



YDA137

D-2

STEREO 5W DIGITAL AUDIO POWER AMPLIFIER

■ Overview

YDA137 (D-2) is a high efficient digital audio power amplifier IC that operates on a single 5V power supply. With YDA137 in BTL connection, an audio power amplifier with a maximum output of 5W ($R_L=2\Omega$) \times 2ch can be configured with one chip.

YDA137 converts an input analog data into a digital pulse by the digital modulation circuit in the IC and outputs a high current digital pulse from the output buffer circuit. This digital pulse signal is converted into an audio signal by an external low-pass filter and is output to the speaker.

Low-distortion rate characteristics and high S/N ratio are realized as a digital amplifier among same class, by adopting Yamaha's unique modulation system.

In addition, class AB headphone amplifier with output of 20mW ($R_L=16\Omega$) \times 2ch is embedded and switching between digital amplifier output and headphone amplifier output can be done by the control of terminal termination.

YDA137 has the over-current protection function for speaker terminals, the high-temperature protection function for IC, and the pop noise rejection function.

IC operation can be restricted by the two control signals of /SLEEP and /MUTE. /SLEEP signal can stop all functions and decrease the consumption power to a minimum. In addition, /MUTE signal can pull-down the output buffer (hereinafter, described as WL) and make the output mute.

■ Features

• High Output Power

5.0 W @ $V_{DD}=5.0V$, $R_L=2\Omega$, THD+N<10%

3.7 W @ $V_{DD}=5.0V$, $R_L=3\Omega$, THD+N<10%

3.0 W @ $V_{DD}=5.0V$, $R_L=4\Omega$, THD+N<10%

• High Efficient Operation

75 % @ $V_{DD}=5.0V$, $R_L=2\Omega$, $P_o=5W$

80 % @ $V_{DD}=5.0V$, $R_L=3\Omega$, $P_o=3W$

• Low Distortion Rate (THD+N)

0.03 % @ 1kHz, $R_L=2\Omega$, $P_o=2.5W$

0.02 % @ 1kHz, $R_L=3\Omega$, $P_o=1.5W$

• High S/N Ratio

105dB @ $V_{DD}=5.0V$, input sensitivity 1.0Vrms,
 $R_L=2\Omega$, $P_o=5W$

98dB @ $V_{DD}=5.0V$, input sensitivity 150mVrms,
 $R_L=2\Omega$, $P_o=5W$

• IC Low Consumption Current

25 mA @ $V_{DD}=5.0V$, no signal (no filter)

10 mA @ $V_{DD}=5.0V$, at mute

1 μ A @ $V_{DD}=5.0V$, at sleep

• CS(Channel Separation)

80dB @ 1kHz

• Class AB headphone amp. is embedded.

20mW @ $V_{DD}=5.0V$, $R_L=16\Omega$, THD+N<1.0%

• Arbitral gain setting with external resistor is possible.

• Sleep function by /SLEEP terminal

• Output mute function by /MUTE terminal

• Output Over-Current Protection Function (Ground short-circuit/Load short-circuit)

• Over-Temperature Protection Function

• Auto Resume Function from Over-Current, High-Temperature Protection.

• Monaural Function by /MONO terminal

• Pop Noise Rejection Function at power-up or power-cutoff.

• Analog input / BTL(Bridge-Tied Load) output

• 28pin plastic TSSOP

• pin lead plating with Pd-free (YDA137-AZ)

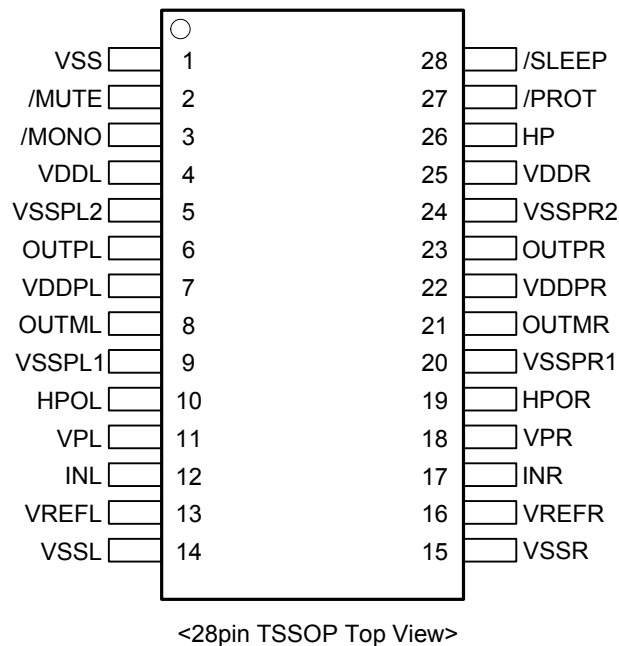
YAMAHA CORPORATION

YDA137 CATALOG

CATALOG No.:LSI-4DA137A30

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Terminal configuration



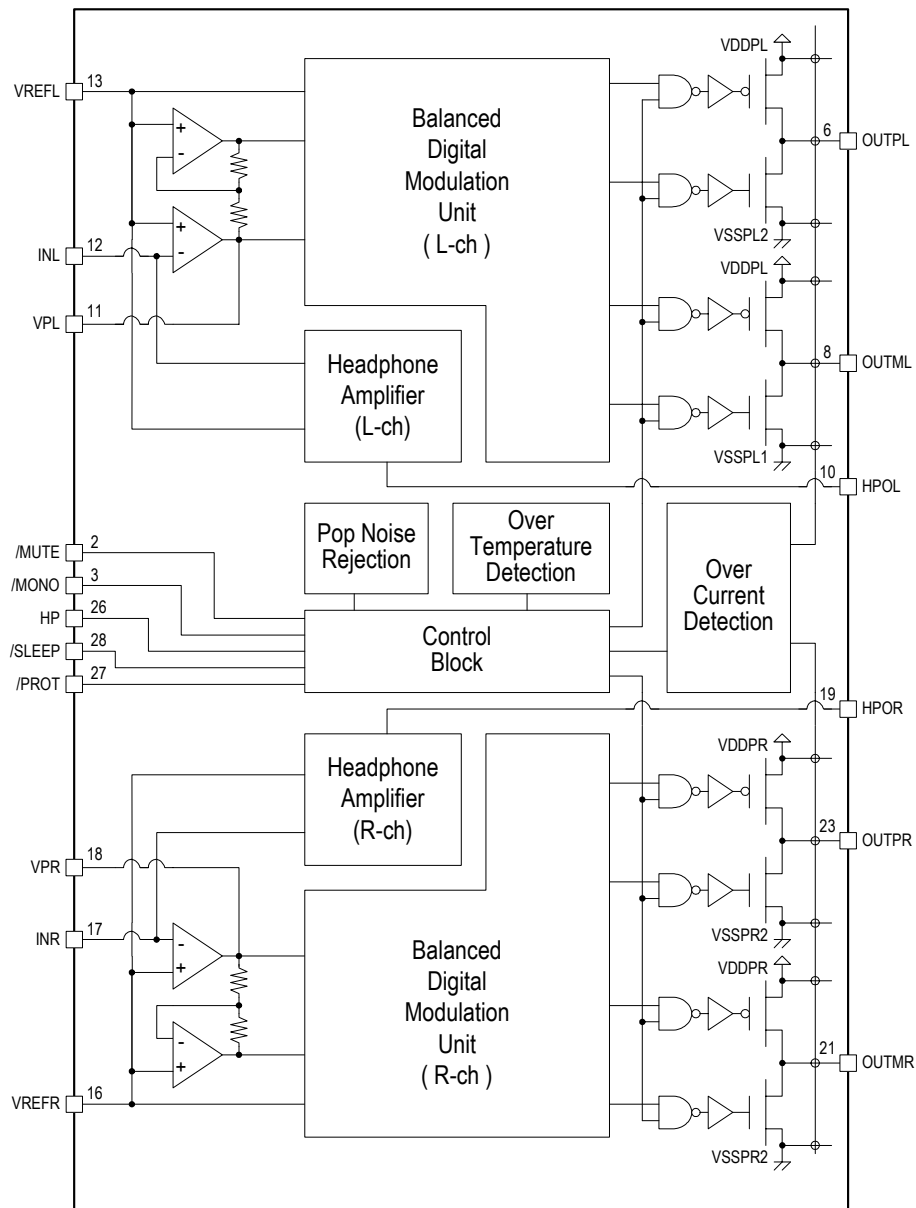
Terminal functions

No.	Name	I/O	Function
1	VSS	—	Ground terminal for reference power supply
2	/MUTE	I	Mute control terminal
3	/MONO	I	Monaural control terminal
4	VDDL	—	L-ch power supply terminal for control stage
5	VSSPL2	—	L-ch ground terminal for output stage
6	OUTPL	O	L-ch PWM signal output terminal for positive side
7	VDDPL	—	L-ch power supply terminal for output stage
8	OUTML	O	L-ch PWM signal output terminal for negative side
9	VSSPL1	—	L-ch ground terminal for output stage
10	HPOL	OA	L-ch headphone output terminal
11	VPL	OA	L-ch first stage operational amplifier output terminal
12	INL	IA	L-ch analog signal input terminal
13	VREFL	OA	L-ch reference voltage output terminal
14	VSSL	—	L-ch ground terminal for control stage
15	VSSR	—	R-ch ground terminal for control stage
16	VREFR	OA	R-ch reference voltage output terminal
17	INR	IA	R-ch analog signal input terminal
18	VPR	OA	R-ch first stage operational amplifier output terminal
19	HPOR	OA	R-ch headphone output terminal
20	VSSPR1	—	R-ch ground terminal for output stage
21	OUTMR	O	R-ch PWM signal output terminal for negative side
22	VDDPR	—	R-ch power supply terminal for output stage
23	OUTPR	O	R-ch PWM signal output terminal for positive side
24	VSSPR2	—	R-ch ground terminal for output stage
25	VDDR	—	R-ch power supply terminal for control stage
26	HP	I	Headphone control terminal
27	/PROT	O	Protection detection terminal
28	/SLEEP	I	Sleep control terminal

