-Pin TQFN	8733A	MSL3	RoHS+HF	6000 units/Tape and Reel



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Absolute Maximum Ratings (1)

Parameter	Unit
Supply voltage V_{DD}	-0.3V to 7V
INP、INN、$\overline{SHDN}$ Pin Voltage	-0.3V to V_{DD}+0.3V
Package Thermal Resistance θ_{JA}	54℃/W
Operating free-air temperature	-40℃ to 85℃
Maximum Junction Temperature T_{JMAX}	125℃
Storage Temperature Range T_{STG}	-65℃ to 150℃
Lead Temperature (Soldering 10 Seconds)	260℃
ESD Rating（2）	
HBM(human body model)	±7KV
Latch-up	
Test Condition：JEDEC STANDARD NO.78D NOVEMBER 2011	+IT：450mA -IT：-450mA

note1: 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.

note2: The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. Test method: MIL-STD-883H Method 3015.8.

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Electrical Characteristics

Test Condition：T_A=25℃，R_L=8Ω+33uH（Unless otherwise specified）

Parameter		Conditions		Min	Typ	Max	Units
V_{DD}	Power Supply			2.5		5.5	V
I_q	Quiescent current				7		mA
I_{SD}	Shutdown current	V_{DD}=3.6V， $\overline{SHUTDOWN}$=0V			0.1		μA
V_{IH}	$\overline{SHDN}$ high-level input			1.2		V_{DD}	V
V_{IL}	$\overline{SHDN}$ low-level input			0		0.35	V
I_{IH}	$\overline{SHDN}$ high-level input current	$\overline{SHDN}$，V_{DD}=5.5V，V_{IH}=5.8V				100	uA
I_{IL}	$\overline{SHDN}$ low-level input current	$\overline{SHDN}$，V_{DD}=5.5V，V_{IH}=-0.3V				5	uA
T_{SD}	Thermal Protect level				160		℃
T_{SDH}	Thermal Hysteresis				40		℃
Charge Pump							
PVDD	Output Voltage	V_{DD} =3.3V to 5.5V，no load		5.8	6.3	7	V
F1	Switching Frequency	VDD=3V to 5.5V			600		kHz
T_{ST}	Soft-start time	No load，COUT=10uF			0.5		ms
I_L	PVDD short to GND current limit				300		mA
Class K							
$\|V_{OS}\|$	Output offset voltage	V_{IN}=0V，no load		-30	0	30	mV
Rini	Internal impedance	Mode1 and Mode2			30		kΩ
		Mode3 and Mode4			5		
Fosc	Modulation Frequency	V_{DD}=2.5V to 5.5V			300		kHz
PSRR	Power supply rejection ratio	V_{DD}=4.2V，Vp-p_sin=200mV	217Hz		70		dB
			1kHz		68		dB
T_{ON}	Start-up time				28		ms
THD+N	Total harmonic distortion plus noise	V_{DD}=4.2V，Po=1W，f=1kHz			0.2		%
		V_{DD}=3.6V，Po=0.5W，f=1kHz			0.23		%
P_O	Output power	THD+N=10%，f=1kHz，V_{DD}=4.2V			2		W
		THD+N=1%，f=1kHz，V_{DD}=4.2V			1.7		W
one-wire pulse control							
T_H	$\overline{SHDN}$ high level hold time	V_{DD}=2.5V to 5.5V		0.75	2	10	us
T_L	$\overline{SHDN}$ low level hold time	V_{DD}=2.5V to 5.5V		0.75	2	10	us
T_{OFF}	$\overline{SHDN}$ delay time	V_{DD}=2.5V to 5.5V				500	us
NCN							
T_{AT}	Attack time	fsin=1kHz			40		ms
T_{RL}	Release time				1.2		s
A_{MAX}	Maximum attenuation gain				-6		dB

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Measurement System

AW8733A features switching output signal. As shown in Figure 4. A Low-Pass RC filter can be used to remove high switching frequency in output signal。

