NIPPON PRECISION CIRCUITS INC.

SM6800A

Class-D Mono Amplifier for Mobile Telephones

OVERVIEW

The SM6800A is an analog-input, class-D mono amplifier. Class-D operation provides high efficiency and low power consumption. The device also incorporates a selectable real-time operation dynamic range compression function that effectively suppresses the distortion in the saturation level region output by soft-clipping, boosting the average sound pressure from the speaker during playback. It also incorporates an input equalizer pin for output speaker frequency characteristics adjustment. These features make the device ideal for use in mobile telephones and speaker applications requiring miniaturization and high-efficiency. The output stage has a BTL output configuration where the output waveform inverts only the modulation components, enabling direct drive connection, without using an LC filter, to a dynamic speaker. The device is available in miniature 20-pin QFN packages, and requires only a peripheral chip capacitor to form a miniature amplifier circuit.

FEATURES

- Operating supply voltage: 2.7 to 4.3V
- Low current consumption: 4.8mA (V_{DD} = 3.6V)
- Output power: 0.7W (V_{DD} = 3.6V, 8Ω load)
- Output fundamental frequency: 125kHz
- Gain
  - 4.5dB (Normal)
  - 12dB to 4.5dB automatic adjustment in response to the input level (Dynamic range compression mode)
- Silicon-gate CMOS process
- Package: 20-pin QFN

APPLICATIONS

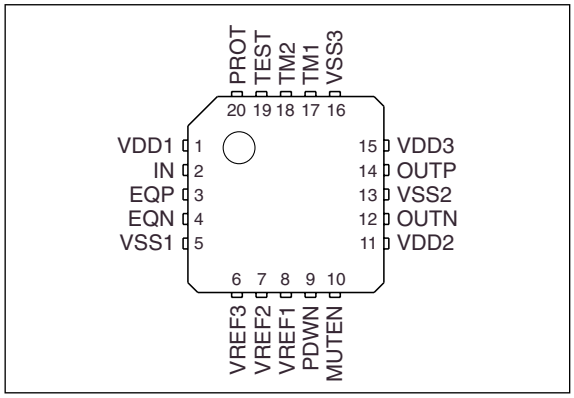
- Cellular phone
- PDA
- Digital still camera

ORDERING INFORMATION

Device	Package
SM6800AB	20-pin QFN

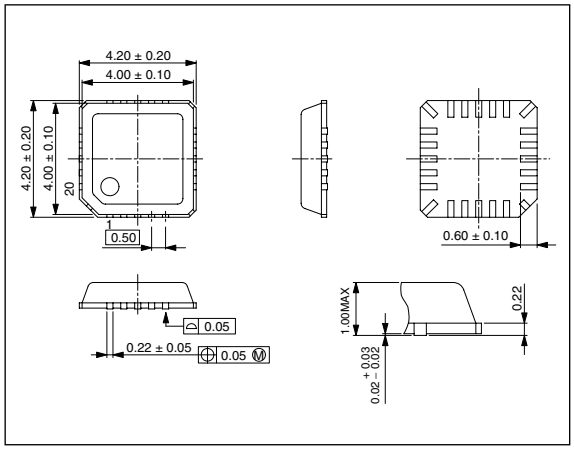
PINOUT

(Top view)

