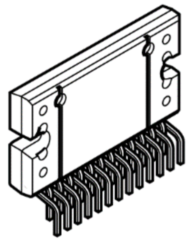
Bi-CMOS Linear Integrated Circuit Silicon Monolithic

TB2996HQ

Maximum Power 49 W BTL × 4ch Audio Power Amp IC

1. Description

The TB2996HQ is a power IC with built-in four-channel BTL amplifier developed for car audio application. The maximum output power P_{OUT} is 49 W using a pure complementary P-ch and N-ch DMOS output stage.
In addition, a standby switch, a mute function and various protection features are included.



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 3.1 Typical characteristics (Note1))
- Built-in various detection functions (output offset voltage and shorted to GND or V_{CC}) (Pin25)
- Built-in various mute functions (for low V_{CC} and standby-ON/OFF)
- Built-in standby switch (Pin4)
- Built-in mute function (Pin22)
- 6 V operations (Engine idle reduction capability)
- Built-in various protection circuits (thermal shut down, over-voltage, short to V_{CC}, short to GND, and output to output short)

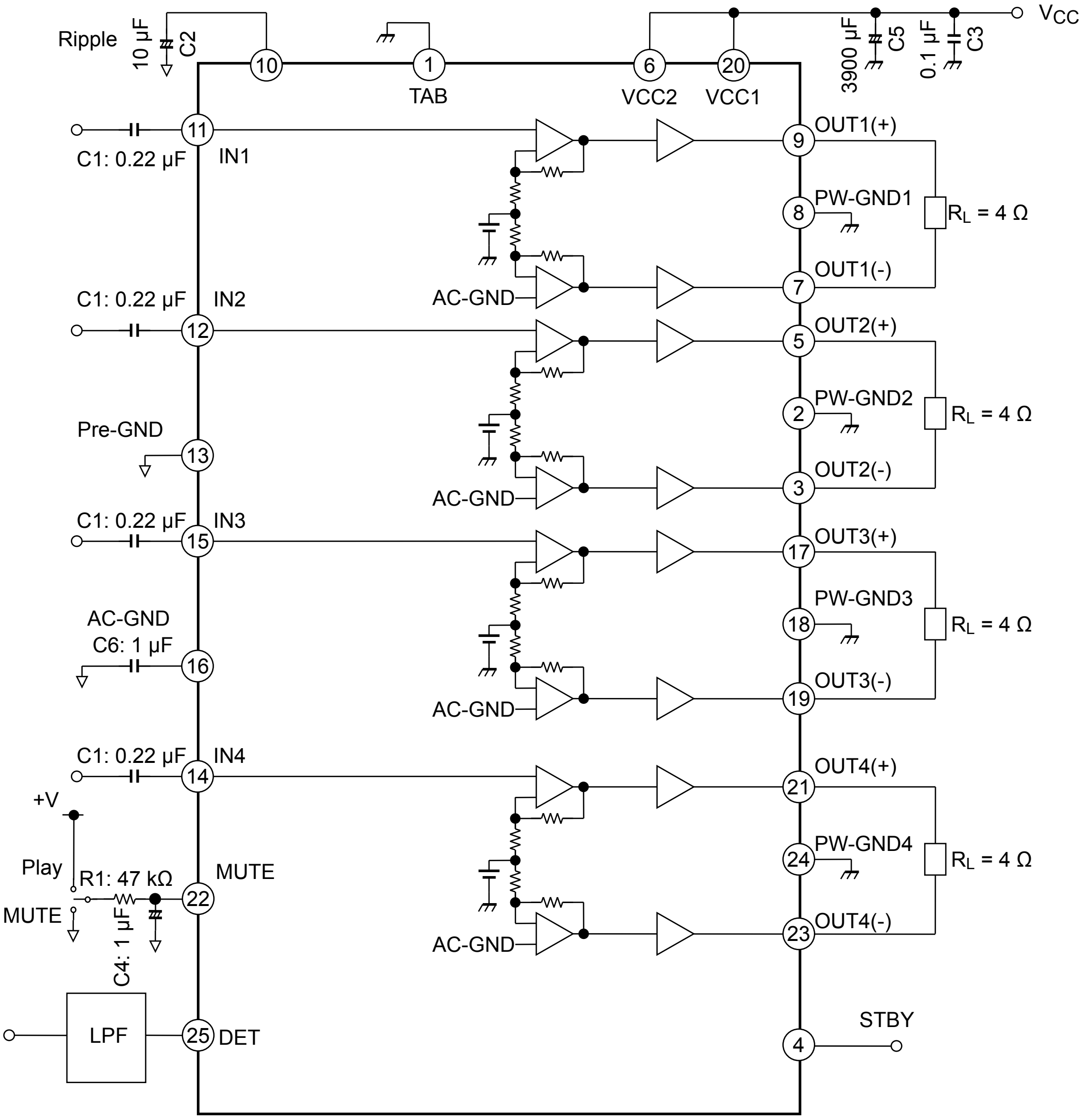
Table 3.1 Typical characteristics (Note1)

Test condition	Typ.	Unit
Output power (P_{OUT})		
V_{CC} = 15.2 V, JEITA max	49	W
V_{CC} = 14.4 V, JEITA max	44	W
V_{CC} = 14.4 V, THD = 10%	29	W
THD = 10%	24	W
Total harmonic distortion (THD)		
P_{OUT} = 4 W	0.006	%
Output noise voltage (V_{NO}) (Rg = 0 Ω) (Note2)		
BW = 20 Hz to 20 kHz	50	μVrms
Operating Supply voltage range (V_{CC})		
R_L = 4 Ω	6 to 18	V
R_L = 2 Ω	6 to 16	V

Note1: Typical test conditions: V_{CC} = 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

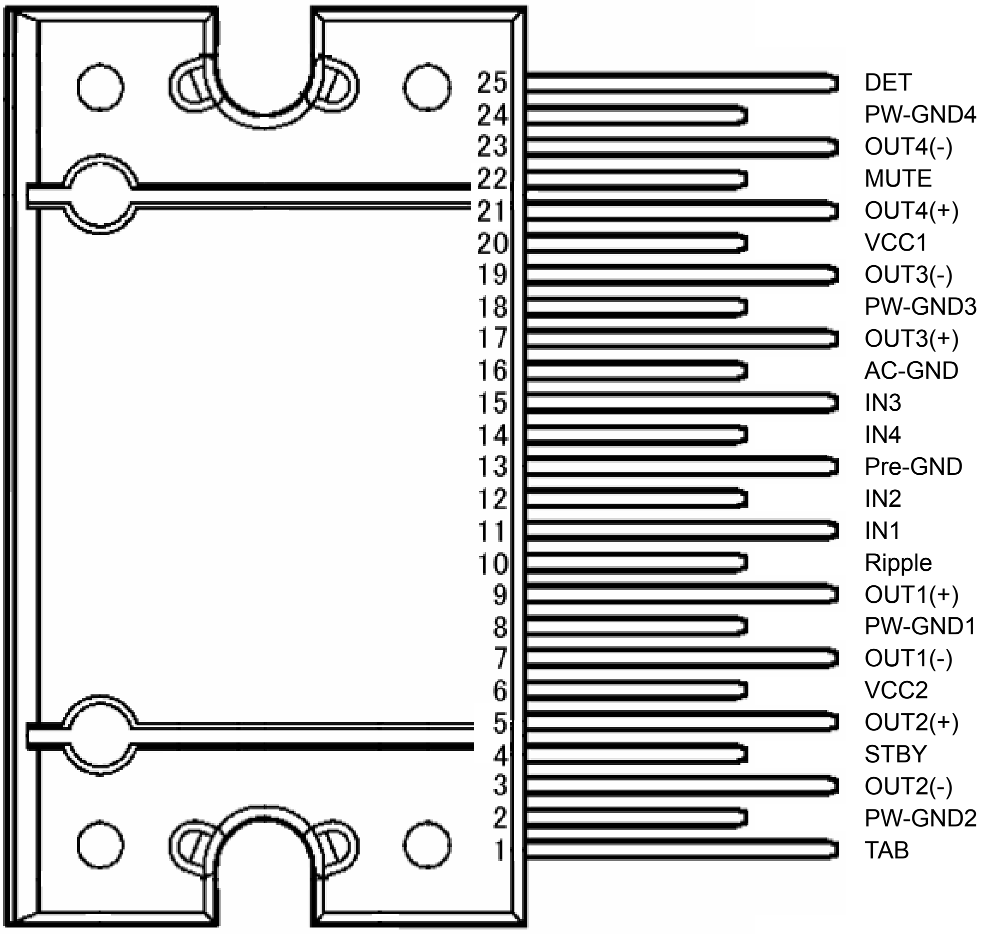
4. Block Diagram



Some of the functional blocks, circuits or constants labels in the block diagram may have been omitted or simplified for clarity.

