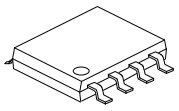
UPA8155

CMOS IC

CLASS AB/D OPTIONAL SECOND GENERATION CLASS-D AUDIO AMPLIFIER



SOP-8

■ DESCRIPTION

The UTC **UPA8155** is a second-generation Class D audio amplifier with crack-free noise (NCN), ultra-low THD+N, no filter, AB/D output mode selection for the most comfortable listening experience for customers.

The UTC **UPA8155** NCN output power can be set for different speakers, this feature is to protect the speaker from damage caused by excessive sound levels.

The filter-less PWM architecture and internal gain Settings reduce the number of external components, board area consumption, system costs, and simplify design. Overcurrent and over-temperature are prepared inside the device.

■ FEATURES

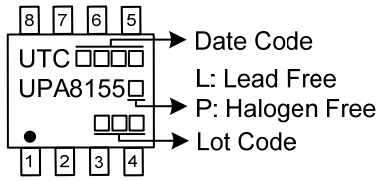
* Power Supply Range: 2.5V~5.5V
* Low Shutdown Current (<0.1μA)
* AB/D Operate Mode
* Two NCN Level: 0.65W and 0.85W
* Ultra Low THD+N: 0.06%
* Over-Temperature Protection
* Excellent Pop-Click Suppression
* One-Pulse Control
* Over-Current Protection
* Filter-Free Class-D Architecture
* High PSRR (-70dB at 217Hz)

■ ORDERING INFORMATION

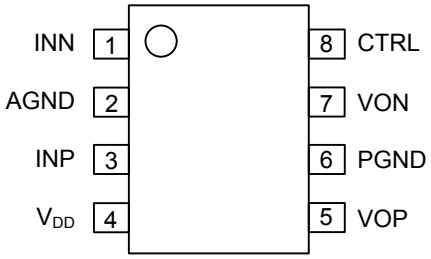
Ordering Number		Package	Packing
Lead Free	Halogen Free		
UPA8155L-S08-R	UPA8155G-S08-R	SOP-8	Tape Reel

UPA8155G-S08-R (1)Packing Type (2)Package Type (3)Green Package	(1) R: Tape Reel (2) S08: SOP-8 (3) P: Halogen Free and Lead Free, L: Lead Free

■ MARKING



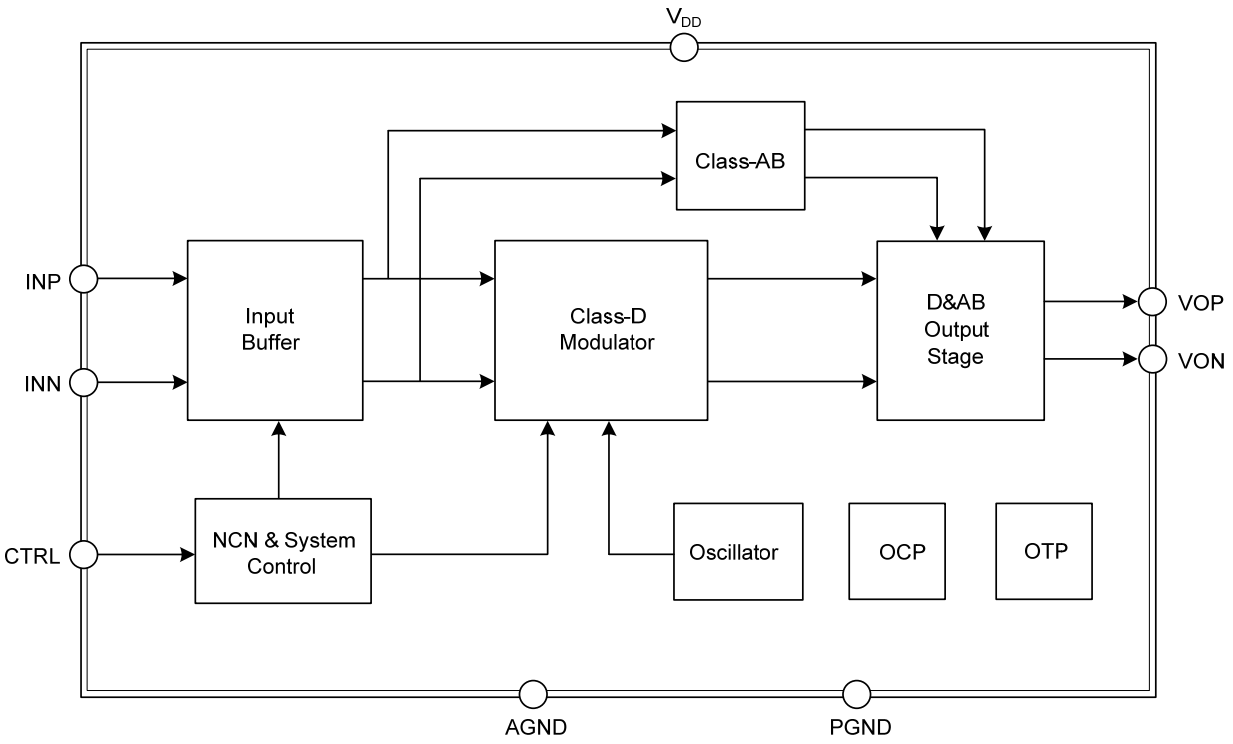
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	INN	Negative audio input
2	AGND	Analog ground
3	INP	Positive audio input
4	V_{DD}	Power Supply
5	VOP	Positive audio output
6	PGND	Power ground
7	VON	Negative audio output
8	CTRL	Shutdown and NCN control pin

