Non-Crack-Noise, Ultra-Low-THD+N,Ultra-Low-EMI, Second Generation Class-D Audio Amplifier

Features

- **Ultra low THD+N:0.007%**
- **AB/D operate mode**
- **Two NCN level：0.65w and0.85w**
- **Unique RNS**
- **High SNR:97dB**
- **EEE Function, Greatly reduces EMI over the full bandwidth**
- **Excellent Pop-Click Supression**
- **No VREF capacitor**
- **Pin compatible with AW8155 AW8145**
- One-pulse control
- Filter-Free Class-D Architecture
- High PSRR (-75dB at 217Hz)
- Low Shutdown Current (<0.1μA)
- Power Supply Range: 2.5V~5.5V
- Over-Current Protection
- Over-Temperature Protection
- Small 1.5mm×1.5mm FC-9 Package

Applications

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

General Description

The AW8155A is a non-crack-noise (NCN), ultra-low-EMI, filter-free, AB/D output mode selection, unique RNS and net audio technology, second generation Class-D audio amplifier. Ultra low THD+N,Unique 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 invites the user to bask in immense musical enjoyment.

AW8155A NCN output power can be set to 0.65w or 0.85w for different speakers, this feature is embedded in order to protect speakers from damage caused by an excessive sound level.

The AW8155A features a unique RNS and net audio technology, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

The AW8155A features the EEE (Enhanced Emission Elimination) function which greatly reduces EMI over the full bandwidth. The AW8155A 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 is prepared inside of the device.

The AW8155A is available in an ultra small 1.5mm×1.5mm FC-9 package. The AW8155A is specified over the industrial temperature range of -40℃ to +85℃.

Pin Configuration and Top Mark

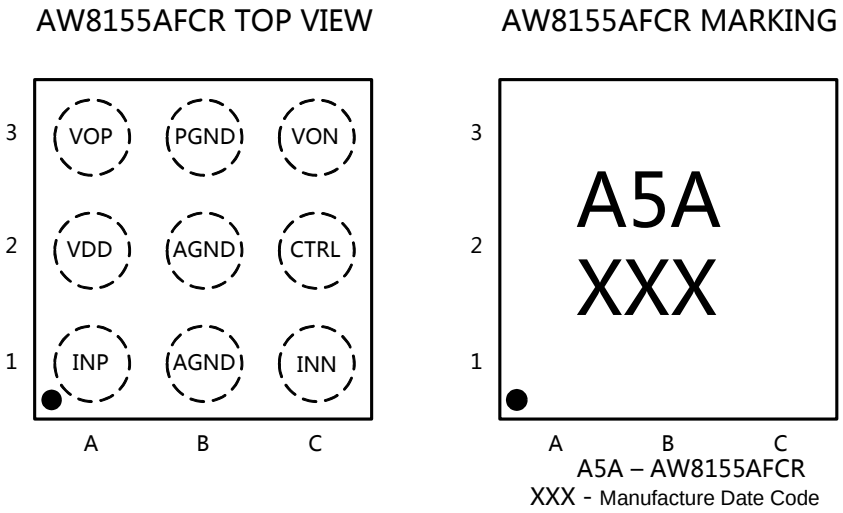


Figure 1. Pin Configuration and Top Mark of AW8155A

Pin Definition

No.	Symbol	Description
A1	INP	Positive audio input
A2	VDD	Power Supply
A3	VOP	Positive audio output
B1	AGND	Analog ground
B2	AGND	Analog ground
B3	PGND	Power ground
C1	INN	Negative audio input
C2	CTRL	Shutdown and NCN control pin
C3	VON	Negative audio output

Typical Application

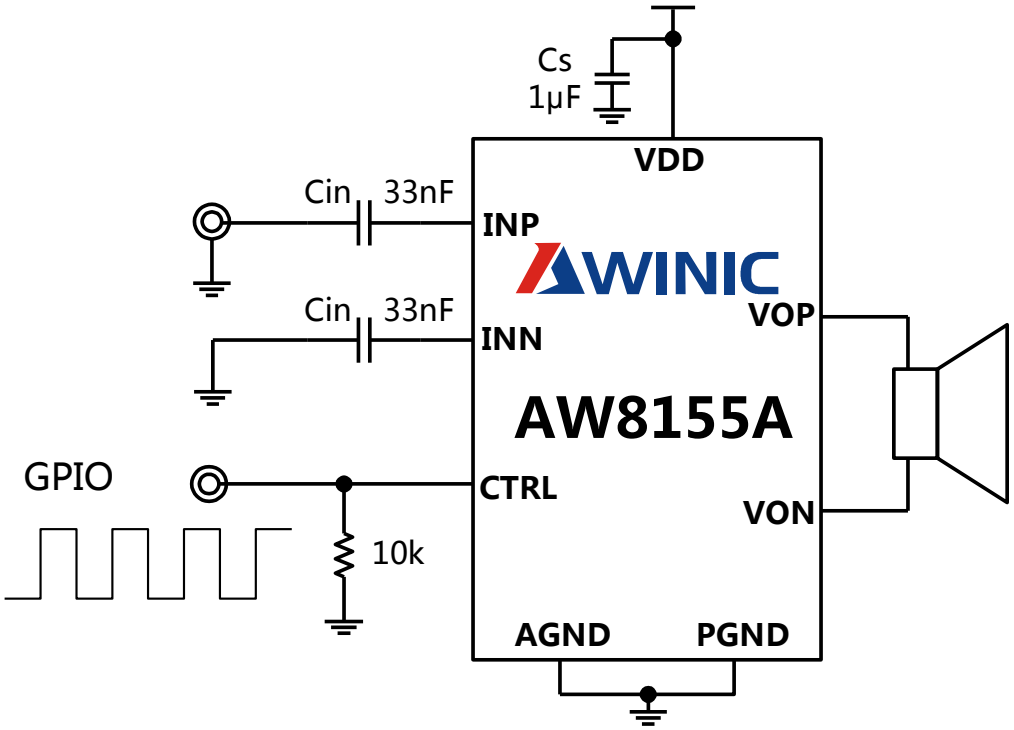


Figure 2. AW8155A Application Schematic With Single-Ended Input

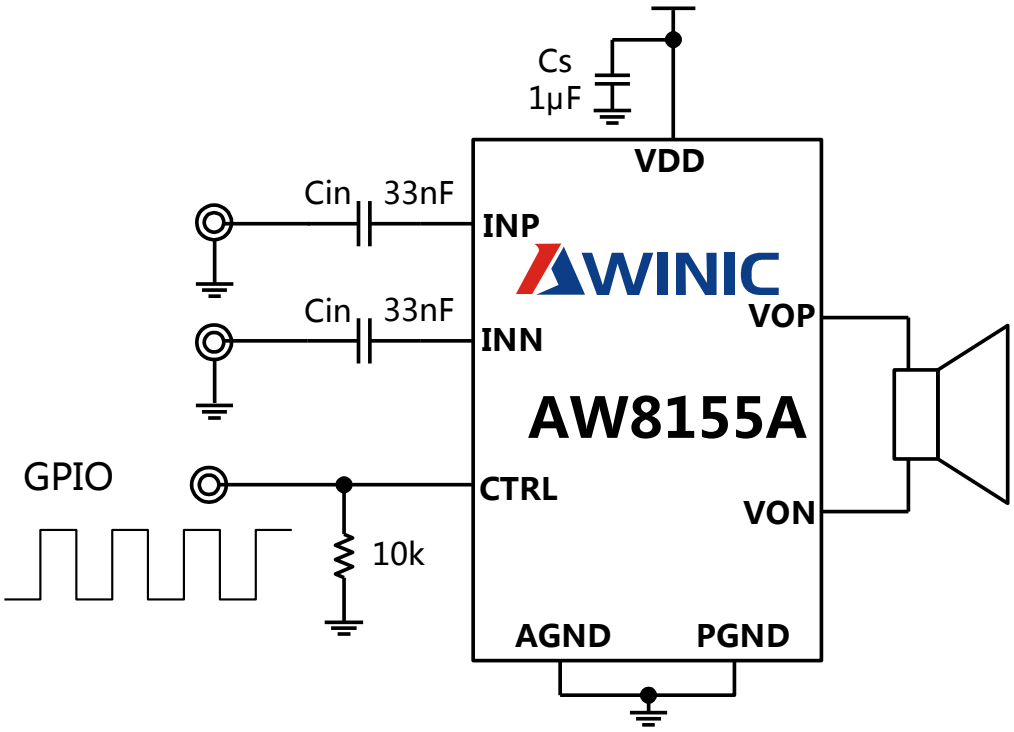
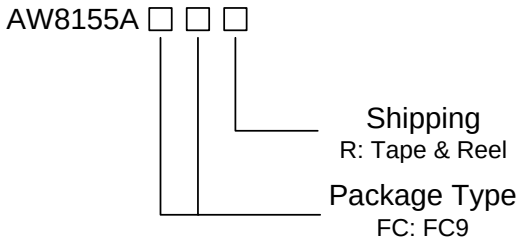