5. Pin Configuration and Function Descriptions

5.1 Pin Configuration (top view)



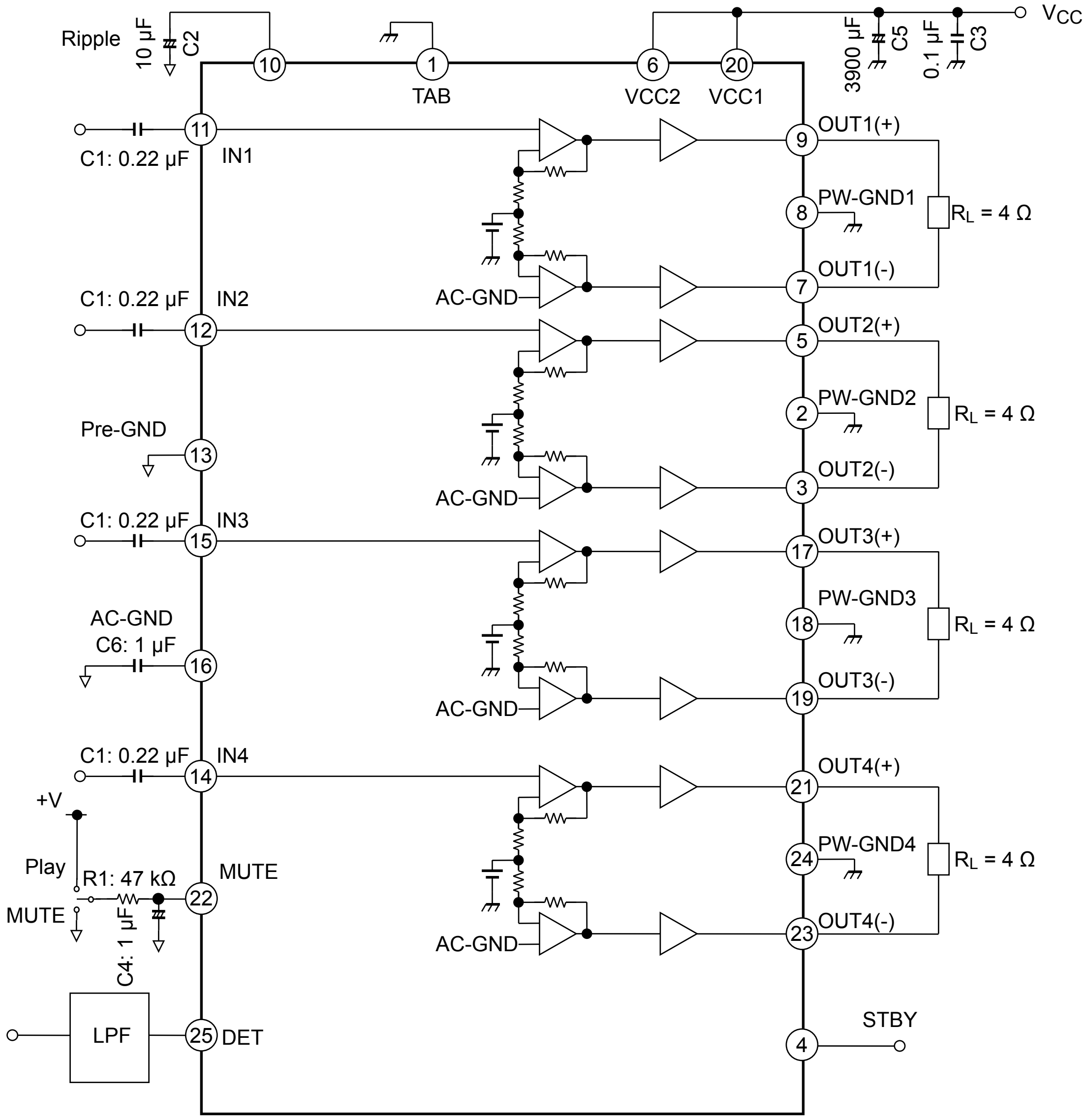
5.2 Pin Function Descriptions

Pin No.	Pin name	I/O	Description
1	TAB	—	TAB pin (always connect to GND)
2	PW-GND2	—	Ground pin for ch2
3	OUT2(-)	OUT	ch2 (-) output pin
4	STBY	V_{ST}-IN	Standby voltage input
5	OUT2(+)	OUT	ch2 (+) output pin
6	VCC2	V_{CC}-IN	Supply voltage pin 2
7	OUT1(-)	OUT	ch1 (-) output pin
8	PW-GND1	—	Ground pin for ch1
9	OUT1(+)	OUT	ch1 (+) output pin
10	Ripple	—	Ripple voltage pin
11	IN1	IN	OUT1 input pin
12	IN2	IN	OUT2 input pin
13	Pre-GND	—	Signal ground pin
14	IN4	IN	OUT4 input pin
15	IN3	IN	OUT3 input pin
16	AC-GND	—	Common reference voltage for all input amplifiers
17	OUT3(+)	OUT	ch3 (+) output pin
18	PW-GND3	—	Ground pin for ch3
19	OUT3(-)	OUT	ch3 (-) output pin
20	VCC1	V_{CC}-IN	Supply voltage 1
21	OUT4(+)	OUT	ch4 (+) output pin
22	MUTE	V_{MUTE}IN	Mute voltage input
23	OUT4(-)	OUT	ch4 (-) output pin
24	PW-GND4	—	Ground pin for ch4
25	DET	OC (Note)	Output pin for detections of output offset and short

Note: OC means Open Collector.

6. Functional Description

6.1 Specifications of External Components



Component Name	Recommended Value	Pin	Purpose	Effect (Note1)	
				Lower than Recommended Value	Higher than Recommended Value
C1 (Note3)	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 time shorter	Turn on time longer
C3	0.1 µF	VCC1, VCC2	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin	
C4	1 µF	MUTE	To reduce pop noise	High pop noise Mute off time shorter	Low pop noise Mute off time longer
C5	3900 µF	VCC1, VCC2	Ripple filter	For power supply hum and ripple filtering	
C6 (Note3)	1 µF	AC-GND	Common reference voltage for all input	Pop noise is suppressed when C1: C6 = 1:4. (Note2)	
R1	47 kΩ	MUTE	To reduce pop noise	Pop noise becomes larger Mute off time shorter	Switching time becomes longer Mute off time longer

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 capacitance (C1) and the AC-GND capacitance (C6) to 1:4

Note3: Use the low leak current capacitor for C1 and C6.

6.2 Standby Function

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

Table 6.1 Pin 4 Control Voltage (V_{SB})

STBY	Power	V_{SB} (V)
ON	OFF	0 to 0.9
OFF	ON	2.2 to V_{CC}

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

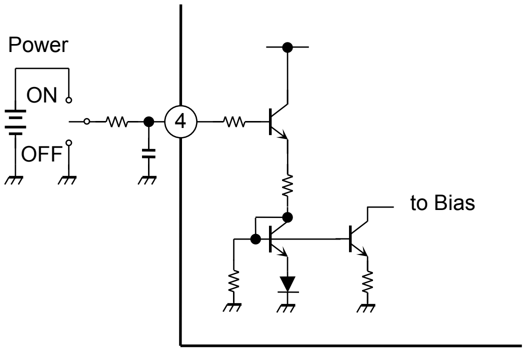


Figure 6.1 Standby Switch Circuit Diagram

<Benefits of the Standby Switch>
V_{CC} can be directly turned on or off by a microcontroller, eliminating the need for a switching relay.

