Small-sized Class-D Speaker Amplifiers

Analog Input Stereo Class-D Speaker Amplifier

BD5471MUV

No.10101EAT03

●Description

BD5471MUV is a low voltage drive class-D stereo speaker amplifier that was developed for note-book PC, cellular phone, mobile audio products and the others. LC filters of speaker outputs are unnecessary, and only 7 external components are needed for speaker system. Also, 3.3V regulator in BD5471MUV can use power supply for audio-codec. BD5471MUV, that is high-efficiency, low consumption, is suitable for application by using battery. Shutdown current is 0μA typically. Also, start-up time is fast from shutdown to active mode. BD5471MUV can use for some applications that change mode between "shutdown state" and "active state".

●Features

1) High power 2.3W typ. (VDD=5V, RL=4Ω, THD+N=10%, stereo input)
   High power 1.5W typ. (VDD=5V, RL=8Ω, THD+N=10%, stereo input)
2) Gain selectable by the external control (6, 12, 18, 24dB)
3) Pop noise suppression circuitry
4) Standby function (Mute function) [I_{SD}=0uA]
5) Protection circuitry (Short protection [Audio, REG], Thermal shutdown, Under voltage lockout)
6) Built-in 3.3V regulator
7) Built-in BEEP detect circuitry
8) Very small package VQFN024V4040

●Applications

Notebook computers,Mobile electronic applications,Mobile phones,PDA etc.

●Absolute Maximum Ratings(Ta=+25℃)

Parameter	Symbol	Ratings	Unit
Power Supply Voltage	VDD	7.0	V
Power Dissipation	Pd	0.7 *1	W
		2.2 *2	W
Storage Temperature Range	Tstg	-55 ~ +150	℃
Input Voltage Range *3	Vin	-0.3 ~ VDD+0.3	V
Control Terminal Input Voltage Range *4	Vctl	-0.3 ~ VDD+0.3	V

*1 74.2mm × 74.2mm × 1.6mm, FR4 1-layer glass epoxy board(Copper on top layer 0%)
Derating in done at 5.6mW/℃ for operating above Ta=25℃. There are thermal via on the board
*2 4.2mm × 74.2mm × 1.6mm, FR4 4-layer glass epoxy board (Copper on bottom 2 and 3 layer 100%)
*3 input Terminal (INL+, INL-, INR+, INR-)
*4 Control Terminal (MUTE, G0, G1, EAPD, BEEP, REG_SD)

●Operating Conditions

Parameter	Symbol	Ratings	Unit
Power Supply Voltage	VDD	+4.5 ~ +5.5	V
Temperature Range	Topr	-40 ~ +85	℃

* These products aren't designed for protection against radioactive rays.

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●**Electric Characteristics**(Unless otherwise specified, Ta=+25℃, VDD=+5.0V, RL=8Ω, AC item= LC Filter(L=22μH, C=1μF))

Parameter		Symbol	Limits			Unit	Conditions
			MIN.	TYP.	MAX.		
Circuit current (Active)		I_{CC}	—	5.5	12.0	mA	Active mode, MUTE=H, EAPD=H, No load
Circuit current (Standby)		I_{STBY}	—	0.1	1.0	mA	Standby mode, MUTE=H,EAPD=L
Circuit current (Regulator)		I_{CCR}	—	0.15	1.0	mA	Regulator Mode, MUTE=EAPD=L REG_SD=H
Circuit current (Shutdown)		I_{SD}	—	0.1	2.0	μA	Shutdown mode, MUTE=L, REG_SD=L
<Speaker Amplifier>							
Output power 1		P_{O1}	0.8	1.2	—	W	BTL, f=1kHz, THD+N=1%, Stereo input, *1, *2
Output power 2		P_{O2}	1.0	1.5	—	W	BTL, f=1kHz, THD+N=10%, Stereo input, *1, *2
Voltage gain		GV	5.5	6.0	6.5	dB	BTL, G0=G1=GND
			11.5	12	12.5	dB	BTL, G0=GND, G1=VDD
			17.5	18	18.5	dB	BTL, G0=VDD, G1=GND
			23.5	24	24.5	dB	BTL, G0=G1=VDD
Total harmonic distortion		THD+N	—	0.2	1.0	%	BTL, Po=0.7*P_{O1} *1, *2
Crosstalk		C_T	60	70	—	dB	BTL, f=1kHz *1, *3
S/N		SNR	70	90	—	dB	BTL, Po=P_{O1} *1, *3
Switching Frequency		fosc	175	250	325	kHz	
Start-up time		Ton	0.78	1.02	1.46	msec	
Input resistance		R_{IN}	63	90	117	kΩ	G0=G1=GND
			42	60	78	kΩ	G0=GND, G1=VDD
			25	36	47	kΩ	G0=VDD, G1=GND
			14	20	26	kΩ	G0=G1=VDD
<Regulator>							
Output voltage		Vo	3.15	3.30	3.45	V	Io=150mA
Maximum output current		Iom	150	200	—	mA	Vo=3.15V
Load regulation		L_{REG}	—	0.2	1	mV/mA	Io=0→150mA
<Control terminal (MUTE, G0, G1, EAPD, BEEP, REG_SD) >							
Control terminal input voltage	High-level	V_{CTLH}	1.4	—	VDD	V	
	Low-level	V_{CTLL}	0	—	0.4	V	
Control terminal input current		I_{CTL}	22	33	44	μA	Control terminal Input voltage V_{CTL}=5V

*1: B.W.=400 ~ 30kHz, BTL:The voltage between 3pin and 6pin, 13pin and 16pin

●**Active / Standby Control**

Mode	Pin level	Conditions
MUTE	H/L	IC active/ shutdown
EAPD	H/L	IC active/standby
BEEP	H/L	IC active/standby
REG_SD	H/L	REG active/shutdown

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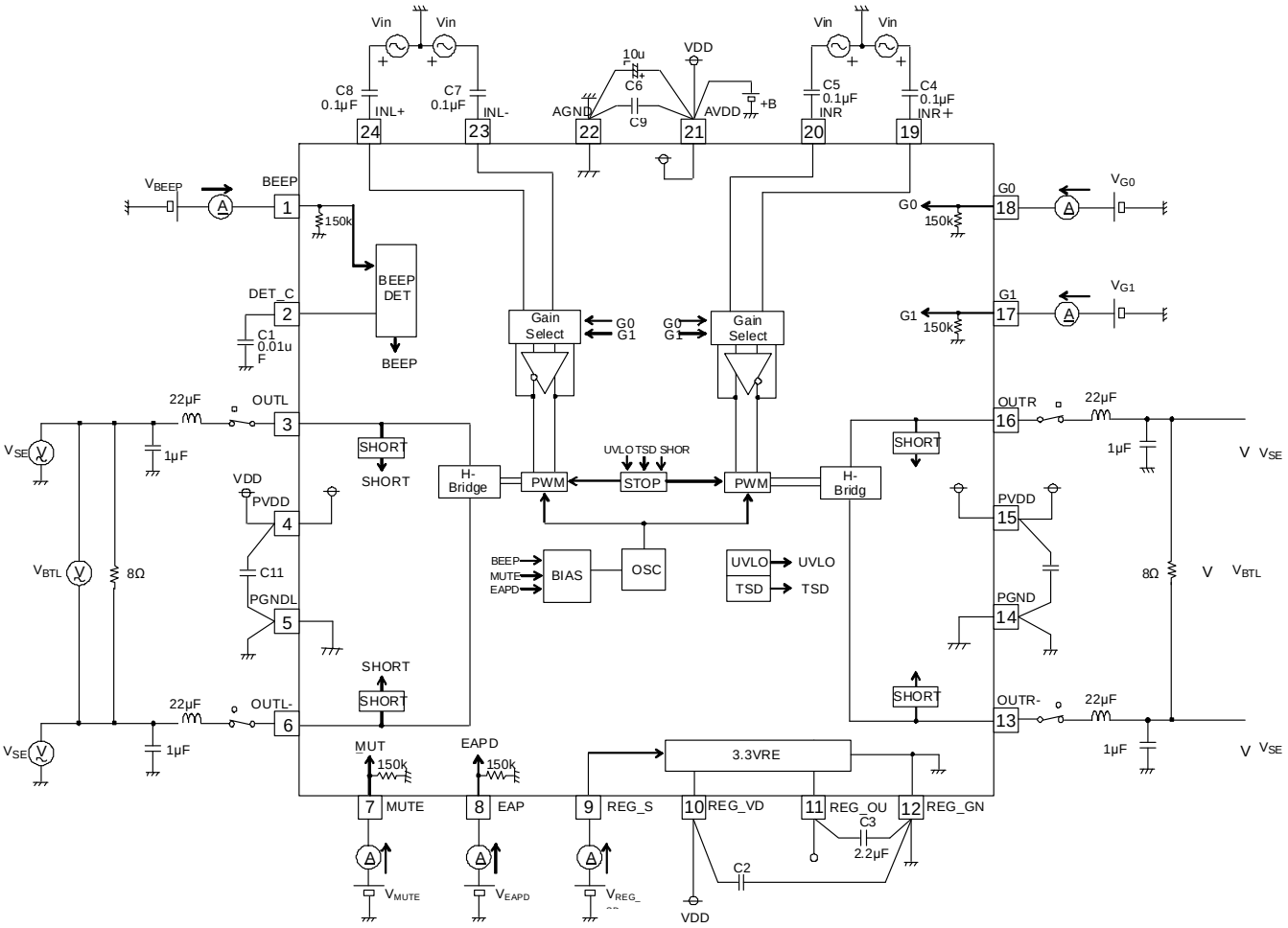
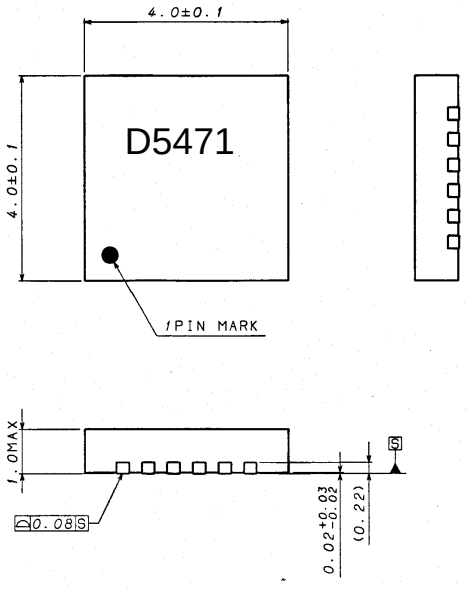
●Measurement Circuit Diagram