Figure 3. AW8155A Application Schematic With Differential Input

Ordering Information

Part Number	Temperature	Package	Marking	Packing Type
AW8155AFCR	-40℃～85℃	FC9	A5A	3000 units/Tape and Reel



Absolute Maximum Ratings(1)

Parameter	Unit
Supply voltage V_{DD}	-0.3V to 6V
Input Voltage	-0.3V to V_{DD}+0.3V
Package Thermal Resistance θ_{JA}	90℃/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)	±6KV
Latch-up	
Test Condition :JEDEC STANDARD NO.78B DECEMBER 2008	+IT:400mA -IT:-400mA

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-883G Method 3015.7.

Operate mode description（T_A=25℃,VDD=4.2V,RL=8Ω +33uH）

mode	CTRL	operating	AV （V/V）	NCN power （W）	RNS	Net audio
mode1		Class_D	8	0.65	√	
mode 2		Class_D	12	0.85	√	
mode 3		Class_D	12	0.85	√	√
mode 4		Class_AB	12			

Electrical Characteristics

Test Condition: V_{DD}=3.6V ,T_A=25℃, R_L=8Ω+33uH，Cin=33nF，f=1kHz (Unless otherwise specified)

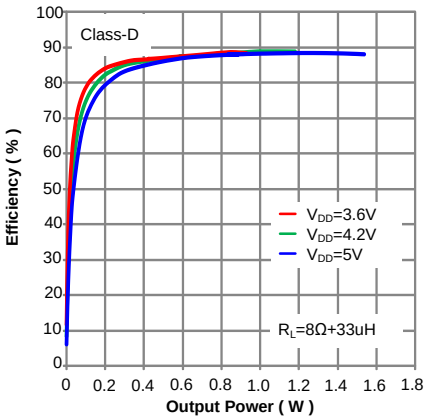
Parameter		Conditions		Min	Typ	Max	Units
V_{DD}	Power supply voltage			2.5		5.5	V
V_{IH}	CTRL high input voltage			1.3		V_{DD}	V
V_{IL}	CTRL low input voltage			0		0.35	V
$\|V_{OS}\|$	Output offset voltage	Input AC grounded，V_{DD}=2.5V to 5.5V		-40	0	40	mV
I_{SD}	Shutdown current	V_{DD}=3.6V，CTRL =0V			0.1	1	μA
f_{SW}	Modulation Frequency	V_{DD}=2.5V to 5.5V		600	800	1000	kHz
T_{SD}	Thermal Protect level				160		℃
T_{SDR}	Thermal Hysteresis				120		℃
T_{ON}	Start-up time				40		ms
Rini	Internal impedance				28.5		kΩ
P_O	Output power	THD+N=10%， R_L=4Ω+33uH，V_{DD}=5V			2.65		W
		THD+N=1%，R_L=4Ω+33uH，V_{DD}=5V			2.19		W
		THD+N=10%， R_L=8Ω+33uH，V_{DD}=5V			1.52		W
		THD+N=1%， R_L=8Ω+33uH，V_{DD}=5V			1.18		W
		THD+N=10%， R_L=4Ω+33uH，V_{DD}=4.2V			1.95		W
		THD+N=1%， R_L=4Ω+33uH，V_{DD}=4.2V			1.60		W
		THD+N=10%， R_L=8Ω+33uH，V_{DD}=4.2V			1.15		W
		THD+N=1%， R_L=8Ω+33uH，V_{DD}=4.2V			0.96		W
		THD+N=10%， R_L=4Ω+33uH，V_{DD}=3.6V			1.39		W
		THD+N=1%， R_L=4Ω+33uH，V_{DD}=3.6V			1.14		W
		THD+N=10%， R_L=8Ω+33uH，V_{DD}=3.6V			0.85		W
		THD+N=1%， R_L=8Ω+33uH，V_{DD}=3.6V			0.70		W
Mode 1							
I_q	Quiescent current	V_{DD}=3.6V，Input AC grounded, no load			3.0		mA
η	Efficiency	V_{DD}=3.6V，Po=0.8W，R_L=8Ω+33uH			87		%
Av	Voltage gain			7	8	9	V/V
PSRR	Power suppression ration	V_{DD}=4.2V，Vp-p_sin=200mV	217Hz	-55	-75		dB
			1kHz	-55	-72		dB
THD+N	Total harmonic distortion plus noise	V_{DD}=4.2V，Po=0.5W，R_L=8Ω+33uH			0.008		%
		V_{DD}=3.6V，Po=0.25W，R_L=8Ω+33uH			0.007		%
P_O NCN	NCN output power	f=1kHz，R_L=8Ω+33uH，V_{DD}=4.2V			0.65		W
T_{AT}	Attack time(-11dB)	V_{DD}=4.2V			45		ms
T_{RL}	Release time(11dB)	V_{DD}=4.2V			1		s
A_{MAX}	Max attenuation	V_{DD}=4.2V			-11		dB
Vn	Output noise	f=20Hz-20kHz,input AC grounded			57		uV

