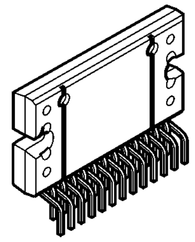
MOS Linear Integrated Circuit Silicon Monolithic

TCB001HQ

Maximum Power 45W BTL × 4-ch Audio Power IC

1. Description

The TCB001HQ is a four-channel BTL power amplifier for car audio applications.
This IC has a pure complementary P-ch and N-ch DMOS output stage, offering maximum output power (P_{OUT} MAX) of 45W.
It includes a standby switch, mute function and various protection features.



HZIP25-P-1.00F

Weight: 7.7 g (typ.)

2. Applications

Power IC developed for car audio applications.

3. Features

- High output power, low distortion, and low noise property (for details, refer to the Table 1)
- Built-in various mute functions (low voltage, standby on/off)
- Built-in standby switch (pin4)
- Built-in mute switch (pin22)
- Built-in various detection circuits (output offset voltage, output short, over voltage) (pin25)
- Start stop Cruising corresponded to V_{DD}=6V (Engine idle reduction capability)
- Built-in various protection circuits (thermal shut down, over voltage, short to V_{DD}, short to GND, and output to output short, prevention of speaker damage)

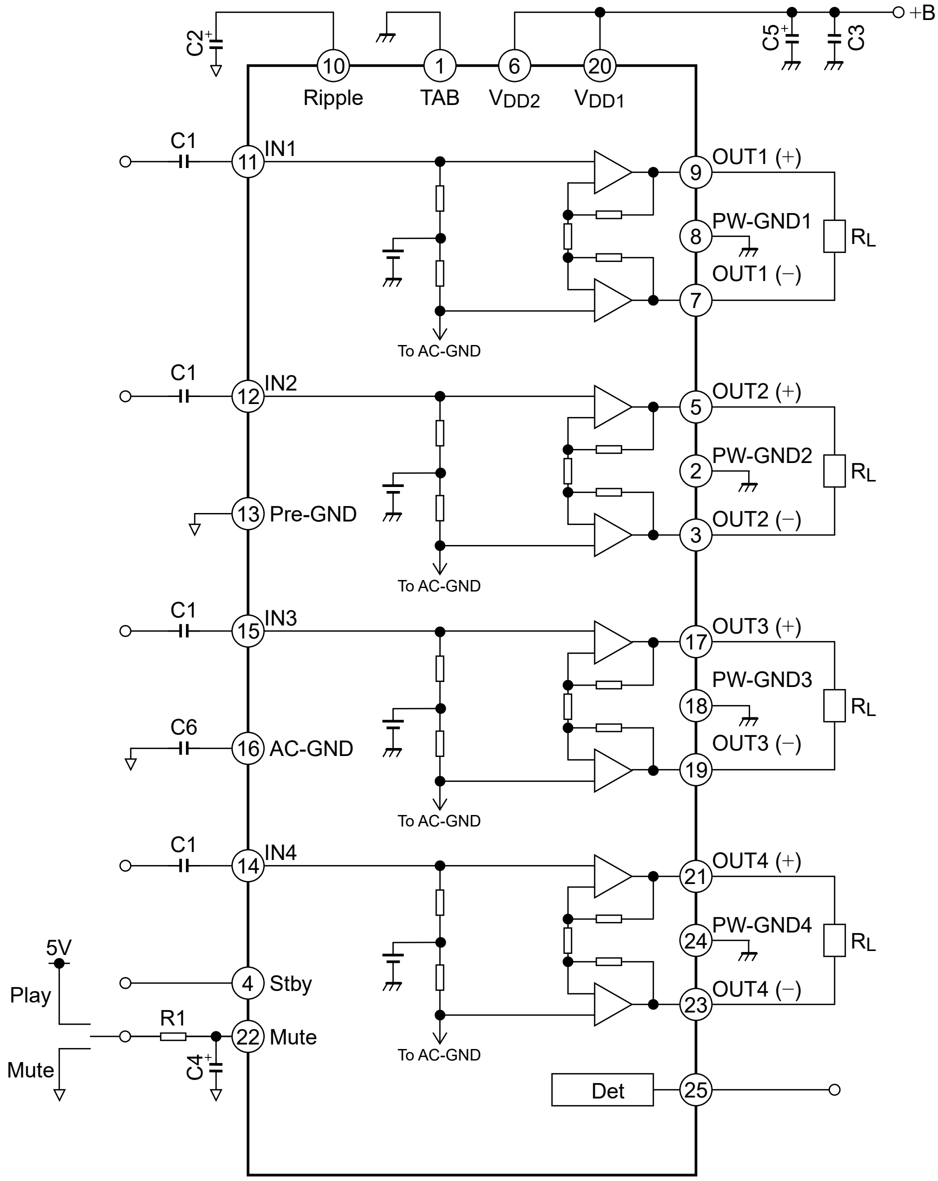
Table1 typical Characteristics (Note1,Note2)

Condition	Typ.	Unit
Output power (P_{OUT})		
V_{DD} = 15.2 V, JEITA max	45	W
V_{DD} = 14.4 V, JEITA max	40	W
V_{DD} = 14.4 V, THD = 10%	26	W
THD = 10%	22	W
Total harmonic distortion (THD)		
P_{OUT} = 4 W	0.01	%
Output noise voltage (V_{NO}) (Rg = 0 Ω),		
BW = 20 Hz to 20 kHz	45	μV
Operating Supply voltage range (V_{DD})		
RL = 4 Ω	6 to 18	V

Note1: Typical test conditions: V_{DD} = 13.2 V, f = 1 kHz, R_L = 4 Ω, G_V = 26 dB, Ta = 25°C, unless otherwise specified.

Note2: Rg: signal source resistance

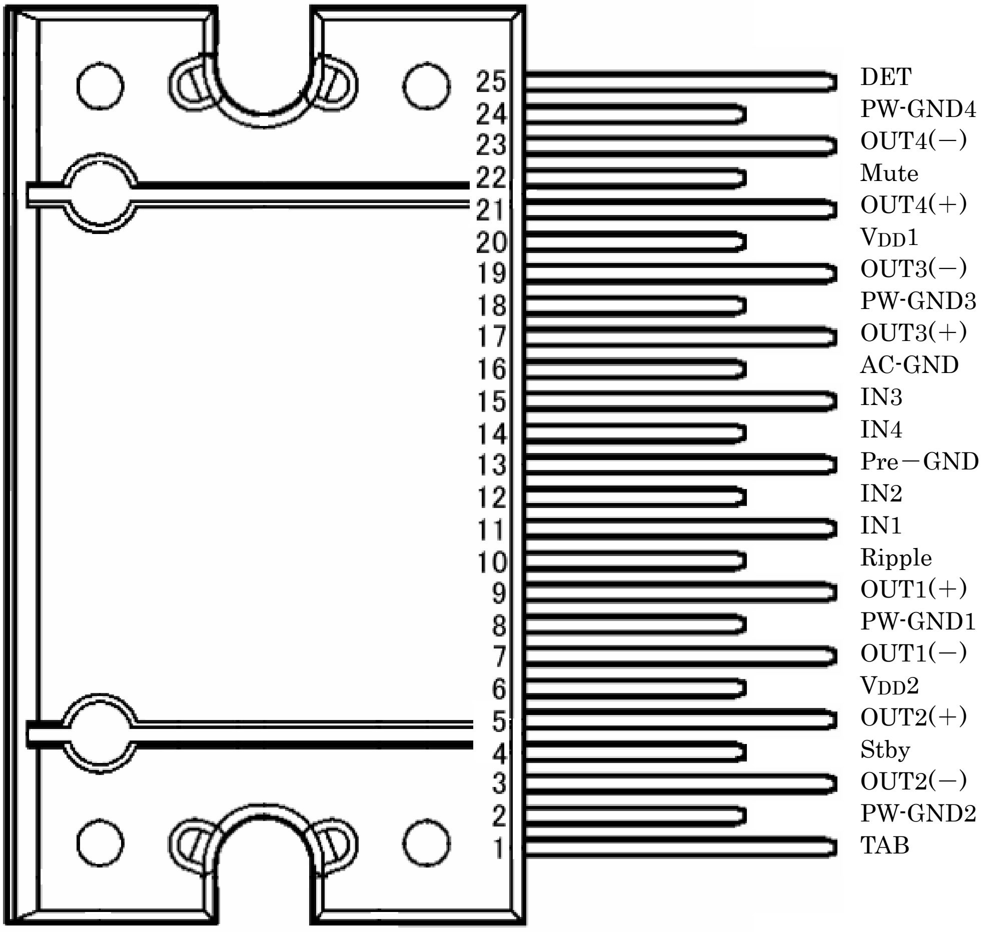
4. Block Diagram



Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes. In the following explanation, a "channel" is a circuit which consists of INx, OUTx (+), OUTx (-), and PW-GNDx. (x: 1 to 4).