(Note) I: Digital input terminal, O: Digital output terminal, IA: Analog input terminal, OA: Analog output terminal

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Block diagram



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■ Description of terminal functions

Hereafter, in the description, L and H in /SLEEP terminal, /MUTE terminal, /MONO terminal, and HP terminal indicate V_{IL} and V_{IH} respectively, and L and H in /PROT terminal, OUTPL terminal, OUTML terminal, OUTPR terminal, and OUTMR terminal indicate V_{OL} and V_{OH} respectively.

In addition, WL indicates weak ground output, and RF indicates reference level output.

● Power Supply Terminals, Ground Terminals

VDDL, VSSL, VDDR, VSSR (Pin No.4, 14, 25, 15)

VDDL, VSSL terminal is a 5.0V power supply terminal, a ground terminal respectively for L channel signal processing circuit.

VDDR, VSSR terminal is a 5.0V power supply terminal, a ground terminal respectively for R channel signal processing circuit.

L channel, R channel has independent power supply terminal and ground terminal respectively.

All ground terminals are connected to the board (low resistance), but power supply terminals for L, R are separated.

VDDPL, VSSPL1, VSSPL2, VDDPR, VSSPR1, VSSPR2 (Pin No.7, 9, 5, 22, 20, 24)

VDDPL, VSSPL1, VSSPL2 terminal is a 5.0V power supply terminal, ground terminals respectively for L channel digital amplifier output and L channel headphone amplifier output.

VDDPR, VSSPR1, VSSPR2 terminal is a 5.0V power supply terminal, ground terminals respectively for R channel digital amplifier output and R channel headphone amplifier output.

L channel, R channel has independent power supply terminal and ground terminal respectively.

All ground terminals are connected to the board (low resistance), but power supply terminals for L, R are separated.

Voltage is supplied to VDDL, VDDR, VDDPL, and VDDPR terminal to the same timing.

VSS (Pin No.1)

VSS terminal is a ground terminal for protection circuit and control circuit.

● Analog Terminals

INL, VPL, INR, VPR (Pin No.12, 11, 17, 18)

INL, VPL terminal is an analog signal input terminal, a gain setting terminal respectively for L channel digital amplifier.

INR, VPR terminal is an analog signal input terminal, a gain setting terminal respectively for R channel digital amplifier.

Simple filter such as a low frequency boost can be configured by using an operational amplifier for the first gain setting.

These terminals are combined with an input for headphone amplifier.

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VREFL, VREFR (Pin No.13, 16)

VREFL terminal is a reference voltage output terminal for L channel. Half of 5.0V power supply terminal (VDDL) voltage is output.

VREFR terminal is a reference voltage output terminal for R channel. Half of 5.0V power supply terminal (VDDR) voltage is output.

Connect a necessary capacitance (See the item of "Pop Noise Rejection Function") to each reference voltage output terminal to make the voltage stable.

OUTPL, OUTML, OUTPR, OUTMR (Pin No.6, 8, 23, 21)

OUTPL, OUTML terminal is a digital amplifier output terminal for L channel. PWM modulated digital pulse signal is output. OUTPL is a positive output terminal, and OUTML is a negative output terminal.

OUTPR, OUTMR terminal is a digital amplifier output terminal for R channel. PWM modulated digital pulse signal is output. OUTPR is a positive output terminal, and OUTMR is a negative output terminal.

Since both channels are specified as BTL (Bridge-Tied Load) output, negative output terminal is not in the ground potential.

In addition, connect these to the speaker through a LC filter according to the example of application circuit to reject carrier frequency.

HPOL, HPOR (Pin No.10, 19)

HPOL terminal is a headphone output terminal for L channel.

HPOR terminal is a headphone output terminal for R channel.

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● Digital Terminals

/SLEEP (Pin No.28)

/SLEEP terminal is a sleep control terminal. It controls digital amplifiers and headphone amplifiers for both L and R channels at the same time.

When /SLEEP terminal is L, all IC functions are stopped to enter the sleep state (hereinafter described as Sleep Mode).

When /SLEEP terminal is changed from L to H, normal operating condition is established after sufficient time (starting time) for each reference voltage to reach the regular potential.

/MUTE (Pin No.2)

/MUTE terminal is a mute control terminal. It controls digital amplifiers and headphone amplifiers for both L and R channels at the same time.

When /MUTE terminal is L, IC enters a mute-state. (hereinafter described as Mute Mode) In this condition, OUTPL, OUTML, OUTPR, and OUTMR terminal become WL, and HPOL, HPOR terminal become reference level output. (hereinafter described as RF)

When /MUTE terminal is H, it enters a normal operating condition.

/MONO (Pin No.3)

/MONO terminal is a monaural output control terminal. Digital amplifier and headphone amplifier are controlled at the same time.

When /MONO terminal is L, it enters a monaural output state. (hereinafter described as Monaural Mode)

When /MONO terminal is H, it enters a normal operating condition.

HP (Pin No.26)

HP terminal is a headphone control terminal. Operation switching between digital amplifier and headphone amplifier is controlled.

When HP terminal is H, it enters the headphone output mode. At this time, digital amplifier enters the Mute Mode.

When HP terminal is L, it enters the digital amplifier output mode. At this time, headphone amplifier enters the Mute Mode.

/PROT (Pin No.27)

/PROT terminal is a warning signal output terminal for over-current and Over-Temperature Detection Function. When failure is detected in either function, L is output. In normal operation, H is output.

■ Mode setting and error detection

/SLEEP	/MUTE	HP	/MONO	/PROT	OUT*L	OUT*R	HPOL	HPOR	Operating Mode
I	I	I	I	O	O	O	O	O	
L	X	X	X	H	WL	WL	WL	WL	Sleep mode
H	L	X	X	H	WL	WL	RF	RF	Mute mode
H	H	L	H	H	PM	PM	RF	RF	2 channel digital amplifier output mode
H	H	L	L	H	PM	x ^{*1}	RF	RF	2 channel digital amplifier output monaural mode
H	H	H	H	H	WL	WL	AO	AO	2 channel headphone output mode
H	H	H	L	H	WL	WL	AO	x ^{*1}	2 channel headphone output monaural mode
H	X	X	X	L	WL	WL	WL	WL	Output protection condition

Note:

"H" : CMOS logic "H" level

"L" : CMOS logic "L" level

"WL" : Weak Low (weak pull-down)

"PM" : PWM pulse output

"Z" : Hi-impedance

"RF" : Reference level output

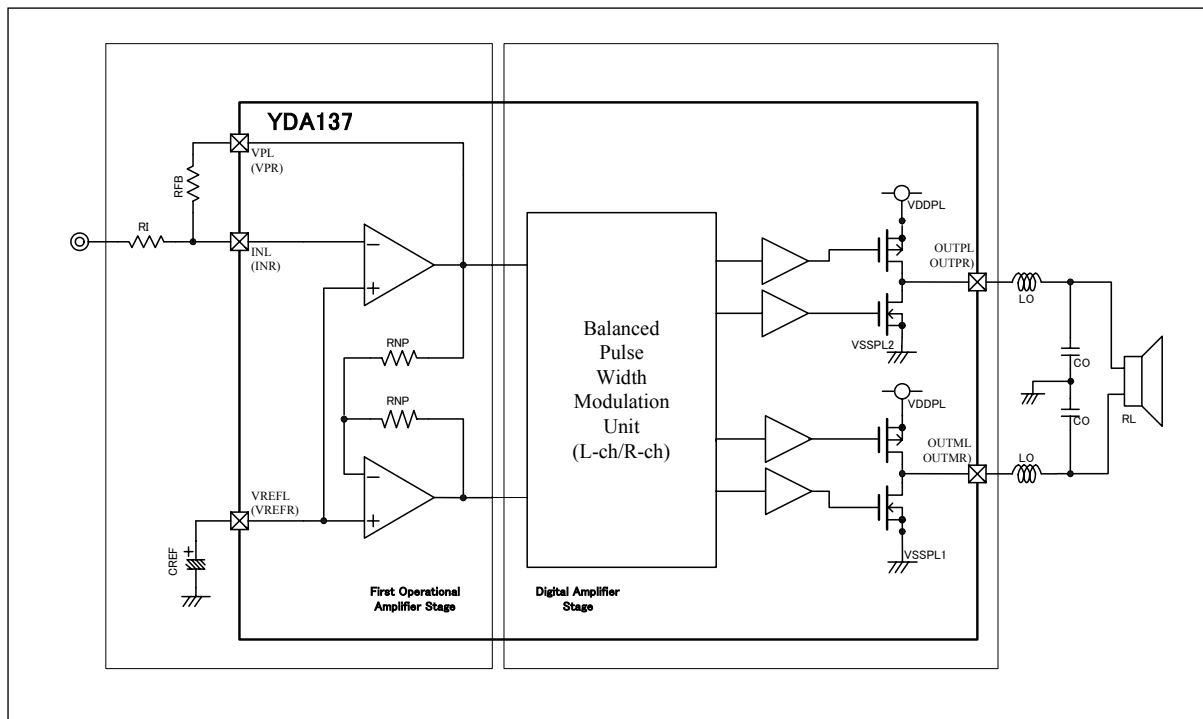
"AO" : Audio signal output

*1: "x" in the output terminal means undefined state.