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING (T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	-0.3 ~ 6	V
Input Voltage		-0.3 ~ V_{DD} + 0.3	V
Package Thermal Resistance	θ_{JA}	90	°C/W
Maximum Junction Temperature	T_J	+125	°C
Operating Free-Air Temperature	T_{OPR}	-40 ~ +85	°C
Storage Temperature	T_{STG}	-65 ~ +150	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ ELECTRICAL CHARACTERISTICS (T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Power Supply Voltage	V_{DD}			2.5		5.5	V
CTRL High Input Voltage	V_{IH}			1.3		V_{DD}	V
CTRL Low Input Voltage	V_{IL}			0		0.35	V
Output Offset Voltage	$\|V_{OS}\|$	Vin=0V, V_{DD}=2.5V ~ 5.5V		-40	0	40	mV
Shutdown Current	I_{SD}	V_{DD}=3.6V, CTRL =0V			0.1	1	μA
Modulation Frequency	f_{SW}	V_{DD}=2.5V ~ 5.5V		600	800	1000	kHz
Thermal Protect Level	T_{SD}			160	170	180	°C
Thermal Hysteresis	T_{SDR}			100	120	130	°C
Start-Up Time	T_{ON}			40	50	60	ms
Internal Impedance	Rini			20	28.5	35	kΩ
Output Power	P_O	THD+N=10%, f=1kHz, R_L=4Ω, V_{DD}=5V			2.61		W
		THD+N=1%, f=1kHz, R_L=4Ω, V_{DD}=5V			2.11		W
		THD+N=10%, f=1kHz, R_L=8Ω, V_{DD}=5V			1.63		W
		THD+N=1%, f=1kHz, R_L=8Ω, V_{DD}=5V			1.32		W
		THD+N=10%, f=1kHz, R_L=4Ω, V_{DD}=4.2V			1.79		W
		THD+N=1%, f=1kHz, R_L=4Ω, V_{DD}=4.2V			1.46		W
		THD+N=10%, f=1kHz, R_L=8Ω, V_{DD}=4.2V			1.13		W
		THD+N=1%, f=1kHz, R_L=8Ω, V_{DD}=4.2V			0.92		W
		THD+N=10%, f=1kHz, R_L=4Ω, V_{DD}=3.6V			1.28		W
		THD+N=1%, f=1kHz, R_L=4Ω, V_{DD}=3.6V			1.05		W
		THD+N=10%, f=1kHz, R_L=8Ω, V_{DD}=3.6V			0.82		W
		THD+N=1%, f=1kHz, R_L=8Ω, V_{DD}=3.6V			0.65		W
MODE 1							
Quiescent Current	I_Q	V_{DD}=3.6V, No V_{IN}, No Load			4.3		mA
Efficiency	η	V_{DD}=3.6V, P_O=0.8W, R_L=8Ω		65	75		%
Voltage Gain	A_V	C_{IN}=33nF, R_{IN}=0		7	8	9	V/V
Power Suppression Ration	PSRR	V_{DD}=4.2V, V_{P-P_SIN}=200mV	217Hz	-55	-72		dB
			1kHz	-55	-69		dB
Total Harmonic Distortion Plus Noise	THD+N	V_{DD}=4.2V, P_O=0.5W, R_L=8Ω, f=1kHz			0.06	0.1	%
		V_{DD}=3.6V, P_O=0.25W, R_L=8Ω, f=1kHz			0.06	0.1	%
NCN Output Power	P_O NCN	f=1kHz, R_L=8Ω, V_{DD}=4.2V			0.65		W
Attack Time(-11dB)	T_{AT}				32		ms
Release Time(11dB)	T_{RL}				3		s
Max Attenuation	A_{MAX}			-9	-10	-11	dB
Speaker Output Noise	Vn	V_{DD}=3.6V, C_{IN}=33nF, R_{IN}=0, R_L=8Ω f=20Hz-20kHz, Input AC Grounded			100		μV
Signal-to-Noise Ratio	SNR	V_{DD}=5V, P_O=1W, R_L=8Ω			92		dB

■ ELECTRICAL CHARACTERISTICS (Cont.)

