Ultra-Low-EMI, RNS, Mono, Filter-Free, Class-D Audio Amplifier

FEATURES

- EEE Function, Greatly reduces EMI over the full bandwidth
- Excellent Pop-Click Supression
- RNS (RF-TDD Noise Suppression)
- 0.1%THD+N（Pout=0.4W,VDD=4.2V）
- Filter-Free Class-D Architecture
- Up to 88% Efficiency
- High PSRR (70dB at 217Hz)
- Low Quiescent Current (3.2mA)
- Low Shutdown Current (<0.1μA)
- Power Supply Range: 2.5V~5.5V
- Over-Current Protection
- Over-Temperature Protection
- Small 1.5mm×1.5mm QFN-9 Package
- RoHS compliant, lead-free packages

APPLICATIONS

- **Cellular Phones、MP3/PMP、GPS、Digital Photo Frame**

DESCRIPTION

The AW8010A is a ultra-low-EMI, RNS, mono, filter-free, Class-D audio amplifier. Unique RNS, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

The AW8010A features the EEE(Enhanced Emission Elimination) function which greatly reduces EMI over the full bandwidth. The AW8010A achieves better than 20dB margin under FCC limits with 24 inch of cable.

The filter-free PWM architecture and internal gain setting reduces external components count, board area consumption, system cost and simplifies the design. In addition, The AW8010 offers efficiencies above 88%. The over-current, over-temperature and undervoltage protection is prepared inside of the device.

The AW8010A is available in an ultra small 1.5mm × 1.5mm QFN-9 package. The AW8010A is specified over the industrial temperature range of -40℃ to +85℃.

TYPICAL APPLICATION CIRCUIT

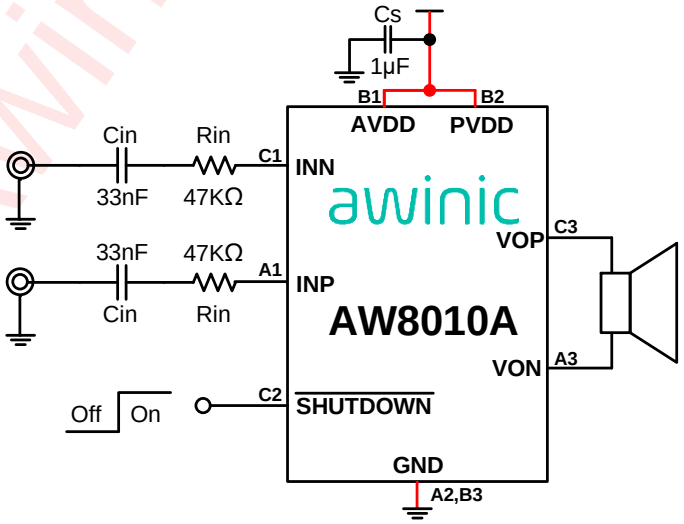
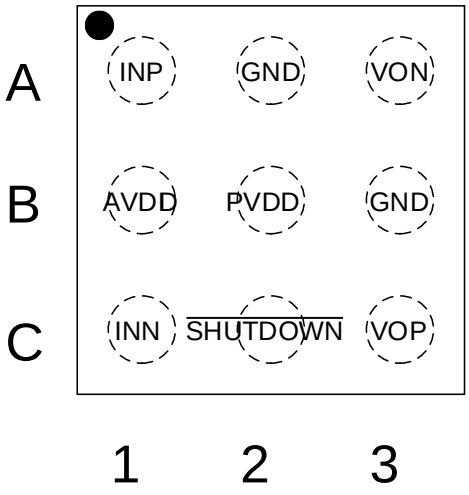


Figure 1　AW8010AQNR Typical Application Diagram

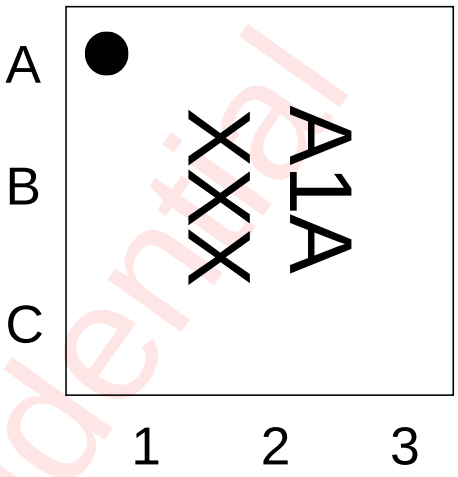
Note: Traces carry high current are marked in red in the above figure

PIN CONFIGURATION AND TOP MARK

AW8010AQNR (Top View)



AW8010AQNR Marking (Top View)



A1A— AW8010AQNR
XXX—Production Tracing Code

Figure 2 AW8010AQNR Pin configuration and Top Mark

PIN DEFINITION

No.	NAME	DESCRIPTION
A1	INP	Positive audio input
A2	GND	Ground
A3	VON	Negative audio output
B1	AVDD	Power Supply
B2	PVDD	Power Supply
B3	GND	Ground
C1	INN	Negative audio input
C2	$\overline{\text{SHUTDOWN}}$	Shutdown pin
C3	VOP	Positive audio output