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■ Description of functions

● Digital Amplifier Function



Amplifier function block diagram

Amplifier Section of YDA137 is composed of the first operational amplifier stage and the latter digital amplifier stage. Gain of the first operational amplifier can be set by connecting input resistor (RI) and feedback resistor (RFB) externally. In digital amplifier stage, digital amplifier output is feed-backed to the modulation circuit, and low distortion rate is realized.

Digital amplifier output is connected to a speaker through the 2nd-order low-pass filter consisting of inductance (Lo) and capacitance (Co). This eliminates carrier frequency content existing at the digital amplifier output, consequently only audio signal is sent to a speaker.

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Gain Setting

Gain of the first operational amplifier can be calculated by the following formula. Gain of an internal digital amplifier is 8.0dB.

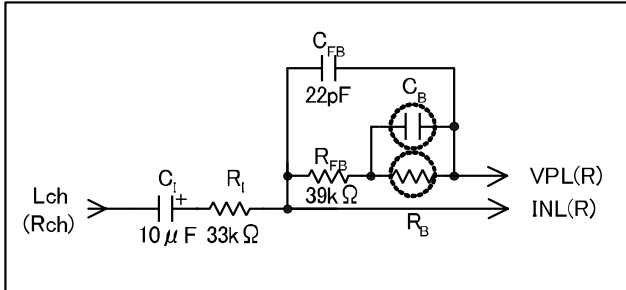
	Gain
First operational amplifier stage	$20 \times \log(R_{FB}/R_I)$ dB (Using R_I and R_{FB} . Conditions: $R_I > 2k\Omega$)
Digital amplifier stage	8.0dB

In the application circuit example, $R_I=33k\Omega$, $R_{FB}=39k\Omega$, total gain (A_v) can be calculated by the following formula. In this setting value, input sensitivity is 1Vrms, the maximum output could be obtained at 1Vrms input. When input sensitivity is set to 150mVrms, it is set as $R_I=4.7k\Omega$ and $R_{FB}=39k\Omega$.

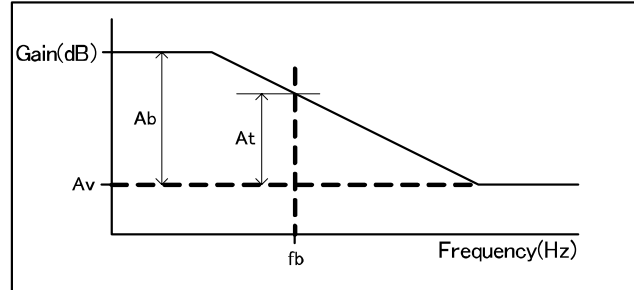
$$A_v(\text{dB}) = 20 \times \log(39/33) + 8 \\ = 9.5 (\text{dB})$$

In gain setting of the first operational amplifier stage, it is necessary to obey the restriction that is described in the "Pop Noise Rejection Function." In addition, feed back resistor (RFB) needs to be 10kΩ or over because of the restriction on operational amplifier drive capability.

The following “low-frequency boost filter circuit “ can be configured by using the first operational amplifier stage. This filter has frequency characteristics as shown in the following “low-frequency boost filter characteristics”, and boost gain (A_b), turn-over frequency (f_b), and turn-over frequency gain (A_t) to the first operational amplifier gain (A_v) are found by the following formulas.



Low-frequency Boost Filter Circuit



Low-frequency Boost Filter Characteristics

$$A_b(\text{dB}) = 20 \times \log((R_{FB} + R_B) / R_{FB})$$

$$f_b(\text{Hz}) = 1/2 \times \pi \times R_B \times C_B$$

$$A_t(\text{dB}) = 20 \times \log(1 + R_B / (2^{1/2} \times R_{FB}))$$

In the application circuit example, high-cut capacitance (C_{FB}) is added for input signal band restriction. The value can be adjusted as necessary. (cut-off frequency is $1/(2 \times \pi \times C_{FB} \times R_{FB})$) In addition, DC-cut capacitance (C_1) is added for input DC current limitation. This capacitance and input resistance (R_1) make a low-cut filter. Set a cut-off frequency low enough (Cut-off frequency is $1/(2 \times \pi \times C_1 \times R_1)$).

Selection of Coil for an output filter

Cut-off frequency (f_c) of LC low-pass filter that is connected to the digital amplifier output can be found by the following formula.

In addition, to obtain the ideal frequency characteristics, select 0.7 or so for Q value of LCR resonance circuit.

$$f_c (\text{Hz}) = 1/(2 \times \pi \times \sqrt{L_o \times C_o})$$

$$Q = (R_L/2) \times \sqrt{C_o/L_o} = 0.7$$

Generally, cut-off frequency is selected to 50kHz, and the following values are used according to the speaker impedance.

R_L (load impedance)	L_o (inductance)	C_o (capacitance)
2 Ω	4.7 μH	2.2 μF
3 Ω	6.8 μH	1.5 μF
4 Ω	10 μH	1 μF

Distortion rate or sound quality may change depending upon the type of coil to use. In addition, select appropriate coils according to the necessary characteristics.

Measure against ringing of output terminal

When ringing with big peak voltage has occurred for the output terminal, IC may incorrect-operate, or IC may be damaged. Perform the measure against ringing by adding capacitor between a VDDPL and VSSPL1 terminals, between VDDPL and VSSPL2 terminals, between VDDPR and VSSPR1 terminals, between VDDPR and VSSPR2 terminal. A ceramic capacitor (4.7 μF) with the sufficient frequency characteristic should be used for the adding capacitor, and if possible, it should set near the terminal.

Even if it performs the above measure, when ringing occurs, add a resistor (R_{rng}) and a capacitor (C_{rng}) to an output terminal like the application circuit example. As a standard of the measure against ringing, adjust a constant so that a peak voltage value becomes less than 9V.

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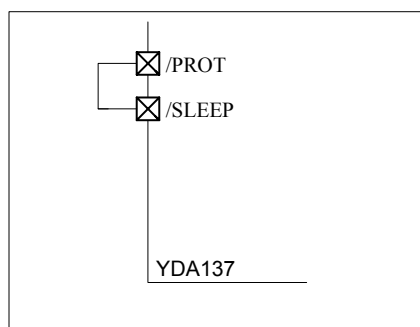
● Over-Current Protection Function

Over-Current Protection Function is a function to detect the over-current condition and protect IC, when excessive current flows in the digital amplifier output terminal for a given period.

At this time, in the internal of IC, digital amplifier output terminal and headphone output terminal becomes WL and L is output from /PROT terminal. (hereinafter described as Protection Mode)

Once entering in the Protection Mode by the over-current protection, the Protection Mode is not canceled even after over-current condition is over. The Protection Mode can be canceled by setting L to /SLEEP terminal once and again setting H to the terminal or, by turning on the power supply again.

It is possible to resume automatically from the Protection Mode by connecting between /PROT terminal and /SLEEP terminal as shown in the diagram below (External automatic resume circuit).



External Automatic Resume Circuit

In Sleep Mode (/SLEEP=L) and Mute Mode (/MUTE=L), Over-Current Detection Function of both L and R channel stops.

This IC can detect the over-current state according to the VSS short circuit of a speaker terminal (after LC filter) and the short circuit between \pm terminals.

In addition, this IC does not correspond to detect the over-current state according to between the VDD short circuit of a speaker terminal, the VSS short circuit of IC output end (before LC filter), a VDD short circuit, and the short circuit between \pm terminals.

● Over-Temperature Protection Function

Over-Temperature Protection Function is a function to detect the over-temperature condition and protect IC, when temperature of YDA137 goes up extraordinarily. At this time, IC enters the Protection Mode.