5. Pin Configuration and Function Descriptions

5.1 Pin Configuration (top view)

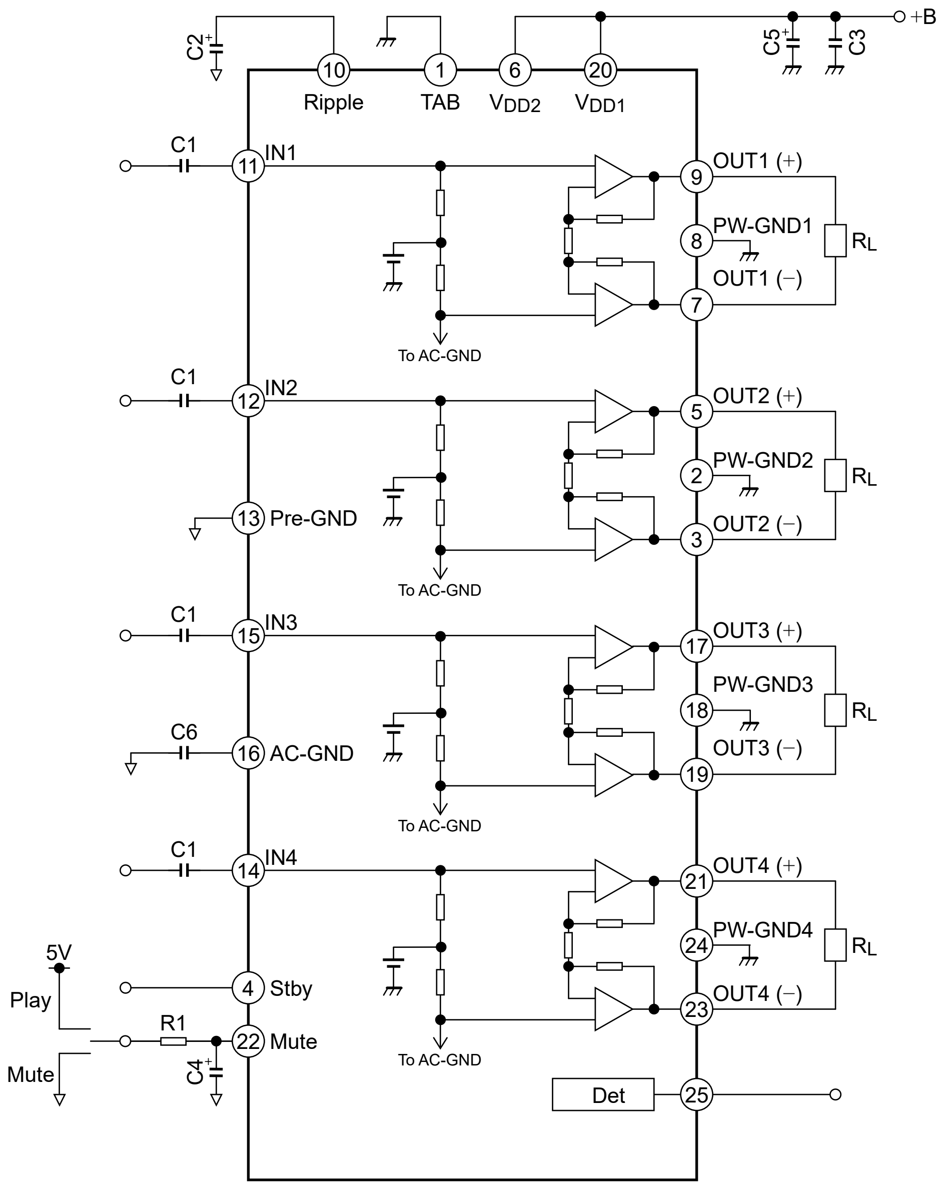


5.2 Pin Function Descriptions

Pin	Symbol	I/O	Description
1	TAB	—	TAB (Always connect with GND)
2	PW-GND2	—	Ground for Rear Left output
3	OUT2(-)	OUT	Rear Left output-
4	Stby	V_{ST}-IN	Standby voltage input
5	OUT2(+)	OUT	Rear Left output+
6	V_{DD}2	V_{DD}-IN	Supply voltage 2
7	OUT1(-)	OUT	Rear Left output+
8	PW-GND1	—	Ground for Front Left output
9	OUT1(+)	OUT	Front Left output-
10	Ripple	—	Ripple voltage
11	IN1	IN	Front Left input
12	IN2	IN	Rear Left input
13	Pre-GND	—	Signal ground
14	IN4	IN	Rear Right input
15	IN3	IN	Front Right input
16	AC-GND	—	Common reference voltage for all input
17	OUT3(+)	OUT	Front Right output+
18	PW-GND3	—	Ground for Front Right output
19	OUT3(-)	OUT	Front Right output-
20	V_{DD}1	V_{DD}-IN	Supply voltage 1
21	OUT4(+)	OUT	Rear Right output+
22	Mute	V_{mute}IN	Mute voltage input
23	OUT4(-)	OUT	Rear Right output-
24	PW-GND4	—	Ground for Rear Right output
25	DET	(OD) Note1	Offset detector output / short detector / over voltage

Note1 OD: Open drain.

6. Detailed Description



Component Name	Recommended Value	Pin	Purpose	Effect (Note1)	
				Lower than Recommended Value	Higher than Recommended Value
C1	0.22 μF	INx (x: 1 to 4)	To eliminate DC	Cut-off frequency becomes higher	Cut-off frequency becomes lower
C2	10 μF	Ripple	To reduce ripple	Turn on/off time and turn-on diag. cycle shorter	Turn on/off time and turn-on diag. cycle longer
C3	0.1 μF	$V_{DD}1$, $V_{DD}2$	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin	
C4	1 μF	Mute	To reduce pop noise(Note2)	High pop noise. Duration until mute function is turned on/off is short.	Low pop noise. Duration until mute function is turned on/off is long.
C5	3900 μF	$V_{DD}1$, $V_{DD}2$	Ripple filter	Power supply ripple filtering	
C6	1 μF	AC-GND	Common reference voltage for all input	Pop noise is suppressed when C1 : C6 = 1 : 4. (Note3)	
R1	47kΩ	Mute	To reduce pop noise	High pop noise. Duration until mute function is turned on/off is short.	Low pop noise. Duration until mute function is turned on/off is long.

Note1: When the unrecommended value is used, please examine it enough by system evaluation.

Note2: Since "AC-GND" pin is a common reference voltage for all input, this product needs to set the ratio of an input apacitance (C1) and the AC-GND capacitance (C6) to 1 : 4.

Note3: Please use the low leak current apacitor for C1 and C6.

7. Standby Switch

The power supply can be turned on or off via pin 4 (Stby). The threshold voltage of pin 4 is below table. The power supply current is about 0.01 μA (typ.) in the standby state.

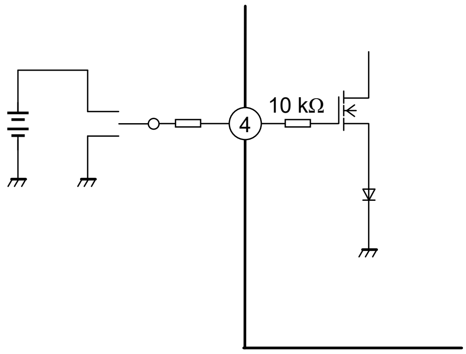


Table1 Standby Control Voltage (V_{stby})

Stby	Power	V_{stby} (V)
ON	OFF	0 to 0.8
OFF	ON	2.2 to V_{DD}

Check the pop levels when the time constant of pin 4 is changed.

Benefits of the Standby Switch

(1) V_{DD} can be directly turned on or off by a microcontroller, eliminating the need for a switching relay.

(2) Since the control current is minuscule, a low-current-rated switching relay can be used.

4

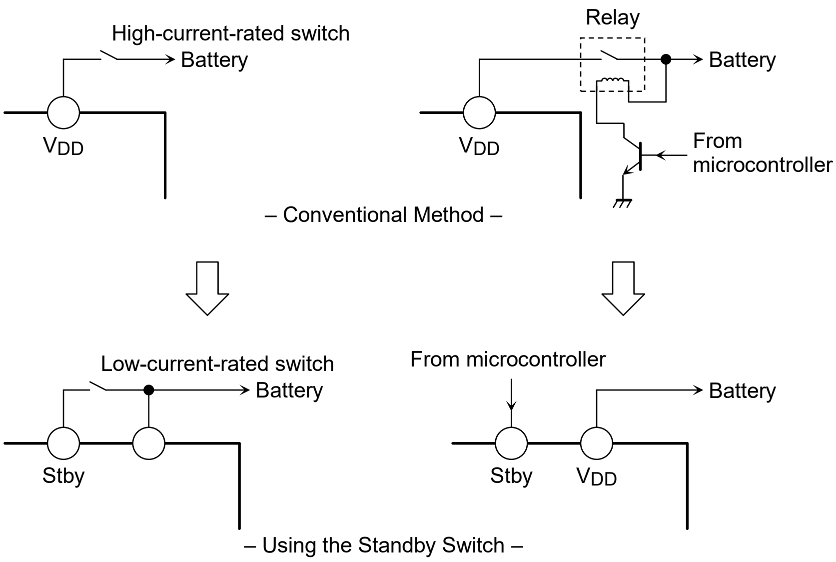


Figure 2 Standby Switch

8. Mute switch

The audio mute switch is enabled by setting pin 22 Low. R_1 and C_4 determine the time constant of the mute. The time constant affects pop noise generated when power or the mute is turned on or off; thus, it must be determined on a per-application basis. And this terminal is designed on the control voltage of 5 V.
The value of the external pull-up resistor is determined, based on pop noise value.

For example, when the control voltage is changed from 5 V to 3.3 V, the pull-up resistor should be:
3.3 V/5 V × 47 kΩ = 31 kΩ

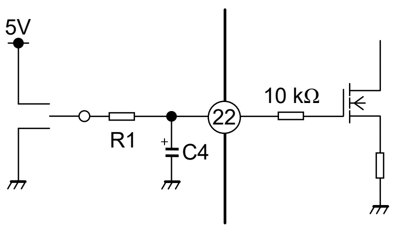


Figure 3 Mute Function

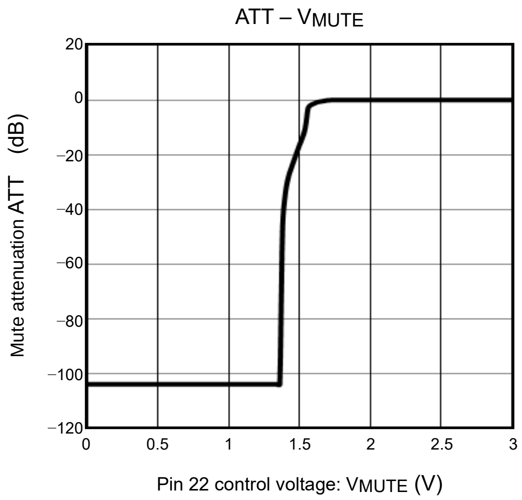


Figure 4 Mute Attenuation– V_{MUTE} (V)

9. Mute Mode

The mute modes in this product are a mute at standby off and an internal mute for low voltage.