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

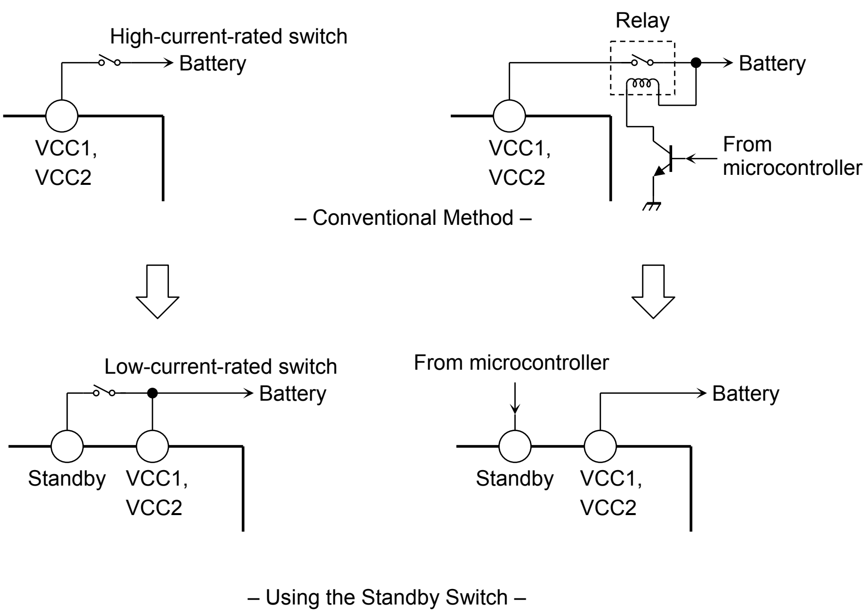


Figure 6.2 Standby Switch

6.3 Mute Switch Function

The audio mute is enabled by setting pin 22 (mute voltage input pin) to Low. R1 and C4 determine the time constant of the mute. The time constant affects pop noise generated when power and the mute is turned on or off; thus, it should be determined with consideration.
This pin is assumed to design for 5 V or 3.3 V control. The typical design value for 5 V is 47 kΩ because the external pull-up resistor influences in pop noise in normal operation.

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

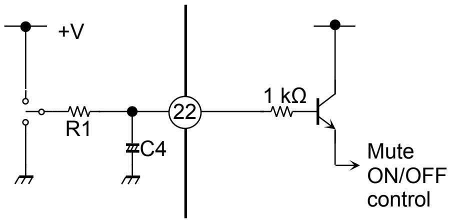


Figure 6.3 Mute Function

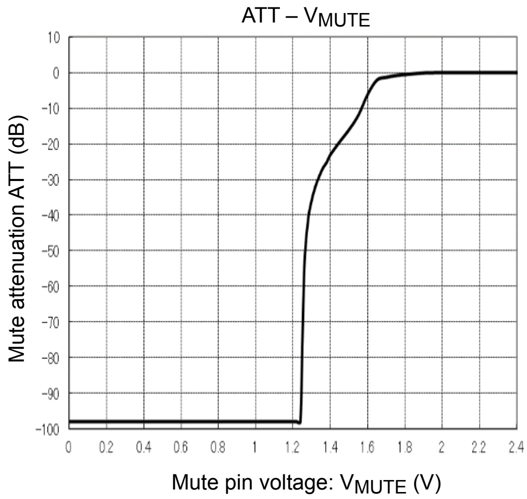


Figure 6.4 Mute Attenuation – V_{MUTE} (V)

6.4 Mute Functions

The automatic mute functions in this product are two types shown below.

a) Low Voltage Mute (auto mute function)
b) Standby OFF Mute

6.4.1 Low Voltage Mute

Low voltage mute is operated inside IC automatically when the V_{CC} voltage is lowered to about 5.5 V or less.

6.4.2 Standby OFF Mute

A mute operation starts automatically inside the IC after setting “Low” of pin 4 (Standby voltage input pin) until the Ripple pin voltage becomes about V_{CC} / 5 V.

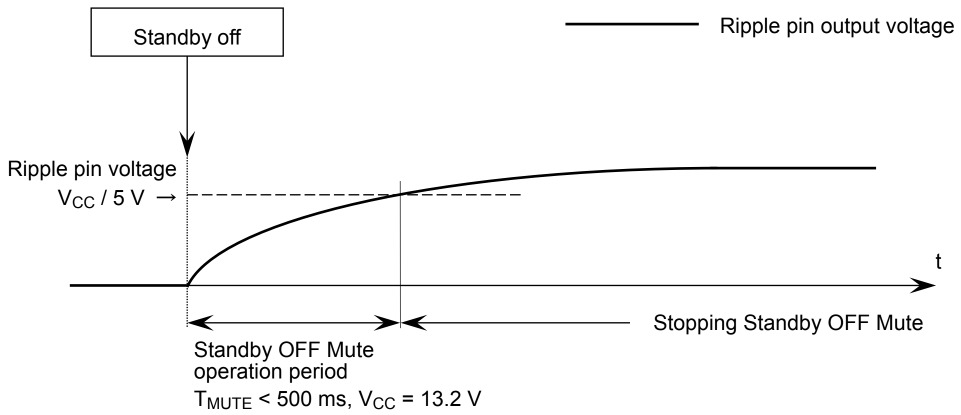


Figure 6.5 Standby Off Mute

6.5 Output Offset Detection

6.5.1 Operation of Offset Detection Circuit

This function detects an abnormal state using this pin when an offset voltage occurs at output pins by an input capacitor leakage and others.

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

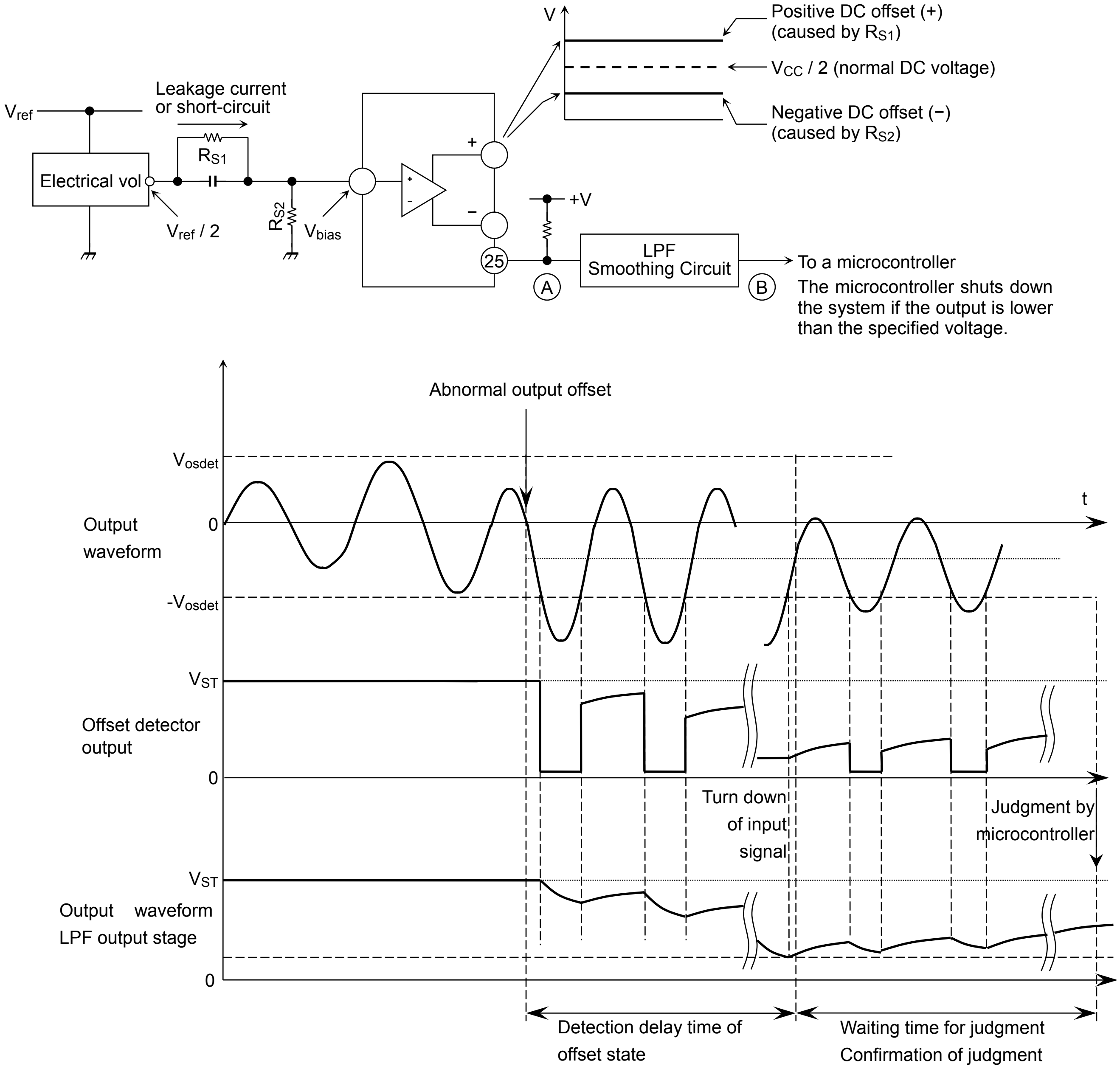


Figure 6.6 Example of application circuit and system principle

6.6 Short detector

The transistor of pin 25 is turned on when output pins of this product are short-circuited to GND or V_{CC}.
When an output pin is short-circuited to another output pin, the transistor of pin 25 repeats to turn on and off in response to output signals.
If it is detected, please shut down with microcontroller.