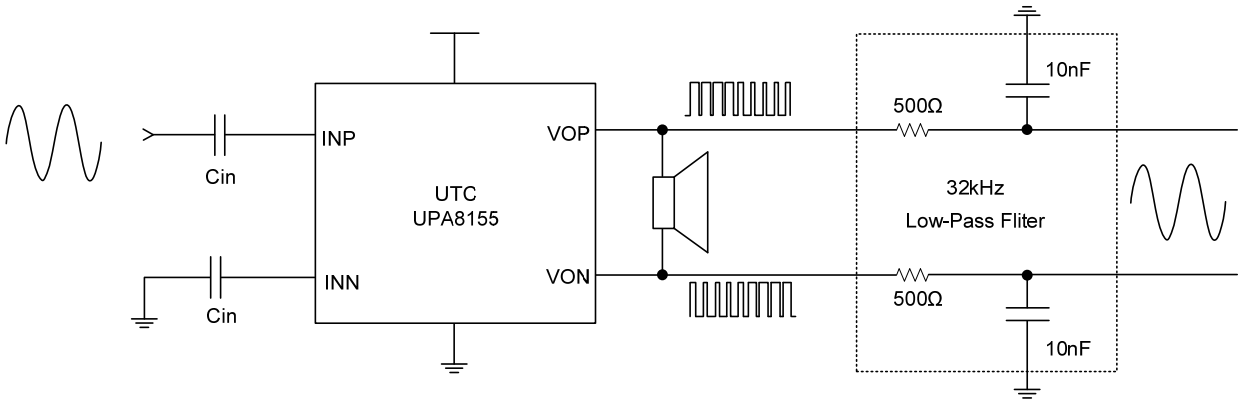
PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNIT
MODE 2							
Quiescent Current	I_Q	V_{DD}=3.6V, No Load			4.3		mA
Efficiency	η	V_{DD}=3.6V, P_O=0.8W, R_L=8Ω		80	85		%
Voltage Gain	A_V	C_{IN}=33nF		11	12	13	V/V
Power Suppression Ration	PSRR	V_{DD}=4.2V, V_{P-P_SIN}=200mV	217Hz	55	-71		dB
			1kHz	55	-70		dB
Total Harmonic Distortion Plus Noise	THD+N	V_{DD}=4.2V, P_O=0.5W, R_L=8Ω, f=1kHz			0.06	0.1	%
		V_{DD}=3.6V, P_O=0.25W, R_L=8Ω, f=1kHz			0.06	0.1	%
NCN Output Power	P_O NCN	f=1kHz, R_L=8Ω, V_{DD}=4.2V			0.85		W
Attack Time(-11dB)	T_{AT}				40		ms
Release Time(11dB)	T_{RL}				3.5		s
Max Attenuation	A_{MAX}			-11	-12	-13	dB
Speaker Output Noise	Vn	V_{DD}=3.6V, C_{IN}=33nF, R_{IN}=0, R_L=8Ω f=20Hz-20kHz, Input AC Grounded			140		μV
Signal-to-Noise Ratio	SNR	V_{DD}=5V, P_O=1W, R_L=8Ω			89		dB
MODE 3							
Quiescent Current	I_Q	V_{DD}=3.6V, No Vin, No Load			4.3		mA
Efficiency	η	V_{DD}=3.6V, P_O=0.8W, R_L=8Ω		80	85		%
Voltage gain	Av	C_{IN}=33nF		11	12	13	V/V
Power Suppression Ration	PSRR	V_{DD}=4.2V, V_{P-P_SIN}=200mV	217Hz	-60	-81		dB
			1kHz	-60	-75		dB
Total Harmonic Distortion Plus Noise	THD+N	V_{DD}=4.2V, P_O=0.5W, R_L=8Ω, f=1kHz			0.06	0.1	%
		V_{DD}=4.2V, P_O=0.25W, R_L=8Ω, f=1kHz			0.06	0.1	%
NCN Output Power	P_O NCN	f=1kHz, R_L=8Ω, V_{DD}=4.2V			0.85		W
Attack Time(-13.5dB)	T_{AT}				40		ms
Release Time(13.5dB)	T_{RL}				3.5		s
Max Attenuation	A_{MAX}				-15		dB
Net Audio Vth(Vp)	V_{LIMIT}	V_{DD}=4.2V			15	30	mVp
Net Audio Max Attenuation	A_{MAX1}			-14	-15	-16	dB
Speaker Output Noise	Vn	V_{DD}=3.6V, C_{IN}=33nF, R_{IN}=0, R_L = 8Ω f=20Hz-20kHz, Input AC Grounded			35		μV
Signal-to-Noise Ratio	SNR	V_{DD}=5V, P_O=1W, R_L=8Ω			101		dB
MODE 4							
Quiescent Current	I_Q	V_{DD}=3.6V, No Vin, No Load			4.5		mA
Efficiency	η	V_{DD}=3.6V, P_O=0.8W, R_L=8Ω		65	70		%
Voltage Gain	A_V	C_{IN}=33nF		11	12	13	V/V
Power Suppression Ratio	PSRR	V_{DD}=4.2V, V_{P-P_SIN}=200mV	217Hz	-55	-70		dB
			1kHz	-55	-68		dB
Total Harmonic Distortion Plus Noise	THD+N	V_{DD}=4.2V, P_O=0.5W, R_L=8Ω, f=1kHz			0.2	0.5	%
		V_{DD}=4.2V, P_O=0.25W, R_L=8Ω, f=1kHz			0.2	0.5	%
Speaker Output Noise	Vn	V_{DD}=3.6V, C_{IN}=33nF, R_{IN}=0, R_L = 8Ω f=20Hz-20kHz, Input AC Grounded			120		μV
Signal-to-Noise Ratio	SNR	V_{DD}=5V, P_O=1W, R_L=8Ω			90		dB
ONE-WIRE PULSE CONTROL							
CTRL High Level Hold Time	T_H	V_{DD}=2.5V~5.5V		0.75	2	10	μs
CTRL Low Level Hold Time	T_L	V_{DD}=2.5V~5.5V		0.75	2	10	μs
CTRL Turn On Delay Time	T_{LATCH}	V_{DD}=2.5V~5.5V				500	μs
CTRL Turn Off Delay Time	T_{OFF}	V_{DD}=2.5V~5.5V				500	μs