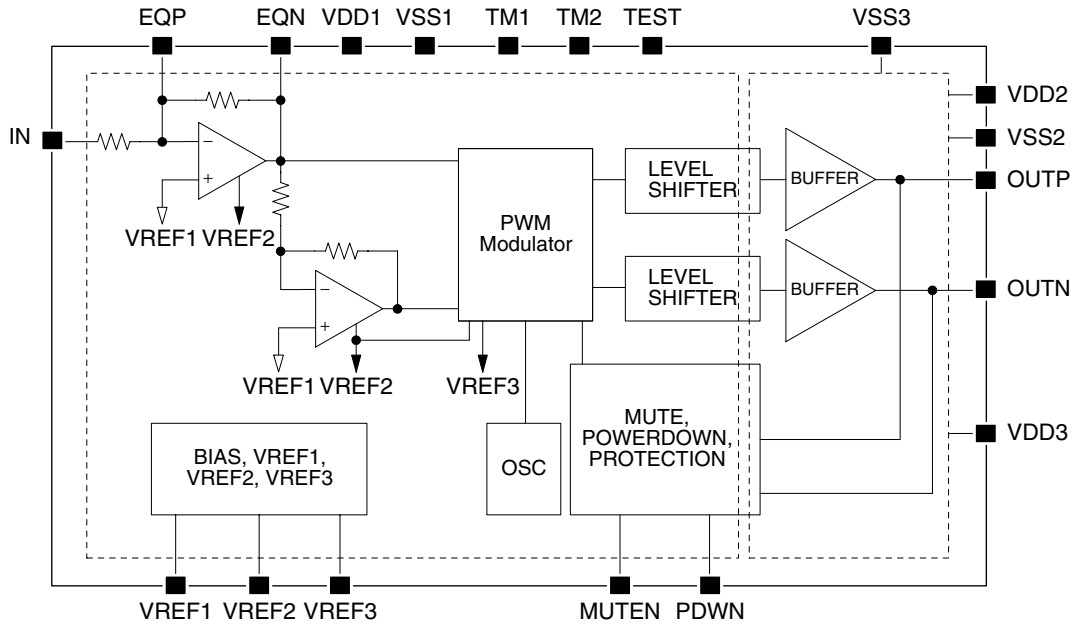


PACKAGE DIMENSIONS

(Unit: mm)



BLOCK DIAGRAM



PIN DESCRIPTION

Number	Name[1]	I/O[2]	Function
1	VDD1	–	Supply (input system)
2	IN	I	Signal input
3	EQP	I	Equalizer network connection
4	EQN	I	Equalizer network connection
5	VSS1	–	Ground (input system)
6	VREF3	–	Reference voltage 3 (internal bias voltage monitor. No connection for normal operation)
7	VREF2	–	Reference voltage 2 (internal bias voltage monitor. No connection for normal operation)
8	VREF1	–	Reference voltage 1 (bias voltage)
9	PDWN	I	Power-down control (active LOW)
10	MUTEN	I	Mute control (active LOW)
11	VDD2	–	Supply (OUTN stage)
12	OUTN	O	Speaker minus (–) output
13	VSS2	–	Ground (OUTP and OUTN stages)
14	OUTP	O	Speaker plus (+) output
15	VDD3	–	Supply (OUTP stage)
16	VSS3	–	Ground (output system)
17	TM1	I	Dynamic range compression mode setting 1
18	TM2	I	Dynamic range compression mode setting 2
19	TEST	Ip	Test pin (HIGH: normal operation, LOW: test mode)
20	PROT	O	Protection circuit output (HIGH: protection circuit operation, LOW: normal operation)

1. V_{DDS} = VDD1, V_{DDP} = VDD2 = VDD3, V_{SS} = VSS1 = VSS2 = VSS3
2. Ip = input pin with built-in pull-up resistor

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage range	V_{DDS}, V_{DDP}	–0.3 to 4.6	V
Supply voltage ground	V_{SS}	0	V
Input voltage range	V_{IN}	V_{SS} – 0.3 to V_{DDS} + 0.3	V
Storage temperature range	T_{STG}	–55 to +125	°C
Output current	I_O	300	mA
Power dissipation[1]	P_D	340	mW

1. Under NPC measurement conditions, θ_{Ja} = 116.2°C/W.
The power dissipation is given by: $P_D = ((T_{JMAX} - Ta)/ \theta_{Ja})$ where T_{JMAX} = 125°C and Ta = 85°C

Recommended Operating Conditions

V_{SS} = VSS1 = VSS2 = VSS3 = 0V, V_{DDS} =VDD1, V_{DDP} = VDD2 = VDD3 unless otherwise noted

Parameter	Symbol	Rating	Unit
Supply voltage 1	V_{DDS}	2.7 to 4.3	V
Supply voltage 2	V_{DDP}	2.7 to 4.3	V
Supply voltage difference	$V_{DD3} - V_{DD2}$	± 0.1	V
Operating temperature range	Ta	–40 to 85	°C

Electrical Characteristics

DC Characteristics

VSS1 = VSS2 = VSS3 = 0V, VDD1 = 2.7 to 4.3V, VDD2 = VDD3 = 2.7 to 4.3V, Ta = –40 to 85°C unless otherwise noted