Once entering in the Protection Mode by the over-temperature protection, IC cancels the Protection Mode by itself after the temperature of IC falls to a certain temperature.

In addition, it is possible to cancel the Protection Mode by the control of /SLEEP terminal and turning on the power supply again, as well as Over-Current Protection Function.

● Sleep Function

When /SLEEP terminal is L, it enters the Sleep Mode. When H, it enters normal operation condition. In the mode, all functions will stop and consumption power will fall to the minimum.

In the mode, digital amplifier output terminal becomes WL, and headphone amplifier output terminal becomes WL. At this time, the protection mode is canceled, and /PROT terminal becomes H.

When /SLEEP terminal is changed from L to H, start-up sequence operates, and it enters normal operating condition after the time set by the capacitance connected at VREFL and VREFR terminals, the input capacitance connected at INL and INR terminals, and input resistance elapsed (Starting-time). General time is shown in the table.

Table: Starting-time

CREF capacitance	CIN capacitance	Input sensitivity	Starting time
33 μ F	4.7 μ F	1.0Vrms	1.8 sec
33 μ F	10 μ F	1.0Vrms	3.0 sec
33 μ F	33 μ F	1.0Vrms	7.5 sec

●Output Mute Function

When /MUTE terminal is L, it enters the Mute Mode. When /MUTE terminal is H, it enters normal operation condition. In Mute Mode, consumption current can be decreased and setting and release can be performed in an instant. In the mode, digital amplifier output terminal becomes WL, and headphone amplifier output terminal becomes RF. In addition, Over-Current Detection Function stops in the mode. Mute Mode in YDA137 points out the state where changed the inside of IC into the standby state, and output disabled. For this reason, minute pop noise may occur under the influence of output offset voltage.

●Pop Noise Rejection Function

A function to reject pop noise caused by power-on, power-off, Sleep Mode setting, and its cancellation is equipped. In power-on, YDA137 operates the start-up sequence after supply voltage (VDDL, VDDR) surpasses each threshold voltage for low voltage malfunction prevention (VUVH). In the start-up sequence, pop noise can be rejected, because the Mute Mode is canceled after input signal terminal (INL, INR) potential and voltage reference terminal (VREFL, VREFR) potential have been stable sufficiently (after the Starting-time has elapsed). Also in the cancellation of the Sleep Mode, pop noise can be rejected by the start-up sequence as well as that in the power-on. When a power supply is power-off, a pop noise is rejected by detect power supply change and mute output.

It is necessary to set each value to these elements to operate Pop Noise Rejection Function effectively in the power-on. The values are found by the following formula, with a capacitance value (CREF) for VREFL terminal and VREFR terminal, a resistor value (R1) and capacitance value (C1) for INL terminal and INR terminal.

$$\begin{aligned} C_{REF} &\geq R_1 \times C_1 / 5000 && (\text{Input sensitivity}=150\text{mVrms}) && C_{REF} \text{ is recommended to } 10 \mu\text{F}. \\ C_{REF} &\geq R_1 \times C_1 / 22000 && (\text{Input sensitivity}=1\text{Vrms}) && C_{REF} \text{ is recommended to } 10 \mu\text{F}. \end{aligned}$$

●Malfunction Prevention Function for Low Voltage

This is a function to stop the operation to prevent malfunction when supply voltage falls for some reason. In YDA137, operation stops when supply voltage falls to operation stop voltage (VUVL) or lower. In addition, operation starts again, when supply voltage goes up to start-up voltage (VUVH) or over.

●Malfunction Prevention Function for Power Supply Fluctuation

This is a function to prevent malfunction when supply voltage fluctuates falls rapidly for some reason. In the digital amplifier output, it enters the Mute Mode to prevent a malfunction when supply voltage falls/rises to the fall fluctuation protection voltage (VML) or lower, or the rise fluctuation protection voltage (VMH) or over. Moreover, in the headphone output, it enters the Mute Mode to prevent it when supply voltage rises to VMH or over, and headphone output stage becomes WL to prevent a malfunction, when supply voltage falls to VML or lower.

●Monaural Output Function

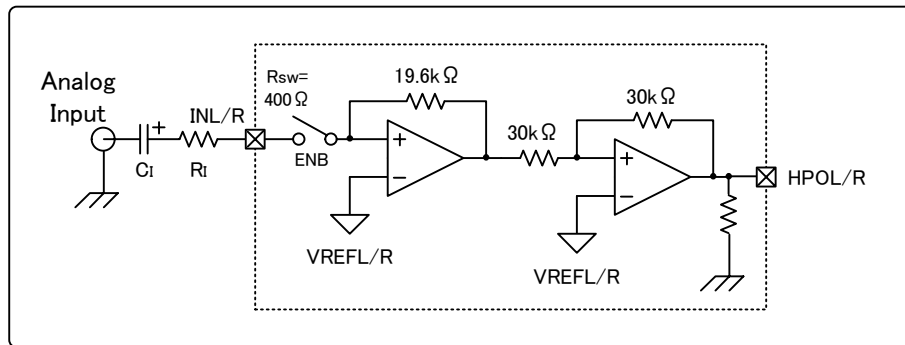
When /MONO terminal is L, it enters the Monaural Mode. When H, it enters the stereo mode. In the Monaural Mode, input signal is input from L channel input terminal and is output from L channel output terminal. At this time, R channel output terminal becomes unfixed. In addition, when YDA137 is used only a monaural output (L channel) fixes, the following change is made to the application circuit example. It is not necessary to connect each resistance, the capacity, and the coil for filters of the R channel side.

Terminal processing when use by monaural output fixation.

Pin No.	Name	Terminal processing	Pin No.	Name	Terminal processing
3	/MONO	Connect to ground	20	VSSPR1	Connect to ground
15	VSSR	Connect to ground	21	OUTMR	Non connection
16	VREFR	Non connection	22	VDDPR	Connect to 5V power supply
17	INR	Non connection	23	OUTPR	Non connection
18	VPR	Non connection	24	VSSPR2	Connect to ground
19	HPOR	Non connection	25	VDDR	Connect to 5V power supply

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● Headphone Amplifier Function



Headphone Amplifier Circuit

When setting H to HP terminal, it enters headphone amplifier output mode. At this time, the digital amplifier enters the Mute Mode.

Headphone amplifier section is comprised of the first stage operational amplifier and a class AB single-end output amplifier.

In the first stage operational amplifier section, gain can be set by connecting an input resistor R_i externally.

The latter stage is a high current output amplifier applicable to $16\ \Omega$ load. VREF terminal voltage (vias) is applied to the headphone amplifier output, so that connect the output to headphone through AC coupling capacitor, as shown in the application circuit example.

Gain Setting

Gain of the first inverting amplifier can be calculated according to the following formula. In addition, class AB amplifier gain is 0dB.

$$A_{VHP} = 20 \times \log_{10}(19.6k / (R_i + 400))$$

$4.7k\ \Omega$ is selected as an input resistor R_i , and total gain is set to 11.7dB.

In this setting, 150mVrms input can yield the maximum output of 20mW.

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Relation between an external resistor value and output level in typical input sensitivity is shown in the table below.

Input Sensitivity	150mVrms	1.0Vrms	2.0Vrms
External input resistor R_i	$4.7k\ \Omega$	$33k\ \Omega$	$68k\ \Omega$
External feedback resistor R_{FB} for digital amplifier	$39k\ \Omega$	$39k\ \Omega$	$43k\ \Omega$
Digital amplifier output ($R_L=3\ \Omega$)	3.14Vrms (3.28W or so)	2.98Vrms (2.96W or so)	3.19Vrms (3.38W or so)
Headphone amplifier output ($R_L=16\ \Omega$)	0.566Vrms (20.0mW)	0.586Vrms (21.4mW)	0.573Vrms (20.5mW)