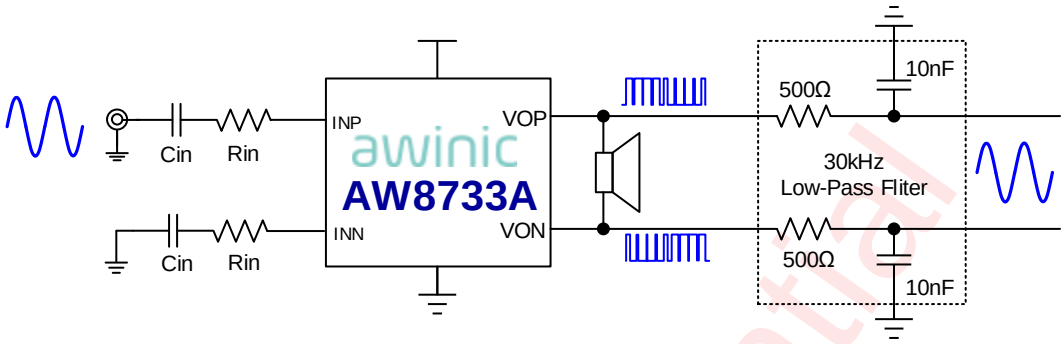

Figure 4 AW8733A measurement system

Table 1 shows recommended values of R_{filter} and C_{filter}。

R_{filter}	C_{filter}	Low-pass cutoff frequency
500Ω	10nF	32kHz
1kΩ	4.7nF	34kHz

Table1 Typical RC Measurement Filter Values

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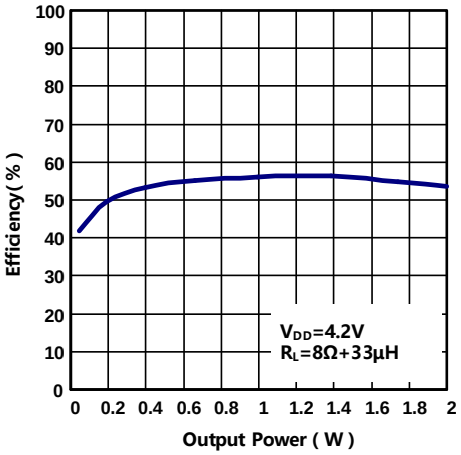
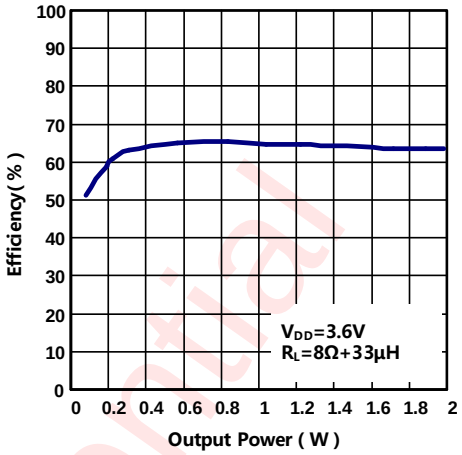
Typical Operating Characteristics