Parameter	Pin	Symbol	Conditions	Rating			Unit
				min	typ	max	
Current consumption	VDD1	I_{DD1A}	(Note 1)	–	4.6	8.0	mA
		I_{DD1S}	(Note 2)	–	0.2	0.5	µA
	VDD2 + VDD3	I_{DDAA}	(Note 1)	–	0.2	0.6	mA
		I_{DDAS}	(Note 2)	–	0.1	0.3	µA
Input voltage 1	TEST	V_{IH1}	HIGH level	$0.8V_{DDS}$	–	–	V
Input voltage 2	TM1, TM2, MUTEN, PDWN	V_{IH2}	HIGH level	$0.9V_{DDS}$	–	–	V
		V_{IL2}	LOW level	–	–	0.4	V
Input leakage current 1	TEST	I_{LH1}	$V_{IN} = V_{DD1}$	–	–	1.0	µA
Input leakage current 2	TM1, TM2, MUTEN, PDWN	I_{LH2}	$V_{IN} = V_{DD1}$	–	–	1.0	µA
		I_{LL2}	V_{IN} = 0V	–	–	1.0	µA

Note 1: MUTEN = HIGH, PDWN = HIGH, input and VREF1 connected by 600Ω, TM1 = TM2 = LOW, no-load output
Note 2: MUTEN = LOW, PDWN = LOW, input and VREF1 connected by 600Ω, TM1 = TM2 = LOW, no-load output

AC Analog Characteristics

VDD1 = VDD2 = VDD3 = 3.6V, VSS1 = VSS2 = VSS3 = 0V, 0.708Vrms analog input amplitude, 1kHz input signal frequency, Ta = 25°C, "Measurement block diagram", "Measurement conditions", "Measurement circuit", TM1 = TM2 = LOW, PDWN = MUTEN = HIGH, unless otherwise noted

Analog input characteristics (IN)

Parameter	Symbol	Conditions	Rating			Unit
			min	typ	max	
Reference input amplitude 1	V_{AI1}	P_O = 0.2W	–	0.708	–	Vrms
Reference input amplitude 2	V_{AI2}	P_O = 0.05W	–	0.178	–	Vrms
Input resistance	R_{IN}		48	60	72	kΩ
Input clipping voltage	V_{CLP}	P_O = 0.5W	0.7	1	1.3	Vrms

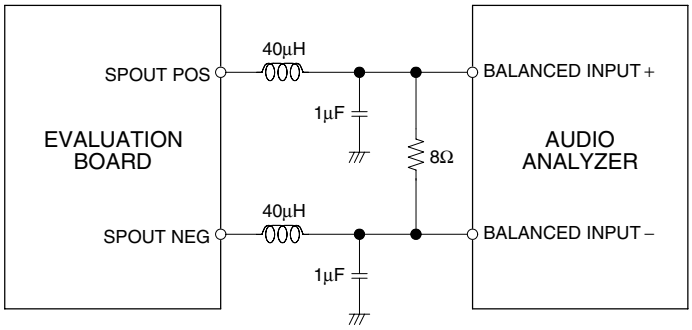
Analog output characteristics (OUTP, OUTN)

Parameter	Symbol	Conditions	Rating			Unit
			min	typ	max	
Voltage gain 1	A_1	TM1 = TM2 = LOW, reference input amplitude 1	2.5	4.5	6.5	dB
Voltage gain 2	A_2	TM1 = HIGH, TM2 = LOW, reference input amplitude 2	10.0	12.0	14.0	dB
Residual noise voltage	V_{NS}	TM1 = TM2 = LOW, input and VREF1 connected by 600Ω	–	68	90	μVrms
Total harmonic distortion + noise	THD + N	P_O = 0.2W, reference input amplitude 1	–	0.4	1.0	%
Maximum output power	P_{OMAX}	Output power when THD = 10%	0.6	0.7	0.8	W
Mute-mode output voltage	V_{MUTE}	Output power when MUTEN = LOW	– 90.0	– 110	–	dBV
HIGH-level output voltage	V_{OH}		V_{DDP} – 0.1	V_{DDP} – 0.02	V_{DDP}	V
LOW-level output voltage	V_{OL}		0	0.02	0.1	V
Efficiency	E_{EF}	Maximum output power conditions	80	83	–	%

Reference voltage characteristics (VREF1)