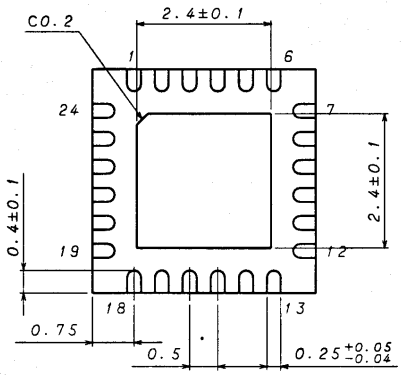


●Package Outlines

Top View



Bottom View



(Unit: mm)

VQFN024V4040 (Plastic Mold)

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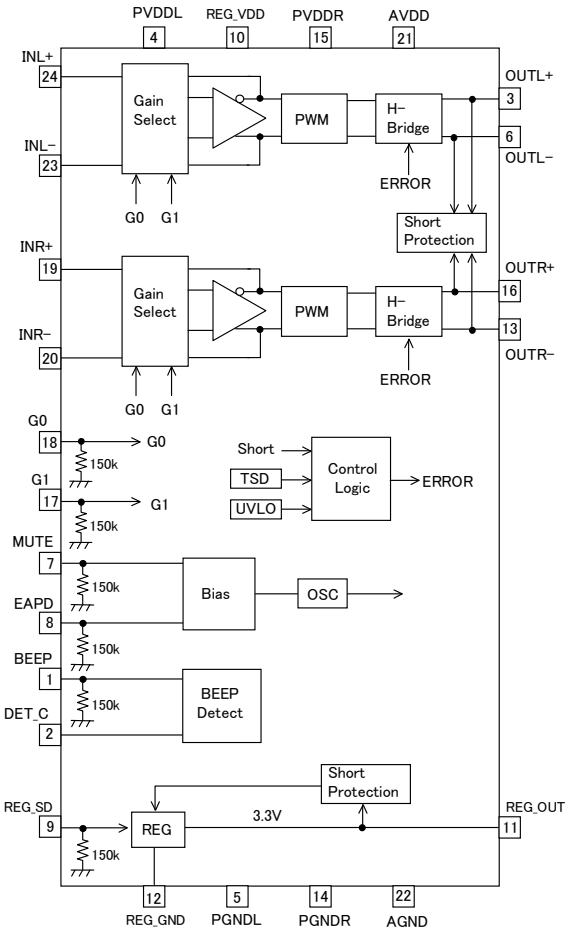
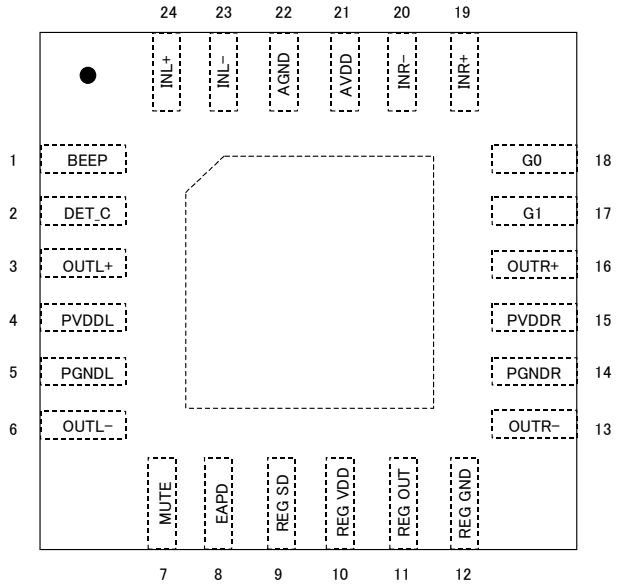
●Block Diagram



●Pin Assignment <top view>



●Pin Assignment Table

PIN No.	PIN Name
1	BEEP
2	DET_C
3	OUTL+
4	PVDDL
5	PGNDL
6	OUTL-
7	MUTE
8	EAPD
9	REG_SD
10	REG_VDD
11	REG_OUT
12	REG_GND
13	OUTR-
14	PGNDR
15	PVDDR
16	OUTR+
17	G1
18	G0
19	INR+
20	INR-
21	AVDD
22	AGND
23	INL-
24	INL+

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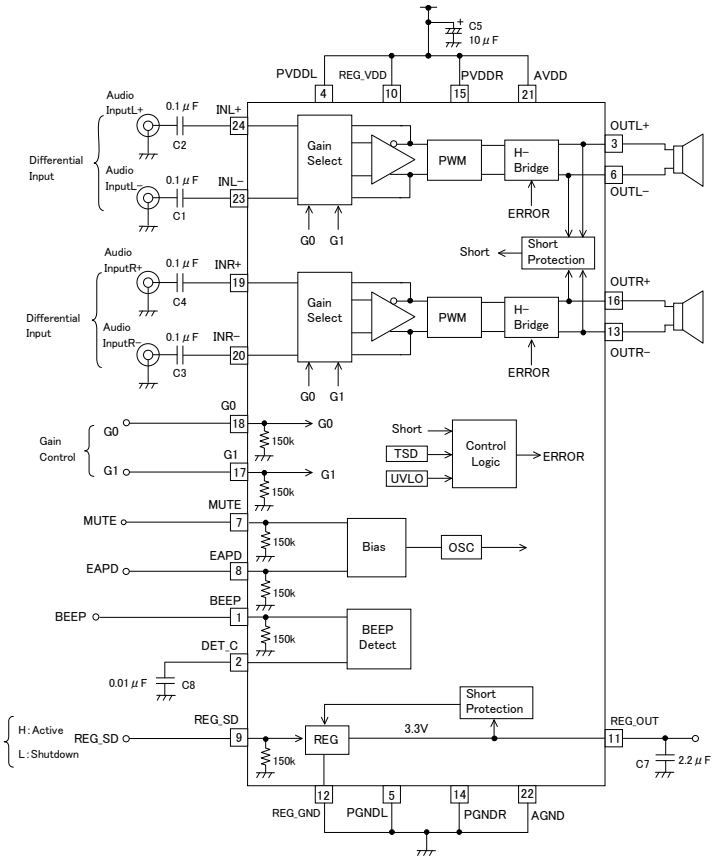
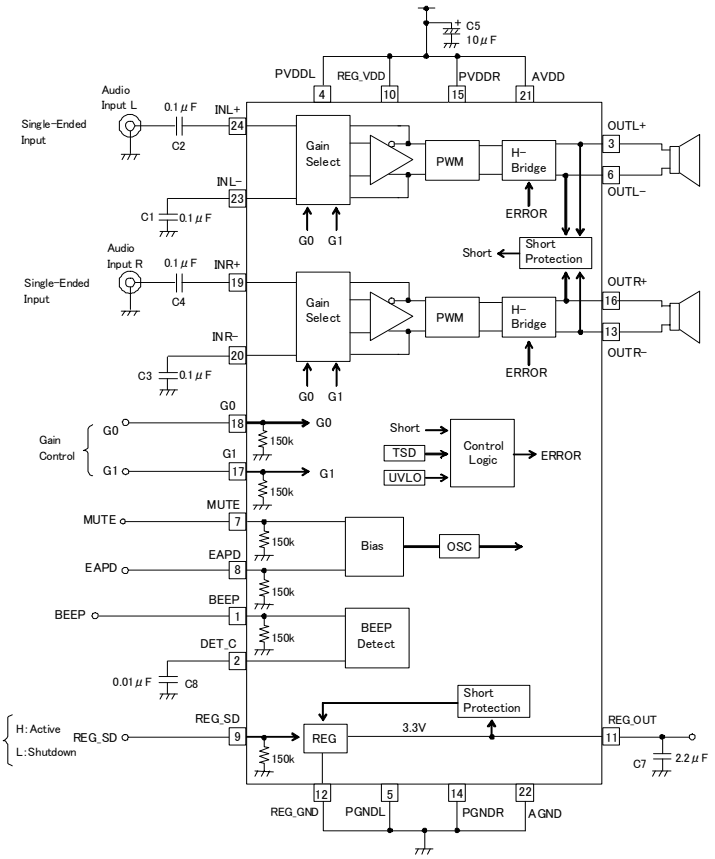
●Application Circuit Example