FUNCTIONAL DIAGRAM

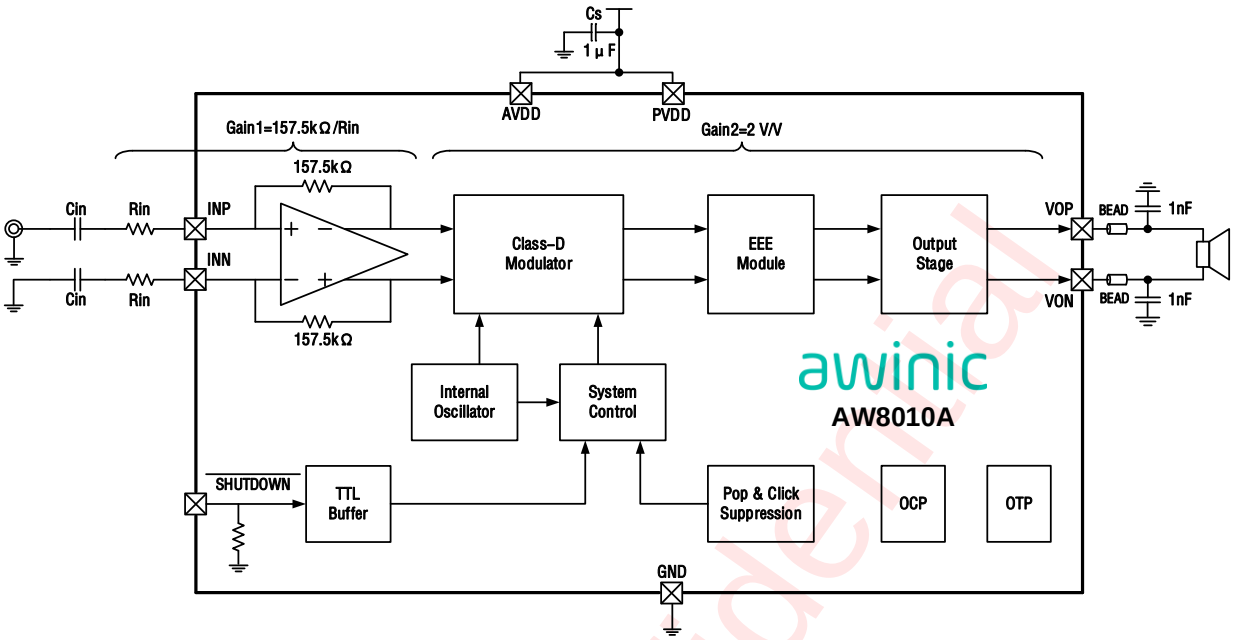


Figure 3 AW8010A Functional Diagram

Typical Application Circuits

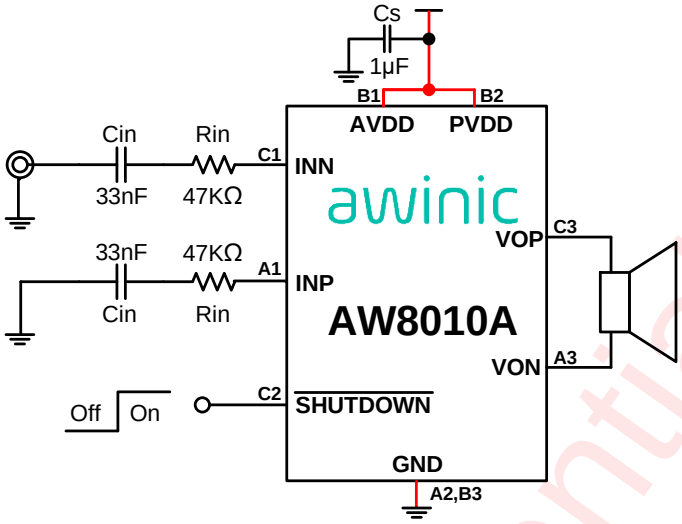


Figure 4 AW8010A Single-ended Input Mode Application Diagram(Note 1)

Note1：*When single-ended input, audio signal line from audio DAC (HPL or HPR) can arbitrarily connected to either of INN or INP input terminal. The other terminal must be connected to reference ground (HPREF) through input capacitor and resistor.*

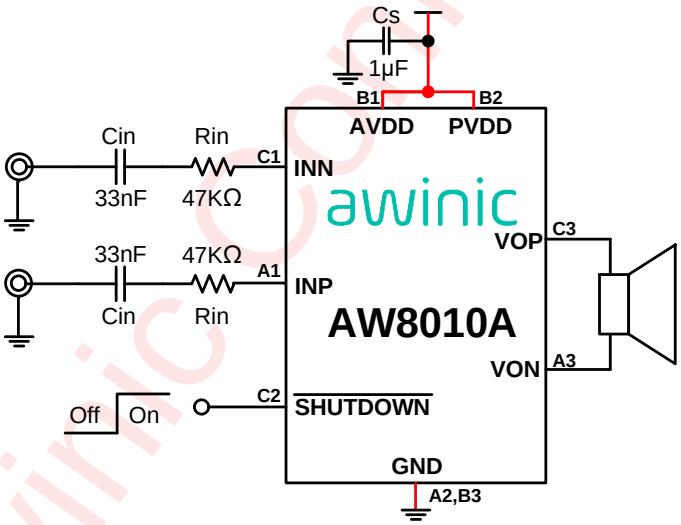


Figure 5 AW8010A Differential Inputs Mode Application Diagram

ORDERING INFORMATION

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW8010AQNR	-40°C～85°C	QFN 1.5×1.5-9L	A1A	MSL3	ROHS+HF	3000 units/ Tape and Reel