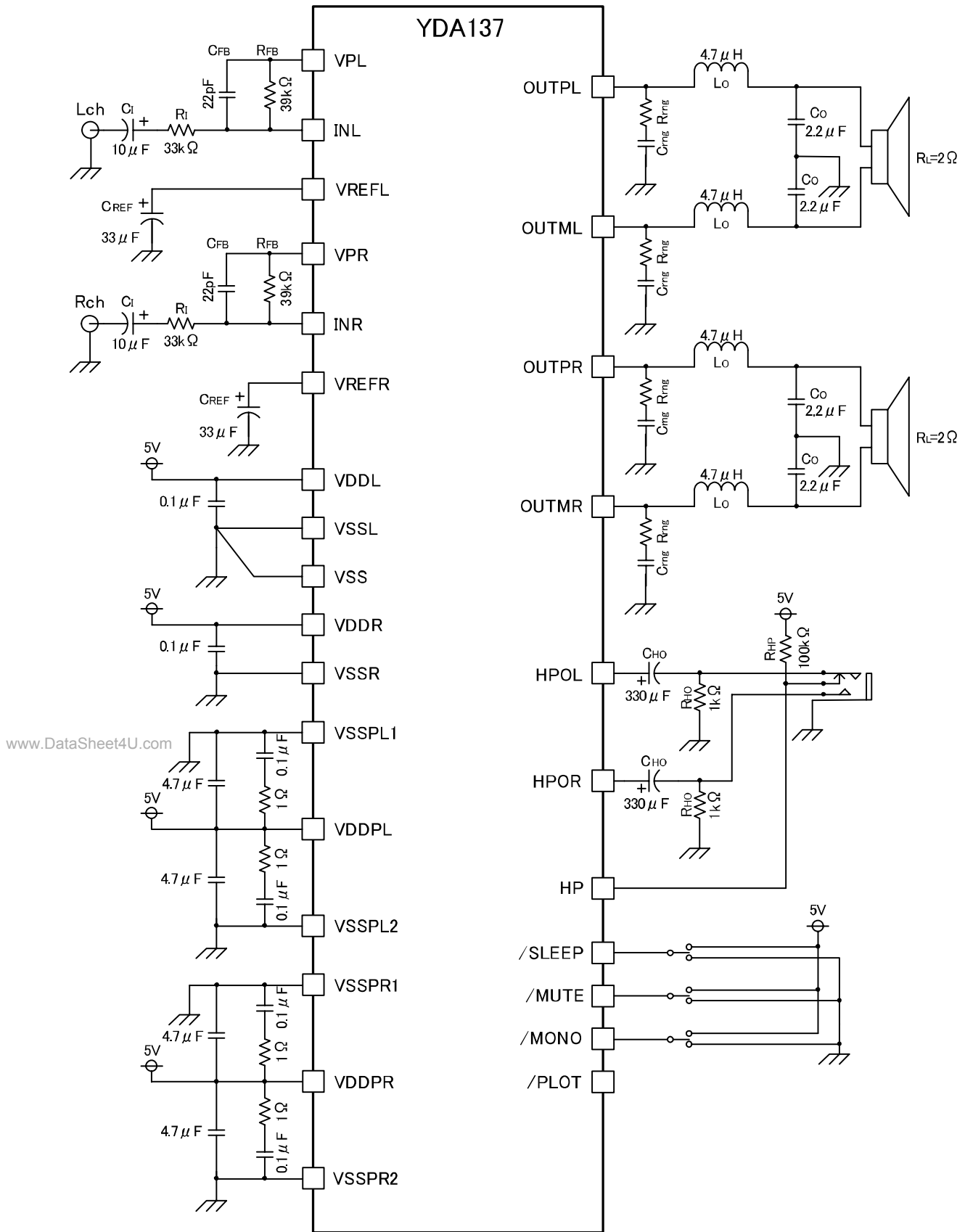
A low cutoff frequency is found by the following formula with an AC coupling capacitor (C_{HO}) and a load resistor (R_{HO}) of the headphone amplifier.

$$f_{CHP} = 1 / (2 \times \pi \times C_{HO} \times R_{HO}) \quad : R_{HO} = \text{load resistor}$$

Headphone Amplifier Switching Function

By making up a headphone circuit as shown in the application circuit example, two modes can be switched automatically according to the existence of headphone.

Application circuit example



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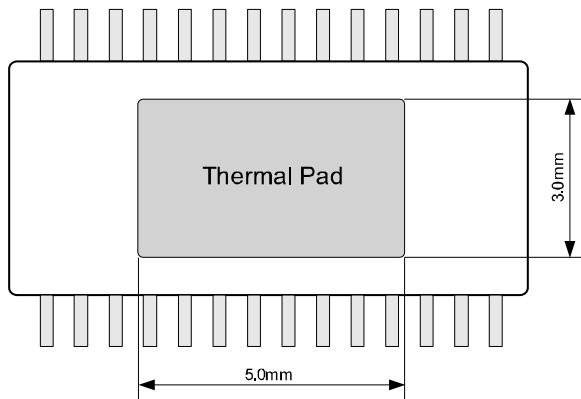
■Precaution for mounting

Thermal Pad for heat radiation is carried in the package backside of YDA137.

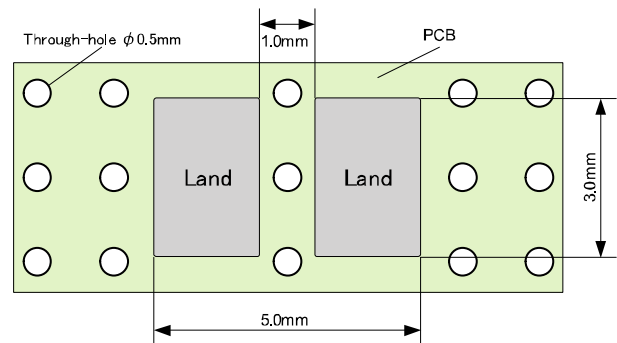
Sufficient heat radiation effect is acquired by creating a land pattern like following "Land pattern example of Thermal Pad connection" and soldering "Thermal Pad" of YDA137 on the printed circuit board which mounts YDA137.

In addition, heat radiation to backside of the printed circuit board can be effectively performed by preparing a through hole on a printed circuit board.

YDA137 Package backside



Land pattern example of Thermal Pad connection



■Application notes

Warning for the device which makes sound using speaker

A speaker radiates heat in a voice-coil by air flow accompanying vibration of an oscillating board. When DC signal (several Hz or less) is inputted, heat radiation characteristics falls rapidly.

In addition, even if it is used lower than rated input, it may lead to disconnection of a voice-coil, emitting smoke or ignition of a speaker.

In order to avoid such situations, be sure to implement one or more preventive measures from the following.

1. Do not select a setup (sound production) which may generate DC signal.
(Since thoroughness of this preventive measure is generally difficult, we recommends the combined use with the following 2, 3, and 4)
2. Add a DC cut digital filter for cutting DC signal into a digital section.
(As long as "Built-in" is not mentioned in the manual, there is no such built-in circuit inside of a device).
3. Add a DC cut capacitor for cutting DC signal into an analog section.
(When addition is specified in the example of a recommended circuit diagram, be sure to add)
4. When a latter stage device exists in the signal path from this device to speaker, DC cut is realized in a latter stage device.

In addition, the above-mentioned measures are made that the device it-self, DC cut condenser, and a latter stage device will be in a normal operation. Therefore, it is also necessary to implement the safety measures supposing failure of these parts separately.

■ Electrical characteristics

● Absolute Maximum Ratings ^{Note 5)}

Item	Symbol	Min.	Max.	Unit
VDD terminal voltage range ^{Note 1, 2, 3)}	V_{DD}	-0.3	6.0	V
Input/Output terminal voltage range ^{Note 4)}	V_{IN}	$V_{SS}-0.5$	$V_{DD}+0.5$	V
Allowable dissipation ($T_a=25^{\circ}\text{C}$)	PD		3.0	W
Storage Temperature	T_{STG}	-50	125	$^{\circ}\text{C}$

Note 1) VSS means VSSL, VSSR, VSSPL1, VSSPL2, VSSPR1, and VSSPR2. Place all VSS terminals in the same potential.

Note 2) The voltage is based on $V_{SS}=0\text{V}$.

Note 3) VDD terminal means VDDL, VDDR, VDDPL, and VDDPR.

Note 4) Input/output terminal means /SLEEP, /MUTE, /PROT, HP, /MONO, INL, VPL, VREFL, INR, VPR, and VREFR.

Note 5) Absolute Maximum Ratings is values which must not be exceeded to guarantee device reliability and life, and when using device in excess even a moment, it may cause damage to device or deteriorate its reliability severely.

● Recommended Operating Condition ^{Note 7)}

Item	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage ^{Note 6)}	V_{DD}	3.0	5.0	5.25	V
Operating Ambient Temperature	T_a	-40	25	85	$^{\circ}\text{C}$
Speaker Impedance	R_L	2			Ω
Headphone Impedance	R_{LHP}	16			Ω

Note 6) The voltage is based on $V_{SS}=0\text{V}$.

Note 7) When using in outside of aforementioned voltage range, IC may cause malfunction and may cause noise at the speaker output as system, and other problems, etc.