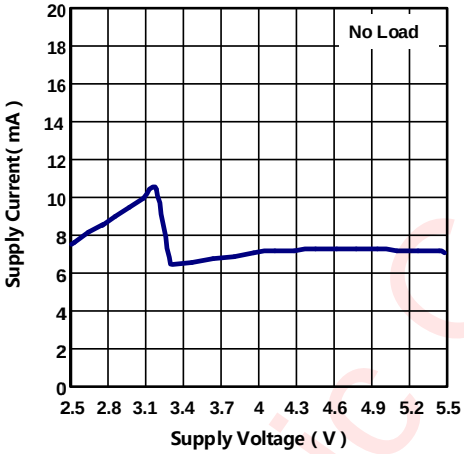
EFFICIENCY vs OUTPUT POWER



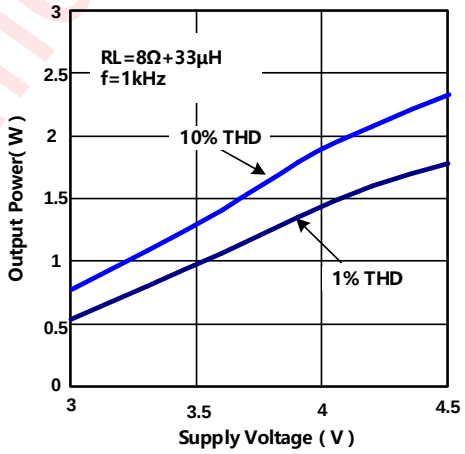
EFFICIENCY vs OUTPUT POWER



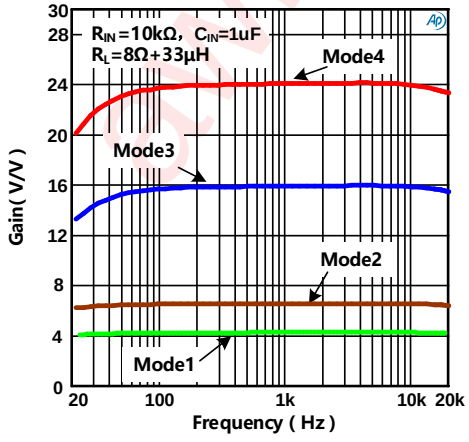
SUPPLY CURRENT vs SUPPLY VOLTAGE



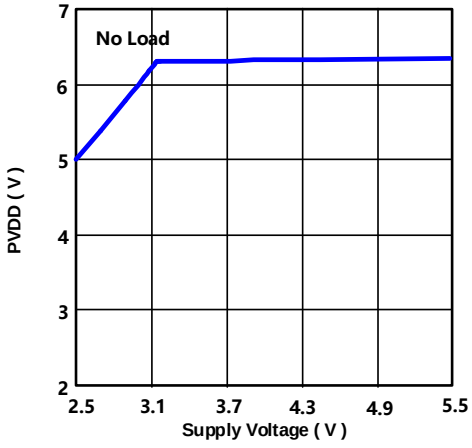
OUTPUT POWER vs SUPPLY VOLTAGE



GAIN vs FREQUENCY



PVDD vs SUPPLY VOLTAGE



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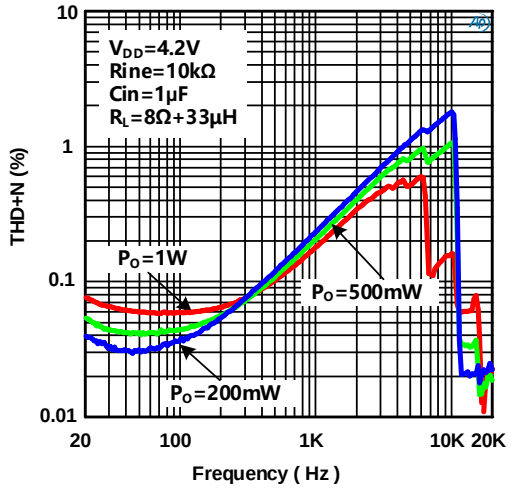
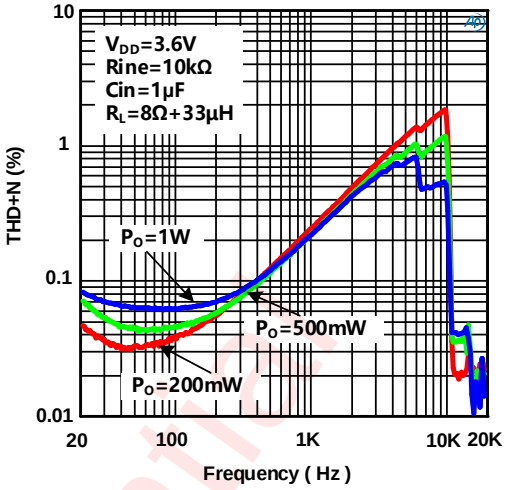
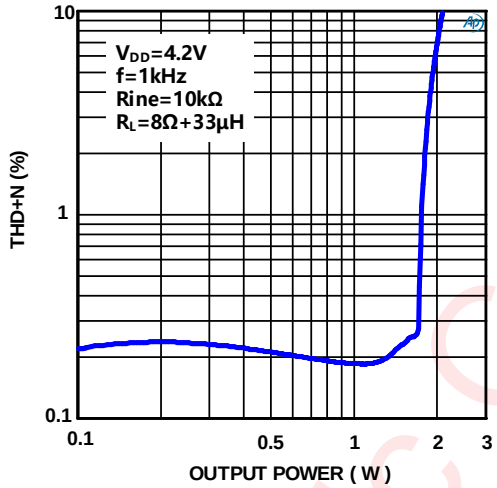
THD+N vs Frequency