ABSOLUTE MAXIMUM RATINGS(NOTE 2)

Parameter	Range
Supply voltage VDD	-0.3V to 6V
Input Voltage	-0.3V to VDD+0.3V
Package Thermal Resistance θJA	90℃/W
Operating free-air temperature	-40℃ to 85℃
Maximum Junction Temperature TJMAX	125℃
Storage Temperature Range TSTG	-65℃ to 150℃
Lead Temperature (Soldering 10 Seconds)	260℃
ESD Rating (Note 3)	
HBM（human body model）	±6kV
CDM（charged-device model）	±2kV
Latch-up	
Test Condition：JESD78F.02-2023	+IT：450mA -IT：-450mA

NOTE2: Conditions out of those ranges listed in "absolute maximum ratings" may cause permanent damages to the device. In spite of the limits above, functional operation conditions of the device should within the ranges listed in "recommended operating conditions". Exposure to absolute-maximum-rated conditions for prolonged periods may affect device reliability.

NOTE3: The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. Test method: ANSI/ESDA/JEDEC JS-001-2023.

Test method of the charge device model: ANSI/ESDA/JEDEC JS-002-2022.

Electrical Characteristics

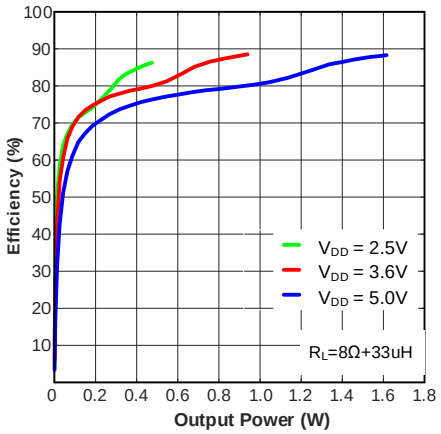
Test condition: T_A=25°C, VDD=3.6V, Cin=33nF, R_L=8Ω+33μH, f=1kHz（unless otherwise noted）

Parameter		Test conditions	Min	Typ	Max	Units
Electrical Characteristics						
V_{DD}	Power supply voltage		2.5		5.5	V
V_{IH}	High-level input voltage		1.3		V_{DD}	V
V_{IL}	Low-level input voltage		0		0.35	V
$\|V_{OS}\|$	Output offset voltage	V_{IN}=0V,A_V=2V/V,V_{DD}=2.5V to 5.5V		5	25	mV
I_Q	Quiescent current	V_{DD}=3.6V		3.2		mA
I_{SD}	Shutdown current	V_{DD}=3.6V, $\overline{SHUTDOWN}$=0V		0.1		μA
PSRR	Power supply rejection ratio	217Hz		70		dB
CMRR	Common mode rejection ratio			70		dB
f_{SW}	Switching frequency	V_{DD}=2.5V to 5.5V		800		kHz
A_V	Gain			$\frac{315k\Omega}{Rin}$		V/V
Operating Characteristics						
P_O	Output power	THD+N=10%，R_L=4Ω+33uH，V_{DD}=5V		2.56		W
		THD+N=1%，R_L=4Ω+33uH，V_{DD}=5V		2.08		W
		THD+N=10%，R_L=8Ω+33uH，V_{DD}=5V		1.61		W
		THD+N=1%，R_L=8Ω+33uH，V_{DD}=5V		1.3		W
		THD+N=10%，R_L=4Ω+33uH，V_{DD}=4.2V		1.78		W
		THD+N=1%，R_L=4Ω+33uH，V_{DD}=4.2V		1.4		W
		THD+N=10%，R_L=8Ω+33uH，V_{DD}=4.2V		1.12		W
		THD+N=1%，R_L=8Ω+33uH，V_{DD}=4.2V		0.90		W
		THD+N=10%，R_L=4Ω+33uH，V_{DD}=3.6V		1.3		W
		THD+N=1%，R_L=4Ω+33uH，V_{DD}=3.6V		1.0		W
		THD+N=10%，R_L=8Ω+33uH，V_{DD}=3.6V		0.81		W
		THD+N=1%，R_L=8Ω+33uH，V_{DD}=3.6V		0.65		W
E_N	Output noise	Gain=6V/V，20Hz to 20kHz，input ac grounded，A-weighting		80		μV
THD+N	Total harmonic distortion plus noise	V_{DD}=5V，Po=0.6W，R_L=8Ω+33uH		0.1		%
		V_{DD}=4.2V，Po=0.4W，R_L=8Ω+33uH		0.1		%
		V_{DD}=3.6V，Po=0.3W，R_L=8Ω+33uH		0.1		%
η	Efficiency	VDD=5V,Po=1W,R_L=8Ω+33uH		80		%
t_{ST}	Start-up time			40		ms