6.7 Protection Functions

This product has internal protection circuits such as thermal shut down, over-voltage, short to V_{CC}, short 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. Even if all outputs are in a mute state, when a temperature rise continues, shutdown function starts.

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

(2) Over-voltage

It operates when voltage exceeding operating range is supplied to V_{CC} pin. If voltage falls, it will return automatically.
When it operates, output bias is turned off and an output is intercepted.
Threshold voltage is 23 V (Typ.).

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

It operates when each output pin is connected incorrectly. If irregular connection is canceled, it will return automatically.
When it operates, output bias is turned off and an output is intercepted.

Note: When a current phase largely slips off by a capacitor which is connected to output, and load line becomes wide, a protect circuit may operate. Therefore, please confirm and use n the actual system when a capacitor is connected.

7. Absolute Maximum Ratings

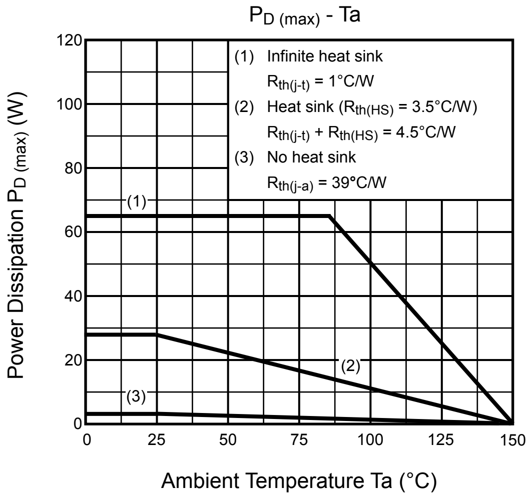
(Ta = 25°C unless otherwise specified)

Characteristics	Condition	Symbol	Rating	Unit
supply voltage (surge)	max0.2 s	$V_{CC\ (surge)}$	50	V
supply voltage (DC)	—	$V_{CC\ (DC)}$	25	V
supply voltage (operation)	—	$V_{CC\ (opr)}$	18	V
output current (peak)	—	$I_{O\ (peak)}$	9	A
power dissipation	(Note)	P_D	125	W
Operating temperature range	—	T_{opr}	-40 to 85	°C
Storage temperature	—	T_{stg}	-55 to 150	°C
Junction temperature	—	$T_{j\ (max)}$	150	°C

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

The maximum rating is the rating that should never be exceeded, even for a shortest of moments. If the maximum rating is exceeded, it could result in damage and/or deterioration of the IC as well as other devices beside the IC. Regardless of the operating conditions, please design so that the maximum rating is never exceeded. Please use within the specified operating range.

7.1 Power Dissipation



8. Operating Ranges

Characteristics	Symbol	Condition	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	R_L=4 Ω	6	—	18	V
		R_L=2 Ω	6	—	16	V