9.1 Low Voltage Mute

When the supply voltage became lower than 5.5(typ.), it operates the mute circuit automatically. This function prevents the large audible transient noise which is generated by low V_{DD}

9.2 Standby off Mute

A mute operation starts automatically inside the IC after standby-off until the Ripple pin voltage becomes about $1/4V_{DD}$(V).

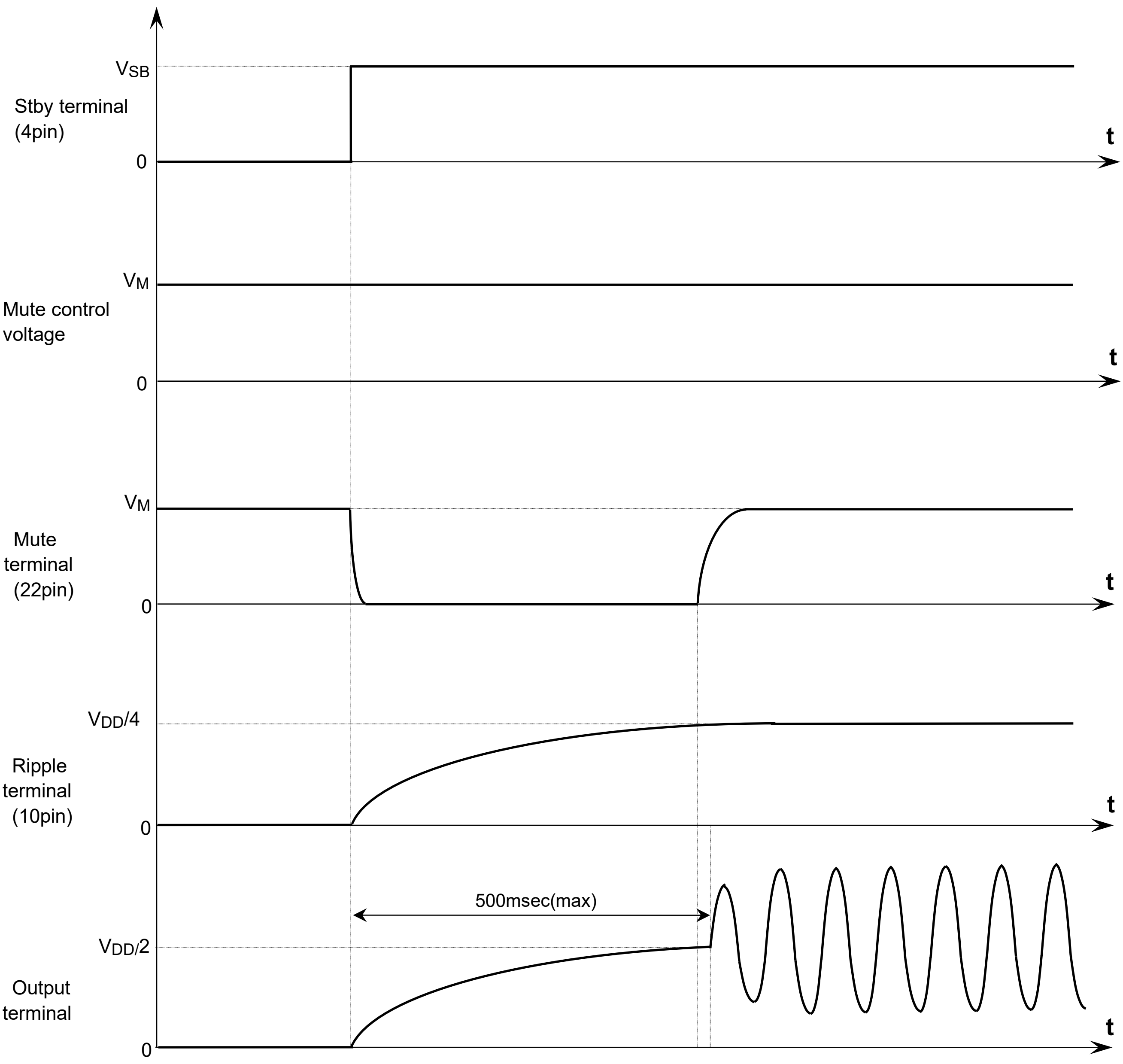


Figure5 The timing chart when standby-off

9.3 Mute off after standby off

It affects pop noise generated when capacitor of ripple, input and ACGND is finished to charge; thus, it must be determined on a per-application basis.
Please set "Mute-off" that it is sufficient margin in considering a enough charge time after the middle point potential stable.

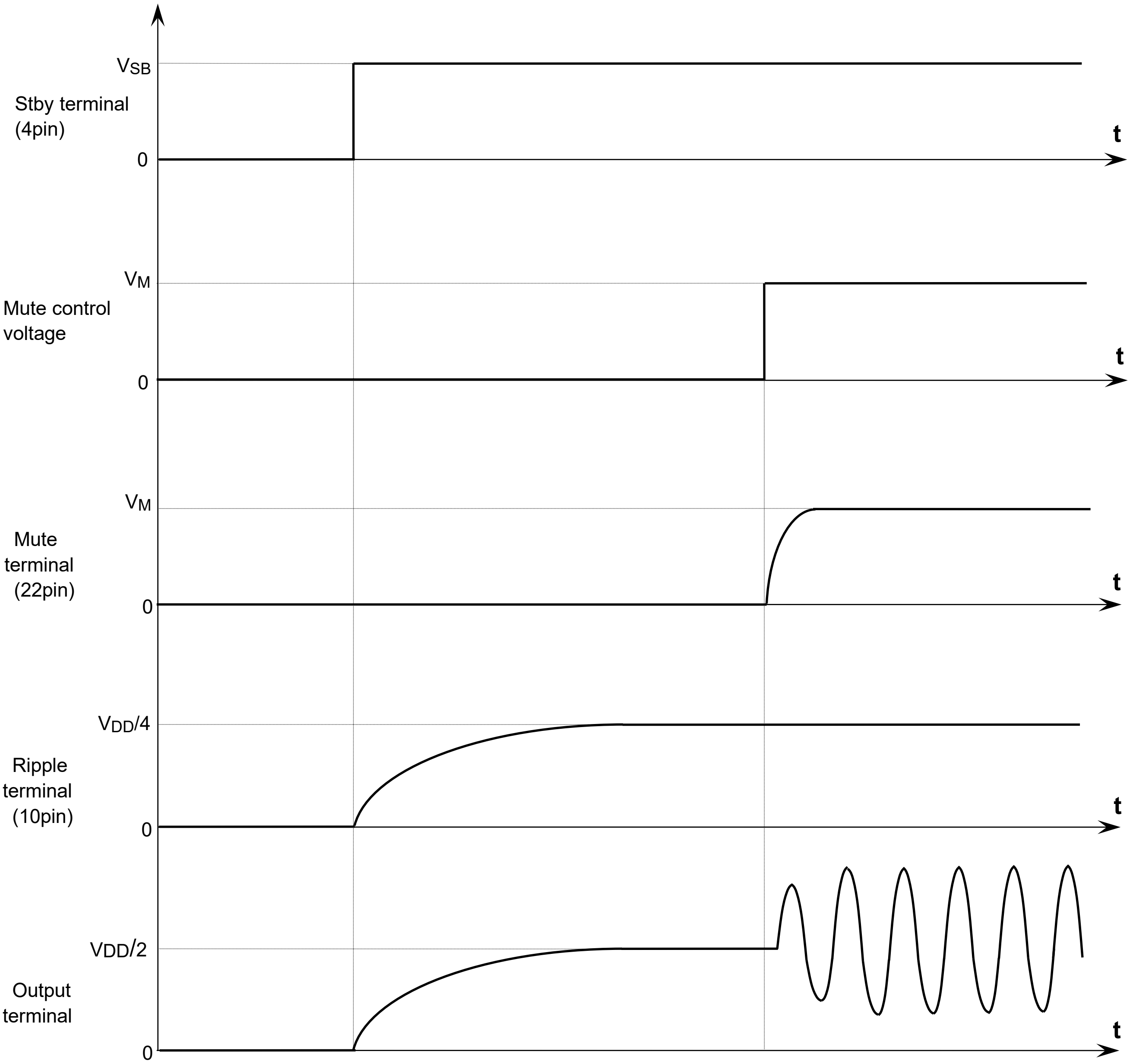


Figure6 The timing chart when standby-off

10. 25pin: Output DC Offset Detection

This function detects the offset voltage between OUT(+) and OUT(-). The detection result is gotten by pin25. When the offset voltage appeared by the external parts accident, for example the leak of coupling capacitor, this function can contribute to a part of safety system to prevent the speaker damage. In case of being unused this function, use this IC as open-connection on pin25.

10.1 Output DC offset detection

This function detects the offset voltage between OUT(+) and OUT(-). The detection result is gotten by pin25. When the offset voltage appeared by the external parts accident, for example the leak of coupling capacitor, this function can contribute to a part of safety system to prevent the speaker damage.

The example flow chart: The safety system to prevent damaging to speakers by abnormal offset.

(a) Offset detection ⇨ (b) Judgment Normal / Abnormal ⇨ (c) To reduce the speaker stress Stby-ON, Mute-ON etc.

The result of detection does not judge the abnormal offset or not. This function detects only the offset voltage which is decided by specification.