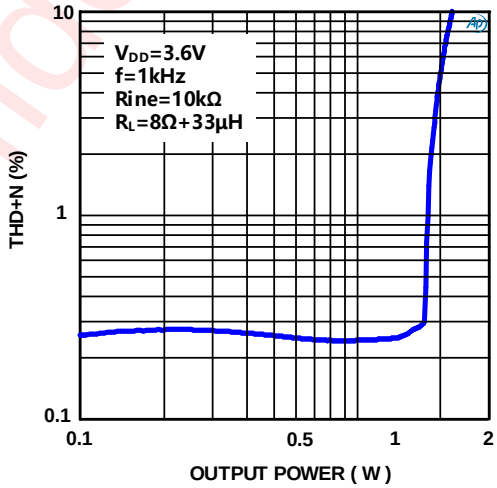
THD+N vs Frequency



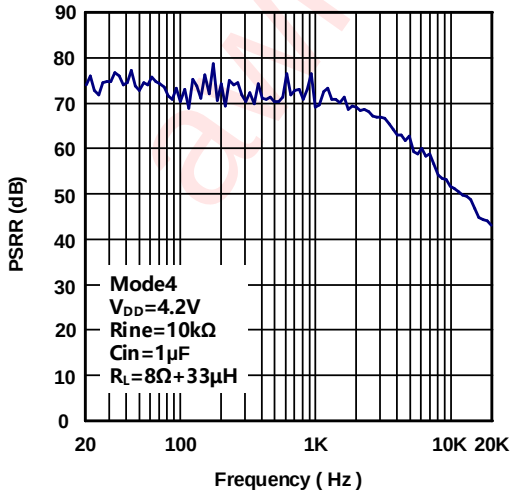
THD+N vs OUTPUT POWER



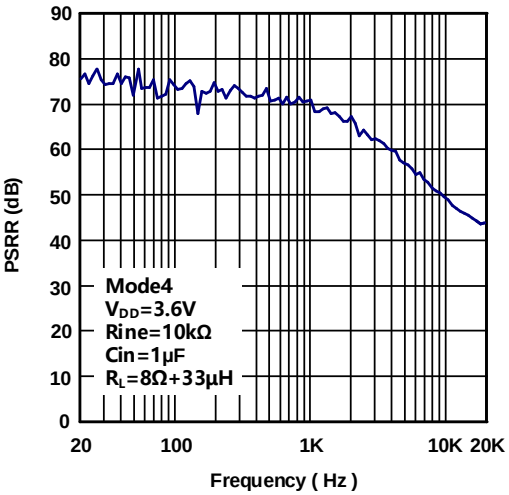
THD+N vs OUTPUT POWER



PSRR vs Frequency



PSRR vs Frequency



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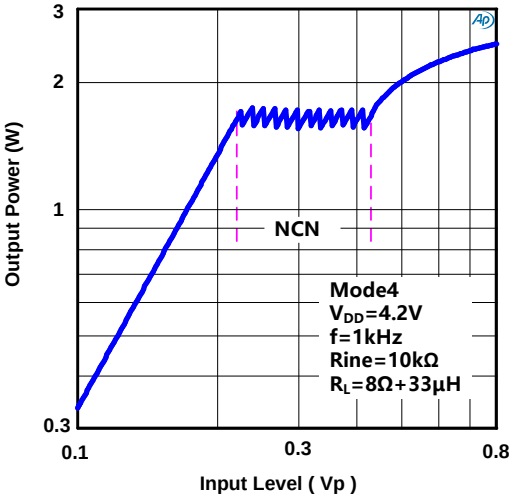
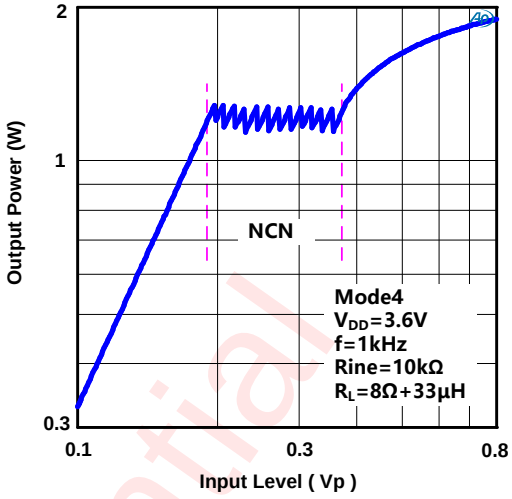
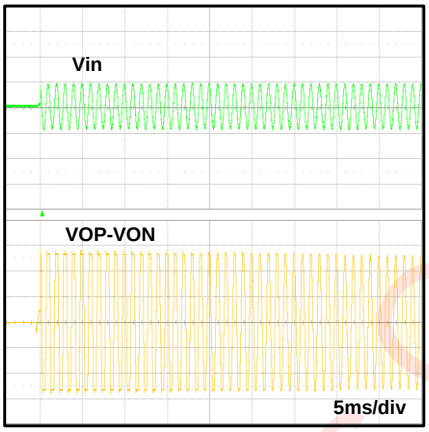
OUTPUT POWER vs INPUT LEVEL