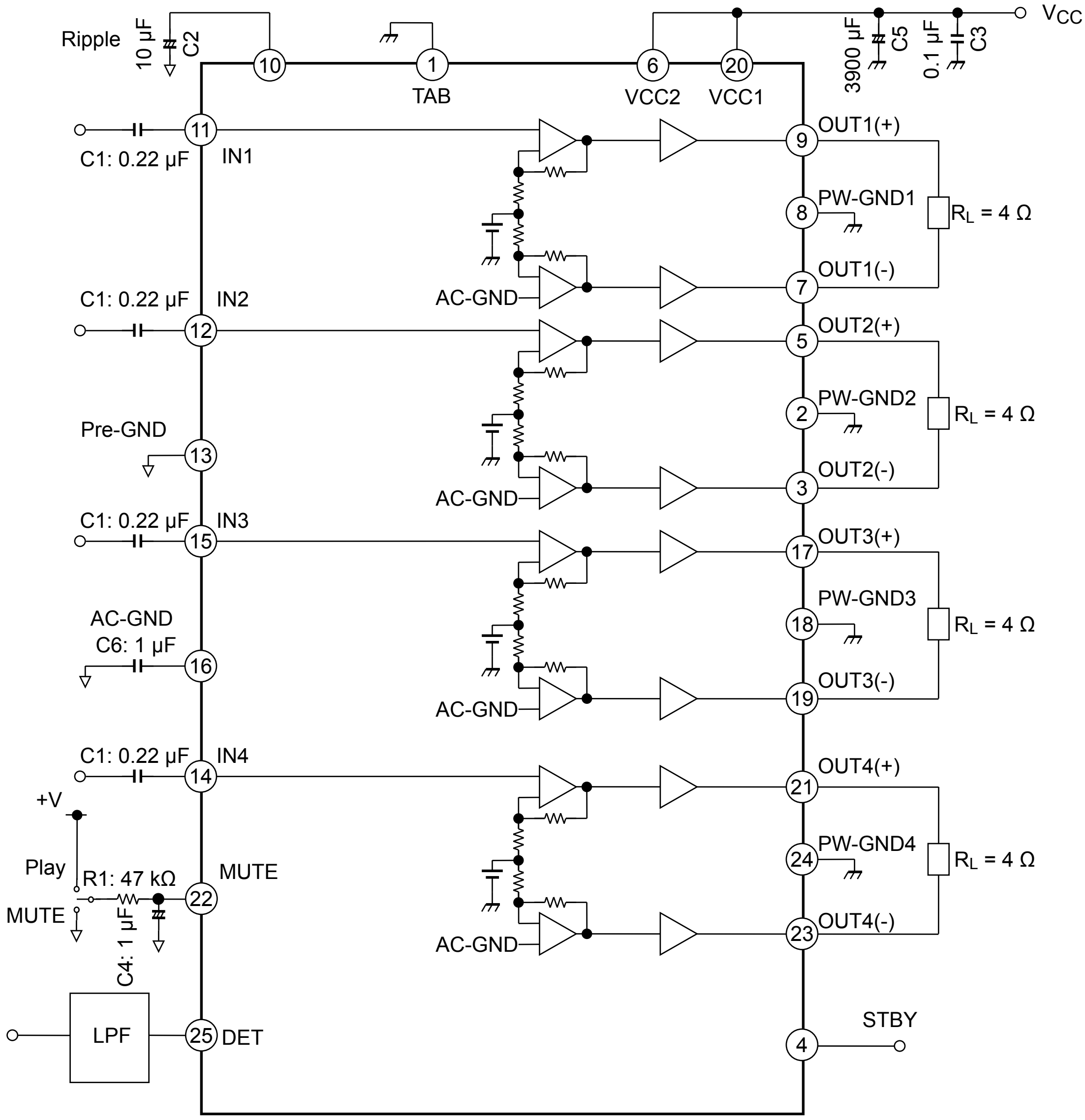
9. Electrical Characteristics

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I_{CCQ}	V_{IN} = 0 V	—	200	320	mA
Output power	P_{OUT} MAX (1)	V_{CC} = 15.2 V, max POWER	—	49	—	W
	P_{OUT} MAX (2)	V_{CC} = 14.4 V, max POWER	—	44	—	
	P_{OUT} MAX (3)	V_{CC} = 13.7 V, max POWER	—	40	—	
	P_{OUT} (1)	V_{CC} = 14.4 V, THD = 10%	—	29	—	
	P_{OUT} (2)	THD = 10%	21	24	—	
Output power (R_L = 2 Ω)	P_{OUT} MAX (4)	V_{CC} = 14.4 V, max POWER	—	80	—	W
	P_{OUT} MAX (5)	V_{CC} = 13.7 V, max POWER	—	73	—	
	P_{OUT} (3)	V_{CC} = 14.4 V, THD = 10%	—	46	—	
	P_{OUT} (4)	THD = 10%	—	45	—	
Total harmonic distortion	THD	P_{OUT} =4 W	—	0.006	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}	Rg = 0 Ω, BW = 20 Hz to 20 kHz	—	50	70	μVrms
Ripple rejection ratio	R.R.	f_{rip} = 100 Hz, Rg = 620 Ω V_{rip} = 0.775 Vrms (Note)	60	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}	V_{SB} = 0 V, V_{MUTE} = 0 V	—	0.01	1	μA
Standby control voltage	V_{SB} H	POWER: ON	2.2	—	V_{CC}	V
	V_{SB} L	POWER: OFF	0	—	0.9	
Mute control voltage	V_M H	MUTE: OFF	2.2	—	V_{CC}	V
	V_M L	MUTE: ON, R1 = 47 kΩ	0	—	0.9	
Mute attenuation	ATT M	MUTE: ON V_{OUT} = 7.75 Vrms → MUTE: OFF	85	100	—	dB
Offset detection threshold voltage	V_{osdet}	Rpull-up = 47 kΩ, +V= 5.0 V Reference of normal DC voltage	±1.0	±1.5	±2.0	V
Pin 25 saturation voltage in operating detection function	P25-Sat	Rpull-up = 10 kΩ, +V = 5.0 V P25 is low in operating detection function	—	100	500	mV

Note: f_{RIP} repple frequency
V_{RIP} Ripple signal voltage (AC fluctuations in the power supply)

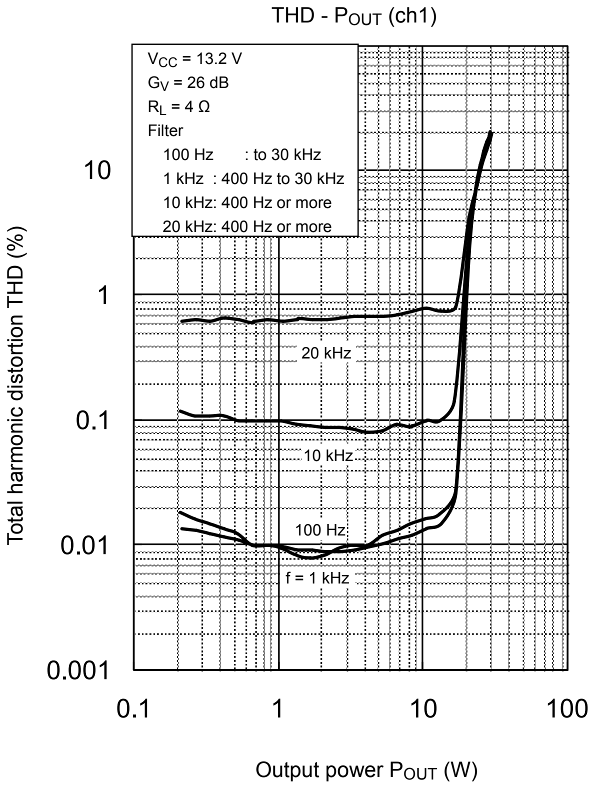
10. Test Circuit

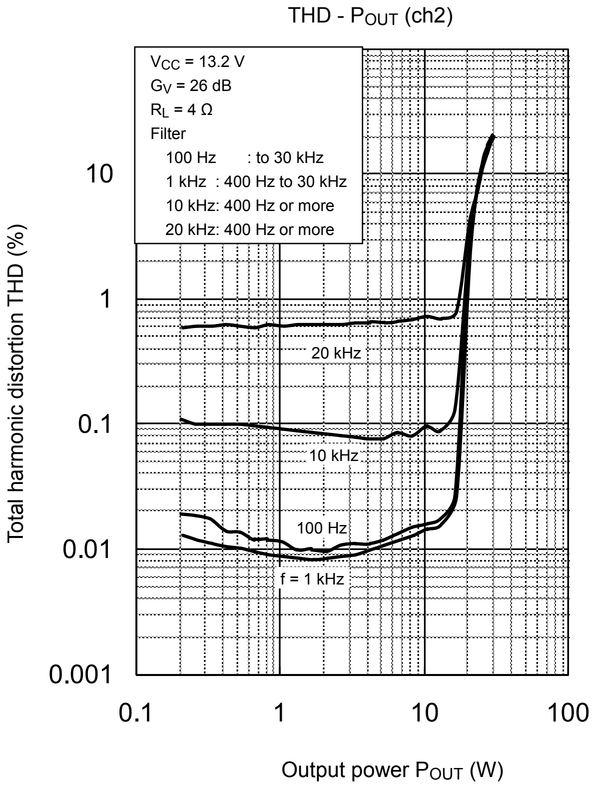


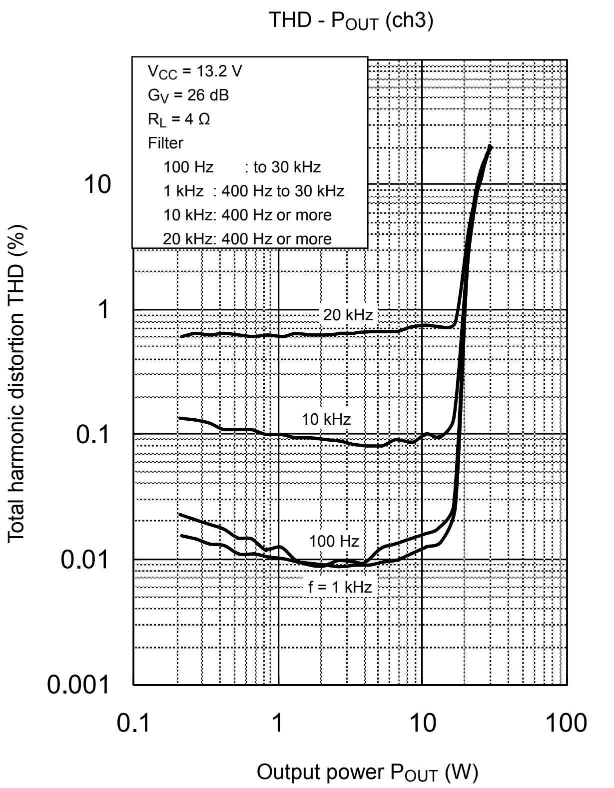
Components in the test circuit are only used to determine the device characteristics.