SNR	Signal-to-noise ratio	V_{DD} = 5 V, P_O = 1 W, R_L = 8Ω+33uH			97		dB
Mode 2							
I_q	Quiescent current	V_{DD}=3.6V，Input AC grounded, no load			3.0		mA
η	Efficiency	V_{DD}=3.6V，Po=0.8W，R_L=8Ω+33uH			87		%
Av	Voltage gain			11	12	13	V/V
PSRR	Power suppression ration	V_{DD}=4.2V，Vp-p_sin=200mV	217Hz		-75		dB
			1kHz		-72		dB
THD+N	Total harmonic distortion plus noise	V_{DD}=4.2V，Po=0.5W，R_L=8Ω+33uH			0.008		%
		V_{DD}=3.6V，Po=0.25W，R_L=8Ω+33uH			0.007		%
P_O NCN	NCN output power	V_{DD}=4.2V , R_L=8Ω+33uH，f=1kHz			0.85		W
T_{AT}	Attack time(-13.5dB)	V_{DD}=4.2V			50		ms
T_{RL}	Release time(13.5dB)	V_{DD}=4.2V			1.2		s
A_{MAX}	Max attenuation	V_{DD}=4.2V			-13.5		dB
Vn	Output noise	f=20Hz-20kHz,input AC grounded			80		uV
SNR	Signal-to-noise ratio	V_{DD} = 5 V, P_O = 1 W, R_L = 8Ω+33uH			94		dB
Mode 3							
I_q	Quiescent current	V_{DD}=3.6V，Input AC grounded, no load			3		mA
η	Efficiency	V_{DD}=3.6V，Po=0.8W，R_L=8Ω+33uH			87		%
Av	Voltage gain			11	12	13	V/V
PSRR	Power suppression ration	V_{DD}=4.2V，Vp-p_sin=200mV，	217Hz	-60	-85		dB
			1kHz	-60	-80		dB
THD+N	Total harmonic distortion plus noise	V_{DD}=4.2V，Po=0.5W，R_L=8Ω+33uH			0.008		%
		V_{DD}=4.2V，Po=0.25W，R_L=8Ω+33uH			0.007		%
P_O NCN	NCN output power	V_{DD}=4.2V，f=1kHz，R_L=8Ω+33uH，			0.85		W
T_{AT}	Attack time(-13.5dB)	V_{DD}=4.2V			50		ms
T_{RL}	Release time(13.5dB)	V_{DD}=4.2V			1.2		s
A_{MAX}	Max attenuation	V_{DD}=4.2V			-13.5		dB
V_{LIMIT}	Net audio Vth(Vp)	V_{DD}=4.2V			15		mVp
A_{MAX1}	Net audio max attenuation	V_{DD}=4.2V			-16		dB
Vn	Output noise	f=20Hz-20kHz,input AC grounded			20		uV
SNR	Signal-to-noise ratio	V_{DD} = 5 V, P_O = 1 W, R_L = 8 Ω+33uH			106		dB
Mode 4							
I_q	Quiescent current	V_{DD}=3.6V，Input AC grounded, no load			3.5		mA
η	Efficiency	V_{DD}=3.6V，Po=0.8W，R_L=8Ω+33uH			77		%
Av	Voltage gain			11	12	13	V/V
PSRR	Power suppression ratio	V_{DD}=4.2V，Vp-p_sin=200mV，	217Hz	-55	-70		dB
			1kHz	-55	-68		dB
THD+N	Total harmonic distortion plus noise	V_{DD}=4.2V，Po=0.5W，R_L=8Ω+33uH			0.2		%
		V_{DD}=4.2V，Po=0.25W，R_L=8Ω+33uH			0.2		%
Vn	Output noise	f=20Hz-20kHz,input AC grounded			100		uV

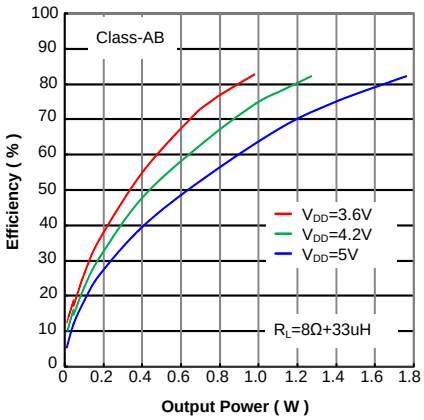
SNR	Signal-to-noise ratio	V_{DD} = 5 V, P_O = 1 W, R_L = 8 Ω+33uH		92		dB
one-wire pulse control						
T_H	CTRL high level hold time	V_{DD}=2.5V to 5.5V	0.75	2	10	us
T_L	CTRL low level hold time	V_{DD}=2.5V to 5.5V	0.75	2	10	us
T_{LATCH}	CTRL turn on delay time	V_{DD}=2.5V to 5.5V			500	us
T_{OFF}	CTRL turn off delay time	V_{DD}=2.5V to 5.5V			500	us