Parameter	Symbol	Rating			Unit
		min	typ	max	
Reference output voltage 1	V_{REF1}	$0.45V_{DDS}$	$0.5V_{DDS}$	$0.55V_{DDS}$	V

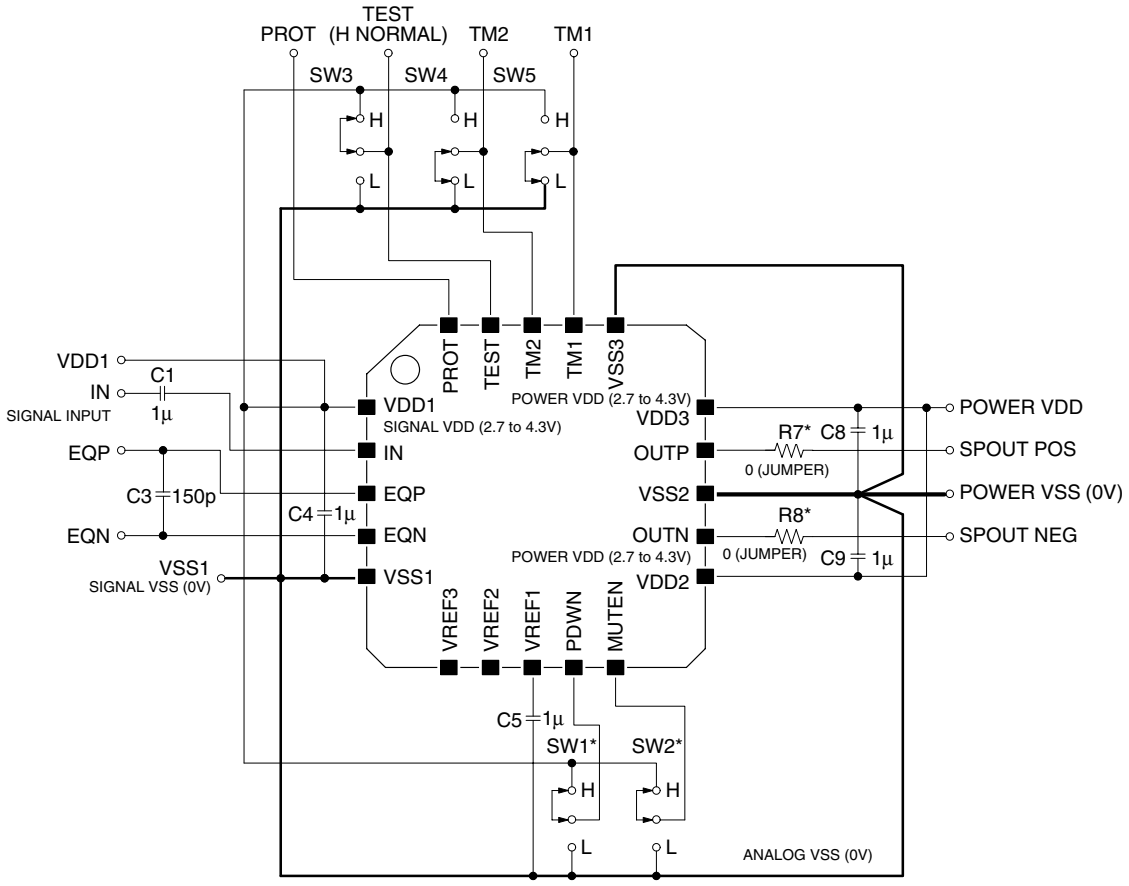
Measurement block diagram



Measurement conditions

Parameter	Audio Analyzer (Audio Precision System Two Cascade) Built-in Filters
Excluding residual noise	Low-pass filter (20kHz) ON High-pass filter (22Hz) ON
Residual noise voltage	Low-pass filter (20kHz) ON High-pass filter (22Hz) ON A-weighted

Measurement circuit



Note. *C2, C6, C7: not inserted
*R1, R2, R3: not inserted
*R7, R8: series resistors for dielectric speaker
*SW1: HIGH = Power on, LOW = Power off
*SW2: LOW = Mute on, HIGH = Mute off