■ OPERATE MODE DESCRIPTION

MODE	CTRL	OPERATING	AV (V/V)	NCN POWER (W)	RNS	Net audio
MODE 1		Class_D	8	0.65	Yes	
MODE 2		Class_D	12	0.85	Yes	
MODE 3		Class_D	12	0.85	Yes	Yes
MODE 4		Class_AB	12		Yes	

■ MEASUREMENT SYSTEM

UTC **UPA8155** features switching output signal when it operate in mode 1~3. As shown in measurement system. A Low-Pass RC filter can be used to remove high switching frequency in output signal.



UTC **UPA8155** 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

Typical RC Measurement Filter Values

■ OPERATION

The UTC **UPA8155** 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.

UTC **UPA8155** 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 UTC **UPA8155** 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 UTC **UPA8155** features the EEE (Enhanced Emission Elimination) function which greatly reduces EMI over the full bandwidth. The UTC **UPA8155** achieves better than 20dB margin under FCC limits with 24 inch of cable.

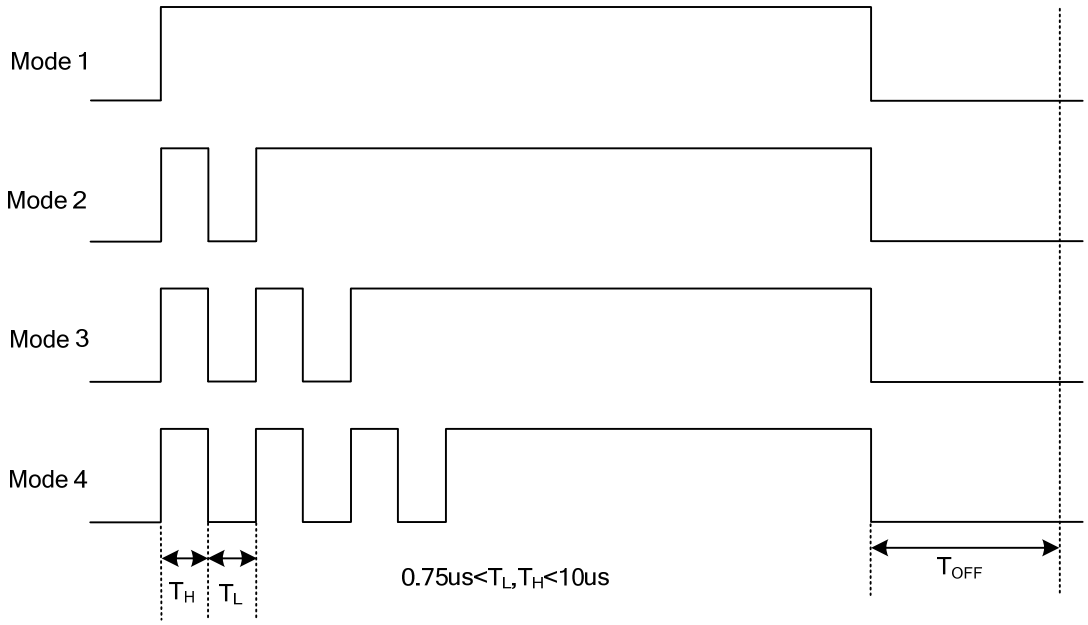
The filter-free PWM architecture and internal gain setting reduces external components count, board area consumption, system cost and simplifies the design. The over-current, over-temperature is prepared inside of the device.

The UTC **UPA8155** is specified over the industrial temperature range of -40°C to +85°C.

One-wire pulse control

UTC **UPA8155** select each mode by one-wire pulse control, as shown in One-Wire pulse control. When CTRL pin pull high form shutdown mode, there is one rising edge, UTC **UPA8155** 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, UTC **UPA8155** start to work and set Gain=21.5dB, NCN level=0.85W. When there are three rising edges, UTC **UPA8155** start to work and set Gain=21.5dB, net audio is enable. When there are four rising edges, UTC **UPA8155** start to work in Class_AB mode, while gain is to be set 21.5dB.

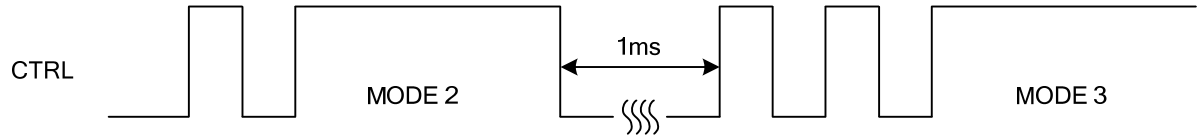
As shown in One-Wire pulse control, when CTRL pull down above 500us, UTC **UPA8155** will enter shutdown mode.



One-Wire pulse control

■ OPERATION (Cont.)

When UTC **UPA8155** work in different mode, PIN CTRL should be low above 500us which make the UTC **UPA8155** shut down, Then series pulse make the UTC **UPA8155** work in right mode.