● DC Characteristics ($V_{SS}=0\text{V}$, $V_{DD}=3\text{V}$ to 5.25V , $T_a=-40^{\circ}\text{C}$ to 85°C , unless otherwise specified)

Item	Symbol	Min.	Typ.	Max.	Unit
/PROT High level output voltage ($I_{OH}=-80\ \mu\text{A}$)	V_{OH}	$0.8 \times V_{DD}$			V
/PROT Low level output voltage ($I_{OL}=1.6\text{mA}$)	V_{OL}			$V_{SS}+0.4$	V
/SLEEP, /MUTE, /MONO, HP High level input voltage	V_{IH}	$0.7 \times V_{DD}$			V
/SLEEP, /MUTE, /MONO, HP Low level input voltage	V_{IL}			$0.3 \times V_{DD}$	V
Power supply: Threshold Voltage for Low voltage Malfunction Prevention	V_{UVL}		2.5		V
Power supply: Threshold Voltage for operation start	V_{UVH}		2.8		V
Malfunction prevention threshold voltage for power supply fluctuation (fall)	V_{ML}		$1.54 \times V_{REF}$		V
Malfunction prevention threshold voltage for power supply fluctuation (rise)	V_{MH}		$2.42 \times V_{REF}$		V
Consumption Current (Sleep Mode) VDD	I_{SLEEP}		1		μA
Consumption Current (Mute Mode) VDD	I_{MUTE}		10		mA
Consumption Current (No-signal, No filter) VDD	I_{DDD}		25		mA
Consumption Current (No-signal, Headphone output) VDD	I_{DDH}		10		mA

● AC characteristics ($V_{SS}=0\text{V}$, $V_{DD}=5\text{V}$, $T_a=25^{\circ}\text{C}$, unless otherwise specified)

Item	Symbol	Min.	Typ.	Max.	Unit
Oscillation Frequency	F_C		800		kHz

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■ Typical analog characteristics

- Analog Characteristics ^{Note 8)} ($V_{SS}=0V$, $V_{DD}=5V$, $T_a=25^{\circ}C$, Frequency:1kHz, $R_I=33k\Omega$, $R_{FB}=39k\Omega$, unless otherwise specified)

Digital Amplifier Section

Item	Condition	Symbol	Min.	Typ.	Max.	Unit
Maximum Output (THD+N=10%)	$R_L=2\Omega$	P_D		5.0		W
	$R_L=3\Omega$			3.7		W
	$R_L=4\Omega$			3.0		W
Voltage Gain		A_V		9.5		dB
Total Harmonic Distortion Rate (BW: 20kHz)	$R_L=2\Omega$, $P_O=2.5W$	THD+N		0.03		%
	$R_L=3\Omega$, $P_O=1.5W$			0.02		%
Signal /Noise Ratio (BW:20kHz A-Filter)	$R_L=2\Omega$, $P_O=5W$, 1Vrms input sensitivity ^{Note 9)}	SNR		105.0		dB
	$R_L=2\Omega$, $P_O=5W$, 150mVrms input sensitivity ^{Note 9)}			98.0		dB
Channel Separation Ratio		CS		80		dB
Maximum Efficiency	$R_L=2\Omega$, $P_O=5W$	η		75		%
	$R_L=3\Omega$, $P_O=3W$			80		%
Output Offset Voltage		V_o		± 10		mV

Note 8) All values of analog characteristics are obtained on the Yamaha's evaluation environment.

Depending upon coil, capacitor, and pattern layout to use, characteristics may be changed.

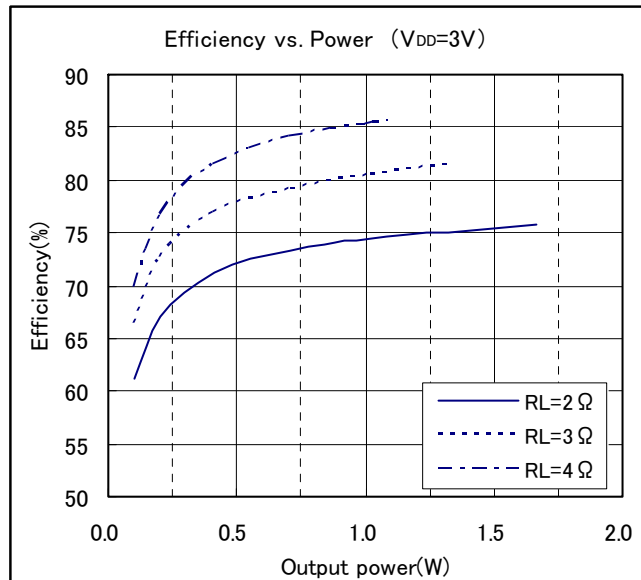
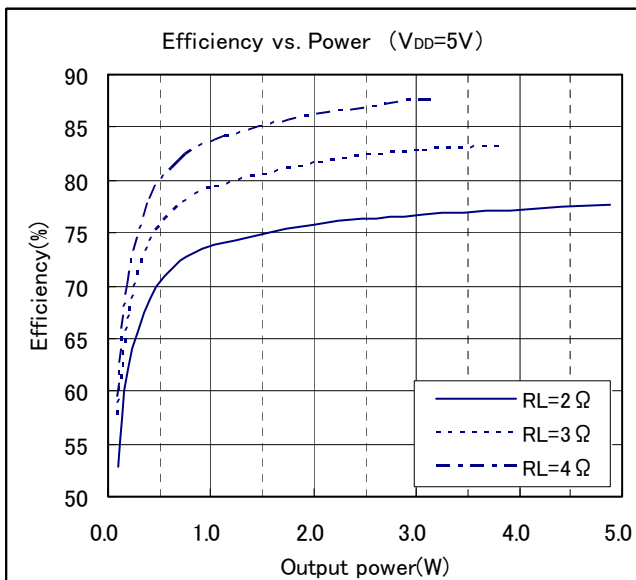
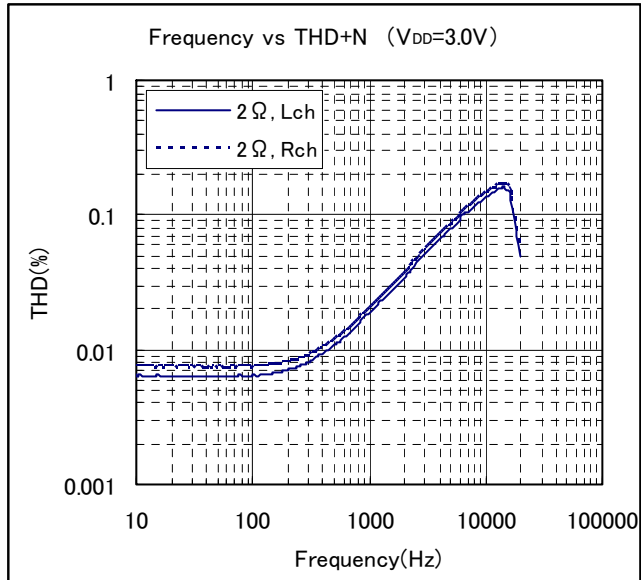
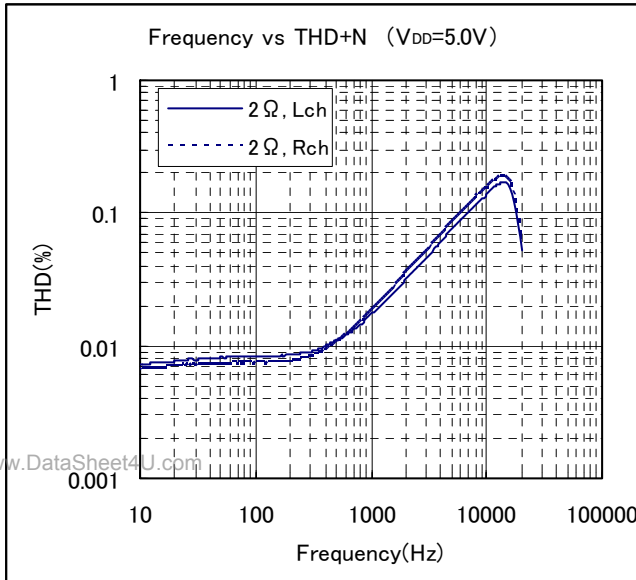
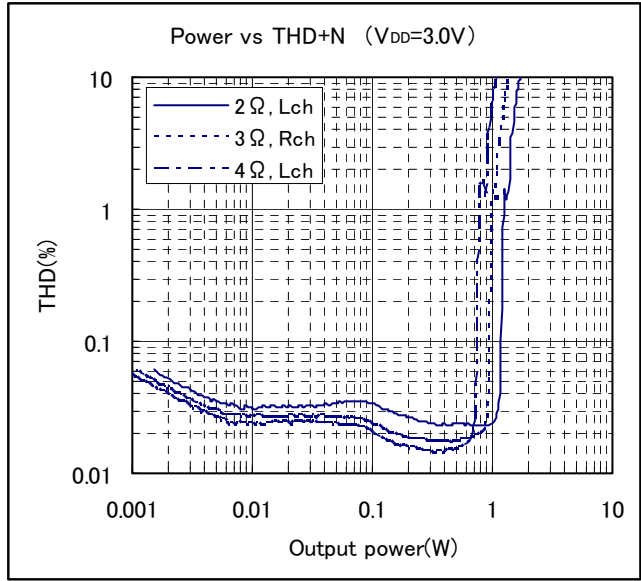
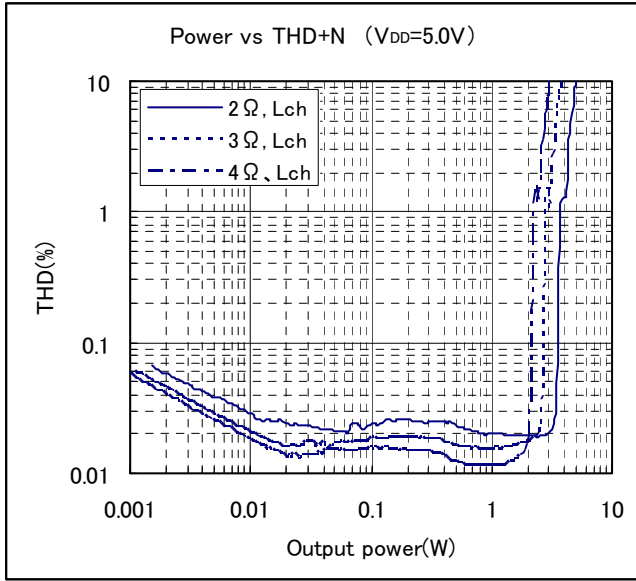
Note 9) 1Vrms input sensitivity means a setting from which maximum output is obtained at 1Vrms input, and here, $R_I=33k\Omega$ and $R_{FB}=39k\Omega$.