D-Range CP MODE		
	TM1	**TM2**
OFF	L	L
1	H	L
2	L	H
3	H	H

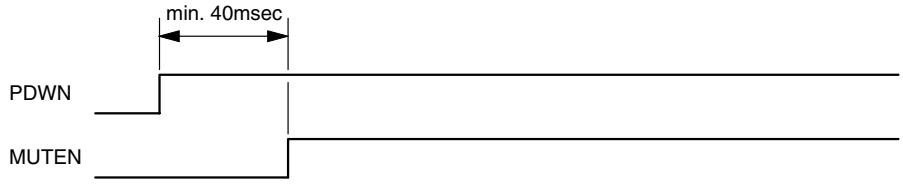
FUNCTIONAL DESCRIPTION

Power-down (PDWN)

The device enters power-down mode when PDWN goes LOW. When powered-down, the outputs become high impedance and the internal oscillation stops. In power-down mode, the MUTEN pin should be held LOW.

Mute (MUTEN)

Mute operation occurs when MUTEN goes LOW. In mute mode, the outputs become high impedance. During mute operation, the protection circuit operation is disabled, but the outputs are protected against output short circuits by their high impedance state. When power is applied, MUTEN should be held LOW for a short interval, shown in the timing diagram below, to prevent pop noise from the speaker. Also, applying and releasing mute operation after power is applied can occur at high speed without generating pop noise.



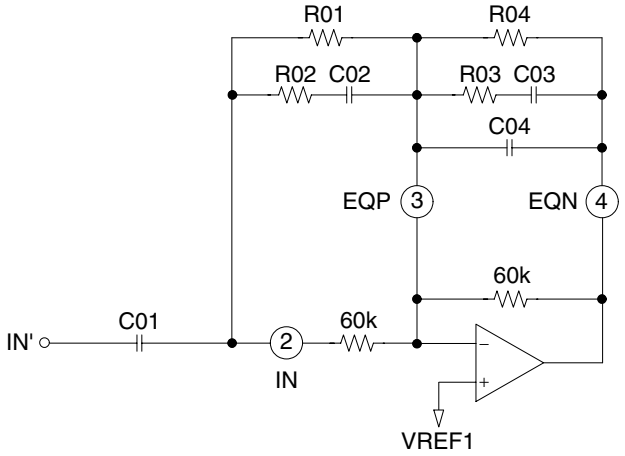
Note. VREF1 load capacitance = 1µF

Protection Circuit

The protection circuit operates if there is an output short-circuit to the supply, short-circuit to ground, or other excessive load abnormal condition lasting longer than approximately 1µs. Normal operation resumes after approximately 5 seconds. When the protection circuit becomes active, the PROT output goes HIGH and the outputs become high impedance.

Input Equalizer (IN, EQP, EQN)

An input equalizer network can be connected to pins IN, EQP, and EQN, as shown in the input equivalent circuit and equalizer circuit below.



The frequency response of the equalizer circuit is given by the following equation, where f is the frequency.

$$\text{Response} = 20 \times \log_{10} \left[\frac{\dfrac{1}{\dfrac{1}{60000} + \dfrac{1}{\text{R03} + \dfrac{1}{2\pi f \text{C03}}} + \dfrac{1}{\text{R04}} + 2\pi f \text{C04}}}{\dfrac{1}{2\pi f \text{C01}} + \dfrac{1}{\dfrac{1}{60000} + \dfrac{1}{\text{R01}} + \dfrac{1}{\text{R02} + \dfrac{1}{2\pi f \text{C02}}}}} \right] \text{[dB]}$$

Dynamic Range Compression Mode (TM1, TM2)

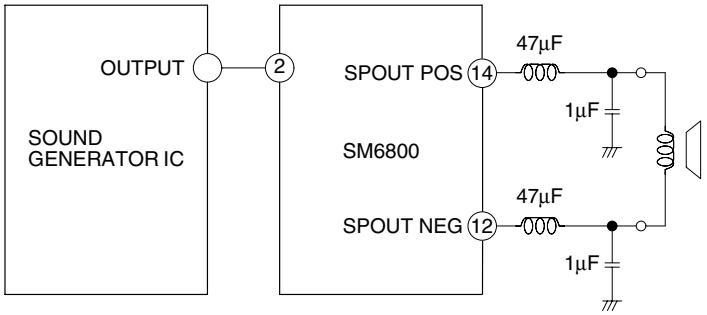
The dynamic range compression mode is selected by the state of the TM1 and TM2 inputs. When a compression mode is used, the gain for small input signals is increased while large input signals are converted using a curve that performs soft-clipping. This increases the average sound pressure level emitted from the speaker during playback.