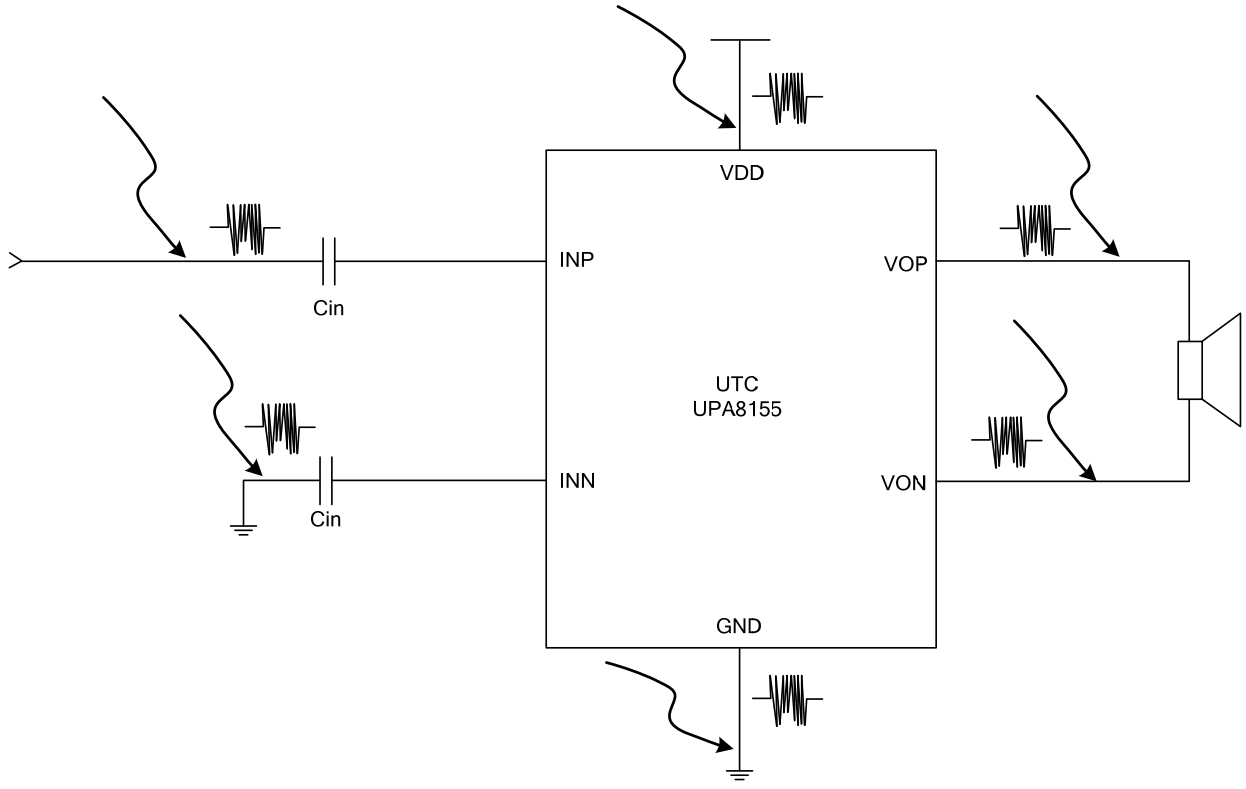
One-wire pulse mode switch

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 UTC **UPA8155**'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 UTC **UPA8155**. 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 UTC **UPA8155**. 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 UTC **UPA8155** features a unique RNS technology, which effectively reduces RF energy, attenuate the RF TDD-noise, an acceptable audible level to the customer.

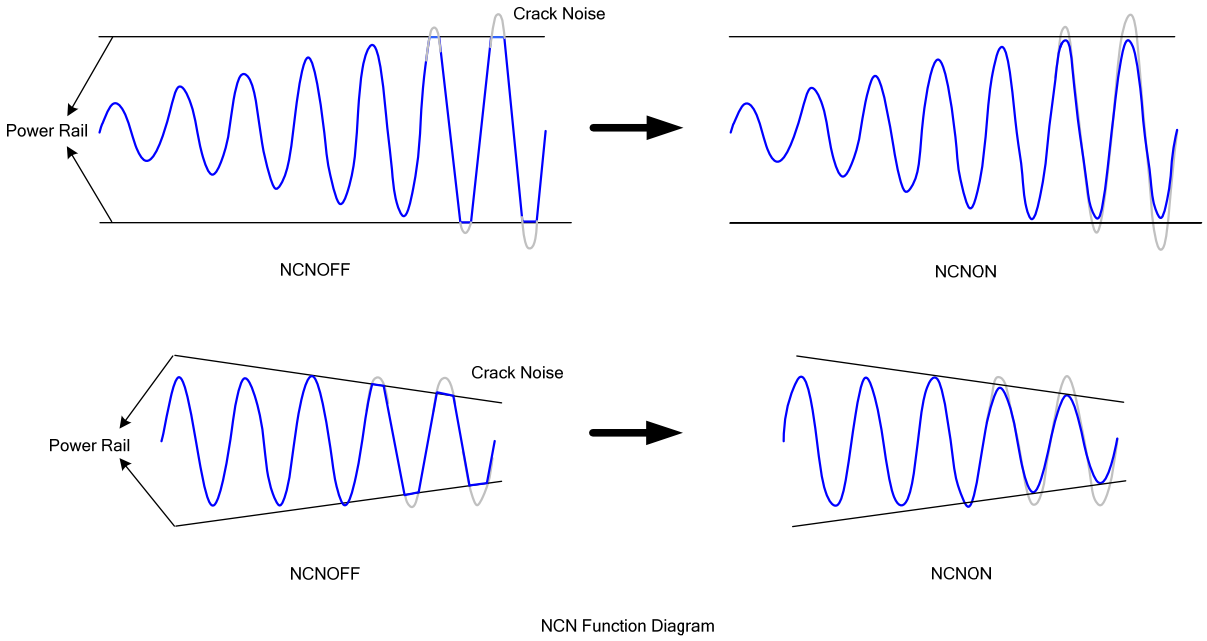


RF Energy Coupling Diagram

■ OPERATION (Cont.)