Likewise, 150mVrms input sensitivity means a setting from which maximum output is obtained at 150mVrms input, and here, $R_I=4.7k\Omega$ and $R_{FB}=39k\Omega$.

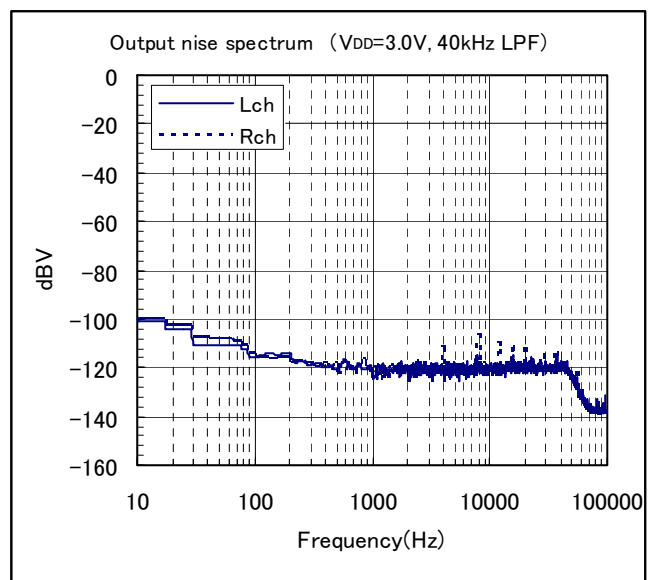
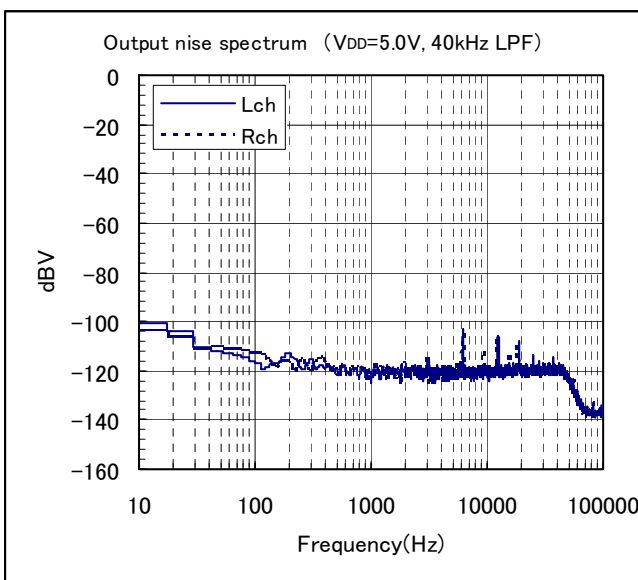
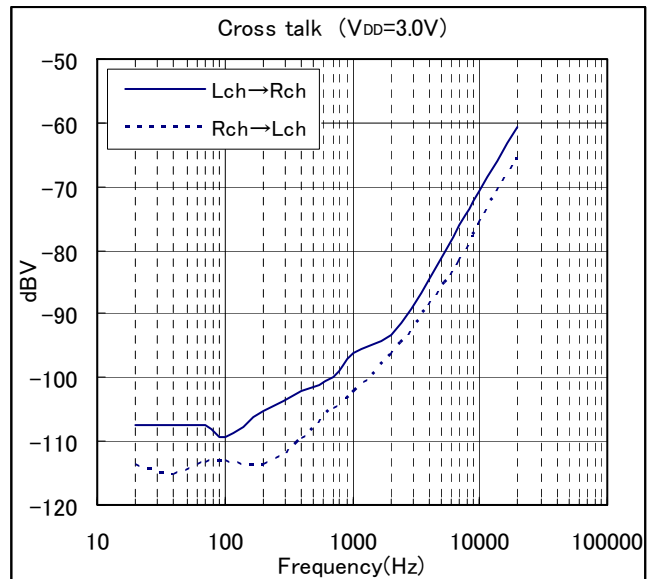
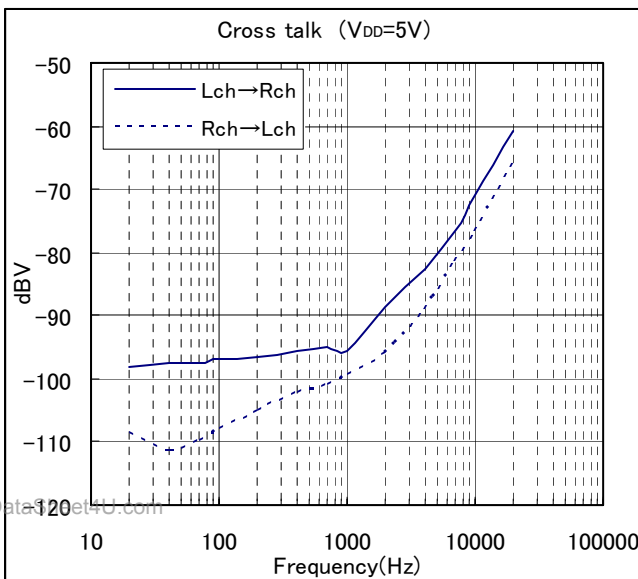
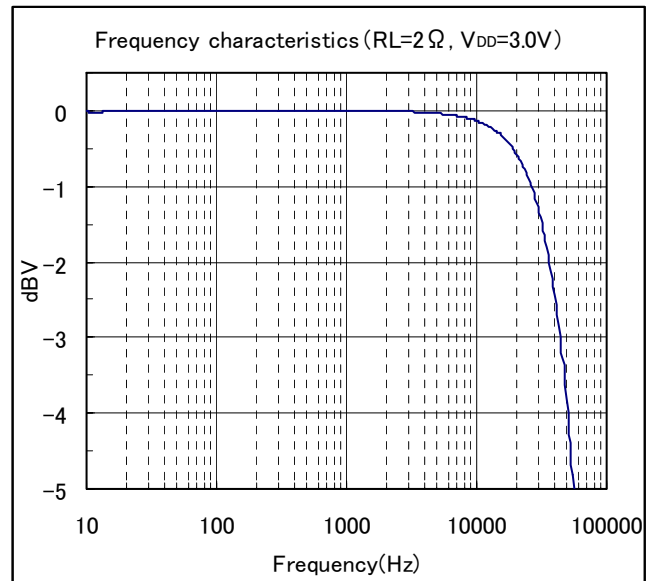
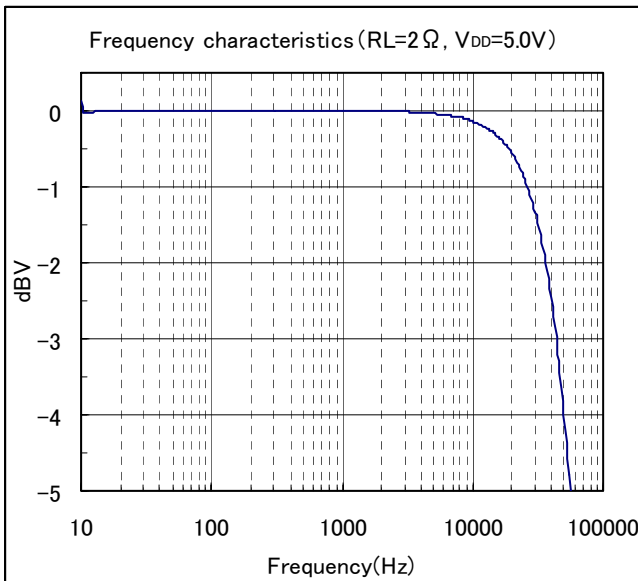
Headphone Amplifier Section