Dynamic range compression mode	TM1	TM2	Effect
OFF	L	L	No effect
1	H	L	Small effect
2	L	H	Medium effect
3	H	H	Large effect

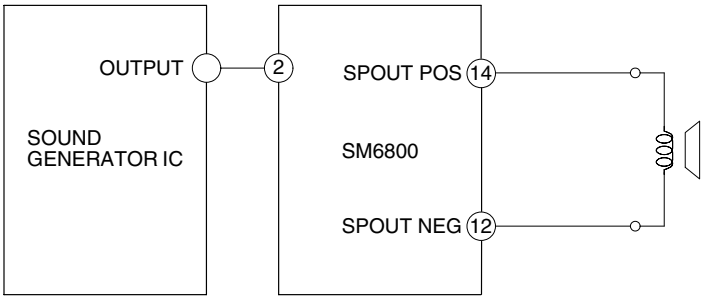
TYPICAL APPLICATION CIRCUITS

Dynamic Speaker

LC-type LPF connection

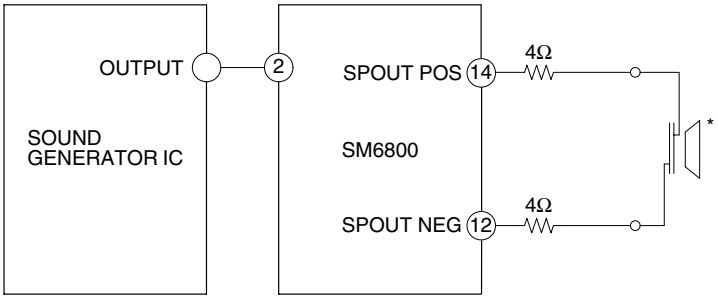


Direct connection



Dielectric Speaker

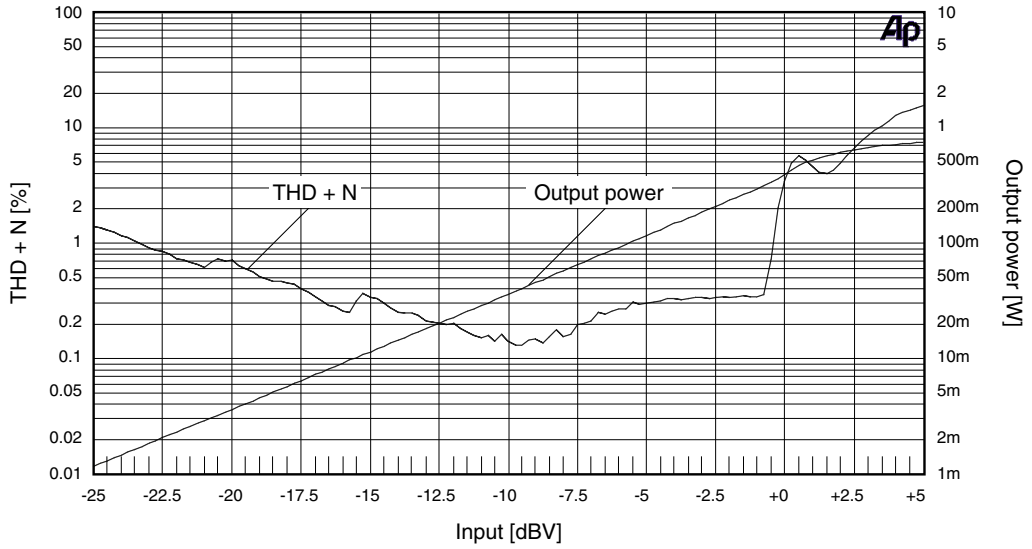
A dielectric speaker is capacitive in nature, and therefore requires output resistor connection.