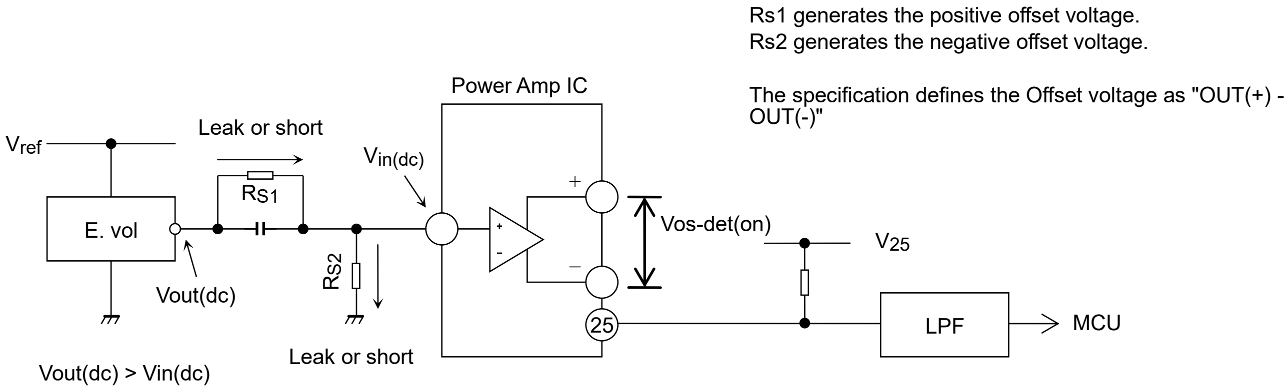


Figure 7 Abnormal output offset voltage

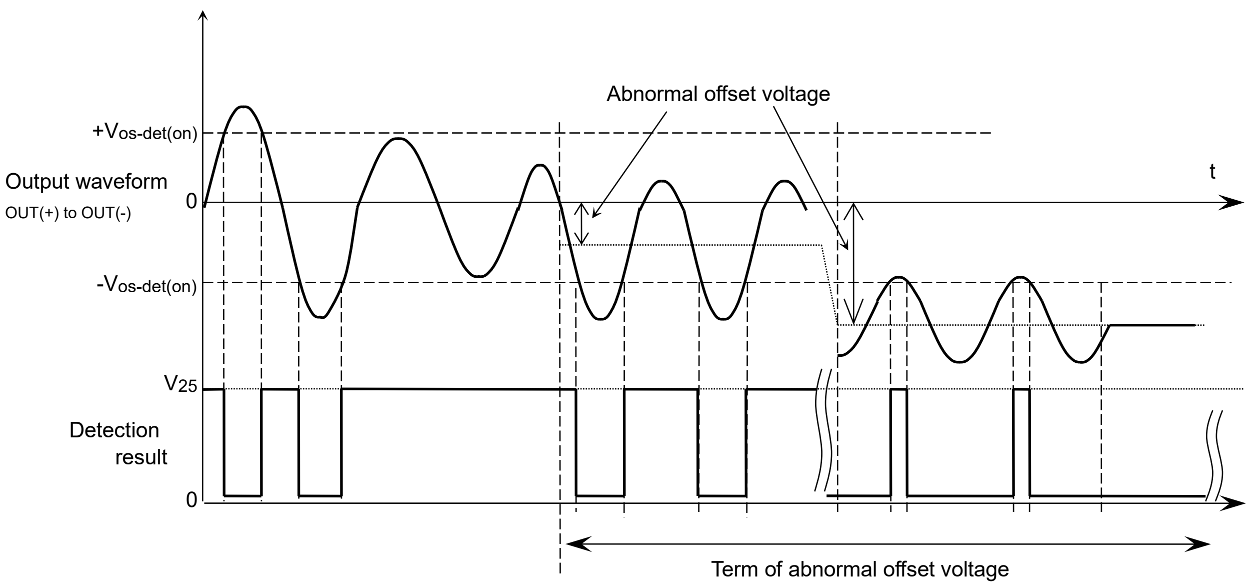


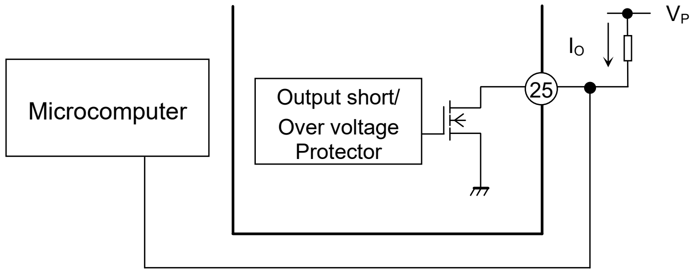
Figure 8 The detected result and audio output waveform

10.2 Output to GND short detection

In case of shorting output to V_{DD}/GND or over power supplied is turned on the MOS transistor and can be detected.(Reference: Figure9) Threshold of over voltage protection: V_{DD}=23V(typ.).

And in the case of output to output is turned on the MOS transistor and can be detected.(Reference: Figure10)

Please use under Io=500μA at the time of a pull-up.



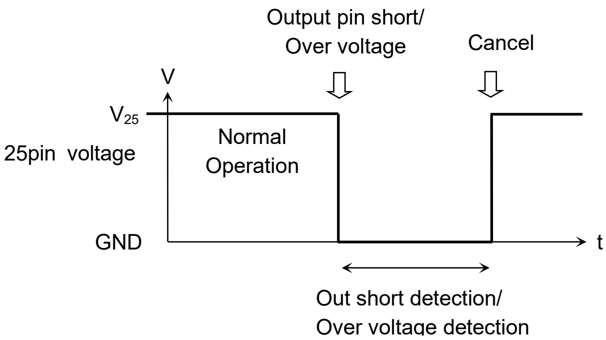


Figure 9 Output short detection/ Overvoltage detection

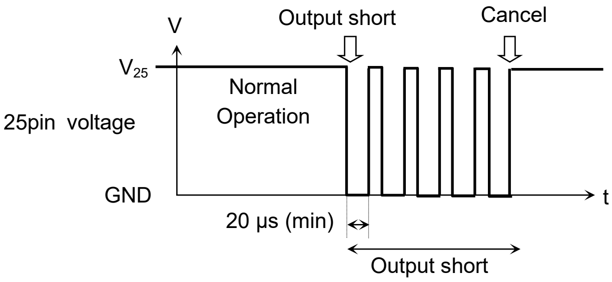


Figure10 Output short detection

11. Engine idle reduction capability

This IC can continually provide audio output when the battery voltage reboot from it rapidly drop(idling stop mode).This function This can reduce the sound cutting and pop sound since it switch to 1/4V_{DD} for middle voltage.

12. Protection Functions

This product has internal protection circuits such as thermal shut down, over voltage, out to V_{DD}, out to GND, and out to out short circuit protections.

(1) Thermal shut down

It operates when junction temperature exceeds 150°C (typ.).
When it operates, it is protected in the following order.

1. An Attenuation of an output starts first and the amount of attenuation also increases according to a temperature rising,
2. All outputs become in a mute state, when temperature continues rising in spite of output attenuation.
3. Shutdown function starts, when a temperature rise continues through all outputs are in a mute state.

In any case if temperature falls, it will return automatically.

(2) Over voltage

It operates when voltage exceeding operating range is supplied to V_{DD} pin. If voltage falls, it will return automatically. When it operates, output bias is turned off and an output is intercepted.

(3) Short to V_{DD}, Short to GND, Output to output short

It operates when each pin is in irregular connection. If irregular connection is canceled, it will return automatically.
Short circuit protection can operate for each channel.
When it operates, output bias of corresponding output is turned off and an output is intercepted.
Example) If channel 1 output shorts, channel 1 is protected but other channels 2 to 4 are available.

(4) Prevention of speaker damage (in case of a layer short-circuit of the speaker)

When the DC resistance between the OUT+ and OUT− pins falls below 1 Ω, the output current exceeds 4 A. At this time, the protection circuit is activated to limit the current draw into the speaker.
This feature prevents the speaker from being damaged, as follows:

< Speaker damaging scenario >

A DC current of over 4 V is applied to the speaker due to an external circuit failure (Note 1).
(Abnormal DC output offset)
↓
The speaker impedance becomes 1 Ω or less due to a layer short.
↓
A current of over 4 A flows into the speaker, damaging the speaker.

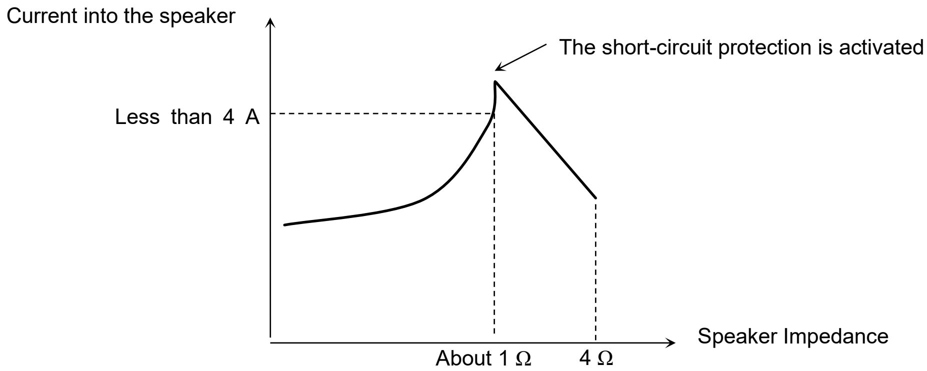


Figure 11 Prevention of speaker damage

Note1: An abnormal DC offset voltage is incurred when the input bias to the power IC is lost due to a leakage current from a coupling capacitor at the input or a short-circuit between the IN and adjacent lines.