Differential input



Single-Ended input

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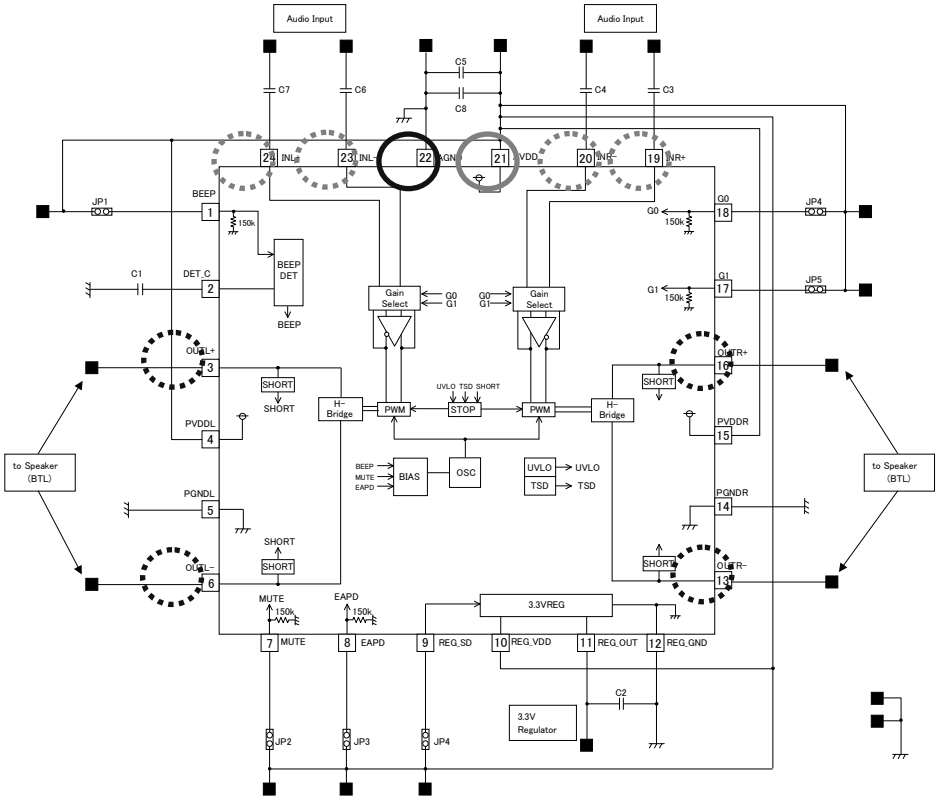
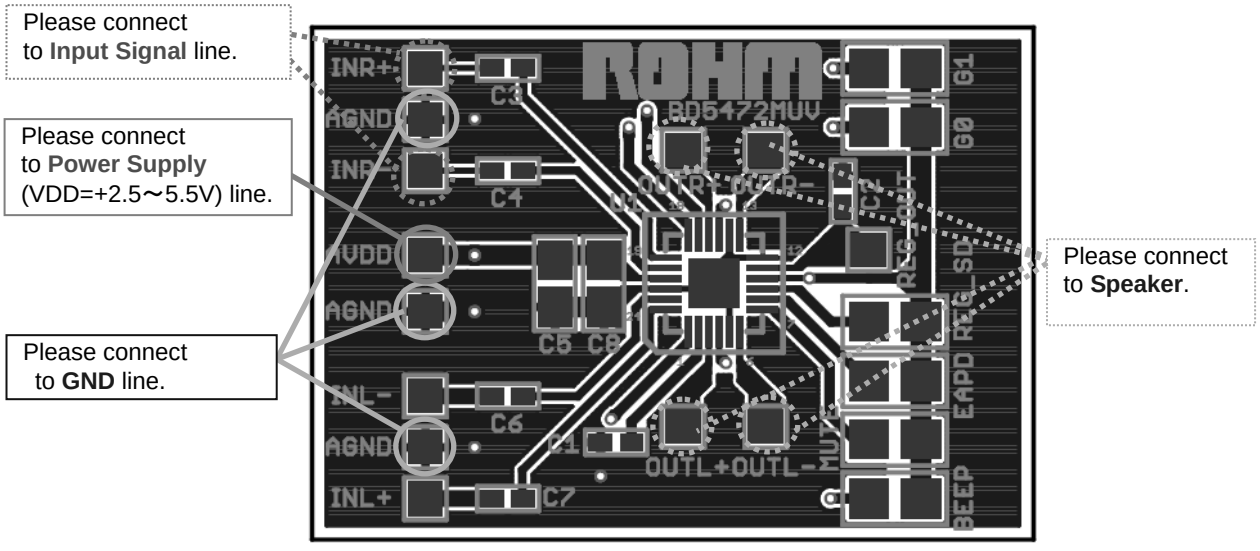
●Evaluation board Circuit Diagram





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●Evaluation board Parts List

Qty.	Item	Description	SMD Size	Manufacturer/Part Number
1	C1	Capacitor, 0.01μF	1608	Murata GRM188R71C103KA01D
1	C2	Capacitor, 2.2μF	1608	Murata GRM188R61C225KE15D
2	C3, C4,C6,C7	Capacitor, 0.1μF	1608	Murata GRM188R71C104KA01D
1	C5, C8	Capacitor, 10μF	A (3216)	ROHM TCFGA1A106M8R
1	U1	IC, BD5471MUV, Stereo Class-D audio amplifier	4.0mm X 4.0mm VQFN Package	ROHM BD5471MUV
1	PCB1	Printed-circuit board, BD5471MUV EVM	—	—

●The relation in the gain setting and input impedance Ri

The gain setting terminal (G0,G1)

G0	G1	Gain[dB]	Ri [Ohm]
L	L	6	90k
L	H	12	60k
H	L	18	36k
H	H	24	20k

●Description of External parts

①Power down timing capacitor (C1)

It's the capacitor which adjusts time from BEEP signal stop to amplifier stop.
Turn off time Toff is set the following formula.

$$Toff = \frac{C1 \times 0.8VDD}{5\mu}[ms]$$

②Regulator output capacitor(C2)

Output capacitor of 3.3V regulator.
Use capacitance equal to or more than 1uF.

③Input coupling capacitor Ci (C3,C4, C6,C7)

It makes an Input coupling capacitor 0.1uF.
Input impedance Ri in each gain setting becomes the above table.
In 18dB gain setting, it is Ri=36kΩ(Typ.).
It sets cutoff frequency fc by the following formula by input coupling capacitor Ci (C3,C4, C6,C7) and input impedance Ri

$$fc = \frac{1}{2\pi \times Ri \times Ci}[Hz]$$

In case of Ri=36kΩ, Ci=0.1uF, it becomes fc=about 44Hz.

④The power decoupling capacitor (C5,C8)

It makes a power decoupling capacitor 10uF.
When making capacitance of the power decoupling capacitor small, there is an influence in the Audio characteristic.
When making small, careful for the Audio characteristic at the actual application.

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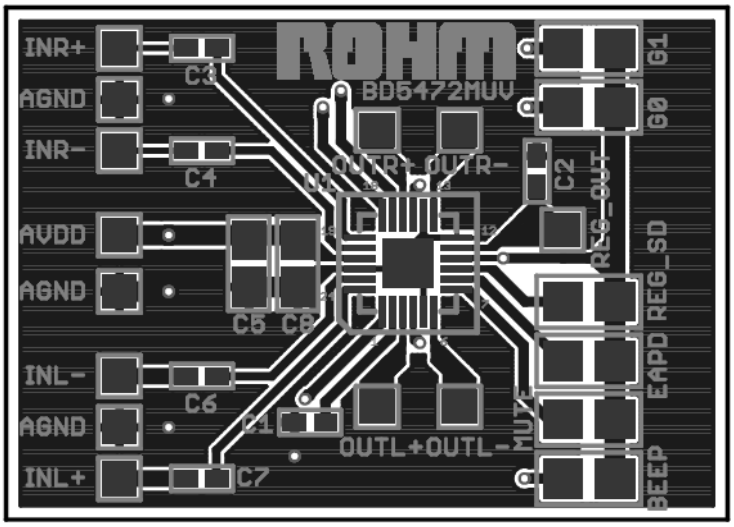
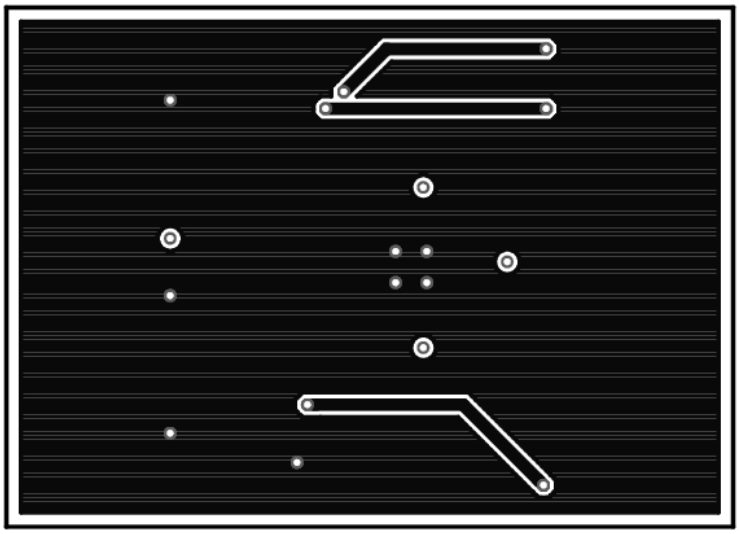
●Evaluation board PCB layer

Top Layer



Bottom Layer



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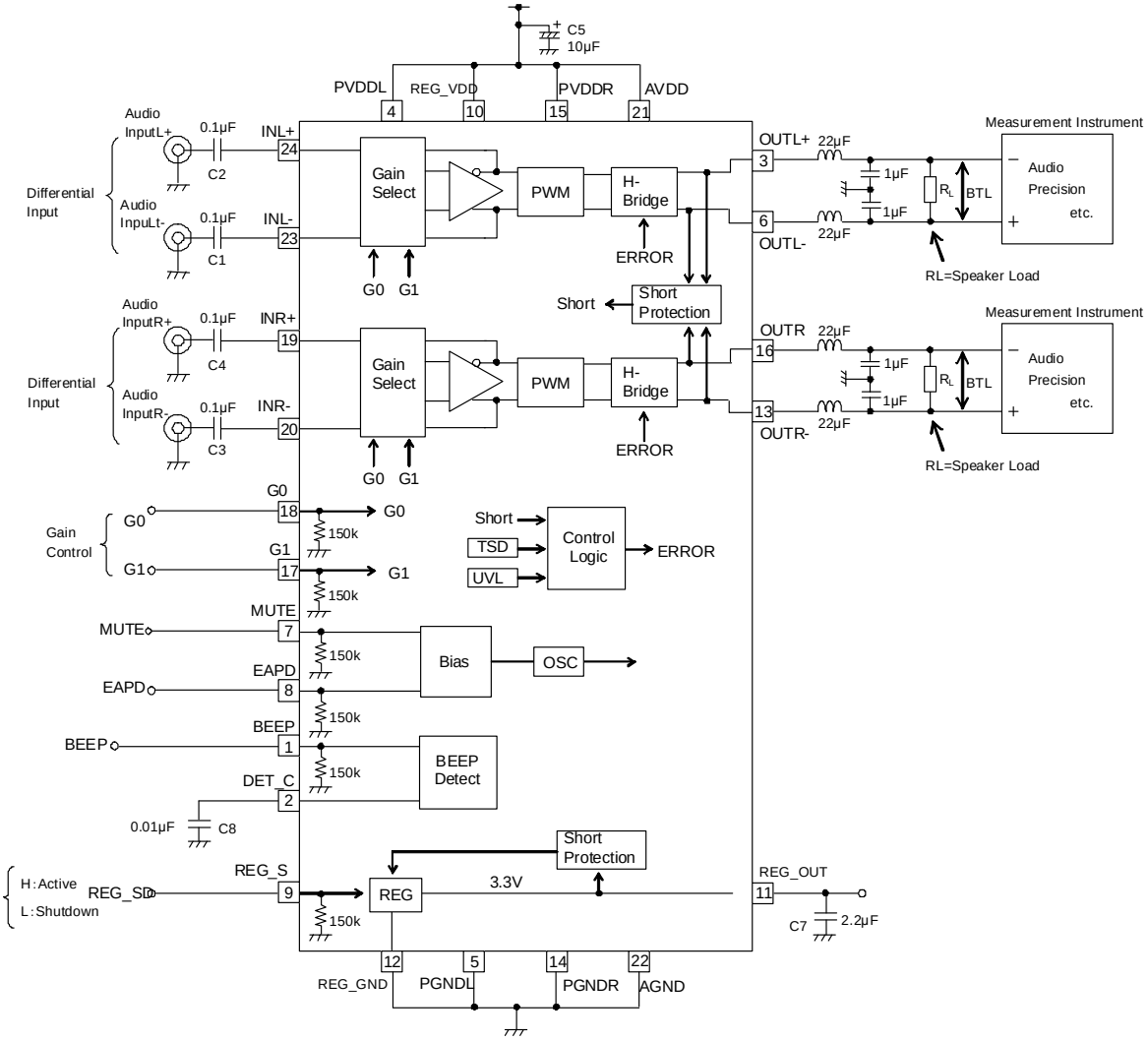
●The way of evaluating Audio characteristics

Evaluation Circuit Diagram



When measuring Audio characteristics, insert LC filter during the output terminal of IC and the speaker load and measure it. it. Arrange LC filter as close as possible to the output terminal of IC.
In case of L=22 μ H, C=1 μ F, the cutoff frequency becomes the following.

$$fc = \frac{1}{2\pi\sqrt{LC}} [Hz]$$

=33.9[kHz]

Use a big current type - Inductor L.