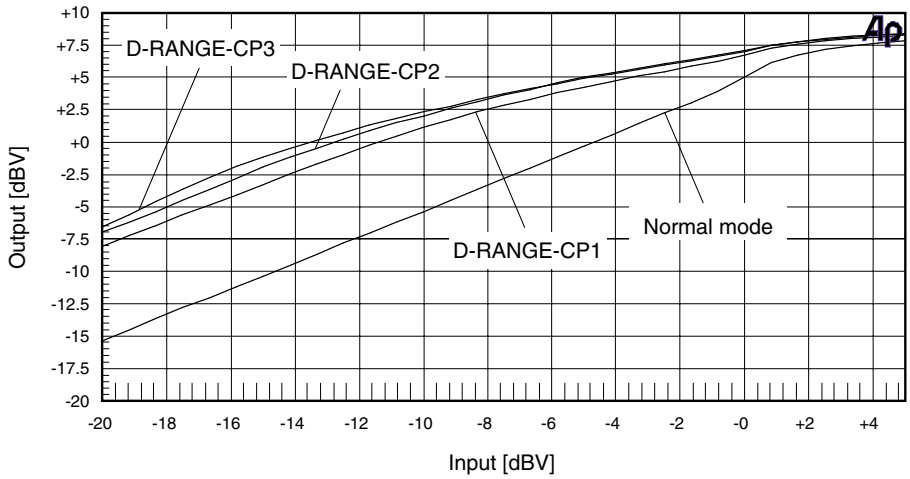
* Dielectric speaker
Taiyo Yuden MLS20070, MLS23070, MLS25070 or similar

TYPICAL CHARACTERISTICS

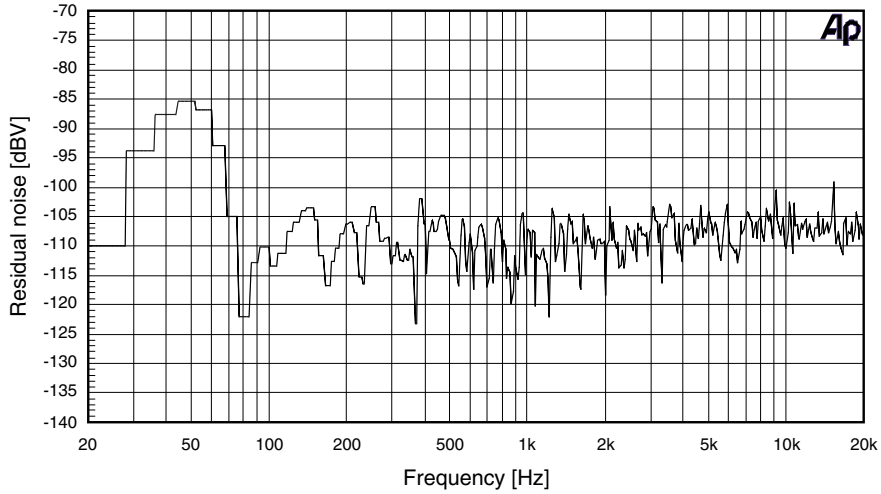
Measurement conditions: Refer to “Analog output characteristics”.
Measurement circuit: Refer to “Measurement circuit”.



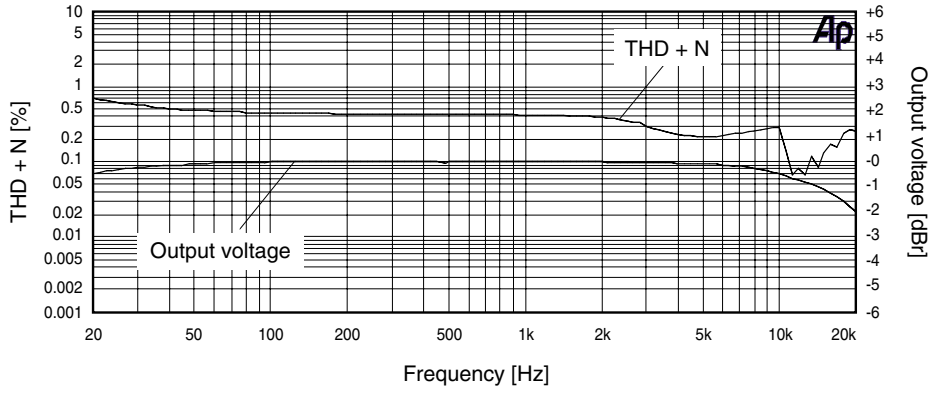
Input vs. THD + N and Output power (V_{DD} = 3.6V)



Input vs. Output (V_{DD} = 3.6V)



Residual noise vs. Frequency (V_{DD} = 3.6V)



THD + N and Output voltage vs. Frequency (V_{DD} = 3.6V)

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