Typical Operating Characteristic

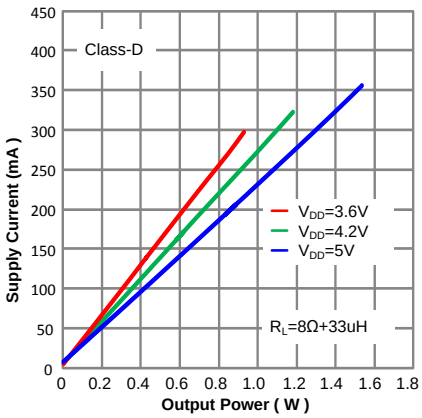
EFFICIENCY vs OUTPUT POWER



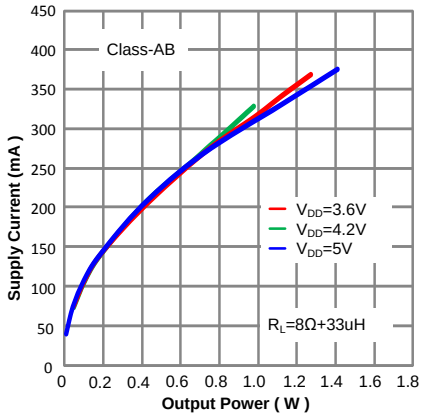
EFFICIENCY vs OUTPUT POWER



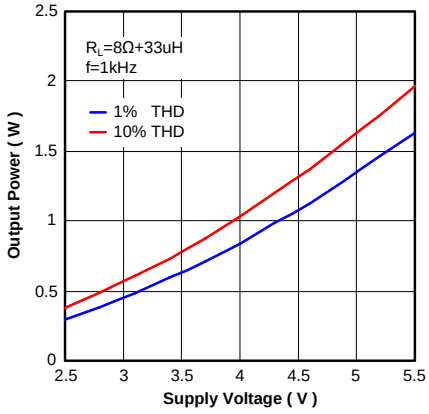
SUPPLY CURRENT VS OUTPUT POWER



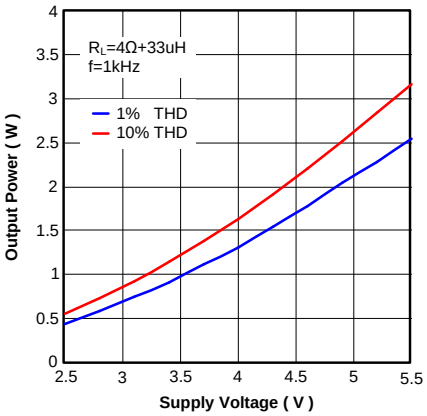
SUPPLY CURRENT VS OUTPUT POWER



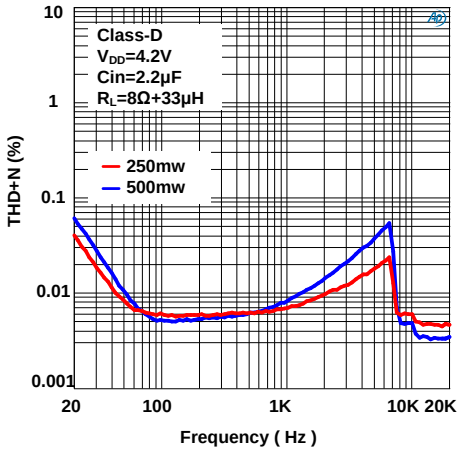
OUTPUT POWER vs SUPPLY VOLTAGE



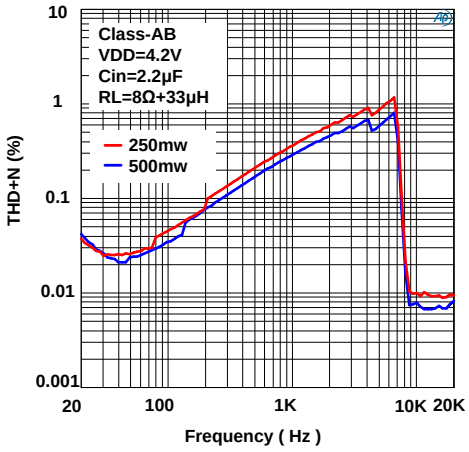
OUTPUT POWER vs SUPPLY VOLTAGE



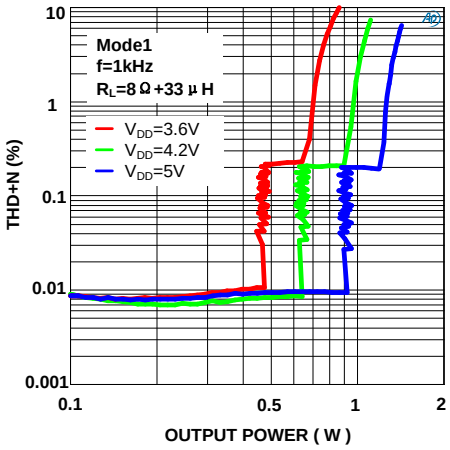
THD+N vs Frequency



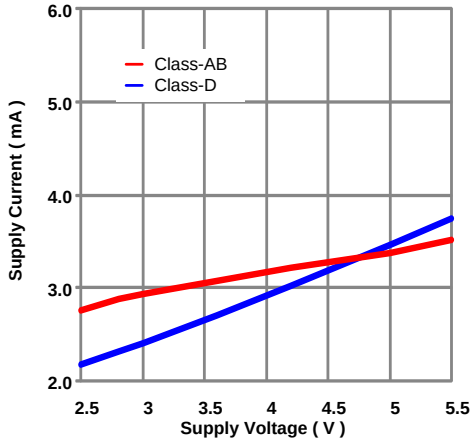
THD+N vs Frequency



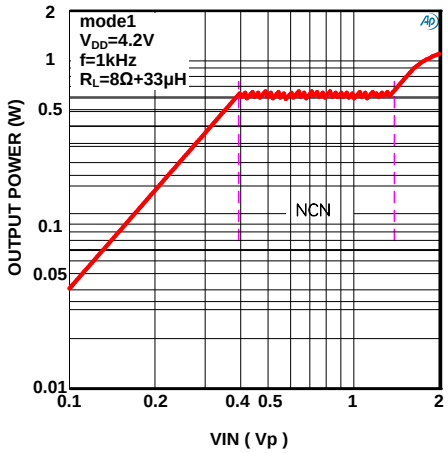
THD+N vs OUTPUT POWER



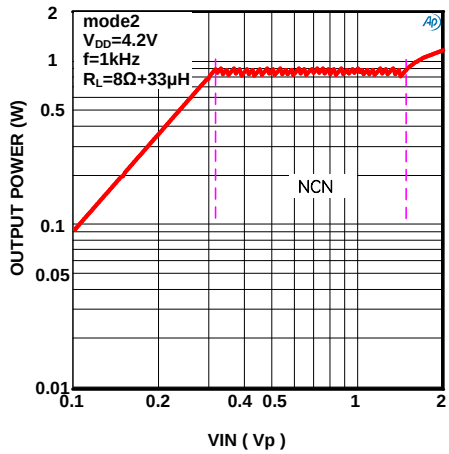
SUPPLY CURRENT vs SUPPLY VOLTAGE

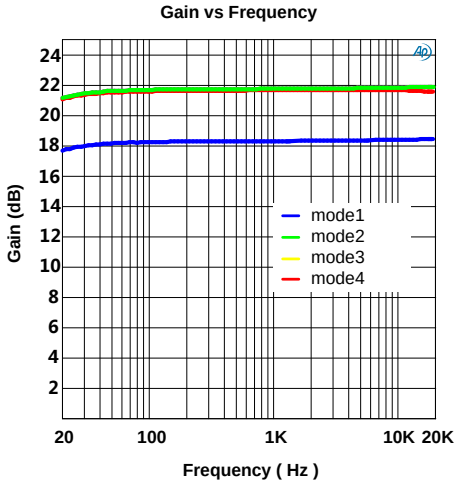


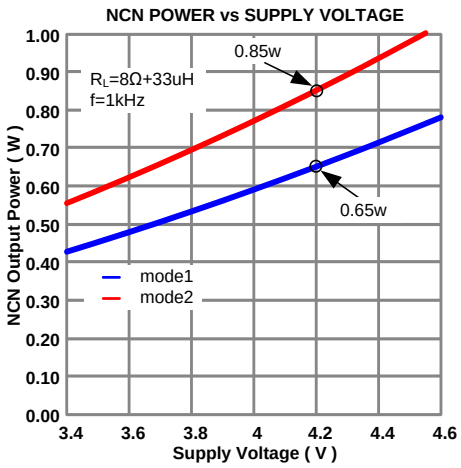
OUTPUT POWER vs VIN

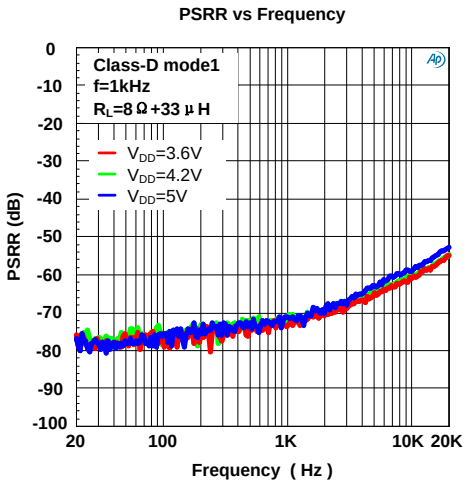


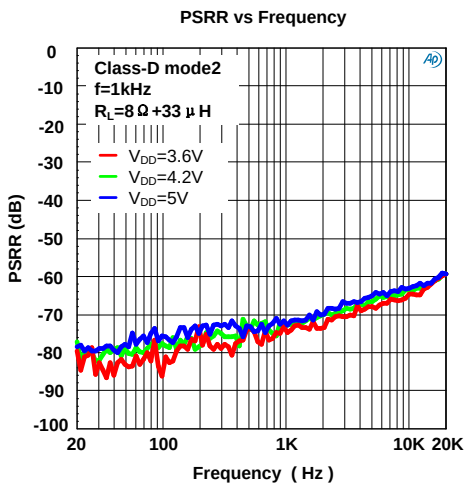
OUTPUT POWER vs VIN

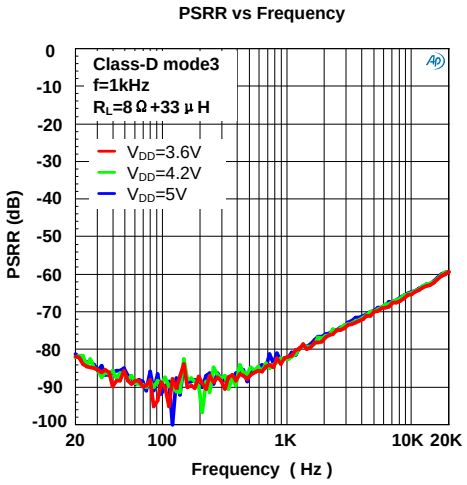


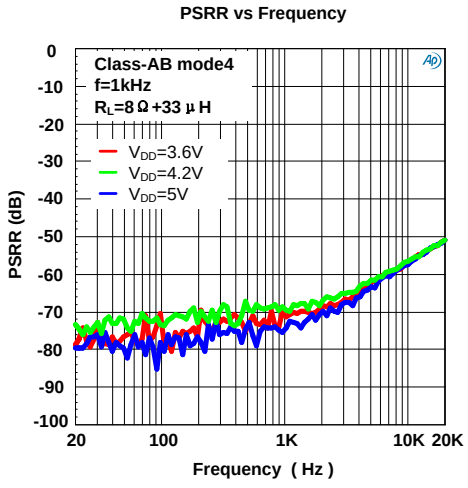




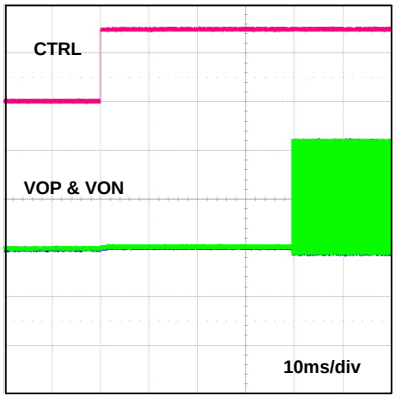




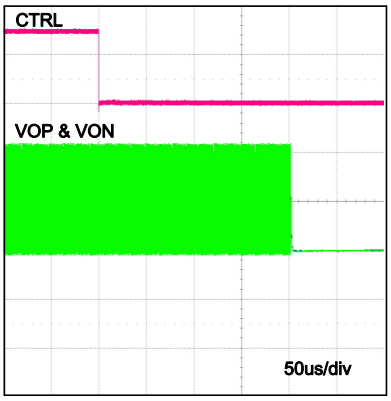




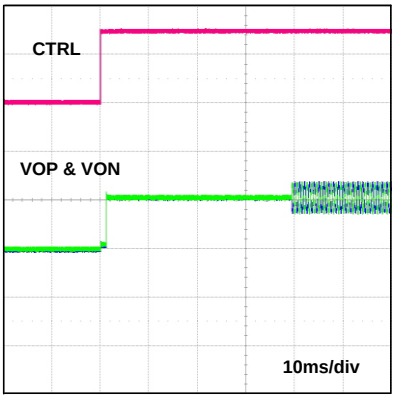
Class_D start up time



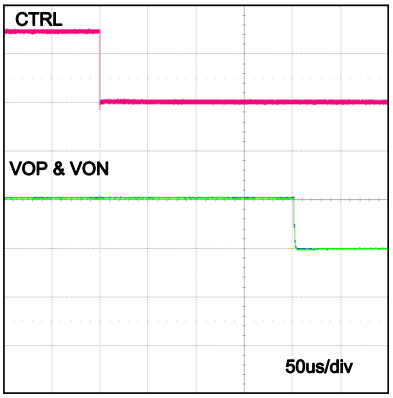
Class_D shutdown time



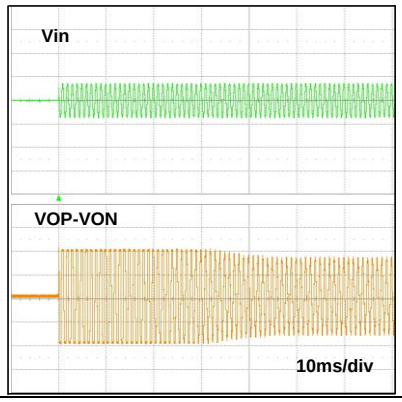