11. Electrical characteristics

11.1 Total Harmonic Distortion vs. Output Power







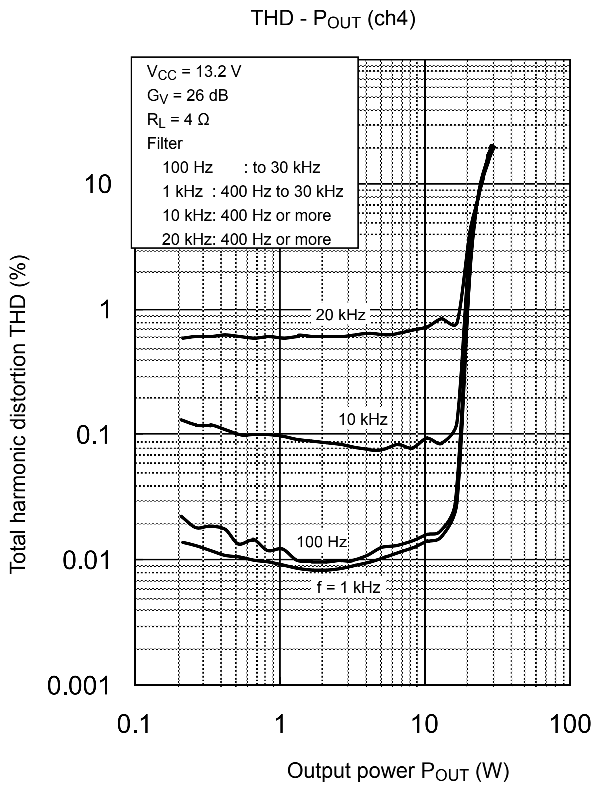
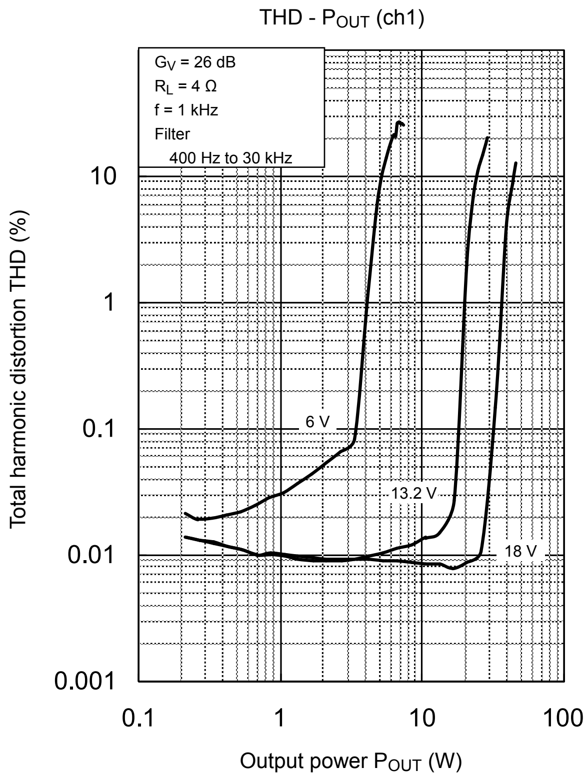
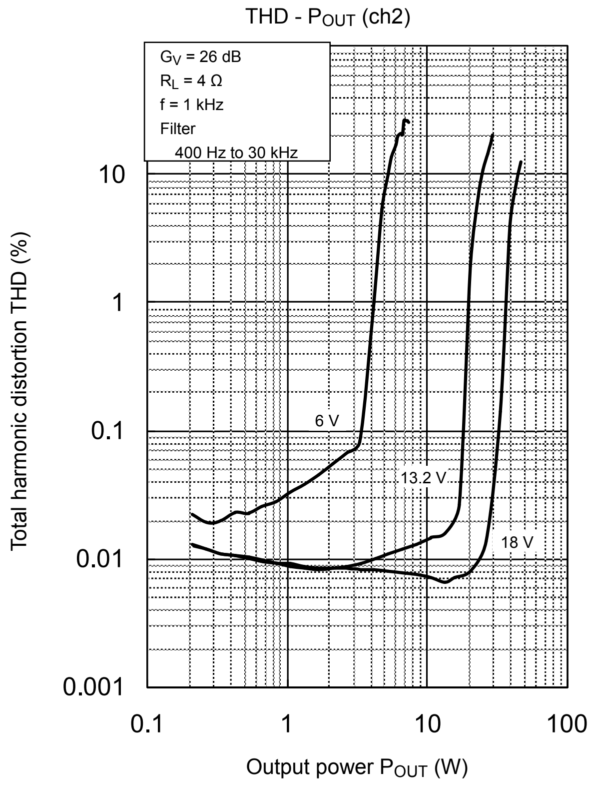
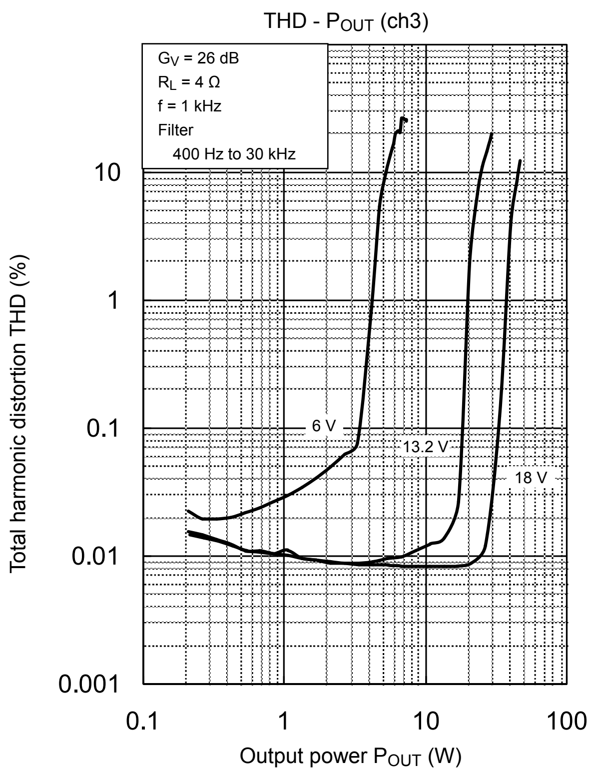


Figure 11.1 Total Harmonic Distortion of Each Frequency (R_L = 4 Ω)







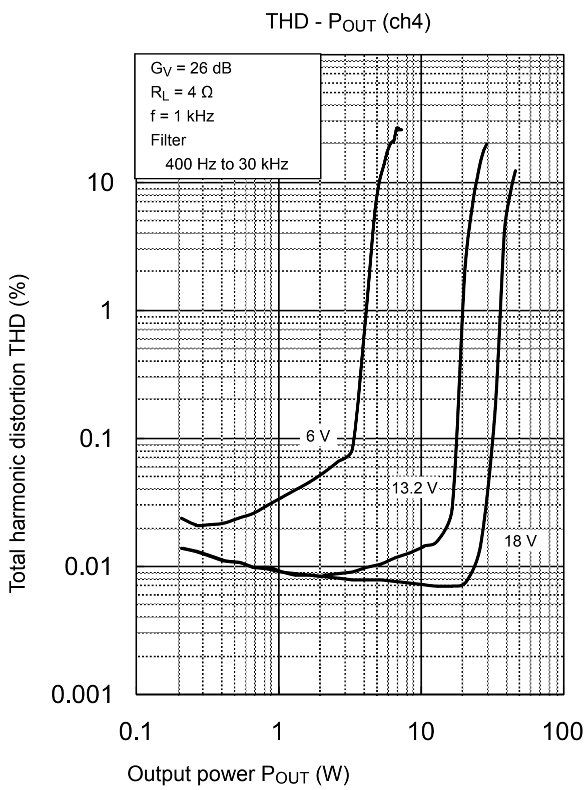


Figure 11.2 Total Harmonic Distortion by Power-supply Voltage (R_L = 4 Ω)