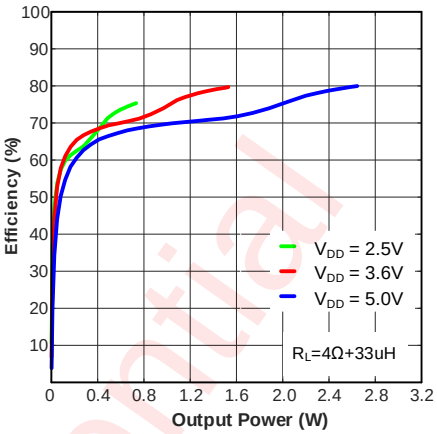
Typical Characteristics

T_A=25°C

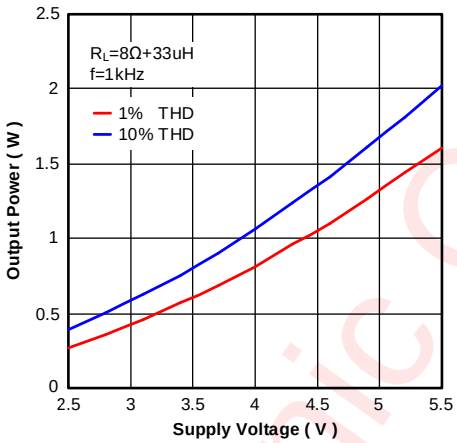
EFFICIENCY vs OUTPUT POWER



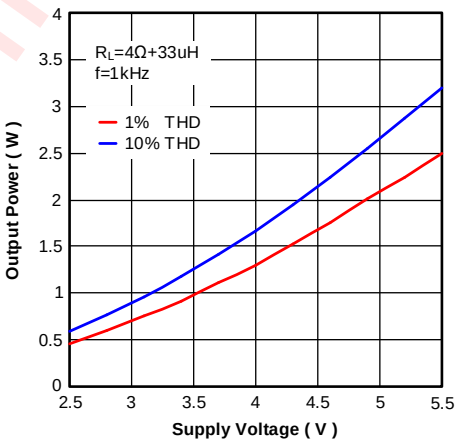
EFFICIENCY vs OUTPUT POWER



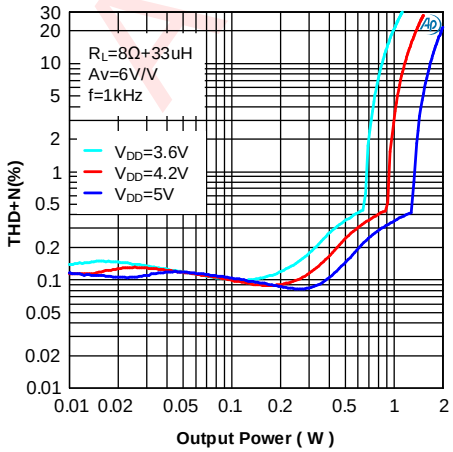
OUTPUT POWER vs SUPPLY VOLTAGE



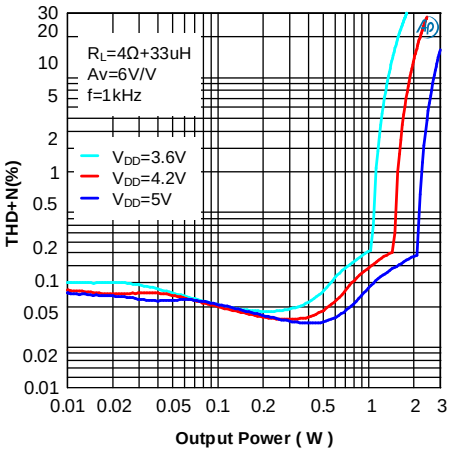
OUTPUT POWER vs SUPPLY VOLTAGE



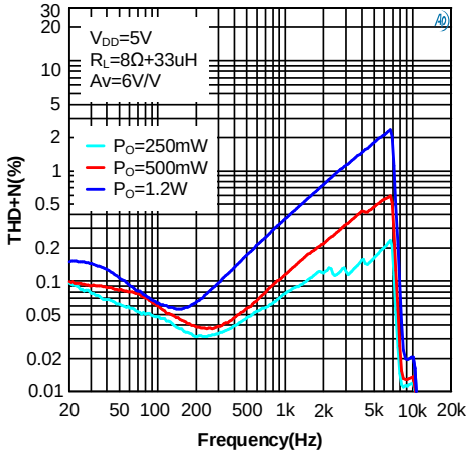
THD+N vs OUTPUT POWER



THD+N vs OUTPUT POWER



THD+N vs FREQUENCY



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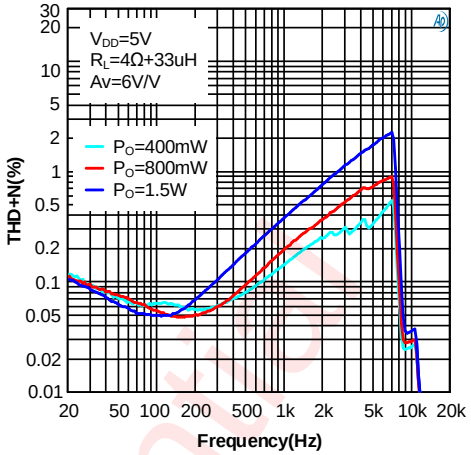