(Reference)
TDK: SLF12575T-220M4R0

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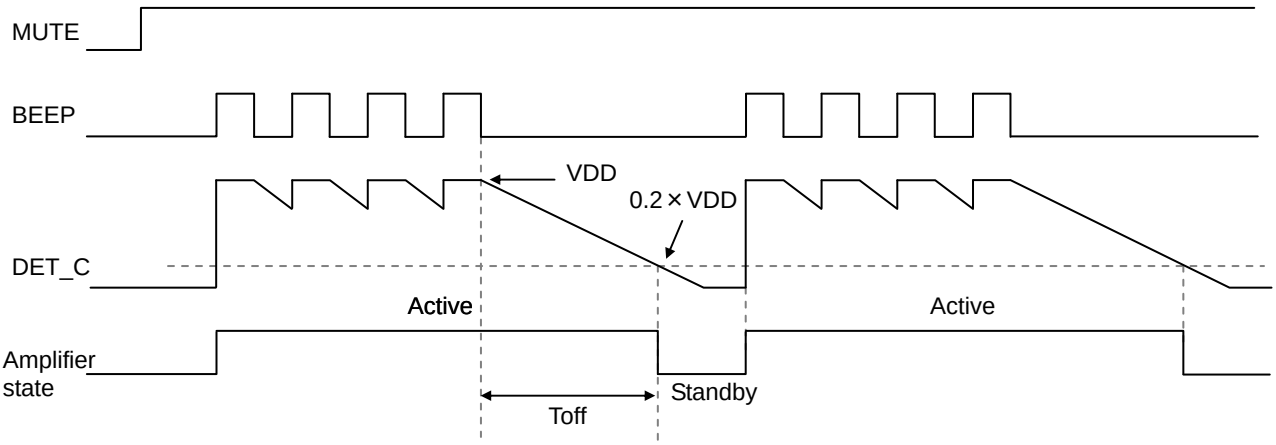
●BEEP Detection Function

This IC has BEEP detection.
When inputting beep signal to 1pin BEEP terminal at standby mode, amplifier becomes standby to active.
When beep signal stops, amplifier becomes active to standby.
It is adjustable the time(Toff) from beep signal stop to amplifier standby by a capacitance connect to 2pin DET_C terminal.
If no need to use BEEP detection, make 1pin BEEP terminal open or connect to GND.



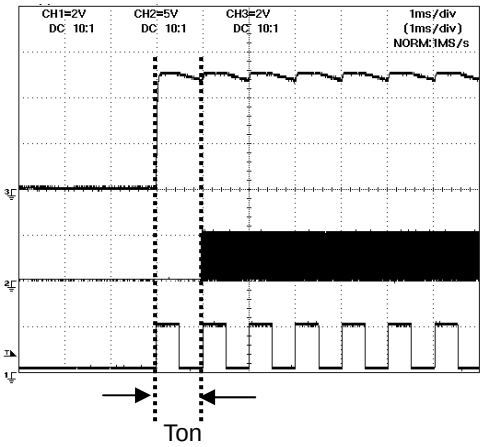
Toff calculation fomula

$$Toff = \frac{C \times 0.8VDD}{5u} \quad [msec]$$

Example C=0.01u, VDD=5V → Toff=8msec

C: Condenser to connect to a 2pin

MUTE=H, BEEP signal input

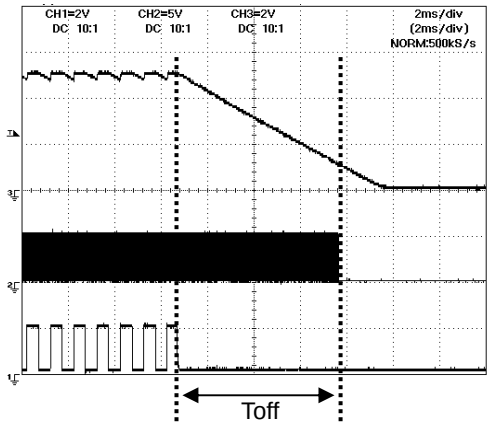


DET_C 2V/div

OUTL+ 5V/div

BEEP 5V/div

MUTE=H, BEEP signal stop



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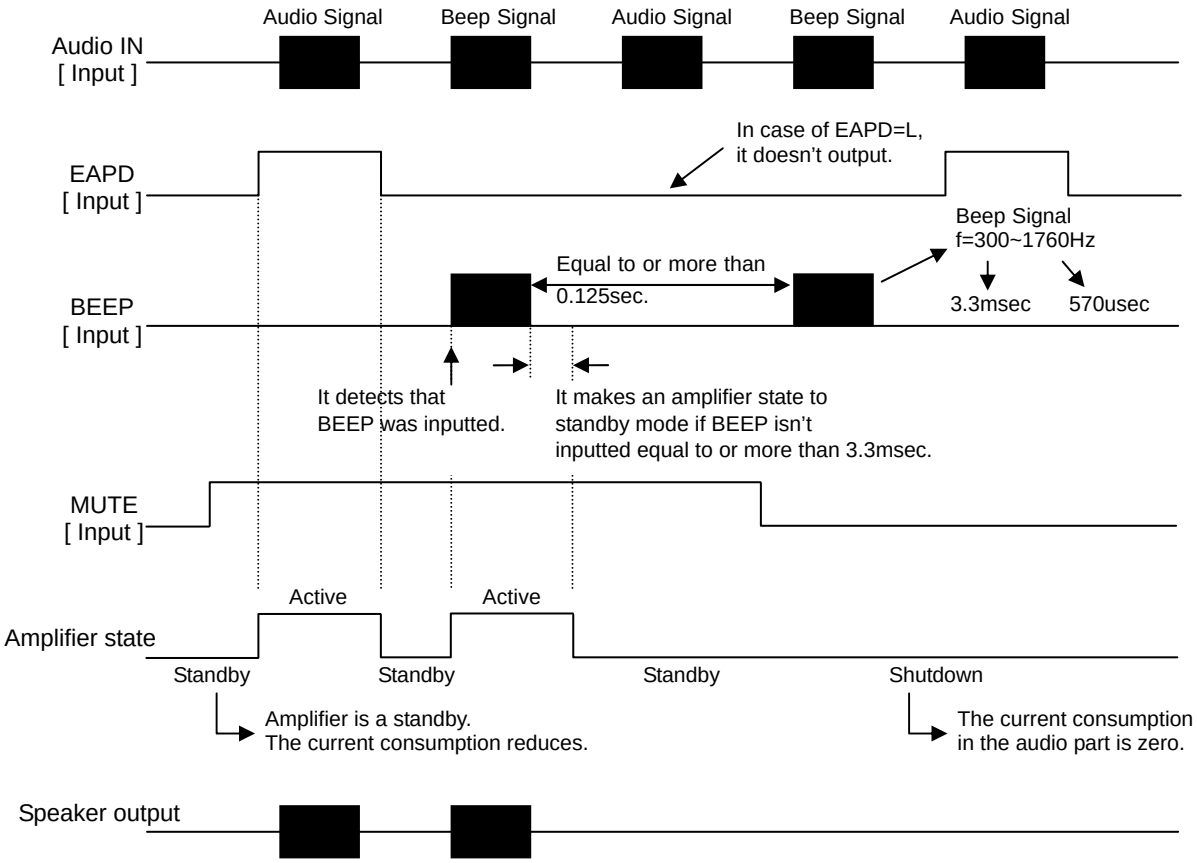
●Cntrol Terminal and output



Input				Output	
MUTE	EAPD	BEEP	Audio IN	Amplifier state	Speaker output
L	L	L	No signal	L(Shutdown)	Hiz
L	L	L	signal	L(Shutdown)	Hiz
L	L	H	No signal	L(Shutdown)	Hiz
L	L	H	signal	L(Shutdown)	Hiz
L	H	L	No signal	L(Shutdown)	Hiz
L	H	L	signal	L(Shutdown)	Hiz
L	H	H	No signal	L(Shutdown)	Hiz
L	H	H	signal	L(Shutdown)	Hiz
H	L	L	No signal	L(Standby)	Hiz
H	L	L	signal	L(Standby)	Hiz
H	L	H	No signal	H(Active)	No signal
H	L	H	signal	H(Active)	signal
H	H	L	No signal	H(Active)	No signal
H	H	L	signal	H(Active)	signal
H	H	H	No signal	H(Active)	No signal
H	H	H	signal	H(Active)	signal

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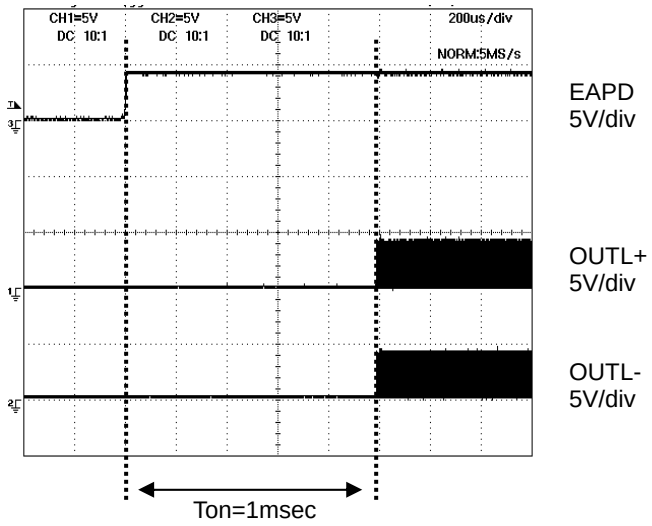
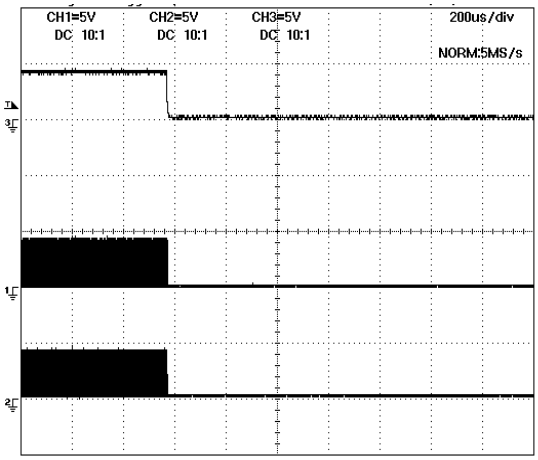
●About output starting and stop

This IC has the cuircuit of pop noise reduction at starting and stop.
Pop noise reduction is realized in controlling to adjust the timing of output at starting and stop.
Turn on time is 1msec.