13. Absolute Maximum Ratings

(Ta = 25°C unless otherwise specified)

Characteristics	Condition	Symbol	Rating	Unit
Supply voltage (surge)	max0.2s	$V_{DD\ (surge)}$	50	V
Supply voltage (DC)		$V_{DD\ (DC)}$	30	V
Supply voltage (operation)		$V_{DD\ (opr)}$	18	V
Output current (peak)		$I_{O\ (peak)}$	9	A
Power dissipation	(Note)	P_D	125	W
Operating temperature range		T_{opr}	-40 to 105	°C
Storage temperature		T_{stg}	-55 to 150	°C
GND potential tolerance		GNDmax	-0.3 to 0.3	V
Vin max voltage		Vinmax	-0.3 to 5.3	V
Max Standby/Mute input voltage		VSTBmax	-0.3 to V_{DD}+0.3	V
AC-GND/ripple max input voltage		VACGmax	-0.3 to 5.3	V

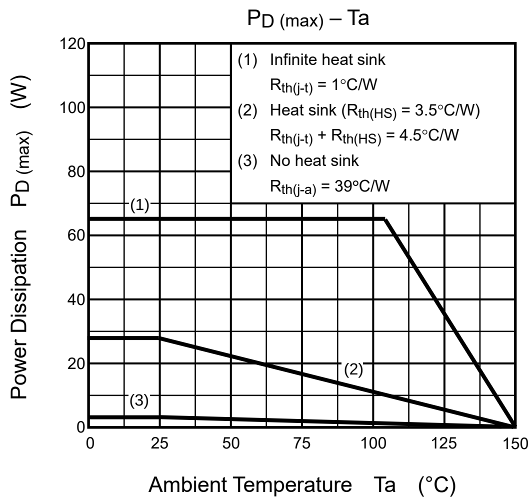
Note: Package thermal resistance $R_{th(j-t)}$ = 1°C/W (typ.) (Ta = 25°C, with infinite heat sink)

The absolute maximum ratings of a semiconductor device are a set of specified parameter values, which must not be exceeded during operation, even for an instant.

If any of these rating would be exceeded during operation, the device electrical characteristics may be irreparably altered and the reliability and lifetime of the device can no longer be guaranteed. Moreover, these operations with exceeded ratings may cause break down, damage, and/or degradation to any other equipment. Applications using the device should be designed such that each maximum rating will never be exceeded in any operating conditions.

Before using, creating, and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

13.1 Power Dissipation



14. Operating Ranges

Characteristics	Symbol	Condition	Min	Typ.	Max	Unit
Supply voltage	V_{DD}	R_L=4Ω	6	—	18	V

15. Electrical Characteristics

(V_{DD} = 13.2 V, f = 1 kHz, R_L = 4 Ω, G_V=26dB, Ta = 25°C unless otherwise specified)

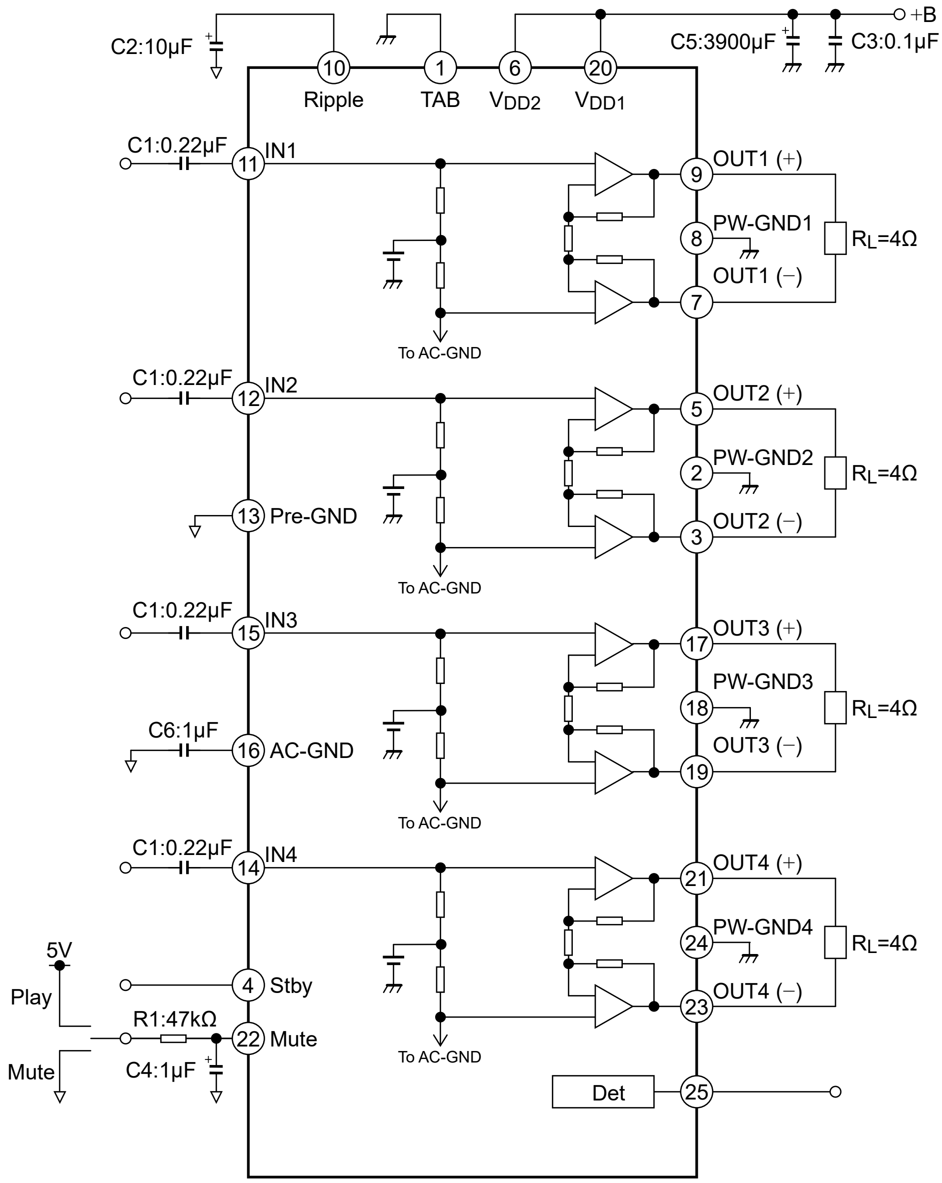
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I_{CCQ}	V_{IN} = 0 V	—	200	300	mA
Output power	P_{OUT} MAX (1)	V_{DD} = 15.2 V, max POWER	—	45	—	W
	P_{OUT} MAX (2)	V_{DD} = 14.4 V, max POWER	—	40	—	
	P_{OUT} (1)	V_{DD} = 14.4 V, THD = 10%	—	26	—	
	P_{OUT} (2)	THD = 10%	—	22	—	
Total harmonic distortion	THD	P_{OUT} = 4 W	—	0.01	0.07	%
Voltage gain	G_V	V_{OUT} = 0.775 Vrms	25	26	27	dB
Channel-to-channel voltage gain	ΔG_V	V_{OUT} = 0.775 Vrms	−1.0	0	1.0	dB
Output noise voltage	V_{NO}	R_g = 0 Ω, BW = 20 Hz to 20 kHz	—	45	70	μVrms
Ripple rejection ratio	R.R.	f_{rip} = 100 Hz, R_g = 620 Ω V_{rip} = 0.775 Vrms (Note1)	50	70	—	dB
Crosstalk	C.T.	R_g = 620 Ω P_{OUT} = 4 W	—	80	—	dB
Output offset voltage	V_{OFFSET}	—	−90	0	90	mV
Input resistance	R_{IN}	—	—	90	—	kΩ
Standby current	I_{STBY}	Standby condition	—	0.01	1	μA
Standby control voltage	V_{SB} H(Note)	POWER: ON	2.2	—	V_{DD}	V
	V_{SB} L	POWER: OFF	0	—	0.8	
Mute control voltage	V_M H(Note)	Mute: OFF	2.2	—	V_{DD}	V
	V_M L	Mute: ON, R_1 = 47 kΩ	0	—	0.8	
Mute attenuation	ATT M	Mute: ON, DIN_AUDIO V_{OUT} = 7.75 Vrms → Mute: OFF	85	100	—	dB
DC offset threshold voltage	$V_{off\text{-}set}$	Io=500μA, Out(+)-Out(-)	±1.0	±1.5	±2.0	V
Pin 25 saturation voltage (at each detector ON condition)	P25-Det(Note)	Io=500μA, (pin 25 = low)	—	100	500	mV

Note: V_{SB}H,V_MH,P25-Sat : 18V(max)

Note1: f_{rip}: Ripple frequency

V_{rip}: Ripple signal voltage (AC fluctuations in the power supply)

16. Test Circuit



Components in the test circuits are only used to obtain and confirm the device characteristics.