Class_AB start up time



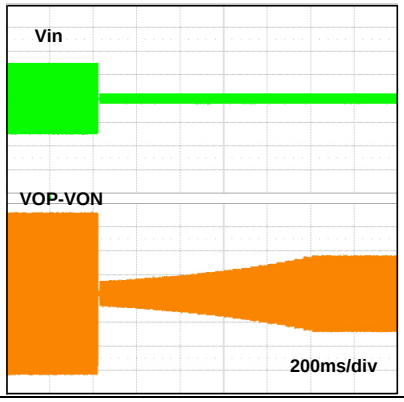
Class_AB shutdown time



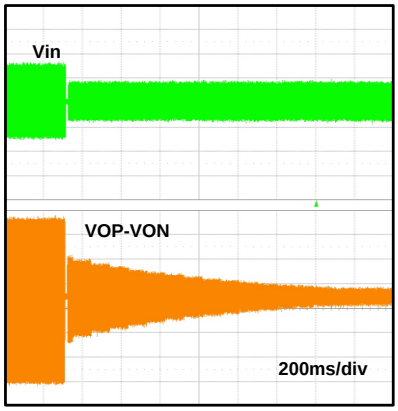
NCN attack time



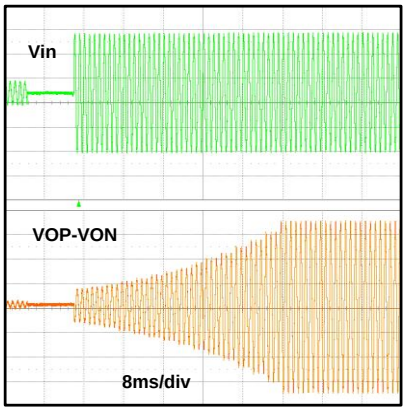
NCN release time



Net audio start up time



Net audio shutdown time



Block Diagram

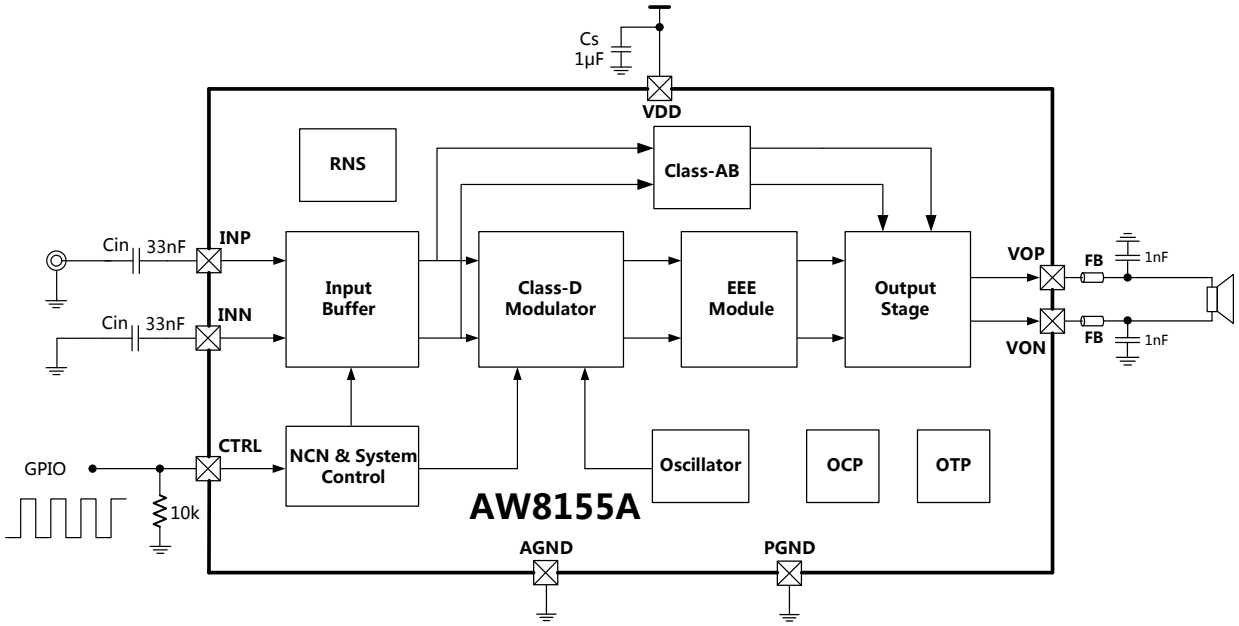


Figure 4. Functional Block Diagram of AW8155A

Operation

The AW8155A is a non-crack-noise (NCN), ultra-low-EMI, filter-free, AB/D output mode selection, second generation Class-D audio amplifier. Ultra low THD+N, Unique 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.

AW8155A NCN output power can be set to 0.65w or 0.85w for different speaker, this feature is embedded in order to protect speakers from damage caused by an excessive sound level.

The AW8155A features a unique RNS and net audio technology, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

The AW8155A features the EEE (Enhanced Emission Elimination) function which greatly reduces EMI over the full bandwidth. The AW8155A 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 is prepared inside of the device.

The AW8155A is available in an ultra small 1.5mm×1. 5mm FC-9 package. The AW8155A is specified over the industrial temperature range of -40℃ to +85℃.