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 UTC **UPA8155** 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.



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 32ms~40ms in UTC **UPA8155**.

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 2s~2.6s in UTC **UPA8155**.

Filter-Free Modulation Scheme

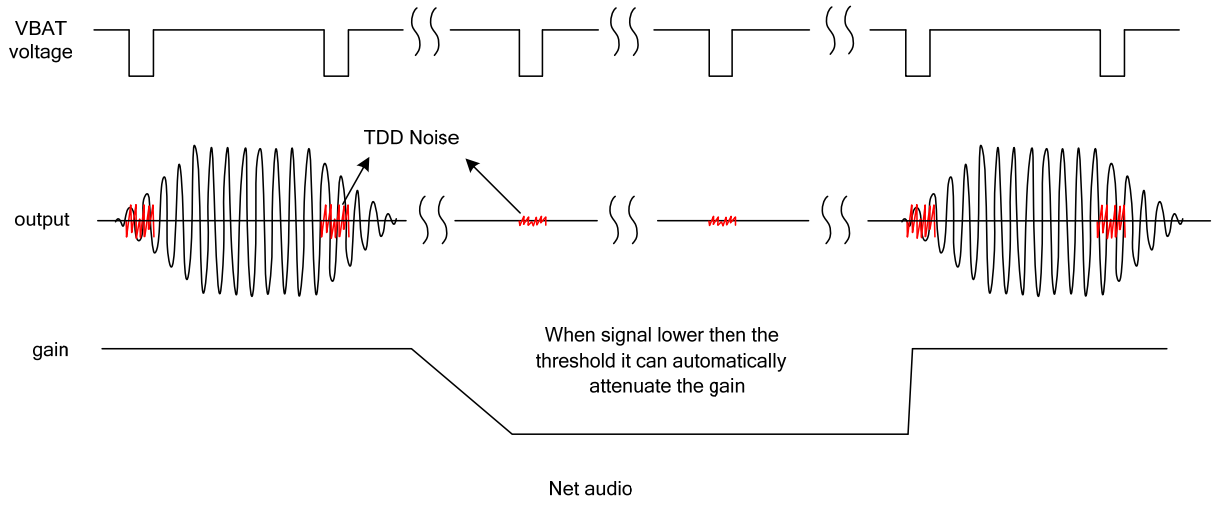
The UTC **UPA8155** features a filter-free PWM architecture that reduces the LC filter of the traditional Class-D amplifier, increasing efficiency, reducing board area consumption and system cost.

Net audio

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

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

■ OPERATION (Cont.)



Pin-Compatible with AW8145, no V_{REF} capacitor

The UTC **UPA8155** is pin compatible with AW8145.Without VREF 1uF 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 I^2R loss of the MOSFET on-resistance and supply current. The UTC **UPA8155** features efficiency of 88%.

EEE

The UTC **UPA8155** 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 UTC **UPA8155** 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 V_{DD}/GND or VOP and VON, the over-current circuit shutdown the device, preventing the device from being damaged. When the condition is removed, the UTC **UPA8155** 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)

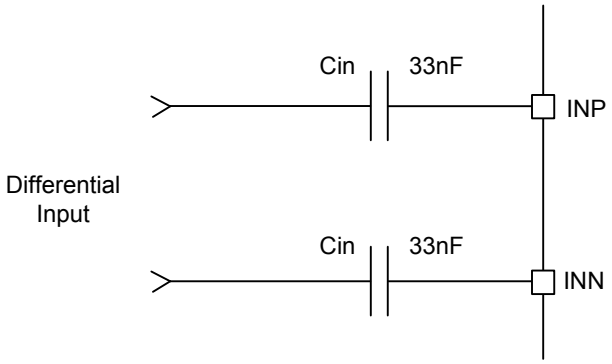
The UTC **UPA8155** is a high-performance audio amplifier that requires adequate power supply decoupling. Place a low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1μF. This choice of capacitor and placement helps with higher frequency transients, spikes, or digital hash on the line. Additionally, placing this decoupling capacitor close to the UTC **UPA8155** 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

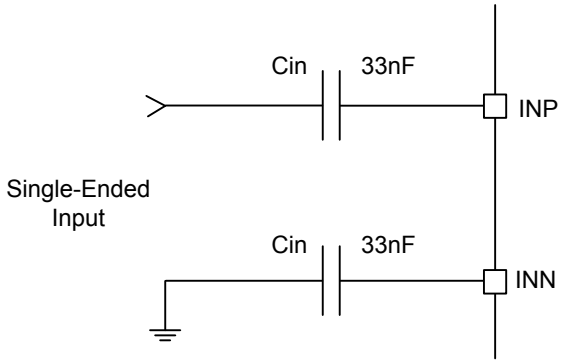
The input coupling capacitor blocks the DC voltage at the amplifier input terminal. The input capacitors and internal input resistors (28.5KΩ) form a high-pass filter with the corner frequency, fc.

$$f_C = \frac{1}{2\pi R_{IN} C_{IN}} = 169Hz$$

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.