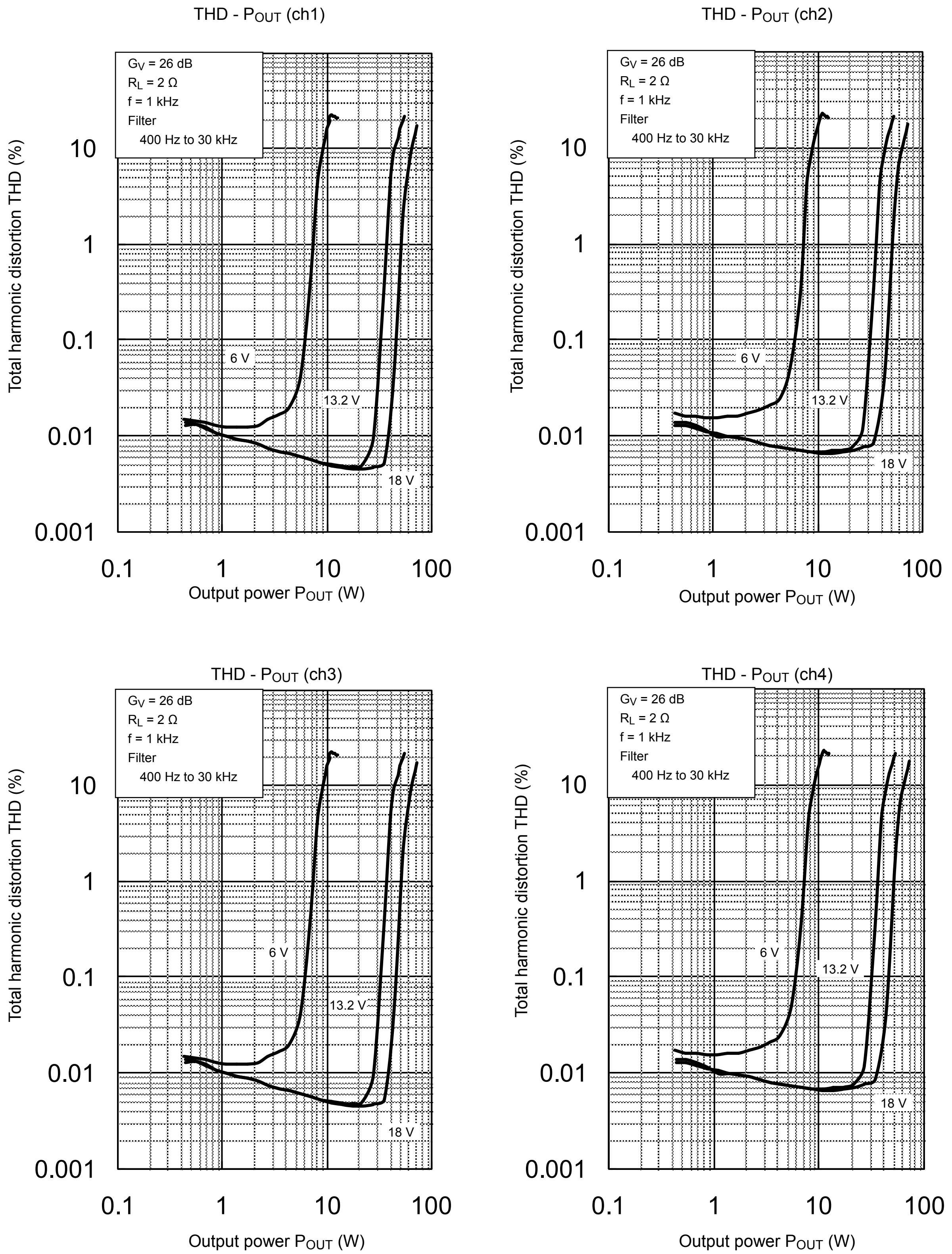


Figure 11.3 Total Harmonic Distortion by Power-supply Voltage (R_L = 2 Ω)

11.2 **Various Frequency Characteristics**

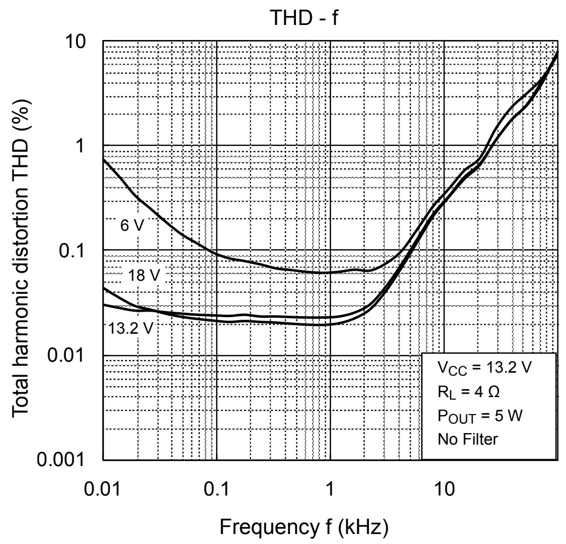
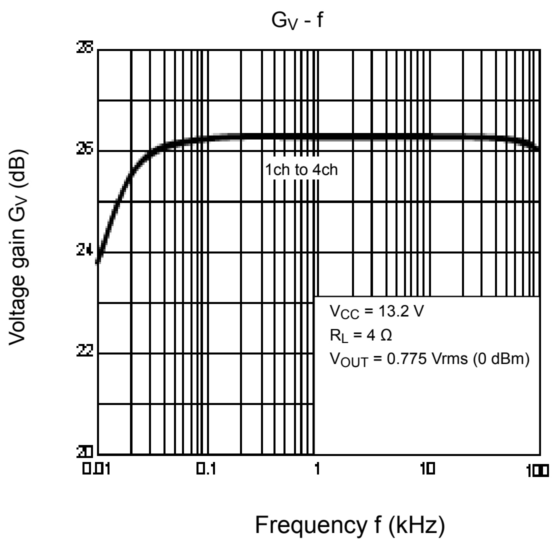