17. Characteristic Chart

17.1 Total Harmonic Distortion vs. Output Power

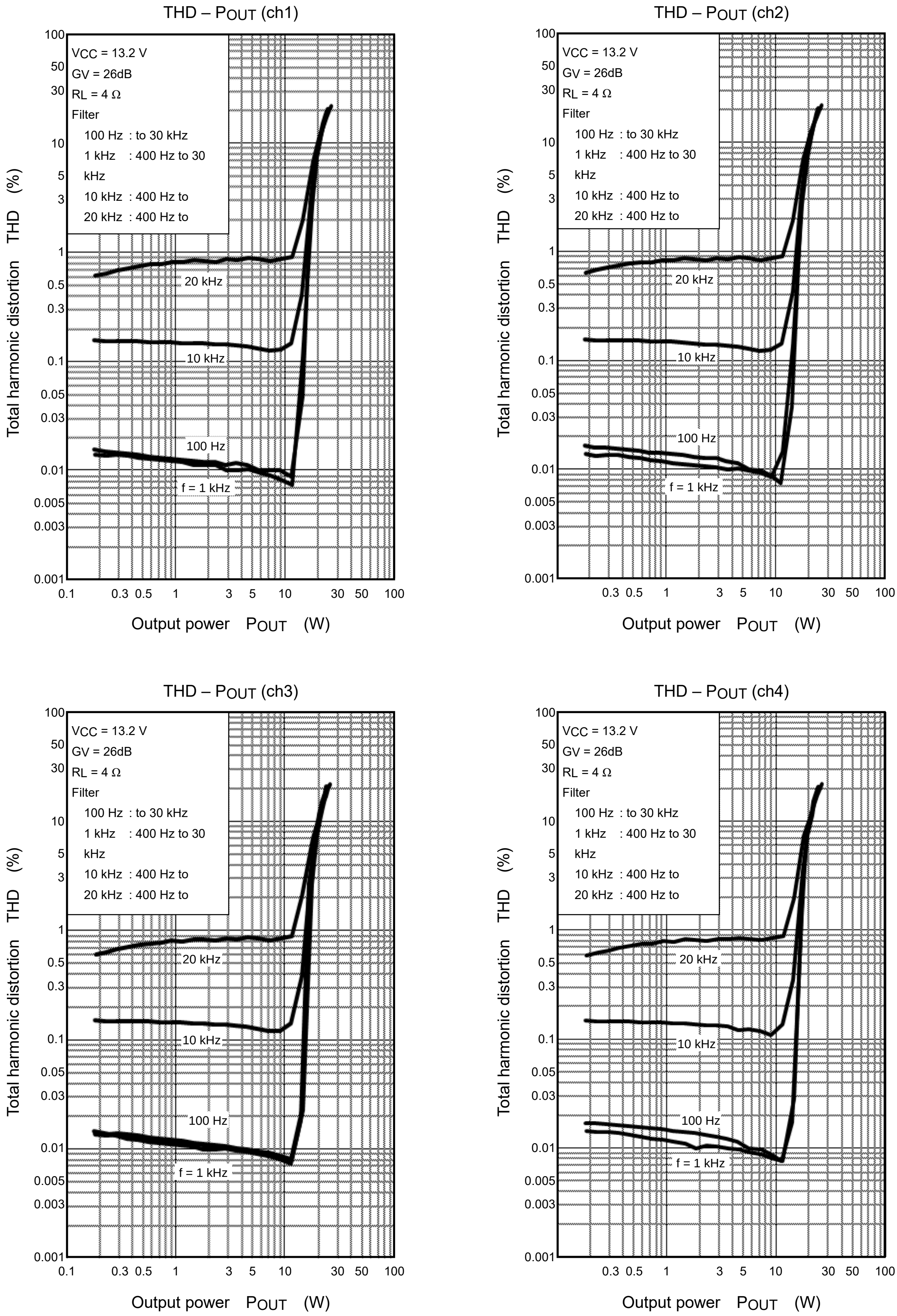
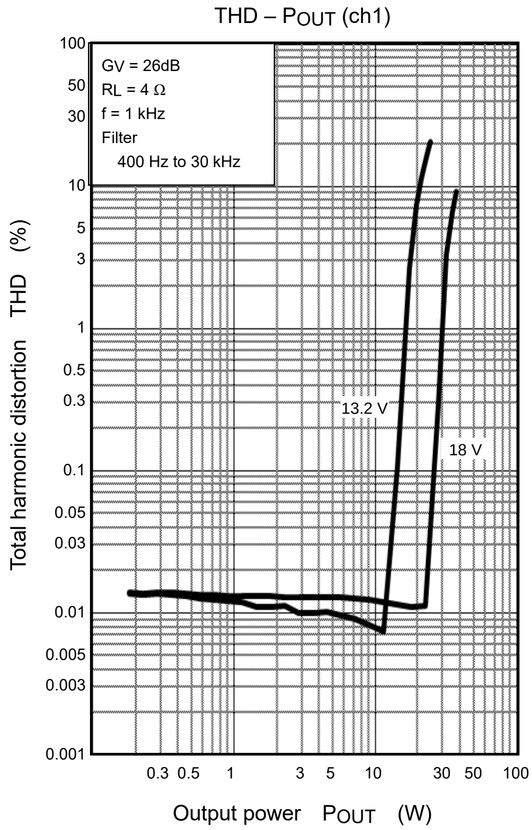
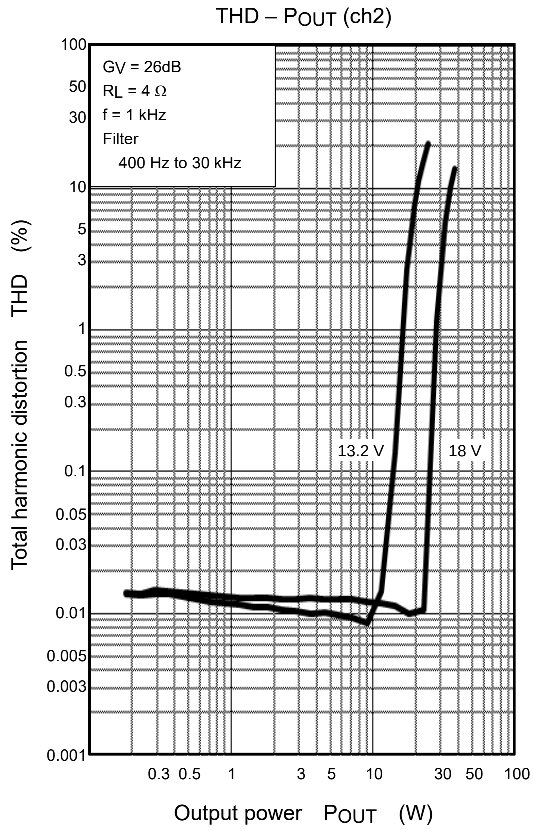
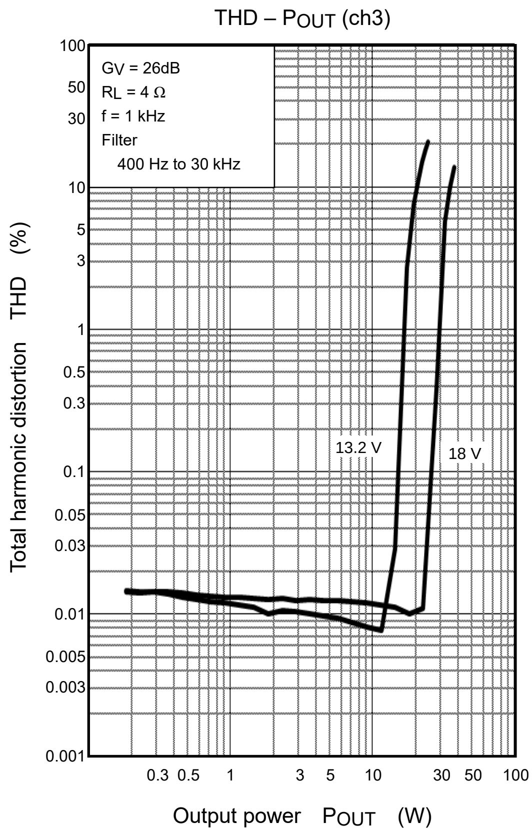


Figure 17-1 Total Harmonic Distortion of Each Frequency (RL = 4 Ω)







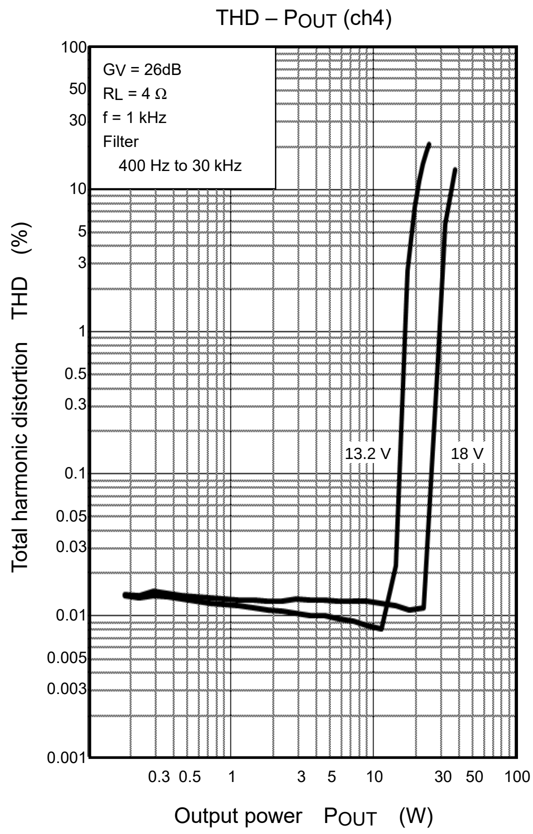


Figure 17-2 Total Harmonic Distortion by Power-supply Voltage (R_L = 4 Ω)

17.2 Various Frequency Characteristics

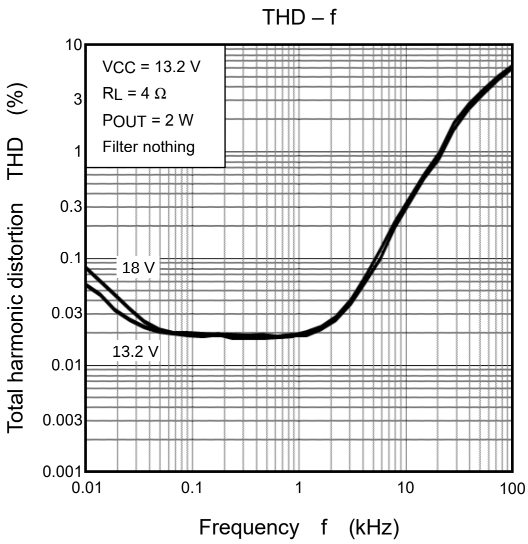
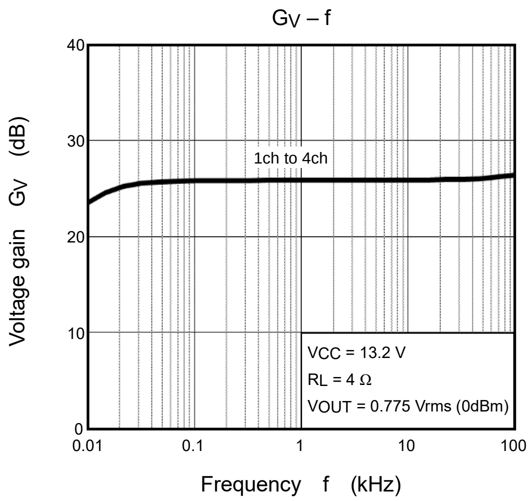