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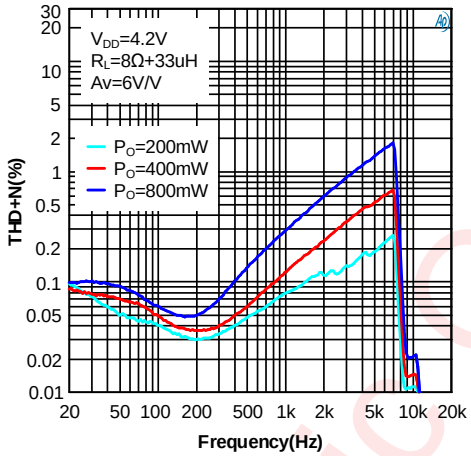
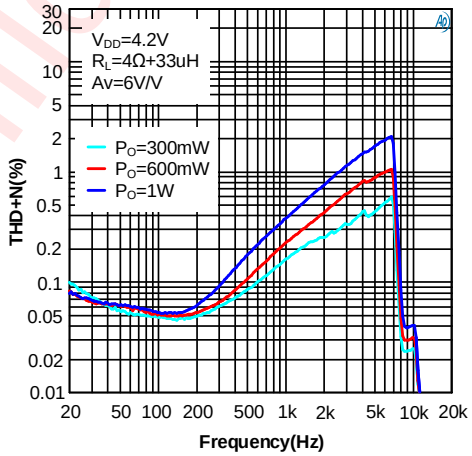
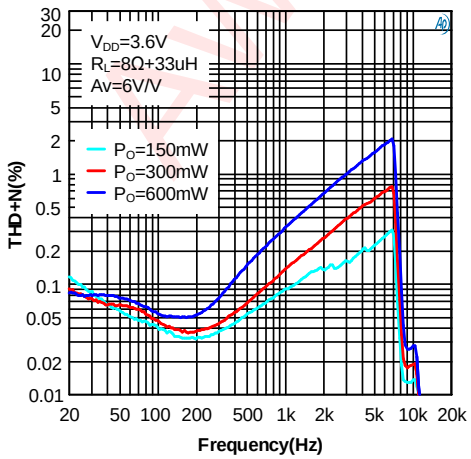