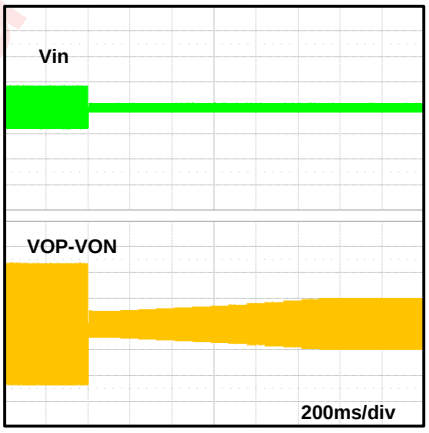
OUTPUT POWER vs INPUT LEVEL



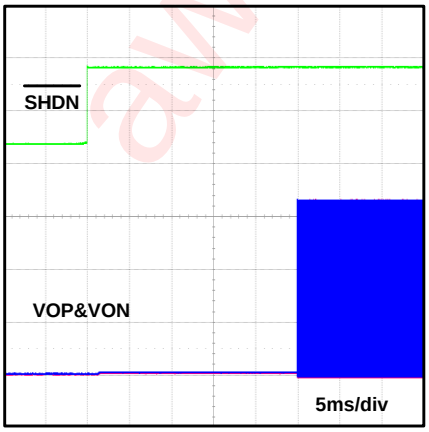
NCN ATTACK TIME



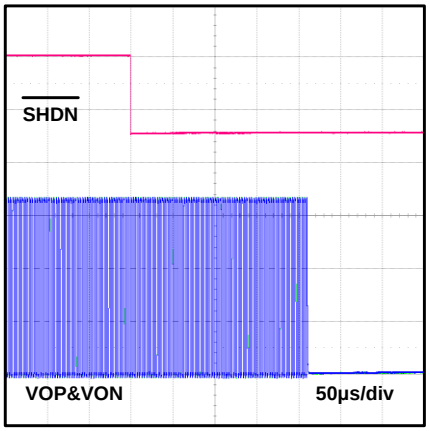
NCN RELEASE TIME



STARTUP TIME



SHDN TIME



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Block Diagram

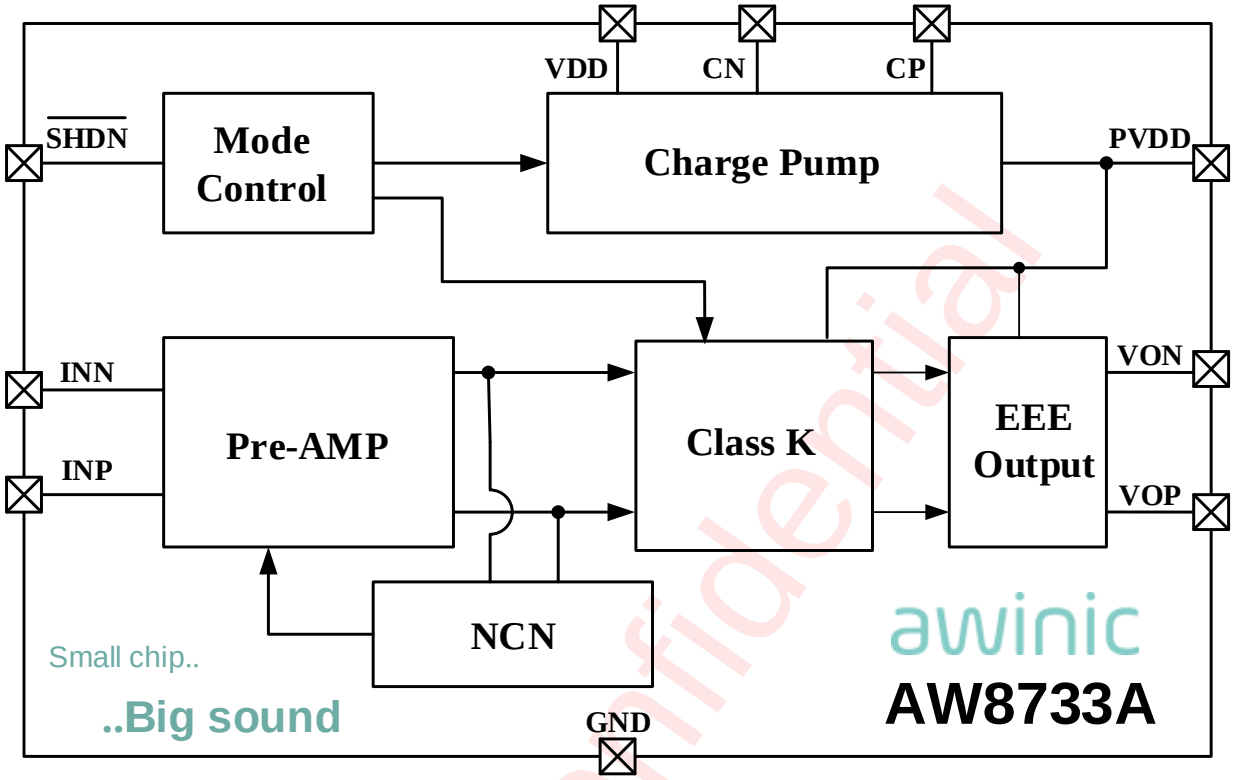

Figure 5 Functional Block Diagram of AW8733A

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Operation

The AW8733A is a powerful Class-K audio amplifier that features RNS (RF-TDD Noise Suppression), NCN (Non-Crack-Noise) and EEE (Enhanced Emission Elimination).

The AW8733A features the RNS function which greatly reduces RF-TDD Noise.

The AW8733A features a built-in charge pump converter generates a 6.3V supply voltage. This provides a louder audio output than a stand-alone amplifier directly connected to the battery. The AW8733A features 2W output power (10% THD+N) into 8Ω load at 4.2V battery voltage.

The AW8733A features the NCN function, which adjusts the system gain automatically while detecting the “Crack” distortion of output signal, protects the speaker from damage at high power levels and brings the most comfortable listening experience to the customers.

The AW8733A is available in a small 3mm×3mm 20-Pin TQFN Package. It is specified over the extended -40℃ to +85℃ temperature range.

One-wire pulse control

AW8733A select each mode by one-wire pulse control, as shown in figure 6. When $\overline{SHDN}$ pin pull high form shutdown mode, there is one rising edge, AW8733A start to work and set Gain=12dB. When high-low-high signal set to $\overline{SHDN}$ pin, there are two rising edges, AW8733A open NCN function and set Gain=16dB. When there are three rising edges, AW8733A close NCN function and set Gain=24dB. When there are four rising edges, AW8733A open NCN function and set Gain=27.5dB.

As shown in figure 6, when $\overline{SHDN}$ pull down above 500us, AW8733A will enter shutdown mode.

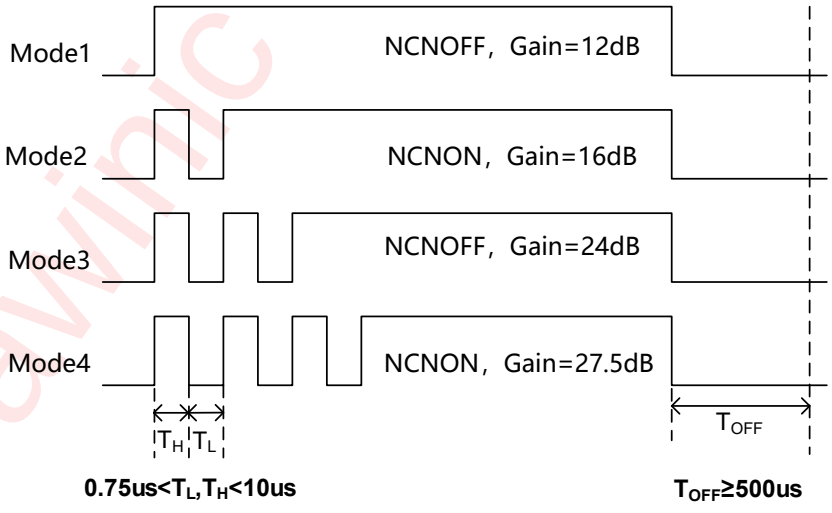

Figure 6 One-Wire pulse control

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RNS (RF TDD Noise Suppression)