Figure 17-3 Frequency Characteristics of Total Harmonic Distortion



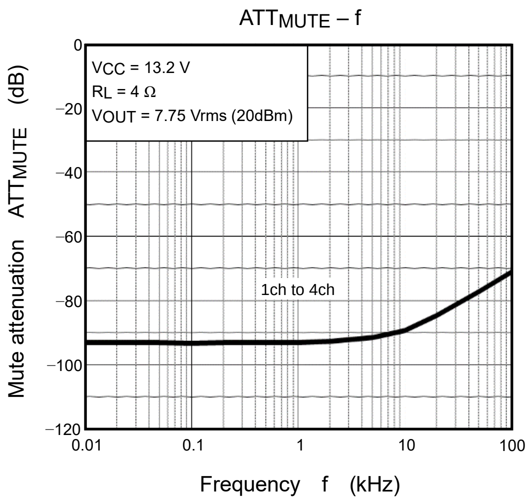


Figure 17-4 Frequency Characteristics of Voltage Gain and Mute Attenuation

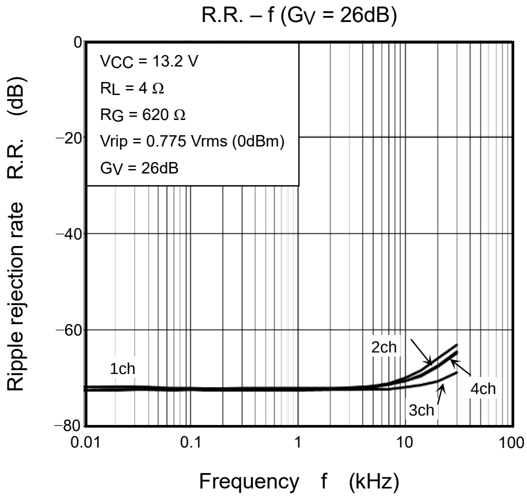


Figure 17-5 Frequency Characteristics of Ripple Rejection Rate

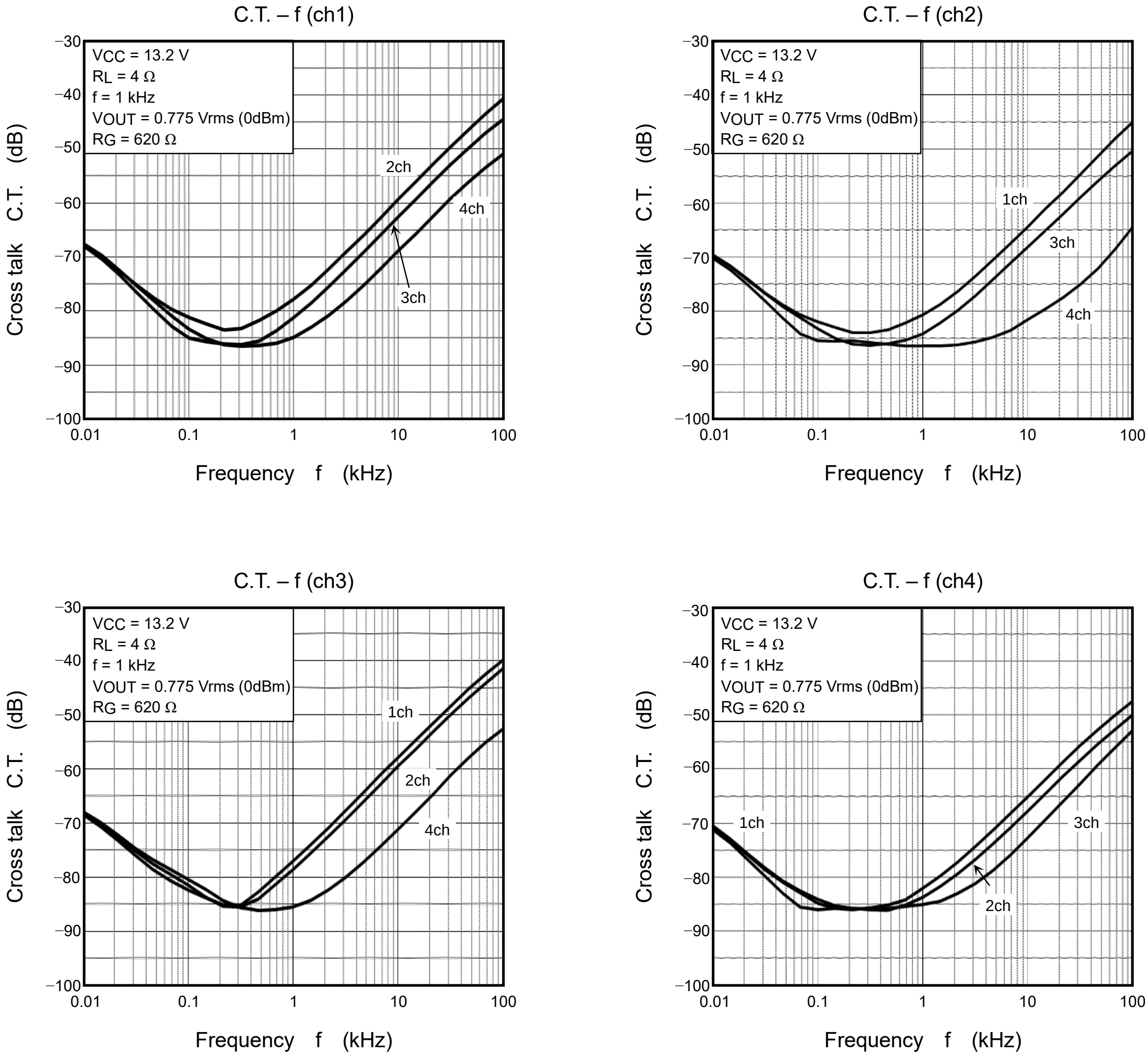
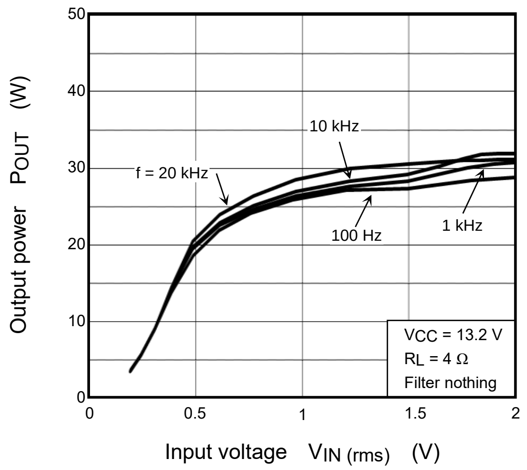


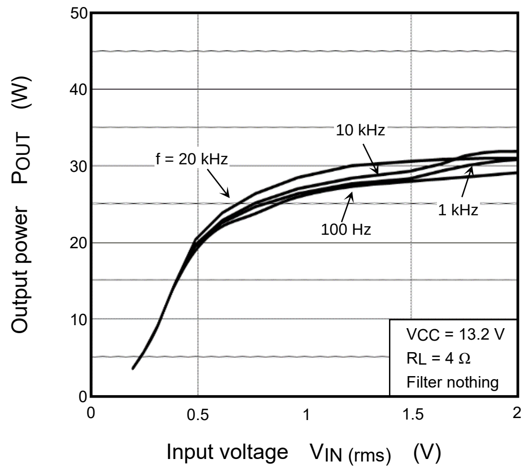
Figure 17-6 Frequency Characteristics of Cross Talk