One-wire pulse control

AW8155A select each mode by one-wire pulse control, as shown in figure 6. When CTRL pin pull high form shutdown mode, there is one rising edge, AW8155A start to work and set Gain=18dB, NCN level=0.65w. When high-low-high signal set to CTRL pin, there are two rising edges, AW8155A start to work and set Gain=21.5dB,NCN level=0.85w. When there are three rising edges, AW8155A start to work and set Gain=21.5dB,net audio is enable. When there are four rising edges, AW8155A start to work in Class_AB mode,while gain is to be set 21. 5dB..

As shown in figure 6, when CTRL pull down above 500us, AW8155A will enter shutdown mode.

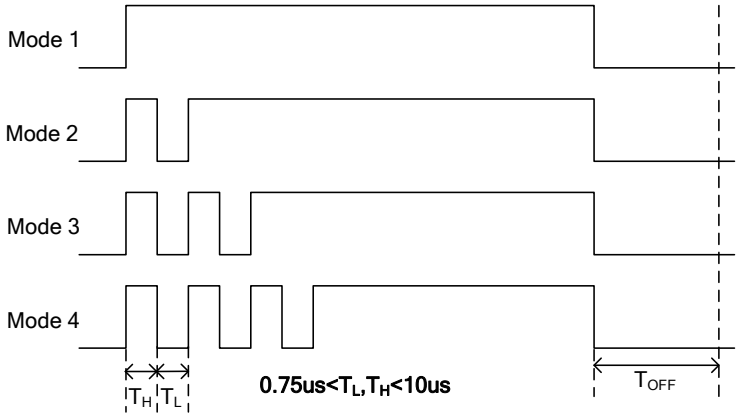


Figure 5. One-Wire pulse control

When AW8155A work in different mode,PIN CTRL should be low above 500us which make the AW8155A shut down, Then series pulse make the AW8155A work in right mode.

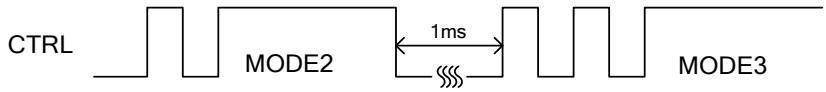


Figure 6. One-wire pulse mode switch

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 AW8155A'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 AW8155A. 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 AW8155A. 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 AW8155A features a unique RNS technology, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

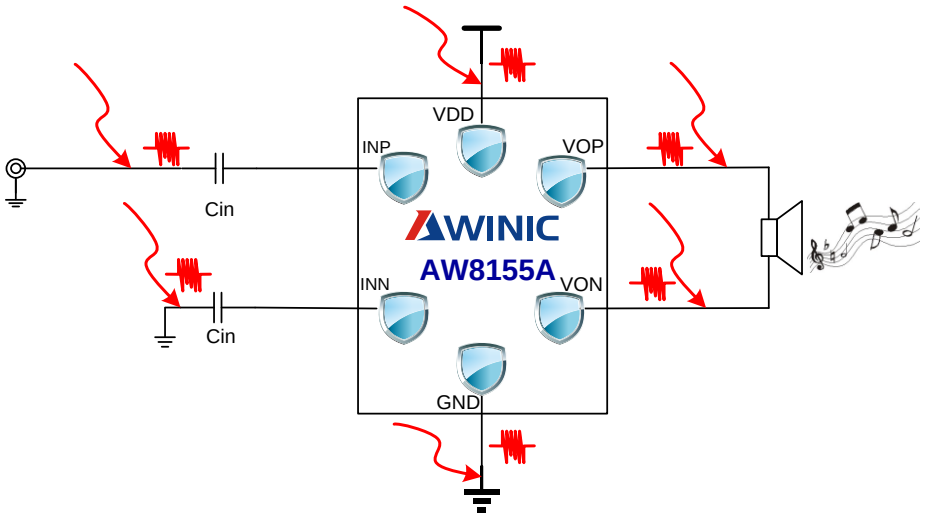


Figure 7. RF Energy Coupling Diagram

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 AW8155A 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.

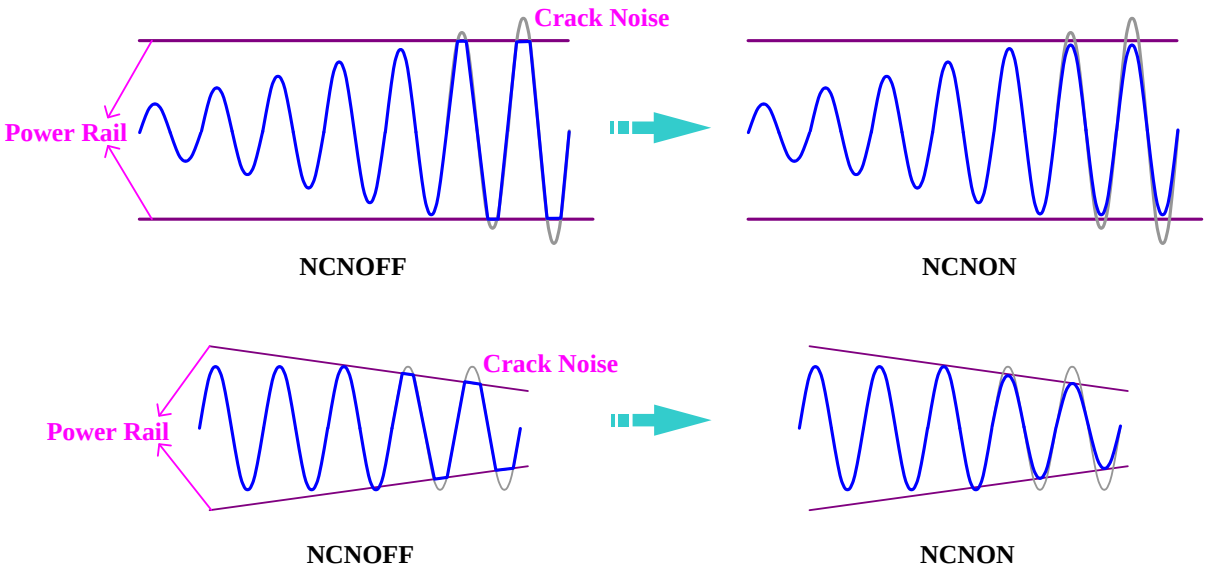


Figure 8. NCN Function Diagram

Attack time

Attack time is the time it takes for the gain to be reduced 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 48ms~55ms in AW8155A.

Release time

Release time is the time it takes for the gain to return 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 1s~1.3s in AW8155A.

Filter-Free Modulation Scheme

The AW8155A 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.

Net audio

The net audio function is the function that removes unwanted noise coming in at no-siganl state. It can suppress the 217Hz TDD nosie from input signal.

It can automatically attenuate the output when a signal level becomes lower then the threshold level,

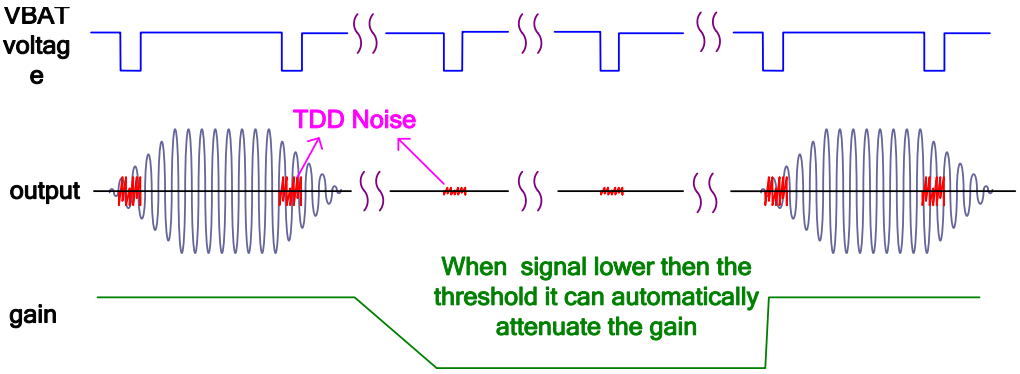


Figure 9. Net audio

Pin-Compatible with AW8155,AW8145, no VREF capacitor

The AW8155A is pin compatible with AW8155 and AW8145.Without VREF 1 uF capacitor it can achieve the same performance as AW8145,which make the PCB design more convenient.