GSM radios transmit using time-division multiple access with 217Hz intervals. The result is an RF signal with strong amplitude modulation at 217Hz and its harmonics that is easily demodulated by audio amplifiers.

In RF applications, improvements to both layout and component selection decrease the AW8733A's susceptibility to RF noise and prevent RF signals from being demodulated into audible noise. Minimizing the trace lengths prevents them from functioning as antennas and coupling RF signals into the AW8733A. Additional RF immunity can also be obtained from relying on the self-resonant frequency of capacitors as it exhibits the frequency response similar to a notch filter. Depending on the manufacturer, 10pF to 20pF capacitors typically exhibit self resonance at RF frequencies. These capacitors, when placed at the input pins, can effectively shunt the RF noise at the inputs of the AW8733A. For these capacitors to be effective, they must have a low-impedance, low-inductance path to the ground plane.

Some RF energy will couple onto audio traces regardless of the effort to prevent this phenomenon from occurring, form audible TDD Noise。The AW8733A features a unique RNS technology, which effectively reduces RF energy, attenuates the RF TDD-noise, an acceptable audible level to the customer.

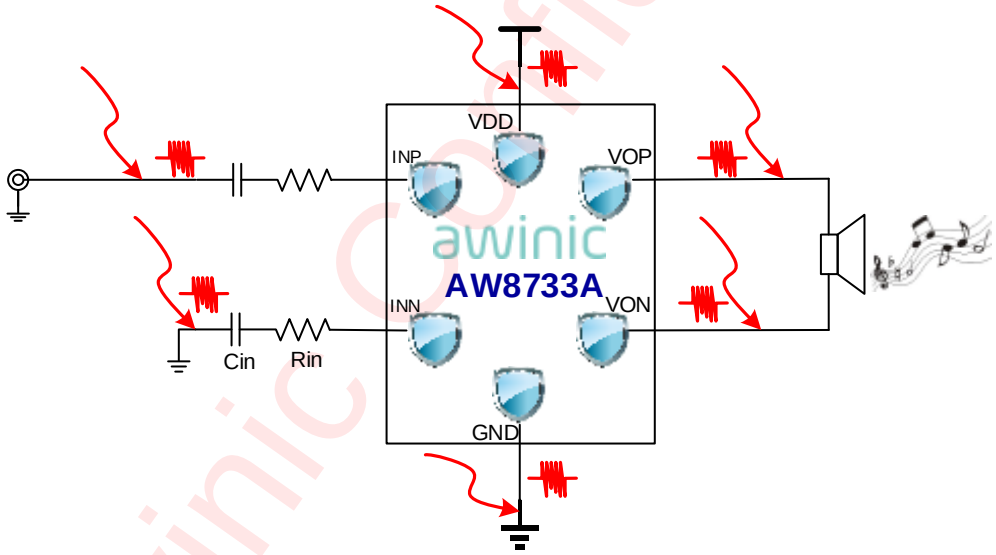

Figure 7 RF Energy Coupling Diagram

NCN

In audio application, output signal will be undesirable distortion caused by too large input and power supply voltage down with battery, and clipped output signal may cause permanent damage to the speaker. The AW8733A features unique non-crack-noise (NCN) Function, which adjusts system gain automatically to generate desired output by detecting the "Crack" distortion of output signal, protects the speaker from damage at high power levels and brings the most comfortable listening experience to the customers.