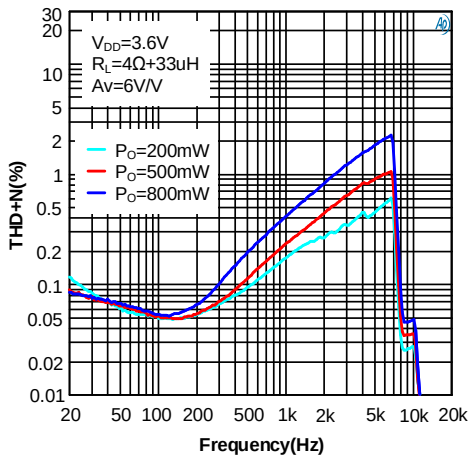
THD+N vs FREQUENCY



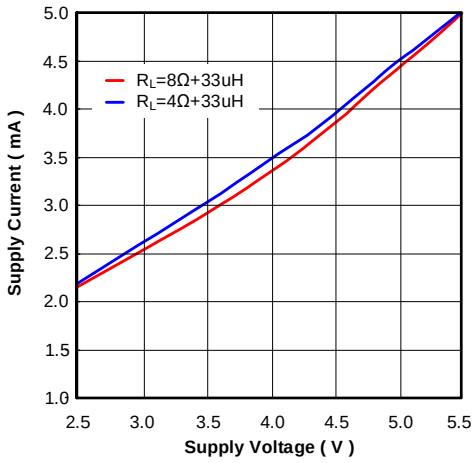
THD+N vs FREQUENCY



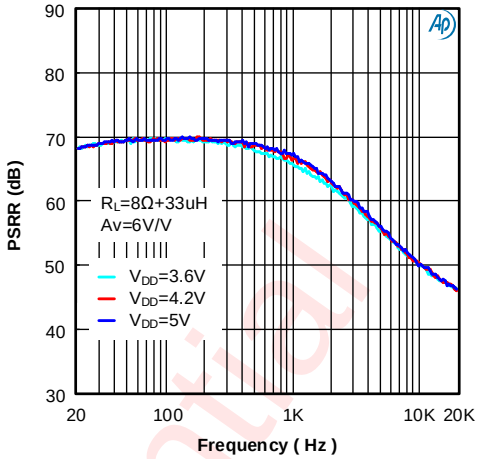
THD+N vs FREQUENCY



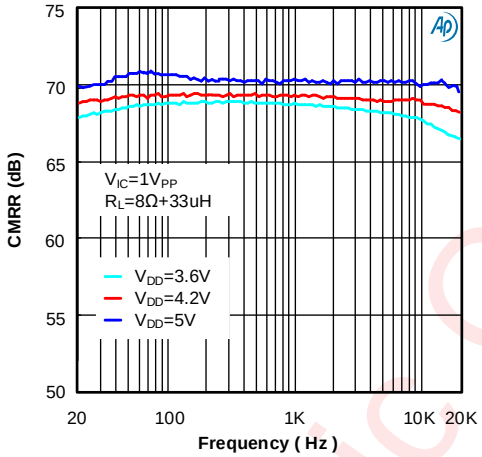
SUPPLY CURRENT vs SUPPLY VOLTAGE



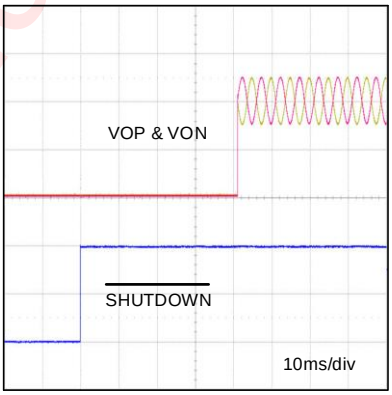
PSRR vs FREQUENCY



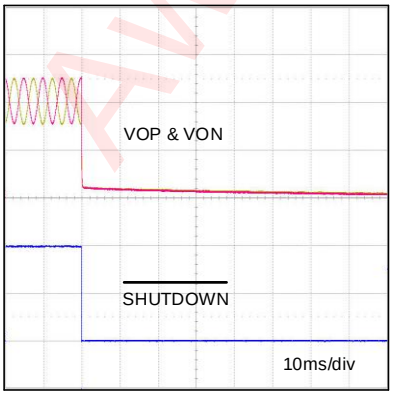
CMRR vs FREQUENCY



Start up time



Shutdown time



Operation

The AW8010A is a ultra-low-EMI,RNS, mono, filter-free, Class-D audio amplifier. Unique RNS, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

The AW8010A features the EEE (Enhanced Emission Elimination) function which greatly reduces EMI over the full bandwidth. The AW8010A achieves better than 20dB margin under FCC limits with 24 inch of cable.

The filter-free PWM architecture and internal gain setting reduces external components count, board area consumption, system cost and simplifies the design. The over-current, over-temperature and undervoltage protection is prepared inside of the device, which prevent the device from damage during fault conditions. When the fault condition is removed, the AW8010A reactivate itself again.

Filter-Free Modulation Scheme

The AW8010A 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.

Pop-Click Suppression

The AW8010A features unique timing control circuit, that comprehensively suppresses pop-click noise, eliminates audible transients on shutdown, wakeup, and power-up/down.

EEE Technology

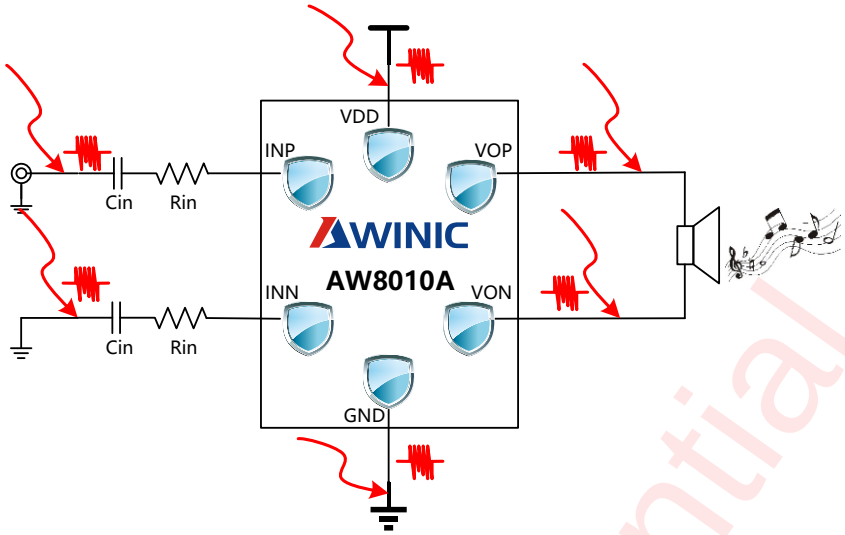
The AW8010A features a unique Enhanced Emission Elimination (EEE) technology, that controls fast transition on the output, greatly reduces EMI over the full bandwidth. The AW8010A achieves better than 20dB margin under FCC limits with 24 inch of cable, as shown in Figure 6.

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 AW8010A'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 AW8010A. 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 AW8010A. 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 AW8010A features a unique RNS technology, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.



RF Energy Coupling Diagram

Efficiency

Efficiency of a Class D amplifier is attributed to the switching operation of the output stage transistors. In a Class D amplifier, the output transistors act as current steering switches and consume negligible additional power. Any power loss associated with the Class D output stage is mostly due to the I2R loss of the MOSFET on-resistance and supply current. The AW8010A features efficiency of 88%.

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 AW8010A 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.