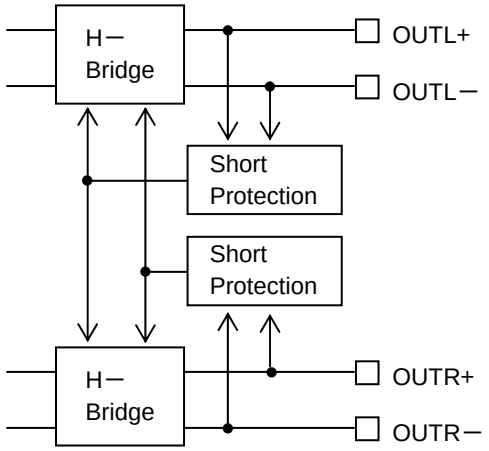
Output starting (MUTE=H, EAPD=L→H)



Output stop (MUTE=H, EAPD=H→L)



●About the short protection



When detecting a short of Lch output,
Lch output stops, and Rch output stops.
Also when detecting a short of Rch output,
Rch output stops, and Lch output stops.

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●About the thermal design by the IC

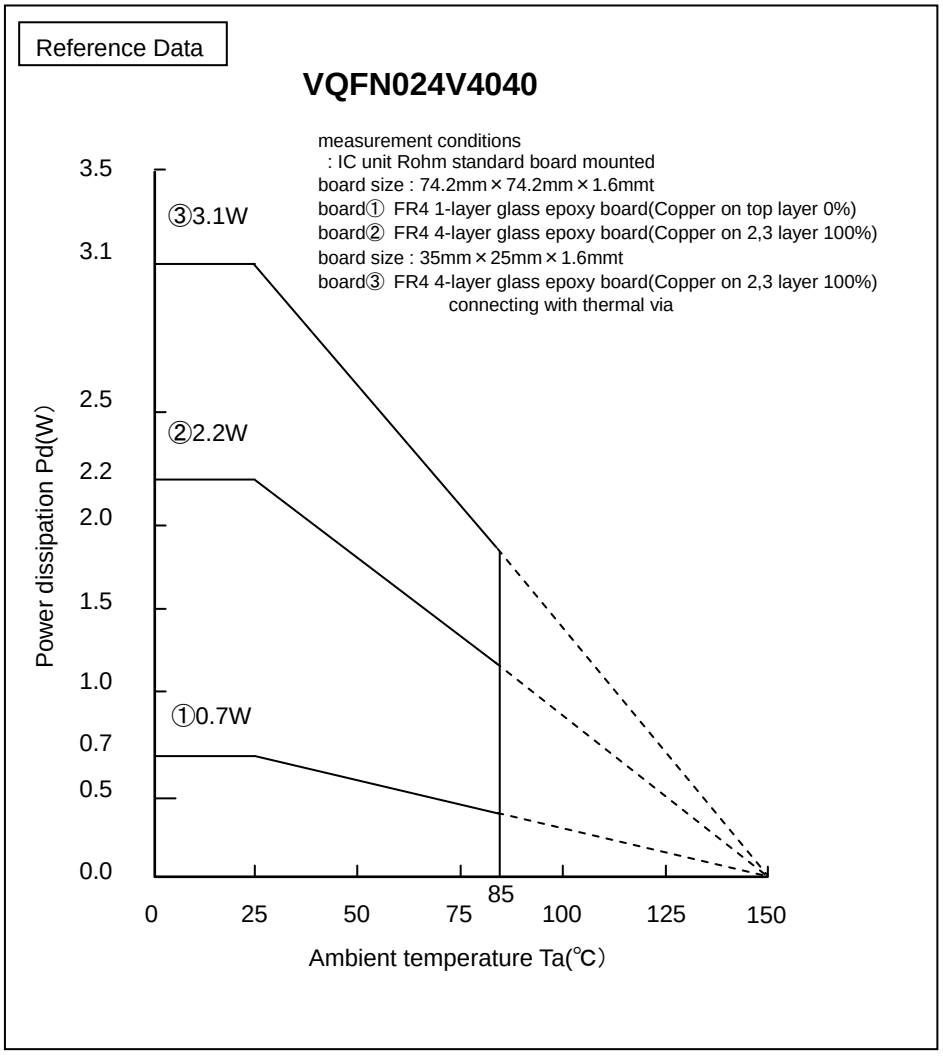
Characteristics of an IC have a great deal to do with the temperature at which it is used, and exceeding absolute maximum ratings may degrade and destroy elements. Careful consideration must be given to the heat of the IC from the two standpoints of immediate damage and long-term reliability of operation. Pay attention to points such as the following.

Since an maximum junction temperature (Tj_{MAX}.)or operating temperature range (Topr) is shown in the absolute maximum ratings of the IC, to reference the value, find it using the Pd-Ta characteristic (temperature derating curve).

If an input signal is too great when there is insufficient radiation, TSD (thermal shutdown) may operate. TSD, which operates at a chip temperature of approximately +180℃, is canceled when this goes below approximately +100℃.

Since TSD operates persistently with the purpose of preventing chip damage, be aware that long-term use in the vicinity that TSD affects decrease IC reliability.

Temperature Derating Curve



Note) Values are actual measurements and are not guaranteed.

Power dissipation values vary according to the board on which the IC is mounted. The Power dissipation of this IC when mounted on a multilayer board designed to radiate is greater than the values in the graph above.

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●Typical Characteristics

TABLE OF GRAPHS

Parameter	Parameter	Figure
Efficiency	vs Output power	1, 2
Power dissipation	vs Output power	3, 4
Supply current (Iccact)	vs Supply voltage	5
Supply current (Istby)	vs Supply voltage	6
Supply current (Ireg)	vs Supply voltage	7
Shutdown current (Isd)	vs Supply voltage	8
Output power (Po)	vs Load resistance	9, 10
	vs Supply voltage	11, 12
Total harmonic distortion plus noise (THD+N)	vs Output power	13, 14
	vs Frequency	15, 16, 17, 18, 19, 20, 21,22
	vs Common-mode input voltage	23, 24
Supply voltage rejection ratio (PSRR)	vs Frequency	25, 26, 27, 28
Common-mode rejection ratio (CMRR)	vs Frequency	29, 30
Gain	vs Frequency	31, 32, 33, 34, 35, 36, 37, 38

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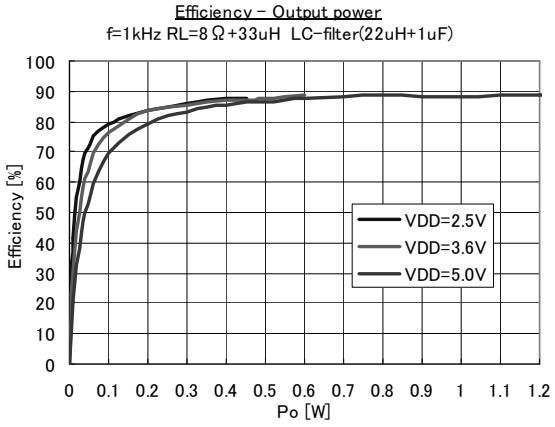