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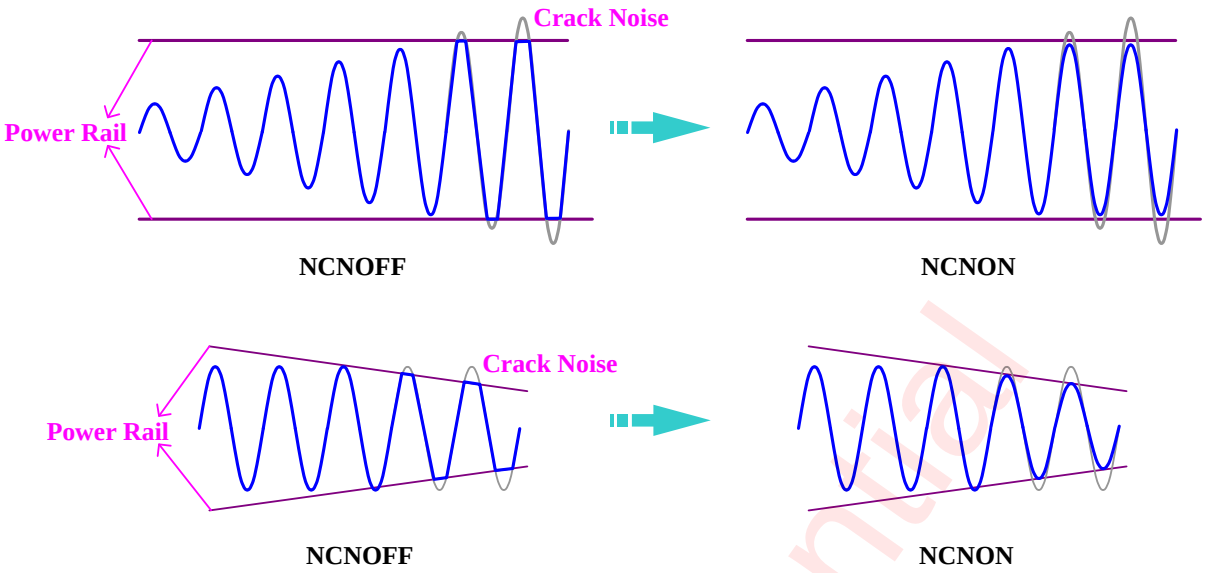

Figure 8 NCN Function Diagram

Attack time

Attack time is the time it takes for the gain to be reduced by 6dB once the audio signal exceeds the NCN threshold. Fast attack times allow the NCN to react quickly and prevent transients such as symbol crashes from being distorted. However, fast attack times can lead to volume pumping, where the gain reduction and release becomes noticeable, as the NCN cycles quickly. Slower attack times cause the NCN to ignore the fast transients, and instead act upon longer, louder passages. Selecting an attack time that is too slow can lead to increased distortion in the case of the No Clip function. Attack time is set 40ms in AW8733A.

Release time

Release time is the time it takes for the gain to return from 6dB to its normal level once the audio signal returns below the NCN threshold. A fast release time allows the NCN to react quickly to transients, preserving the original dynamics of the audio source. However, similar to a fast attack time, a fast release time contributes to volume pumping. A slow release time reduces the effect of volume pumping. Release time is set 1.2s in AW8733A.

Filter-Free Modulation Scheme

The AW8733A features a filter-free PWM architecture that reduces the LC filter of the traditional Class-D amplifier, increasing efficiency, reducing board area consumption and system cost.

EEE

The AW8733A features a unique Enhanced Emission Elimination (EEE) technology, that controls fast transition on the output, greatly reduces EMI over the full bandwidth.

Pop-Click Suppression

The AW8733A features unique timing control circuit, that comprehensively suppresses pop-click noise, eliminates audible transients on shutdown, wakeup, and power-up/down.

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Protection Function

When a short-circuit occurs between VOP/VON pin and VDD/GND or VOP and VON, the over-current circuit shutdown the device, preventing the device from being damaged. When the condition is removed, the AW8733A reactivate itself. When the junction temperature is high, the over-temperature circuit shutdown the device. The circuit switches back to normal operation when the temperature decreases to safe levels.

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Applications Information

External Input Resistor-R_{ine}（Gain setting）

The AW8733A is a differential audio amplifier. The IC integrates two internal input resistors, which 30kΩ in mode1 and mode2, 5kΩ in mode3 and mode4. Take external input resistor R_{ine}=10kΩ for an example, gain setting as follows：

Mode1： $$A_V = \frac{160k\Omega}{R_{ine}+R_{ini}} = \frac{160k\Omega}{10k\Omega+30k\Omega} = 4V/V$$

Mode2： $$A_V = \frac{240k\Omega}{R_{ine}+R_{ini}} = \frac{240k\Omega}{10k\Omega+30k\Omega} = 6V/V$$

Mode3： $$A_V = \frac{240k\Omega}{R_{ine}+R_{ini}} = \frac{240k\Omega}{10k\Omega+5k\Omega} = 16V/V$$

Mode4： $$A_V = \frac{360k\Omega}{R_{ine}+R_{ini}} = \frac{360k\Omega}{10k\Omega+5k\Omega} = 24V/V$$

Input Capacitor-C_{in}（input high-pass cutoff frequency）

The input coupling capacitor blocks the DC voltage at the amplifier input terminal. The input capacitors and input resistors form a high-pass filter with the corner frequency:

$$f_H(-3dB) = \frac{1}{2*\pi*R_{intotal}*C_{in}}(Hz)$$

Setting the high-pass filter point high can block the 217Hz GSM noise coupled to inputs. Better matching of the input capacitors improves performance of the circuit and also helps to suppress pop-click noise.