APPLICATIONS INFORMATION

Filter-Free Modulation Scheme

The AW8010A is a high-performance class-D audio amplifier that requires adequate power supply decoupling to ensure the efficiency is high and total harmonic distortion (THD) is low. For higher frequency transients, a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1μF, placed as close as possible to the device VDD pin works best. For filtering lower-frequency noise signals, a 10 μF or greater capacitor placed near the audio power amplifier would also help.

Input Resistors

The input resistors set the gain of the amplifier according to equation as follow.

$$Gain = \frac{2\times 157.5k\Omega}{Rin} \quad \left(\frac{V}{V}\right)$$

The resistors matching is very important. CMRR, PSRR and THD diminish if resistor mismatch occurs. Therefore, it is recommended use 1% tolerance resistors or better to keep the performance optimized. Place the input resistors very close to the AW8010A to limit noise injection on the high- impedance nodes.

Input Capacitor

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, fc.

$$f_C = \frac{1}{2\pi RinCin}.$$

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 help to suppress pop-click noise.

Ferrite Chip Bead and Capacitor

The AW8010A passed FCC and CE radiated emissions with no ferrite chip beads and capacitors with speaker trace wires 24 inch. 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.

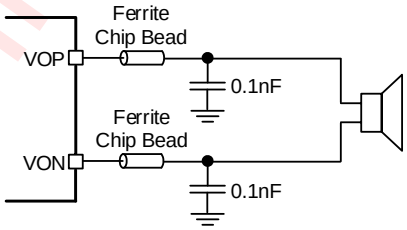
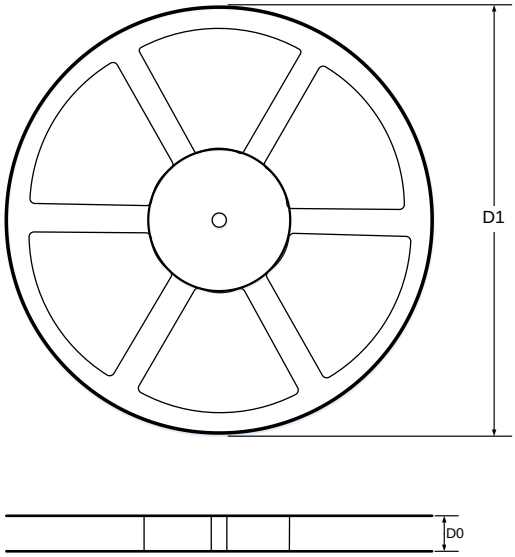


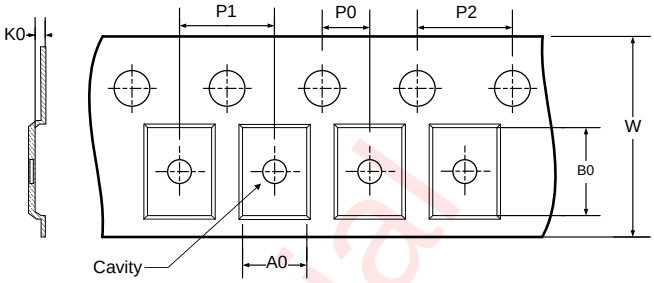
Figure 6 Ferrite Chip Bead and capacitor

TAPE AND REEL INFORMATION

REEL DIMENSIONS

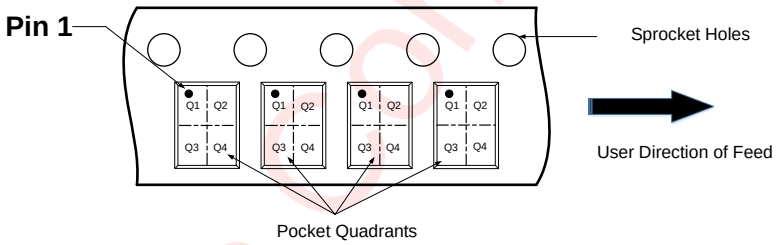


TAPE DIMENSIONS



A0：Dimension designed to accommodate the component width
B0：Dimension designed to accommodate the component length
K0：Dimension designed to accommodate the component thickness
W：Overall width of the carrier tape
P0：Pitch between successive cavity centers and sprocket hole
P1：Pitch between successive cavity centers
P2：Pitch between sprocket hole
D1：Reel Diameter
D0：Reel Width

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



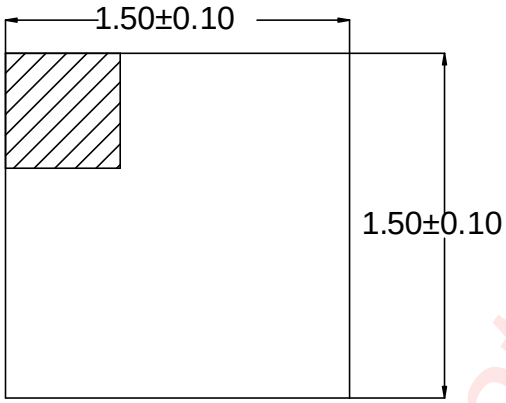
Note：The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