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 AW8155A features efficiency of 88%.

EEE

The AW8155A 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 AW8155A features unique timing control circuit, that comprehensively suppresses pop-click noise, eliminates audible transients on shutdown, wakeup, and power-up/down.

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 AW8155A 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

Supply Decoupling Capacitor（C_S）

The AW8155A 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 AW8155A is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss. In addition to the 0.1μF ceramic capacitor, place a 1μF 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.

Input Capacitor

The input coupling capacitor blocks the DC voltage at the amplifier input terminal. The input capacitors and internal input resistors (28.5KΩ) form a high-pass filter with the corner frequency, fc.

$$f_C = \frac{1}{2\pi RinCin} = 169Hz$$

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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.

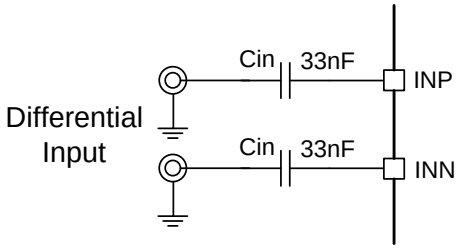


Figure 10. Differential Input

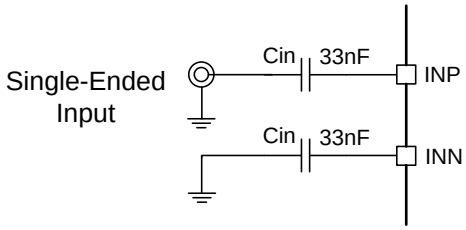


Figure 11. Single-Ended Input

Ferrite Chip Bead and Capacitor

The AW8155A 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.

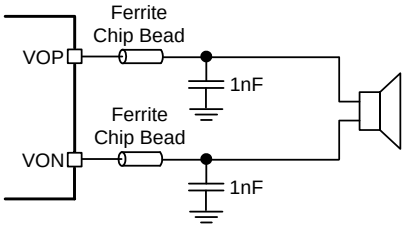
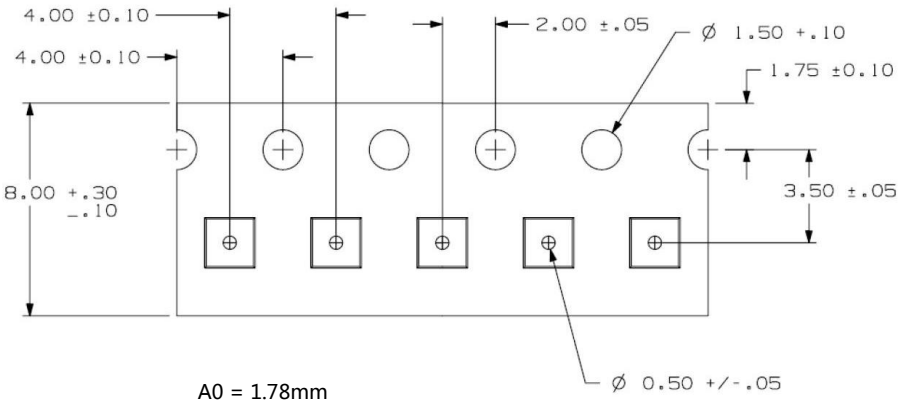