Fig.1

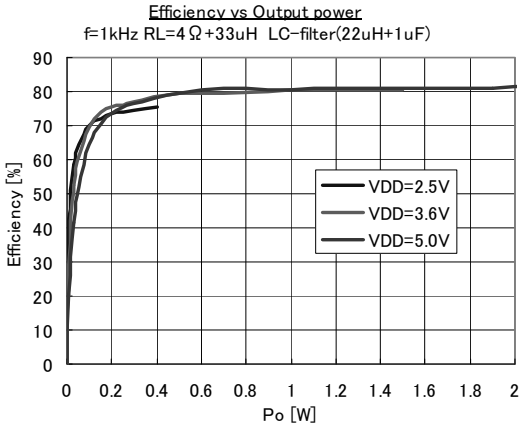

Fig.2

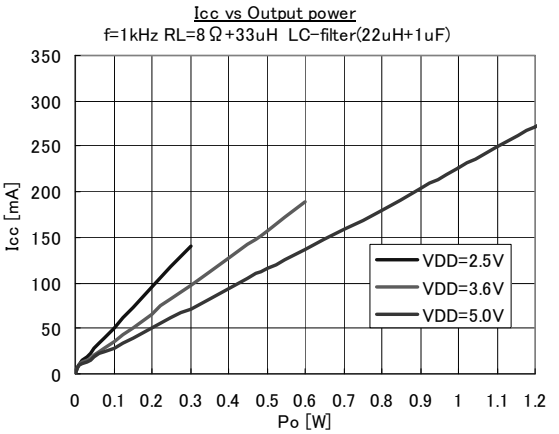

Fig.3

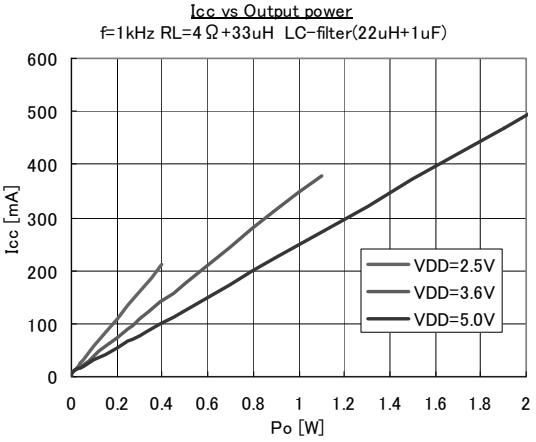

Fig.4

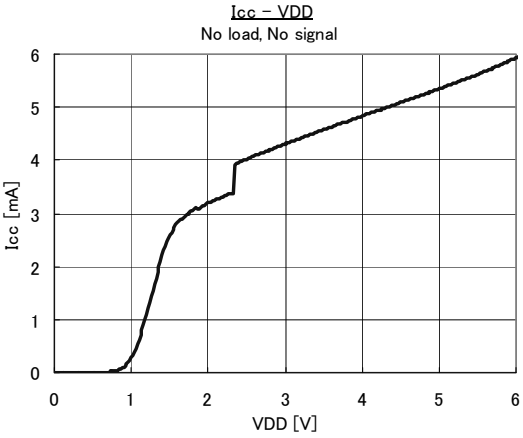

Fig.5

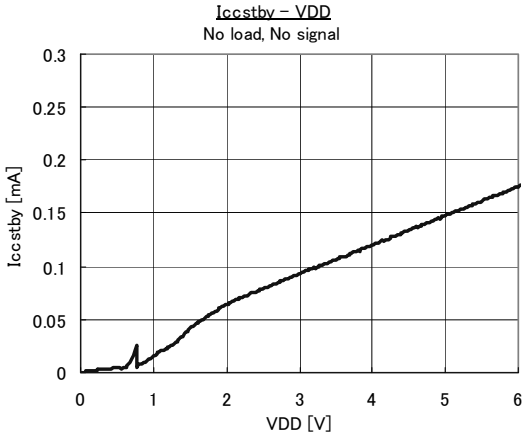

Fig.6

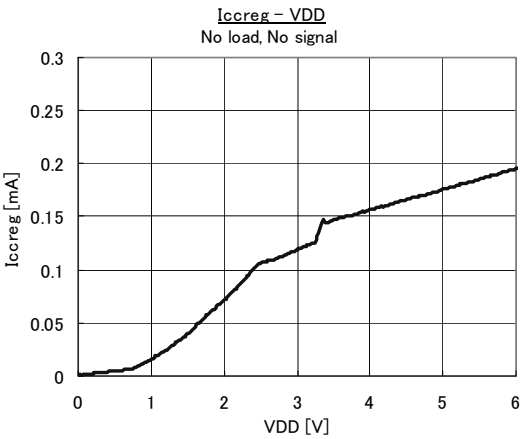

Fig.7

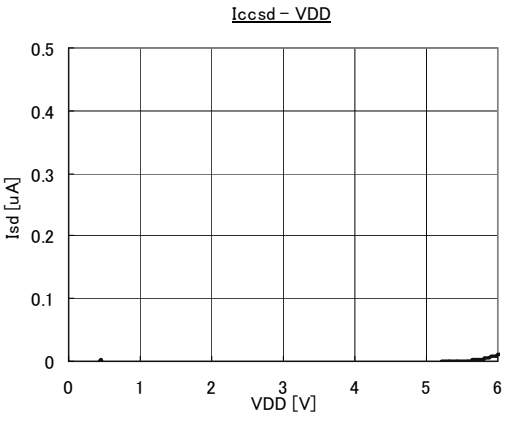

Fig.8

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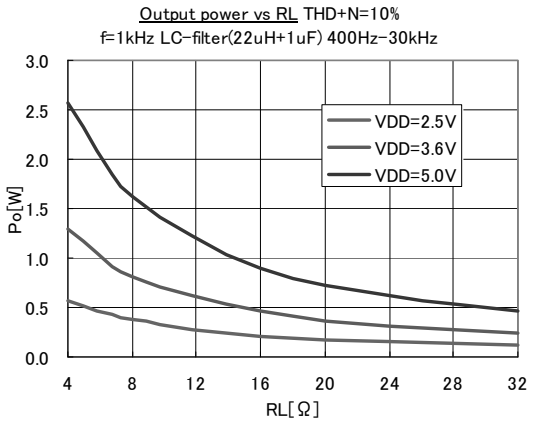


Fig.9

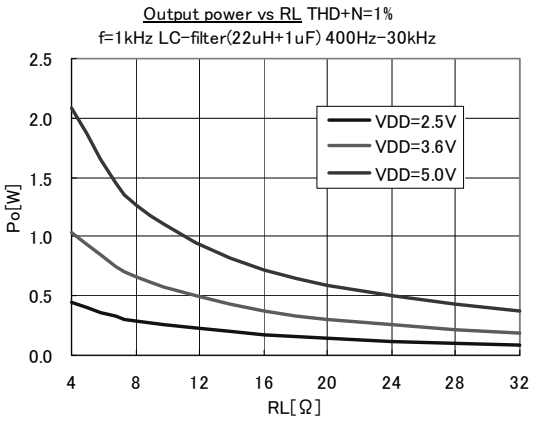
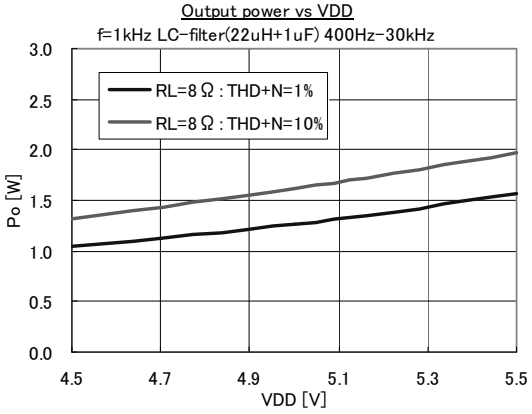


Fig.10



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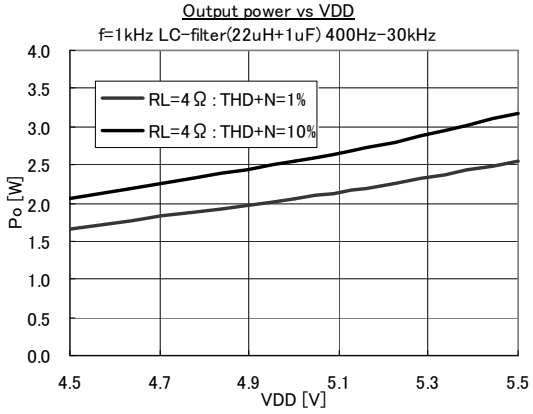

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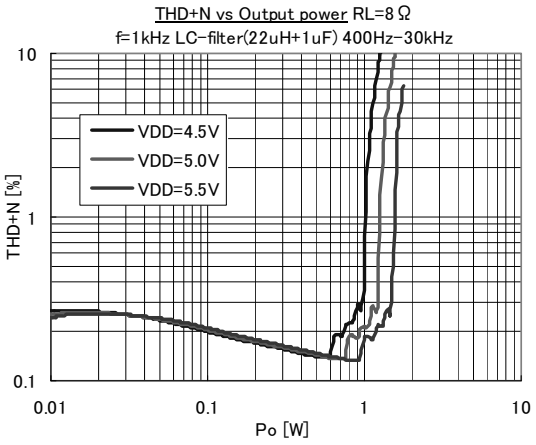

Fig.13

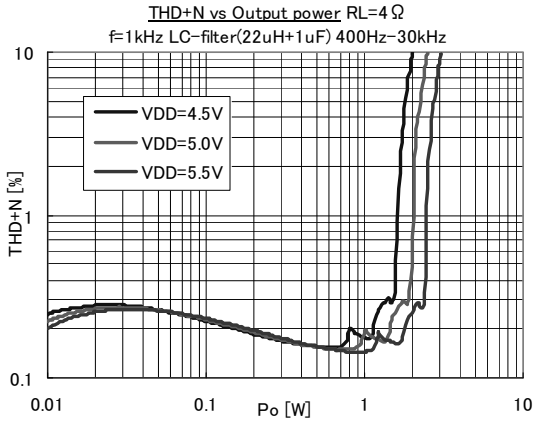

Fig.14

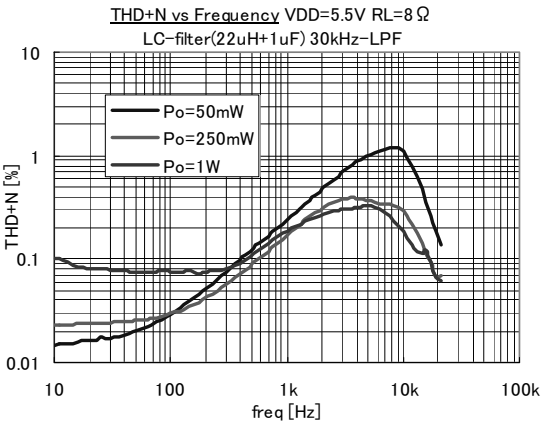

Fig.15

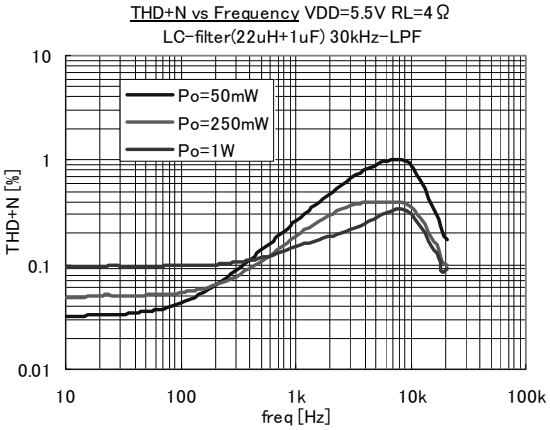

Fig.16

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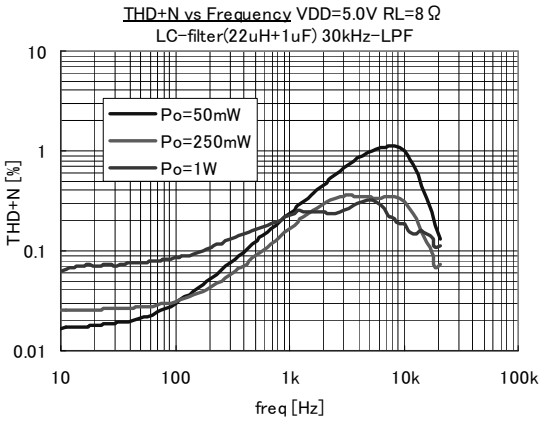
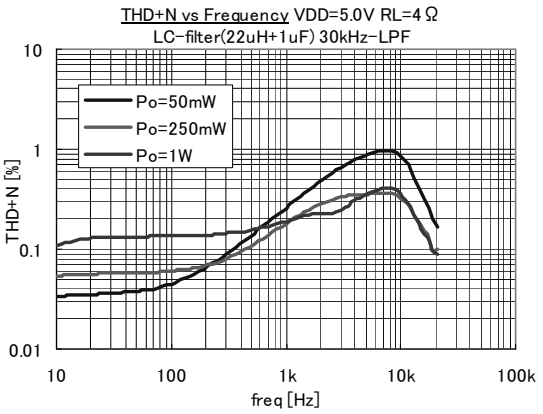