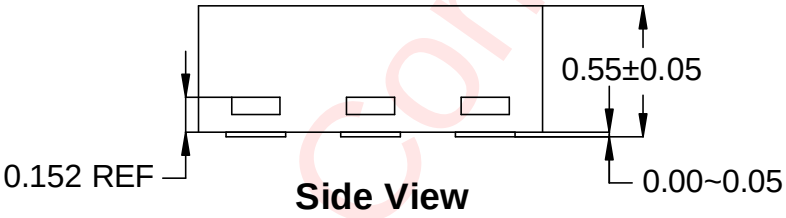
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
178.00	8.40	1.75	1.75	0.70	2.00	4.00	4.00	8.00	Q1

All dimensions are nominal

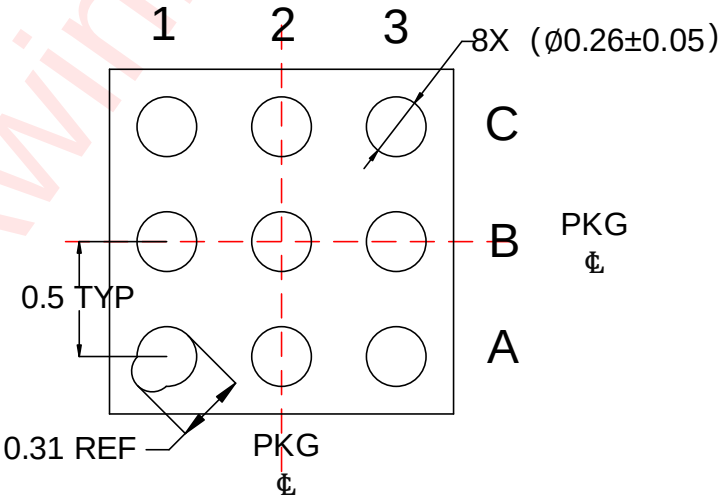
PACKAGE DESCRIPTION



Top View



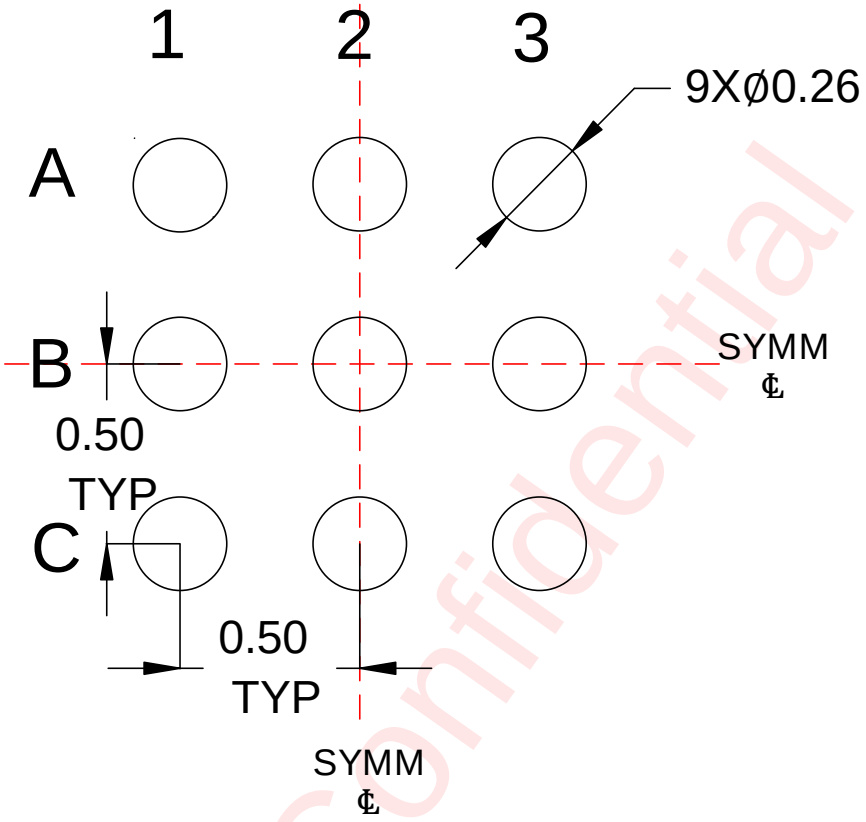
Side View

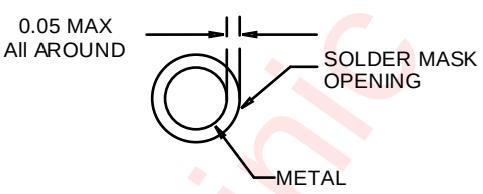


Bottom View

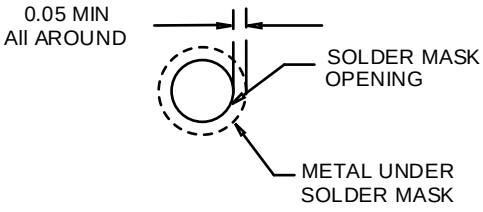
Unit: mm

LAND PATTERN DATA





NON-SOLDER MASK DEFINED



SOLDER MASK DEFINED

Unit: mm

REVISION HISTORY

Version	Date	Change Record
V1.0	Nov.2024	Officially Released

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