Differential Input

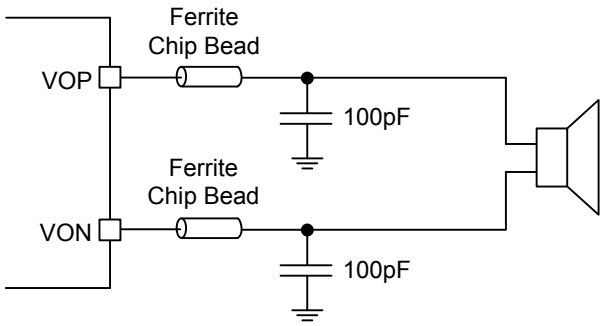


Single-Ended Input

■ OPERATION (Cont.)

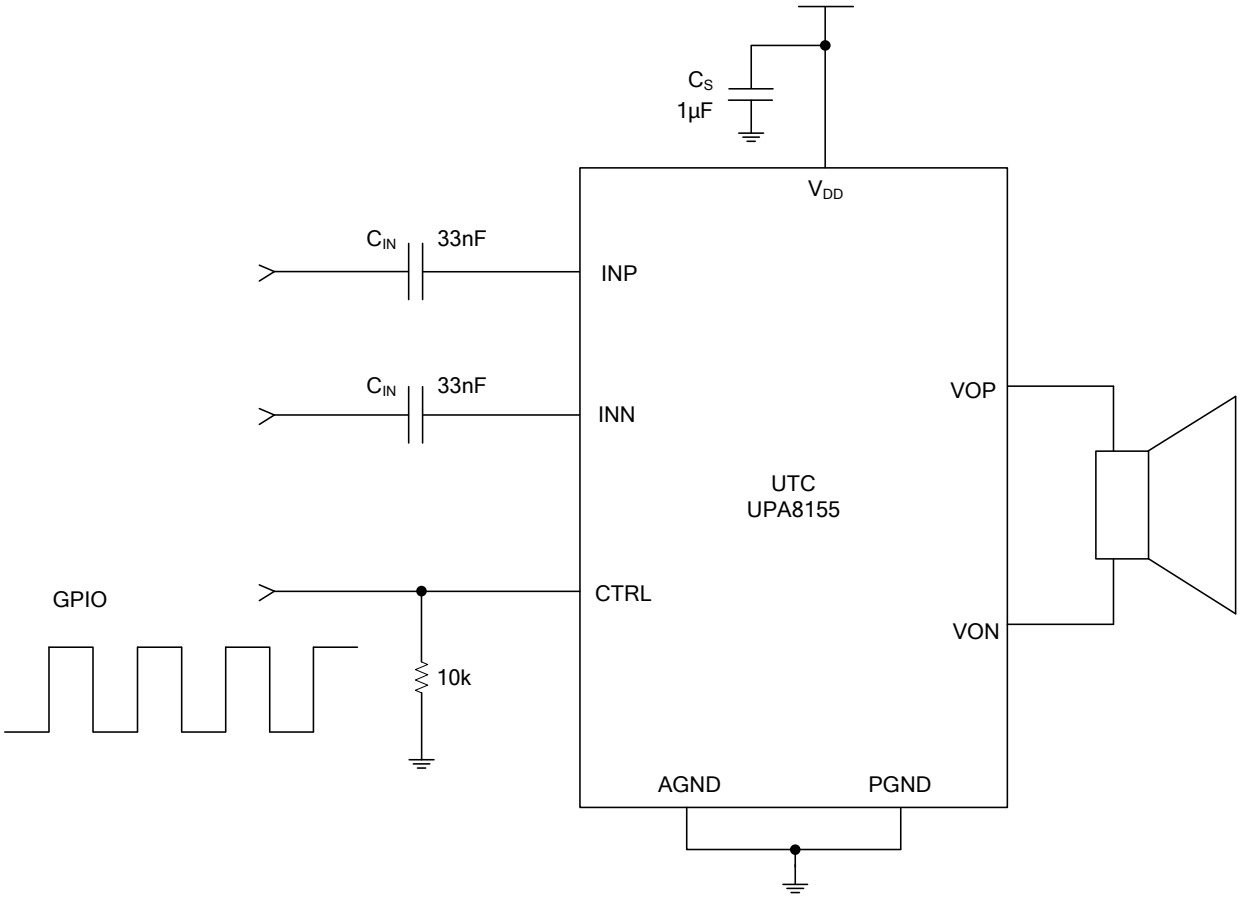
Ferrite Chip Bead and Capacitor

The UTC **UPA8155** 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.