Fig.17



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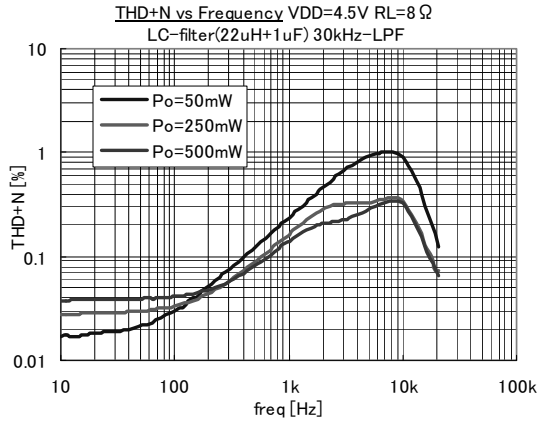

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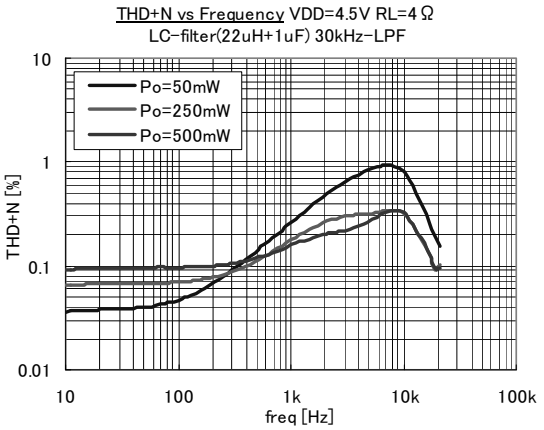


Fig.20

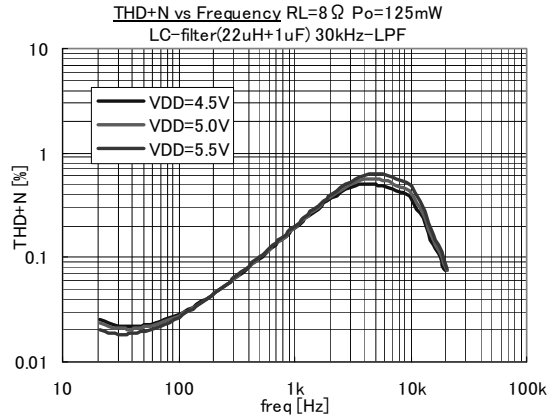


Fig.21

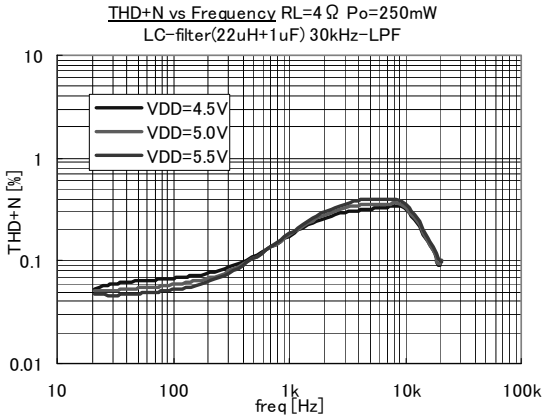
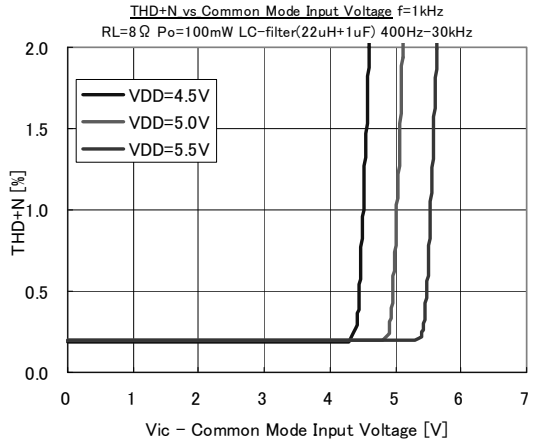


Fig.22



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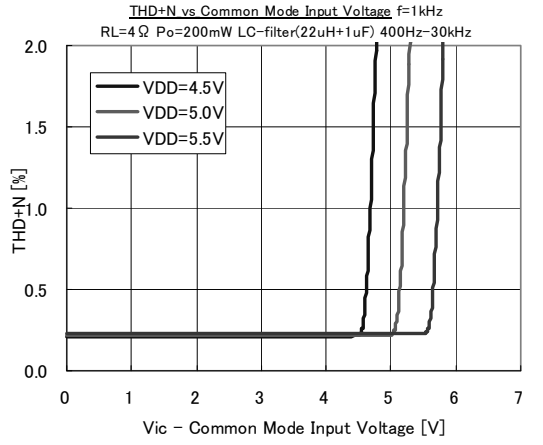

Fig.24

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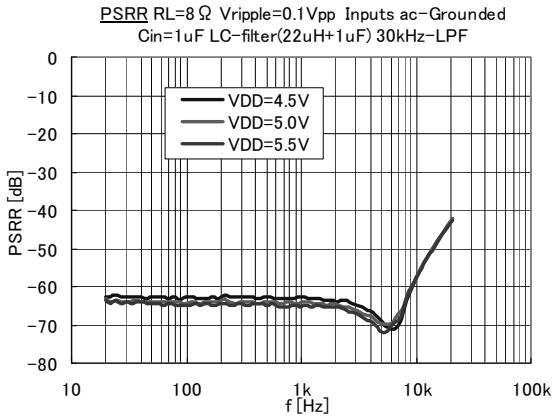
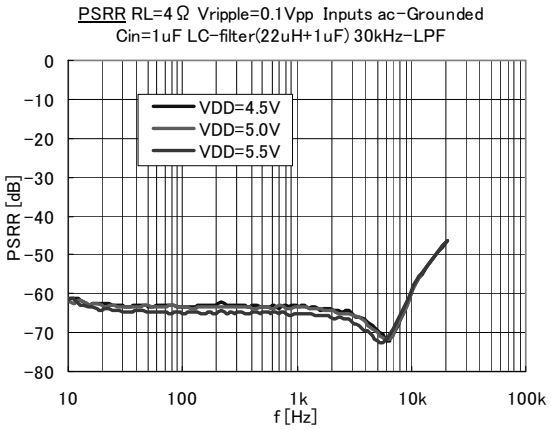


Fig.25



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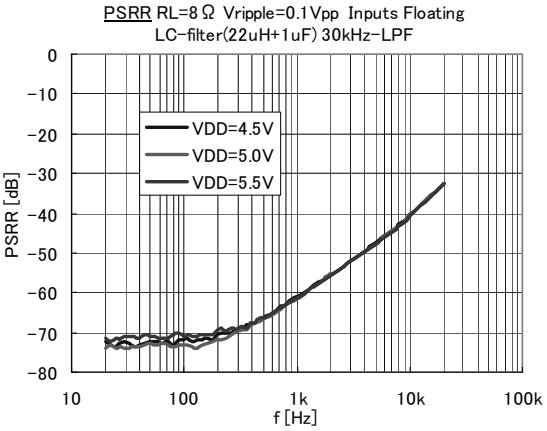

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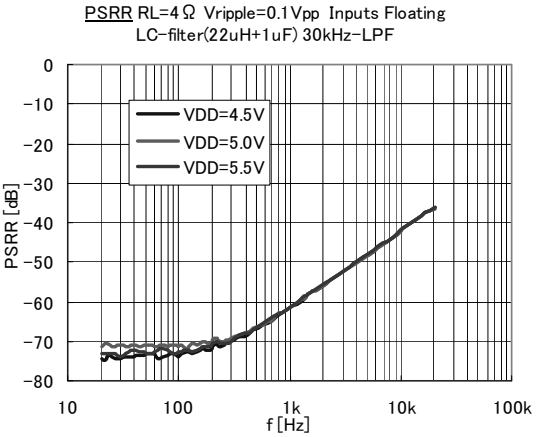


Fig.28

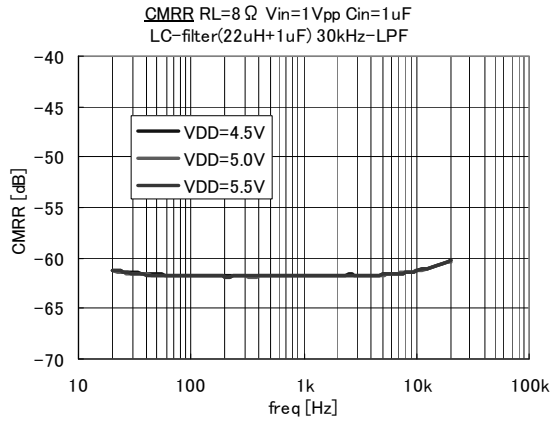


Fig.29

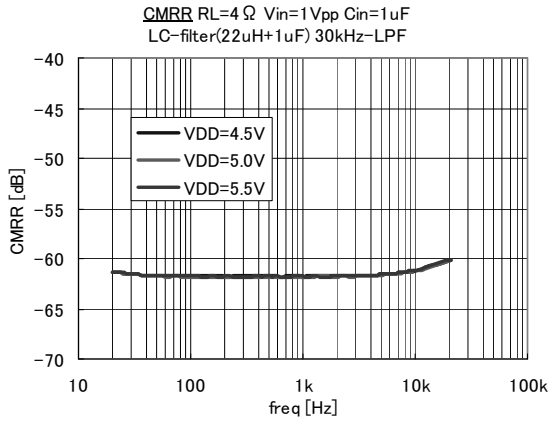
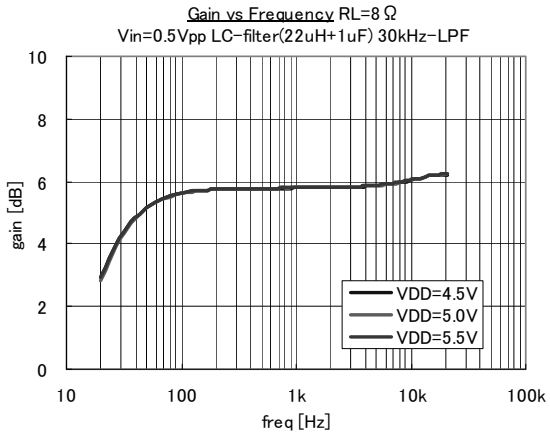