Take typical application in Figure 2 as an example:

Mode1，Mode2：

$$f_H(-3dB) = \frac{1}{2*\pi*R_{intotal}*C_{in}}(Hz) = \frac{1}{2*\pi*40k\Omega*22nF}(Hz) = 182Hz$$

Mode3，Mode4：

$$f_H(-3dB) = \frac{1}{2*\pi*R_{intotal}*C_{in}}(Hz) = \frac{1}{2*\pi*15k\Omega*22nF}(Hz) = 485Hz$$

Supply Decoupling Capacitor（C_S）

The AW8733A is a high-performance audio amplifier that requires adequate power supply decoupling. Place a low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1μF. 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 AW8733A is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss. In addition to the

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0.1μF ceramic capacitor, place a 4.7μF capacitor on the VBAT supply trace. This larger capacitor acts as a charge reservoir, providing energy faster than the board supply, thus helping to prevent any droop in the supply voltage.

Flying Capacitor（C_F）

The value of the flying capacitor (C_F) affects the load regulation and output resistance of the charge pump. A C_F value that is too small degrades the device's ability to provide sufficient current drive. Increasing the value of C_F improves load regulation and reduces the charge pump output resistance to an extent. A 4.7μF capacitor is recommended.

Hold Capacitor（C_H）

The output capacitor value and ESR directly affect the ripple at PVDD. Increasing C_H reduces output ripple. Likewise, decreasing the ESR of C_H reduces both ripple and output resistance. A 4.7μF@10V capacitor is recommended.

Optional Ferrite Bead Filter

The AW8733A passed FCC and CE radiated emissions with no ferrite chip beads and capacitors. Use ferrite chip beads and capacitors if device near the EMI sensitive circuits and/or there are long leads from amplifier to speaker, placed as close as possible to the output pin.

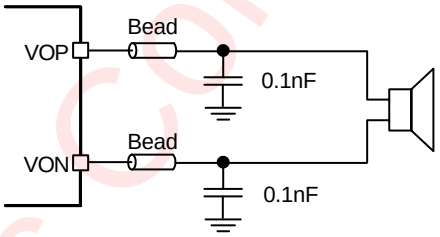

Figure 9 Ferrite Chip Bead and capacitor

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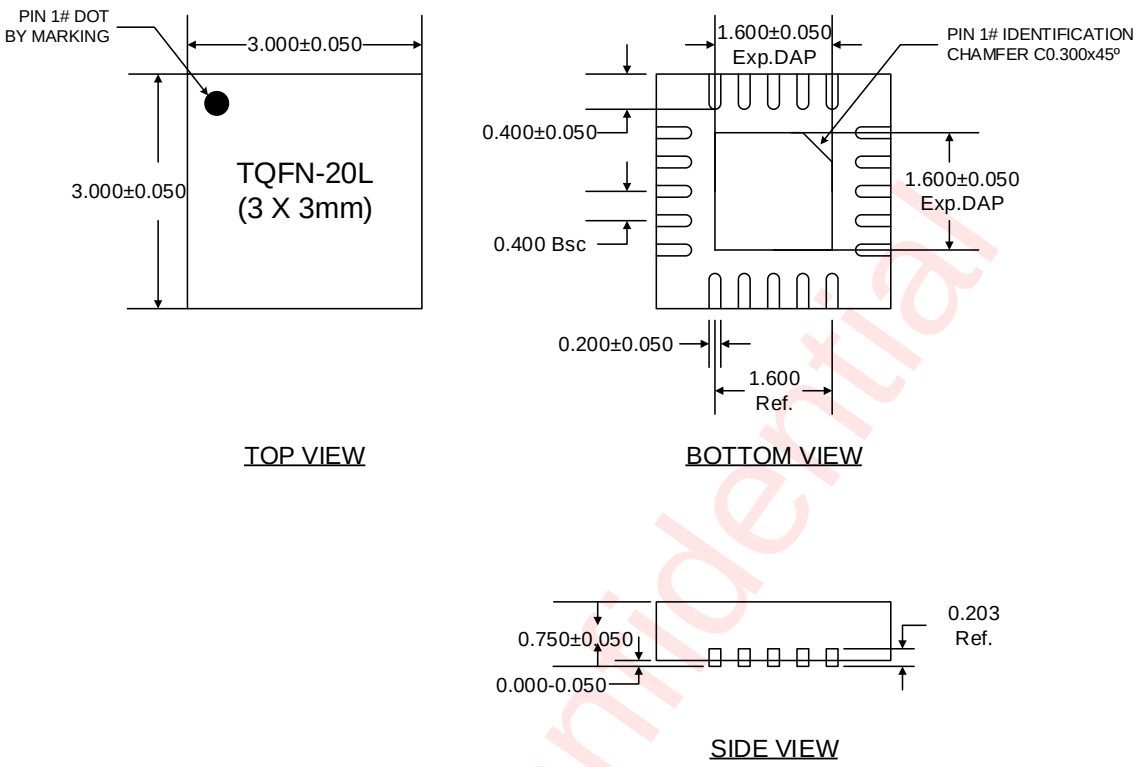
Package Description



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VERSION INFORMATION

Version	Date	Description
V1.0	2012-06	AW8737A datasheet V1.0
V1.1	2020-04-24	1. Update both C_S and C_H; and change it from 10uF to 4.7uF 2. Update the PSRR value and the relative expression 3. Update the PSRR characteristics curve 4. Change the capacitance from 1nF to 0.1nF in Figure 9

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