17.3 Output Power Characteristics to Input Voltage

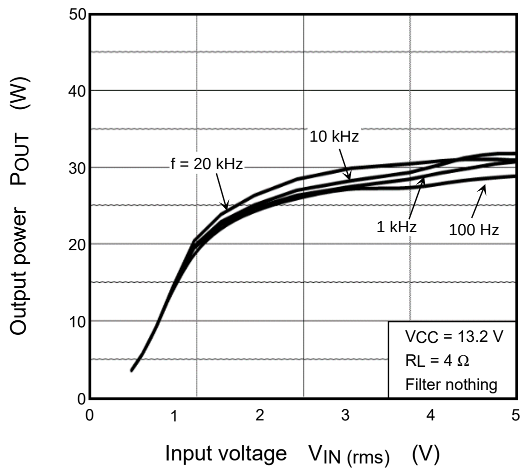
POUT (ch1) – VIN



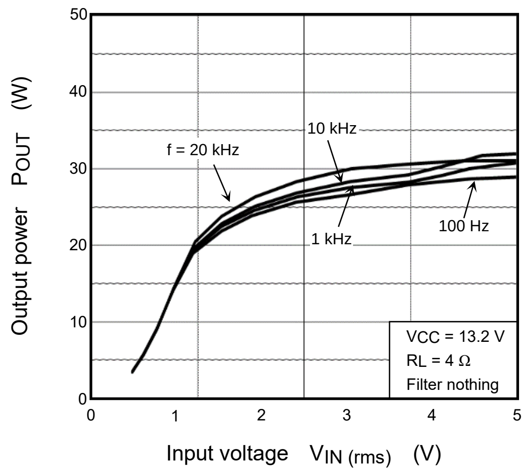
POUT (ch2) – VIN



POUT (ch3) – VIN

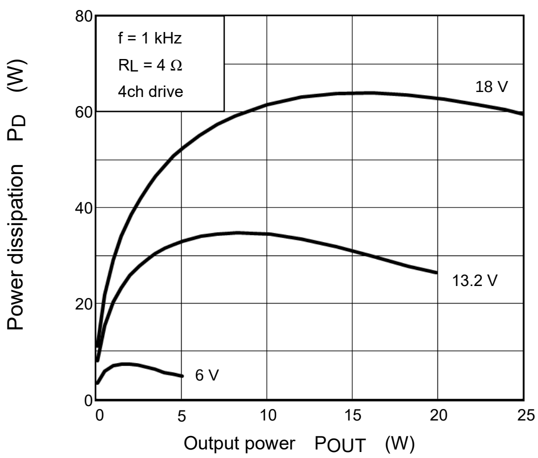


POUT (ch4) – VIN

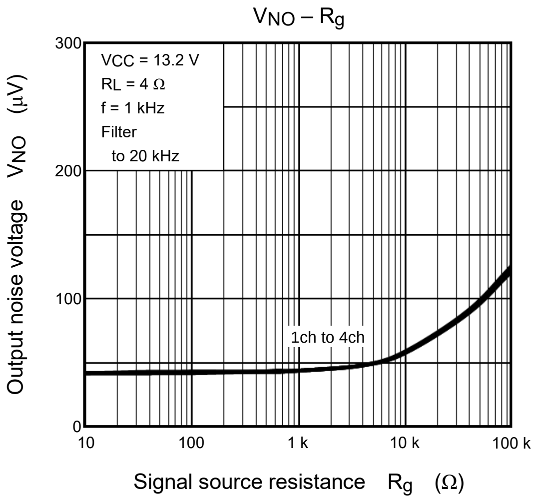


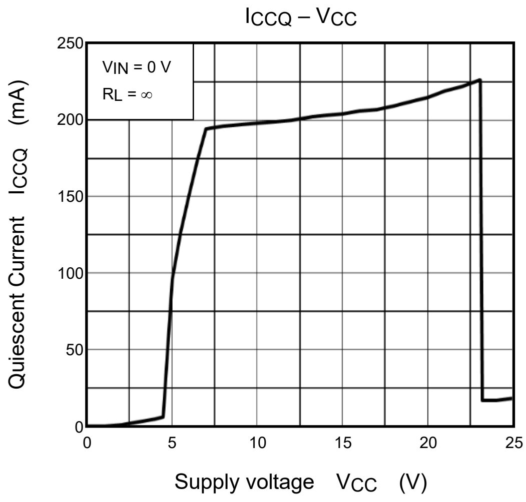
17.4 Power Dissipation vs. Output Power

PD – POUT (RL = 4 Ω)



17.5 Other Characteristic

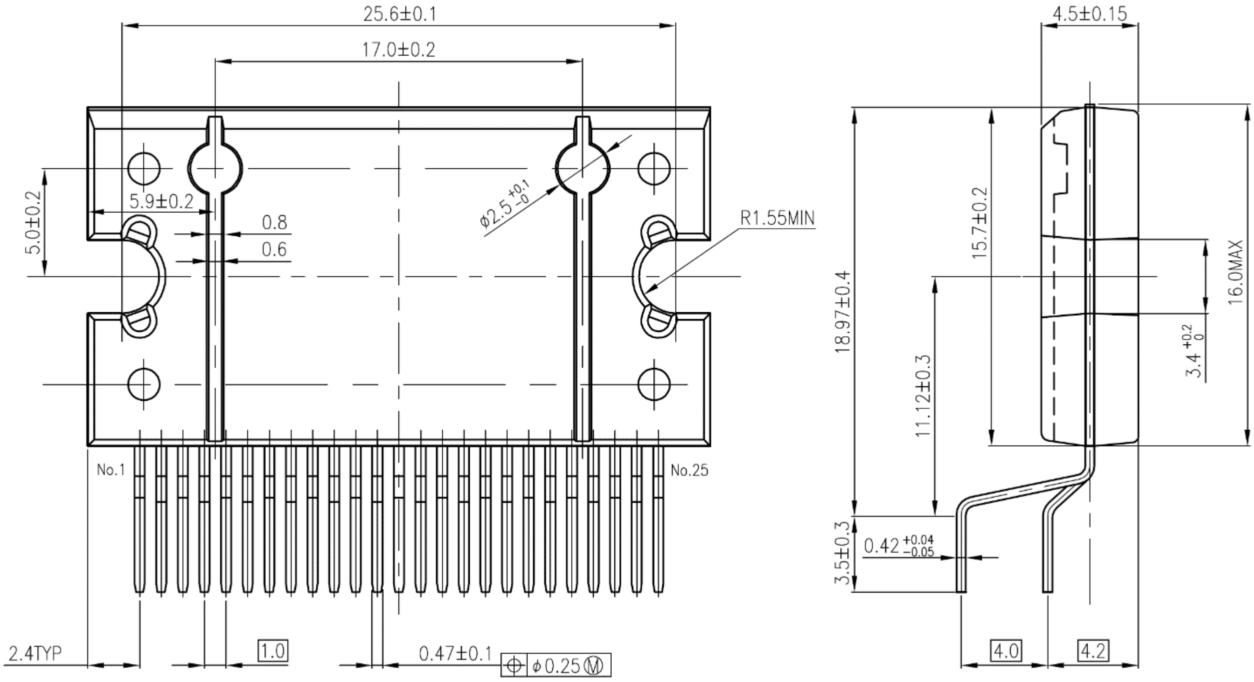


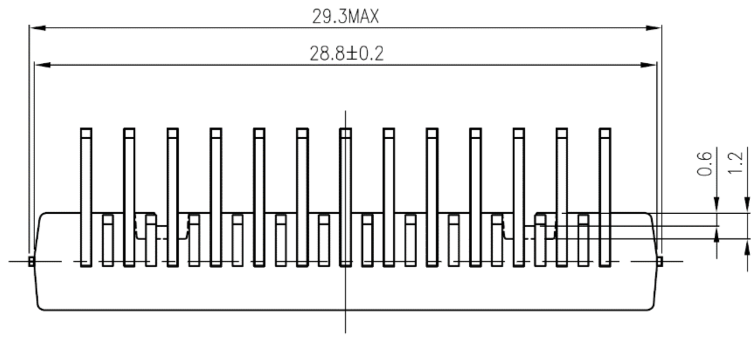


18. Package Dimensions

HZIP25-P-1.00F

Unit: mm





Weight: 7.7 g (typ.)

19. 4ch Power IC Evaluation Board

This drawing is a component side, and a schematic diagram of evaluation board "RP-2024 for 4ch power IC using HZIP25-P-1.00F (SPP25), a solder side.

Note: This board can be shared with some products.
Please confirm external parts of the evaluated product beforehand when you unite the evaluation board.

- Component side

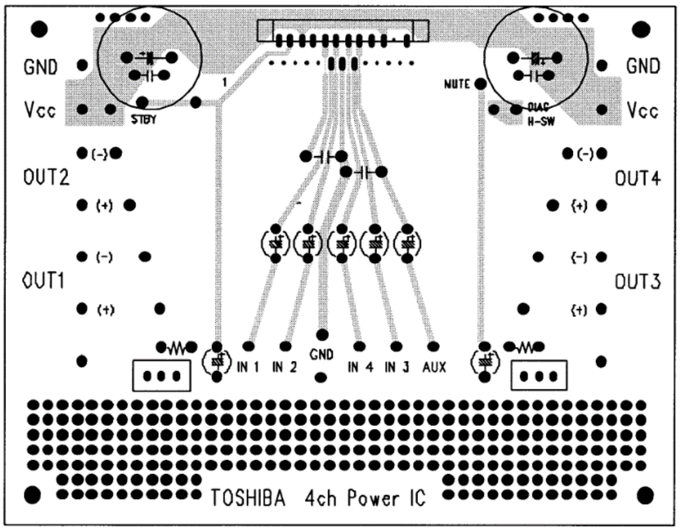


Figure 19-1 Pattern of Evaluation Board (component side)

- Solder side

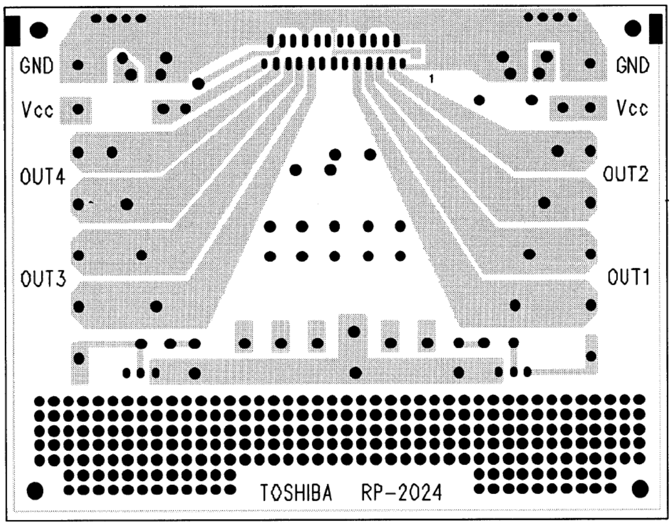


Figure 19-2 Pattern of Evaluation Board (solder side)

20. Attention in Use

- Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. For details on how to connect a protection circuit such as a current limiting resistor or back electromotive force adsorption diode, refer to individual IC datasheets or the IC databook. IC breakdown may cause injury, smoke or ignition.
- Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator. If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure can cause smoke or ignition. (The over current can cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.
- Over current Protection Circuit
  Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.
- Thermal Shutdown Circuit
  Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the Thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.
- Heat Radiation Design
  When using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (Tj) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.
  - Installation to Heat Sink
    Please install the power IC to the heat sink not to apply excessive mechanical stress to the IC. Excessive mechanical stress can lead to package cracks, resulting in a reduction in reliability or breakdown of internal IC chip. In addition, depending on the IC, the use of silicon rubber may be prohibited. Check whether the use of silicon rubber is prohibited for the IC you intend to use, or not. For details of power IC heat radiation design and heat sink installation, refer to individual technical datasheets or IC databooks.

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