Fig.30



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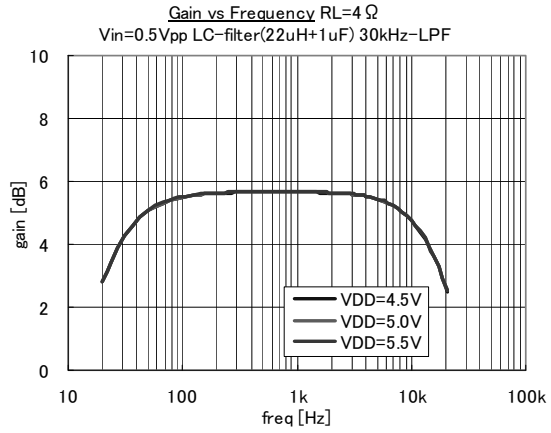

Fig.32

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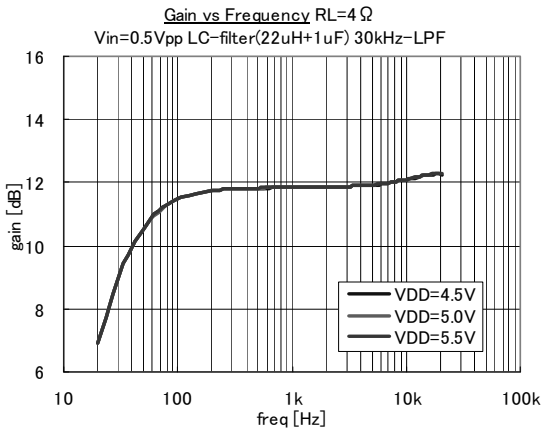
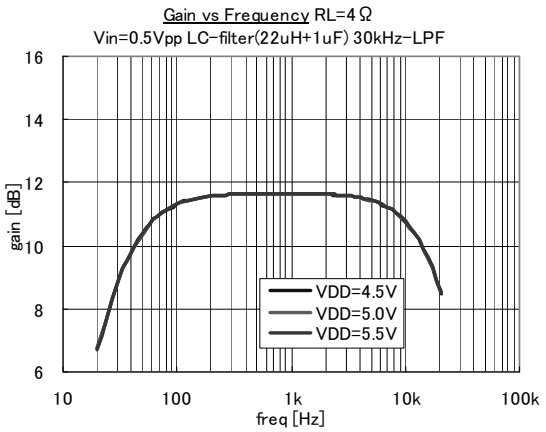


Fig.33



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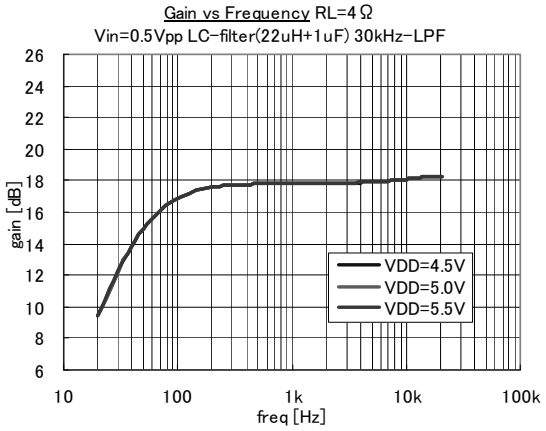

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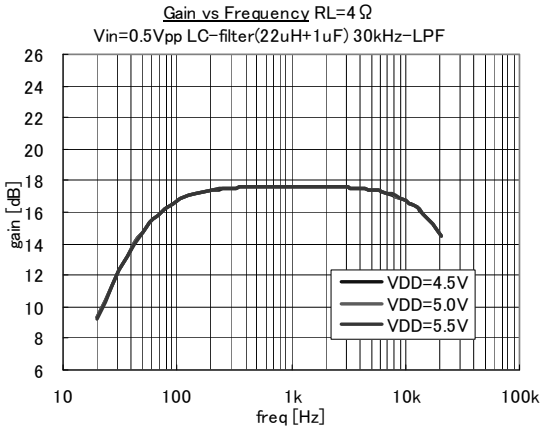

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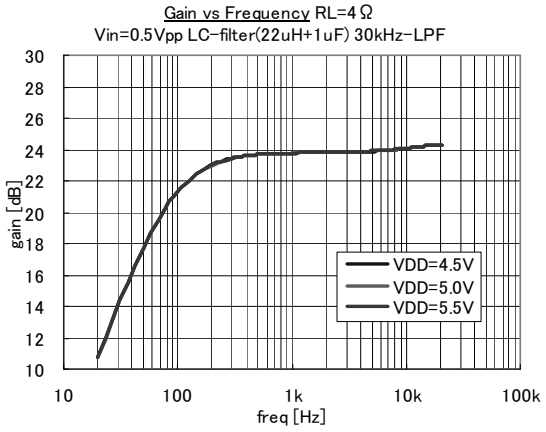

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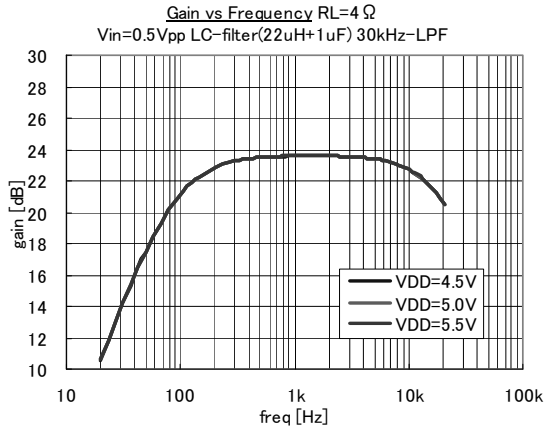

Fig.38

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●Notes for use

(1) Absolute maximum ratings
This IC may be damaged if the absolute maximum ratings for the applied voltage, temperature range, or other parameters are exceeded. Therefore, avoid using a voltage or temperature that exceeds the absolute maximum ratings. If it is possible that absolute maximum ratings will be exceeded, use fuses or other physical safety measures and determine ways to avoid exceeding the IC's absolute maximum ratings.

(2) GND terminal's potential
Try to set the minimum voltage for GND terminal's potential, regardless of the operation mode.

(3) Shorting between pins and mounting errors
When mounting the IC chip on a board, be very careful to set the chip's orientation and position precisely. When the power is turned on, the IC may be damaged if it is not mounted correctly. The IC may also be damaged if a short occurs (due to a foreign object, etc.) between two pins, between a pin and the power supply, or between a pin and the GND.

(4) Operation in strong magnetic fields
Note with caution that operation faults may occur when this IC operates in a strong magnetic field.

(5) Thermal design
Ensure sufficient margins to the thermal design by taking in to account the allowable power dissipation during actual use modes, because this IC is power amp. When excessive signal inputs which the heat dissipation is insufficient condition, it is possible that thermal shutdown circuit is active.

(6) Thermal shutdown circuit
This product is provided with a built-in thermal shutdown circuit. When the thermal shutdown circuit operates, the output transistors are placed under open status. The thermal shutdown circuit is primarily intended to shut down the IC avoiding thermal runaway under abnormal conditions with a chip temperature exceeding Tjmax = +150℃, and is not intended to protect and secure an electrical appliance.

(7) Load of the output terminal
This IC corresponds to dynamic speaker load, and doesn't correspond to the load except for dynamic speakers.

(8) The short protection of the output terminal
This IC is built in the short protection for a protection of output transistors. When the short protection is operated, output terminal become Hi-Z condition and is stopped with latch. Once output is stopped with latch, output does not recover automatically by canceling the short-circuiting condition. The condition of stopping with latch is cancelled, when power supply or mute signal is turned off and turned on again.

(9) Operating ranges
The rated operating power supply voltage range (VDD=+4.5V ~ +5.5V) and the rated operating temperature range (Ta=-40℃ ~ +85℃) are the range by which basic circuit functions is operated. Characteristics and rated output power are not guaranteed in all power supply voltage ranges or temperature ranges.

(10) Electrical characteristics
Electrical characteristics show the typical performance of device and depend on board layout, parts, power supply.
The standard value is in mounting device and parts on surface of ROHM's board directly.

(11) Maximum output power
When stereo inputs at RL=4Ω, maximum output power may not achieve up to typical value because the device heats.
Ensure sufficient margins to the thermal design to get larger output power.

(12) Power decoupling capacitor
Because the big peak current flows through the power line, the class-D amplifier has an influence on the Audio characteristic by the capacitance value or the arrangement part of the power decoupling capacitor.

(13) Power supply
Use single power supply, because power supplies (4,10,15,21pin) of audio amplifier and regulator are shorted inside. Audio

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●**Ordering part number**

B	D	5	4	7	1	M	U	V	-	E	2

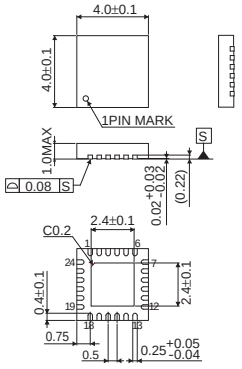
Part No.

Part No.
5471

Package
MUV:VQFN024V4040

Packaging and forming specification
E2: Embossed tape and reel

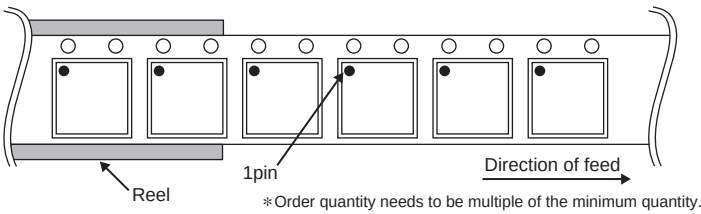
VQFN024V4040



(Unit : mm)

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

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Notes

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Examples of application circuits, circuit constants and any other information contained herein illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.

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ROHM SEMICONDUCTOR

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