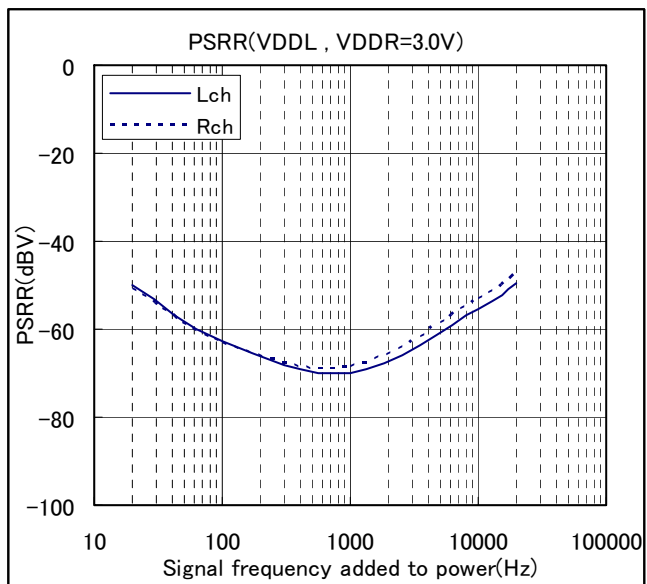
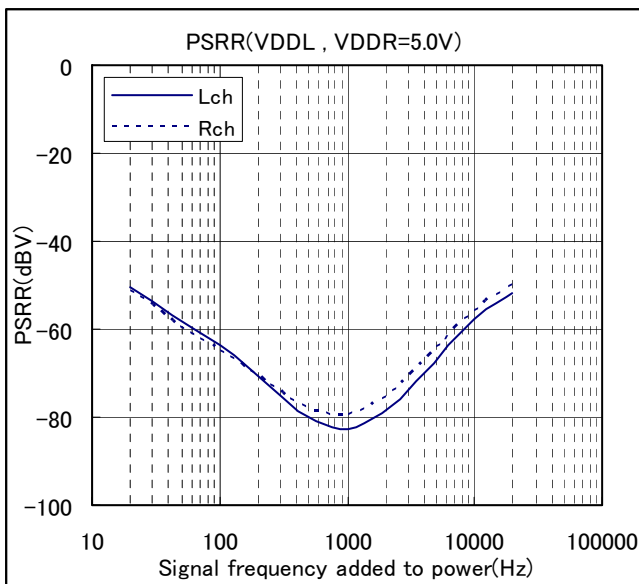
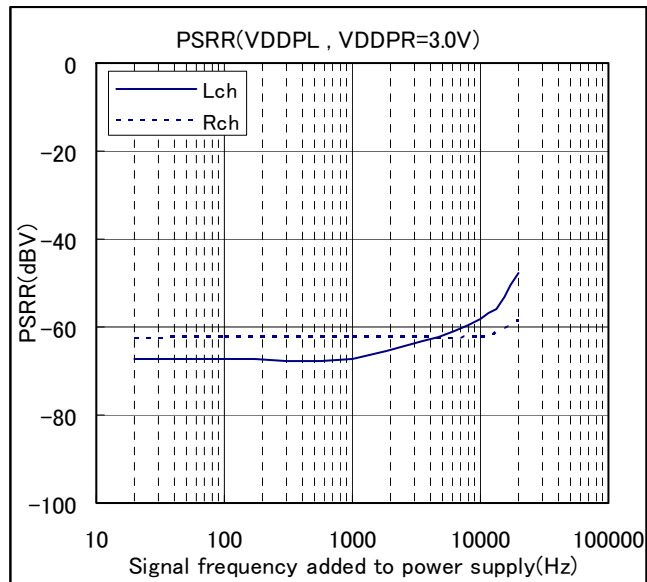
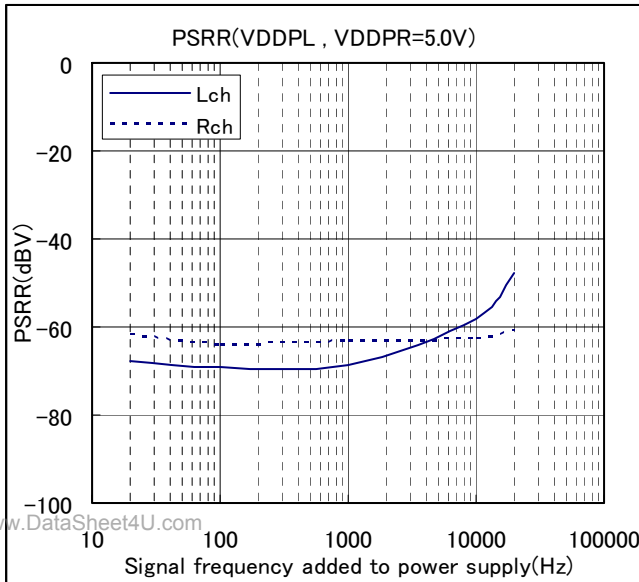
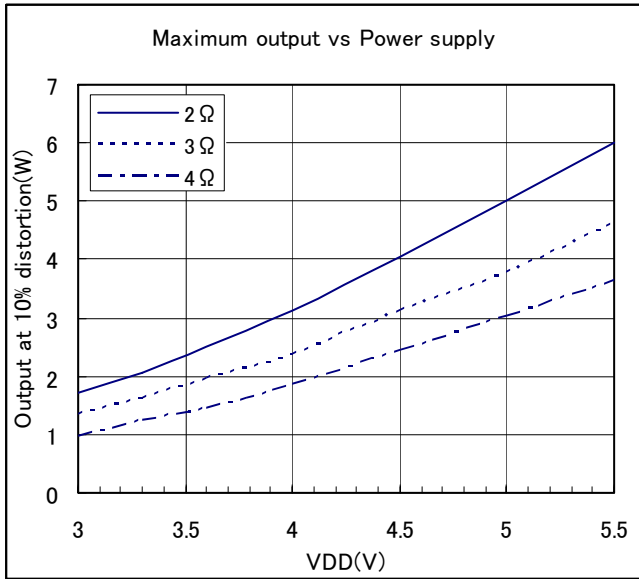
Item	Condition	Symbol	Min.	Typ.	Max.	Unit
Maximum Output (THD+N=1.0%)	$R_L=16\Omega$	Pho		20.0		mW
Total Harmonic Distortion Rate (BW:20kHz)	$R_L=16\Omega$, $P_O=10mW$	THD+N		0.25		%
Signal /Noise Ratio (BW: 20kHz A-Filter)	$R_L=16\Omega$, $P_O=20mW$, 1Vrms input sensitivity ^{Note 9)}	V_N		97.0		dB
	$R_L=16\Omega$, $P_O=20mW$, 150mVrms input sensitivity ^{Note 9)}			90.0		dB
Channel Separation Ratio	$R_L=16\Omega$	CS		80		dB

Typical characteristics examples



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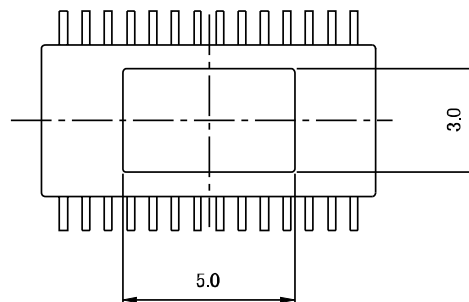
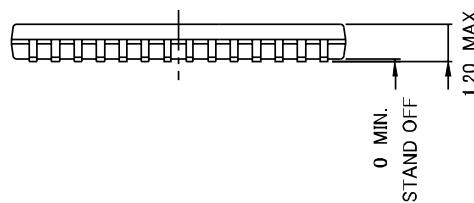
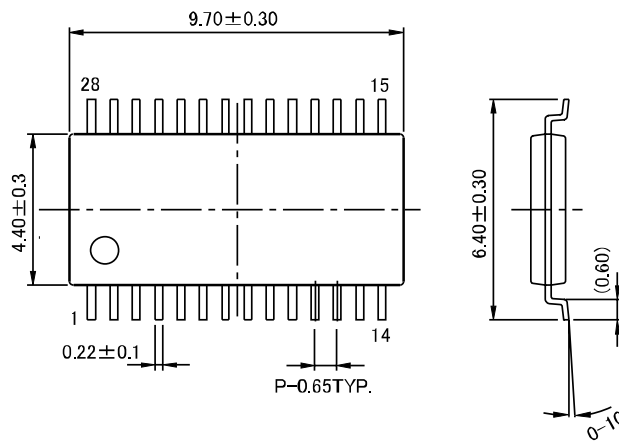




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■Package outline

C-PK28AP-1



端子厚さ: 0.14 ± 0.10
LEAD THICKNESS

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カッコ内の寸法値は参考値です。
モールド外形寸法はバリを含みません。
単位 : mm

The figure in the parentheses () should be used as a reference.
Plastic body dimensions do not include resin burr.
UNIT: mm

注) 表面実装LSIは、保管条件、及び半田付けについての特別な配慮が必要です。
詳しくはヤマハ代理店までお問い合わせください。

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YAMAHA CORPORATIONAddress inquiries to:
Semiconductor Sales & Marketing Department

- Head Office 203, Matsunokijima, Toyooka-mura
Iwata-gun, Shizuoka-ken, 438-0192, Japan
Tel. +81-539-62-4918 Fax. +81-539-62-5054
- Tokyo Office 2-17-11, Takanawa, Minato-ku,
Tokyo, 108-8568, Japan
Tel. +81-3-5488-5431 Fax. +81-3-5488-5088
- Osaka Office 3-12-12, Minami Senba, Chuo-ku,
Osaka City, Osaka, 542-0081, Japan
Tel. +81-6-6252-6221 Fax. +81-6-6252-6229