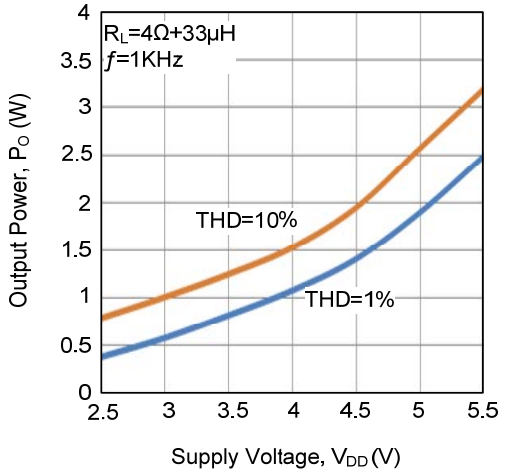
Ferrite Chip Bead and capacitor

■ TYPICAL APPLICATION CIRCUIT

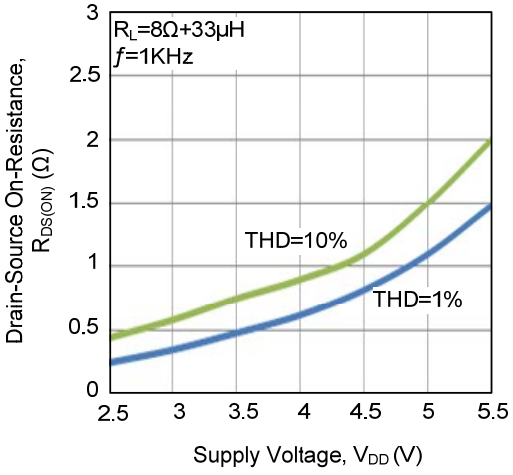


■ TYPICAL CHARACTERISTICS

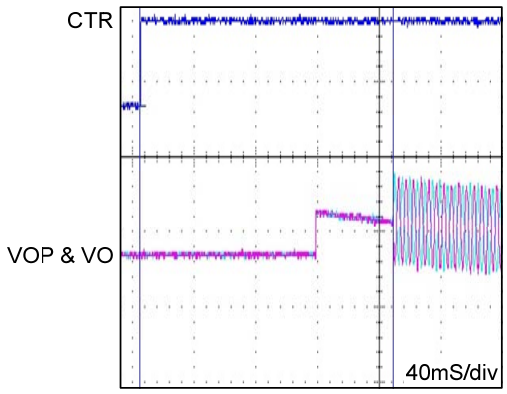
Output Power vs. Supply Voltage



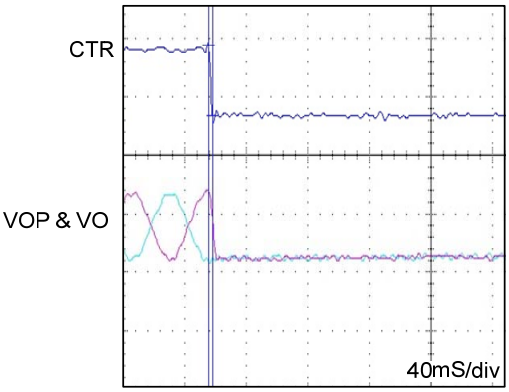
Output Power vs. Supply Voltage



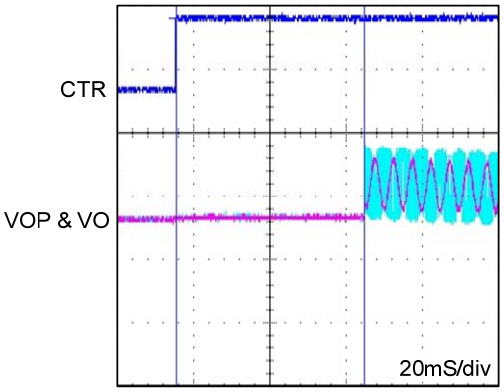
Class A/B Start Up Time



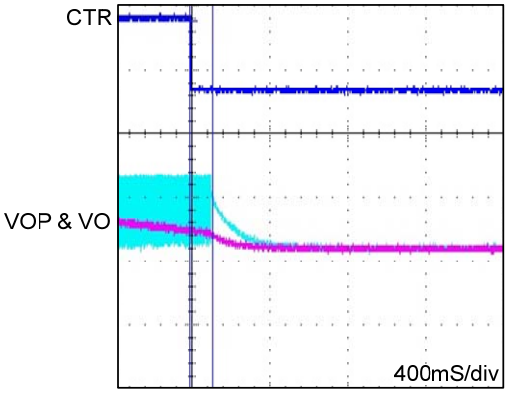
Class A/B shutdown Time



Class D Start Up Time

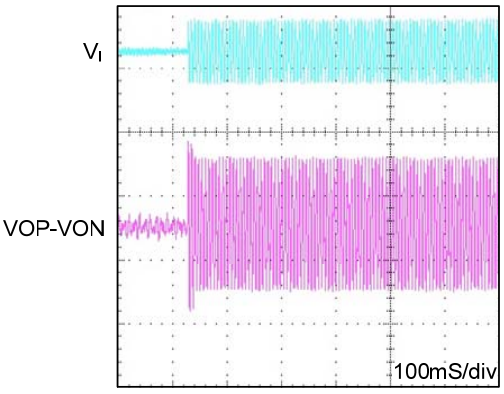


Class D shutdown Time



■ TYPICAL CHARACTERISTICS (Cont.)

NCN Attack Time



NCN Release Time