Figure 12. Ferrite Chip Bead and capacitor

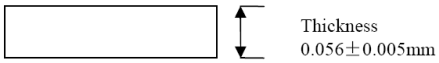
Volume description

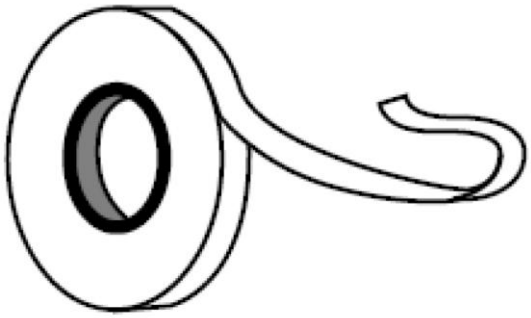
Carrier Tape



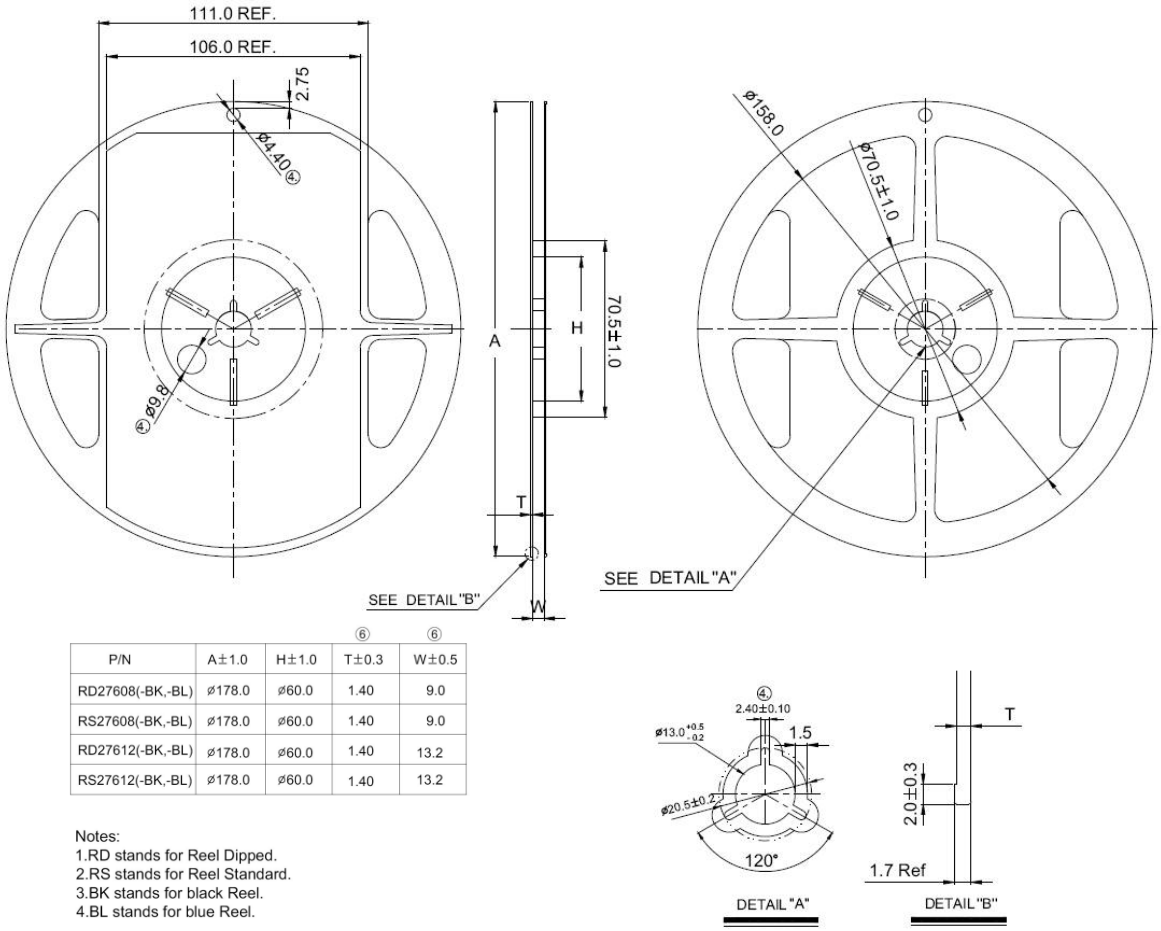
A0 = 1.78mm
B0 = 1.78mm
K0 = 0.69mm

Cover Tape





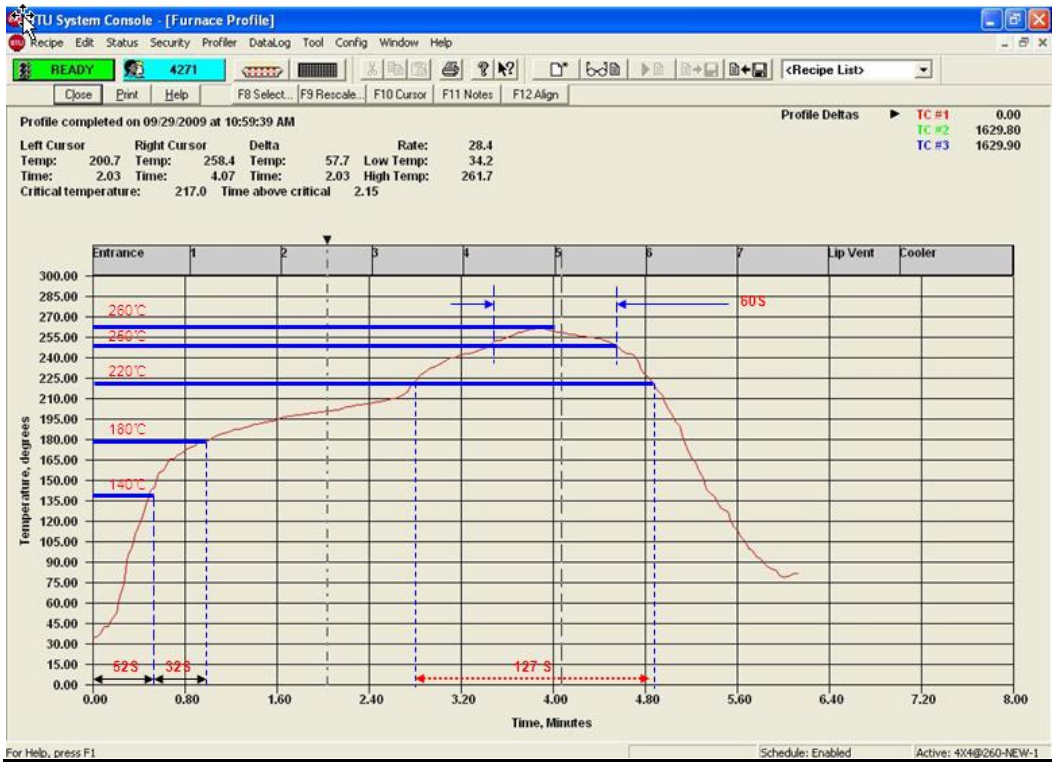
Reel



P/N	A±1.0	H±1.0	T±0.3	W±0.5
			⑥	⑥
RD27608(-BK,-BL)	ø178.0	ø60.0	1.40	9.0
RS27608(-BK,-BL)	ø178.0	ø60.0	1.40	9.0
RD27612(-BK,-BL)	ø178.0	ø60.0	1.40	13.2
RS27612(-BK,-BL)	ø178.0	ø60.0	1.40	13.2

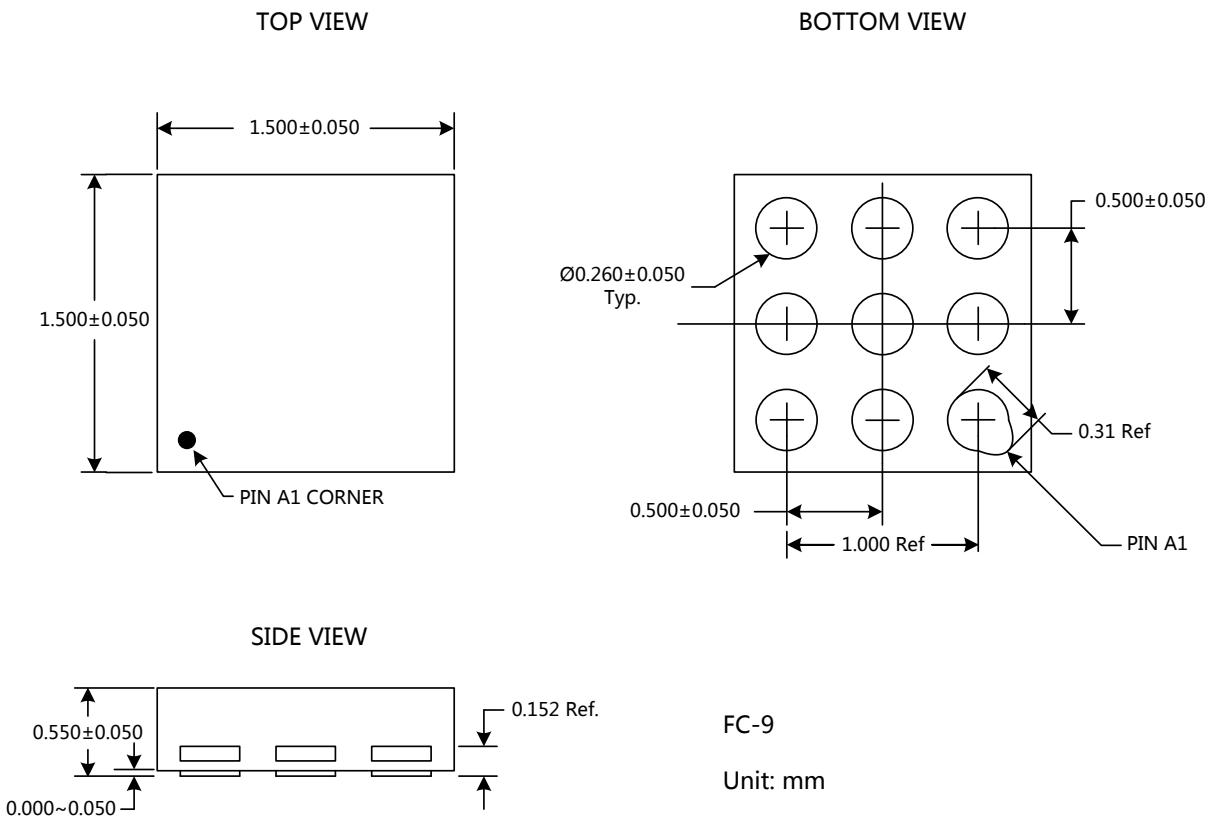
Notes:
1.RD stands for Reel Dipped.
2.RS stands for Reel Standard.
3.BK stands for black Reel.
4.BL stands for blue Reel.

Reflow



Reflow Note	spec	Setting value	Actual
Average ramp-up rate (217℃ to Peak)	Max. 3℃/sec	Zone 1: 220℃	0.69℃/sec
Time of Preheat temp.(from 150℃ to 200℃)	60-120sec	Zone 2: 197℃	85.8sec
Time to be maintained above 217℃	60-150sec	Zone 3: 204℃	129sec
Peak Temperature	>260℃	Zone 4: 212℃	261.7℃
Time within 5℃ of actual peak temp	20-40sec.	Zone 5: 257℃	31.8sec
Ramp-down rate	Max. 6℃/sec	Zone 6: 271℃	0.721℃/sec
Time from 25℃ to peak temp	Max. 8min.	Zone 7: 252℃	3.87min

Package Description



FC-9

Unit: mm

VERSION INFORMATION

Version	Release date	Description
V1.0	2012-10-11	Initial release