Figure 11.4 Frequency Characteristics of Total Harmonic Distortion



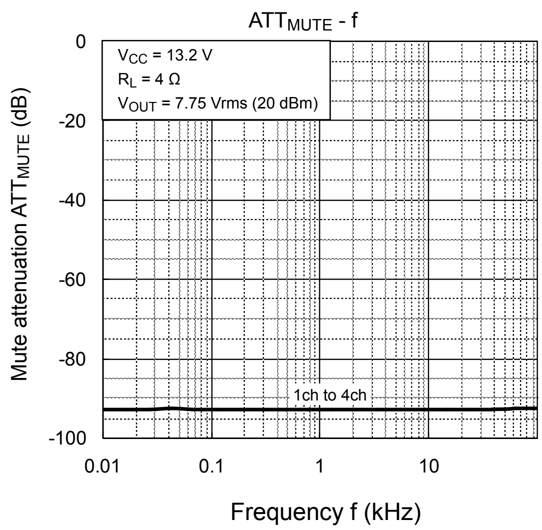


Figure 11.5 Frequency Characteristics of Voltage Gain and Mute Attenuation

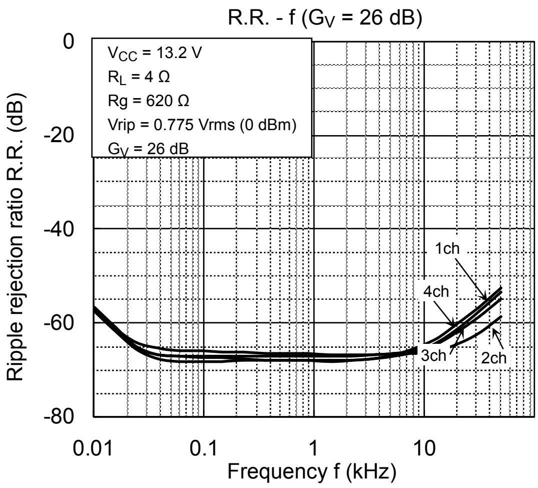


Figure 11.6 Frequency Characteristics of Ripple Rejection Rate

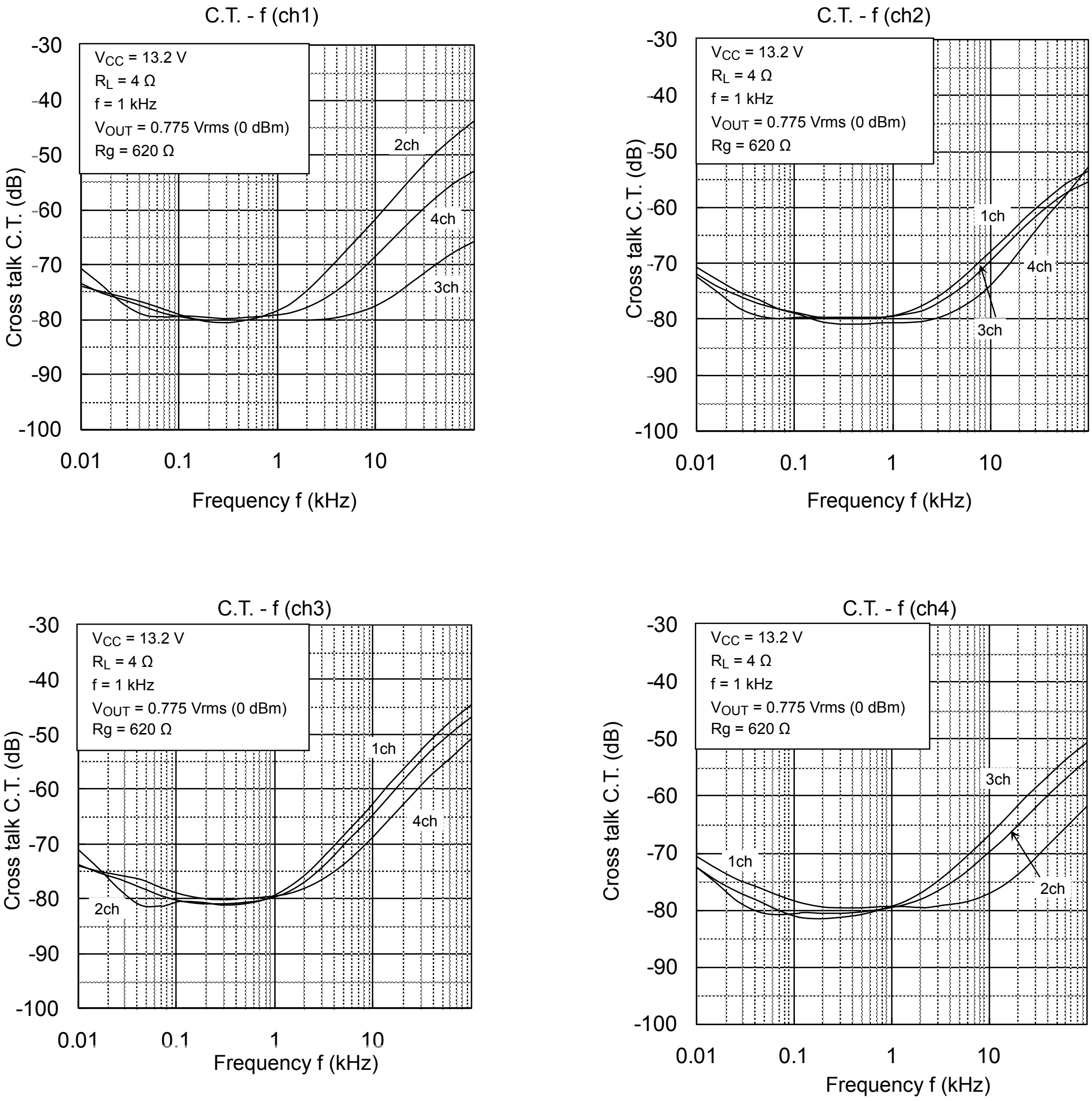


Figure 11.7 Frequency Characteristics of Cross Talk

11.3 Output Power Characteristics vs Input Voltage

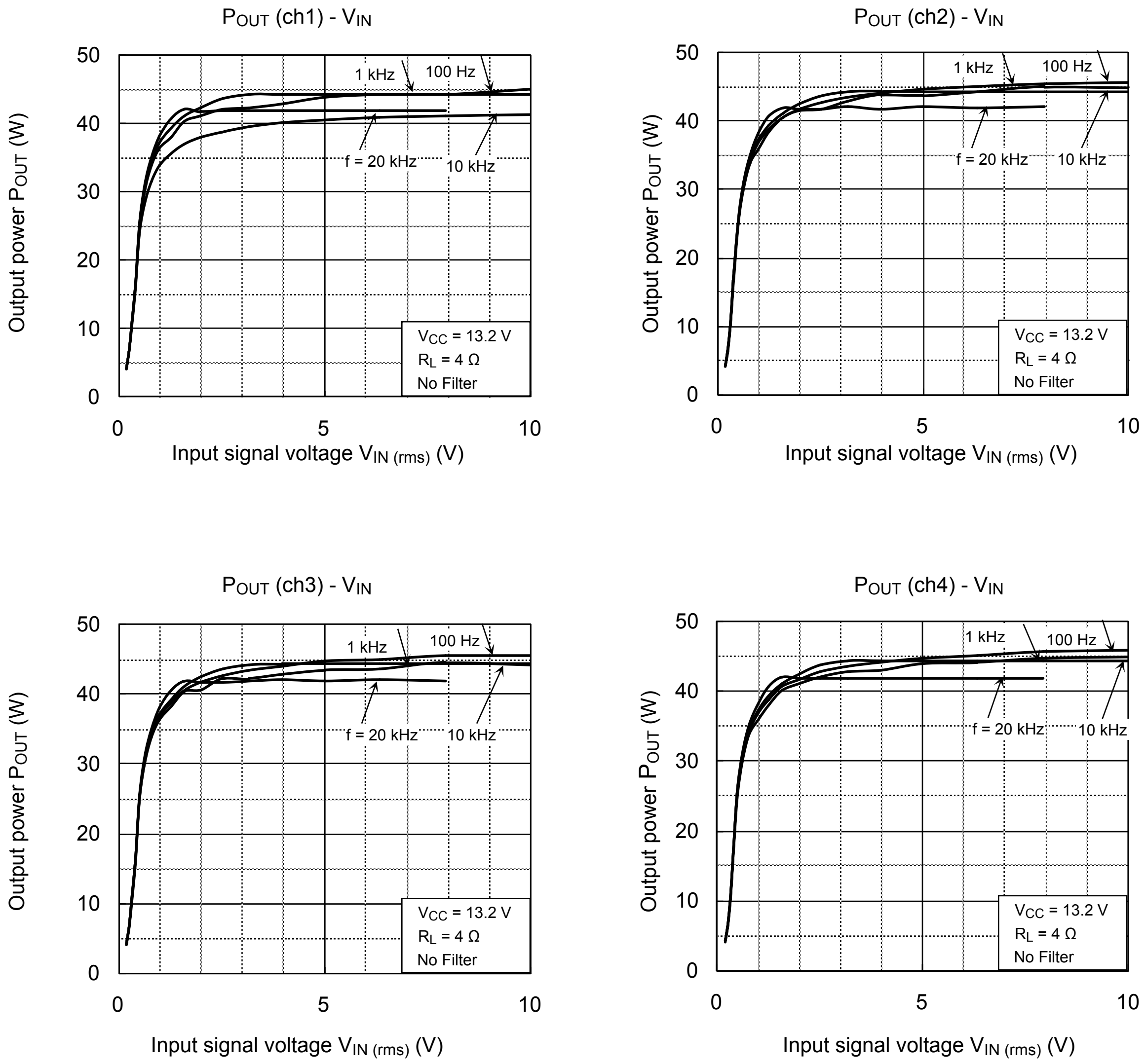


Figure 11.8 Output Power Characteristics vs Input Voltage

11.4 Power Dissipation vs. Output Power

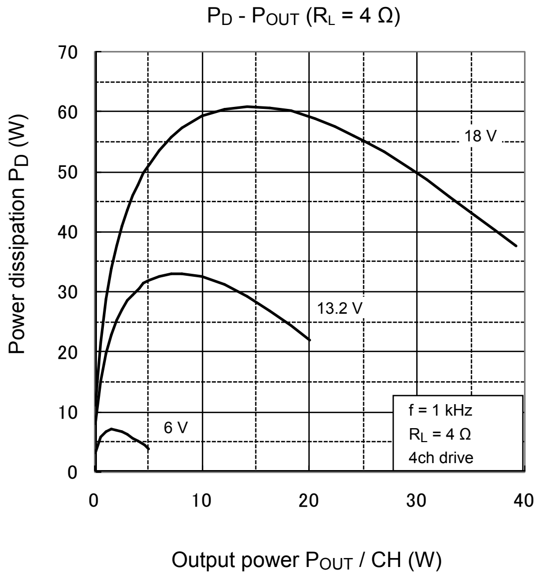
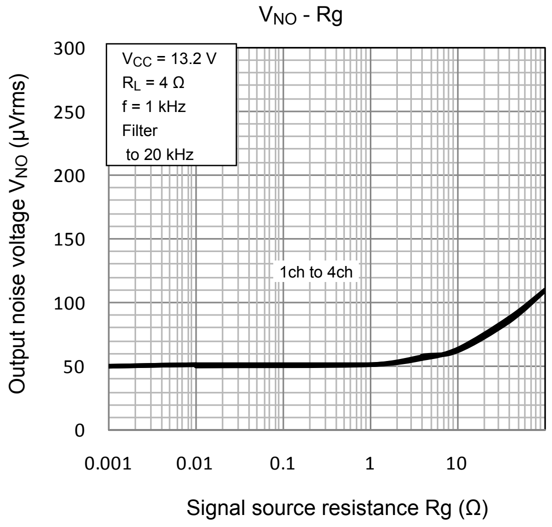


Figure 11.9 Power Dissipation vs. Output Power (R_L = 4 Ω)

11.5 Other Characteristics



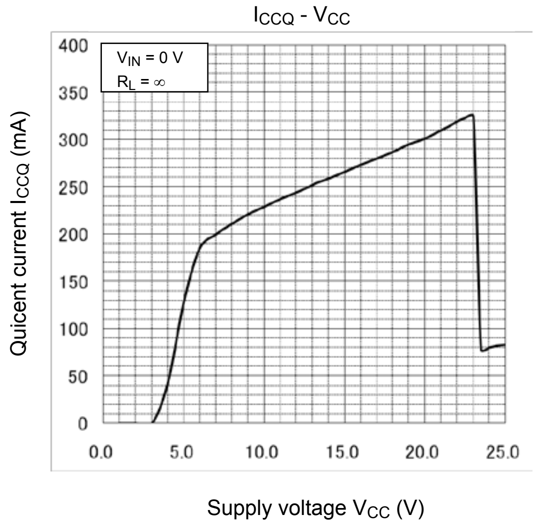
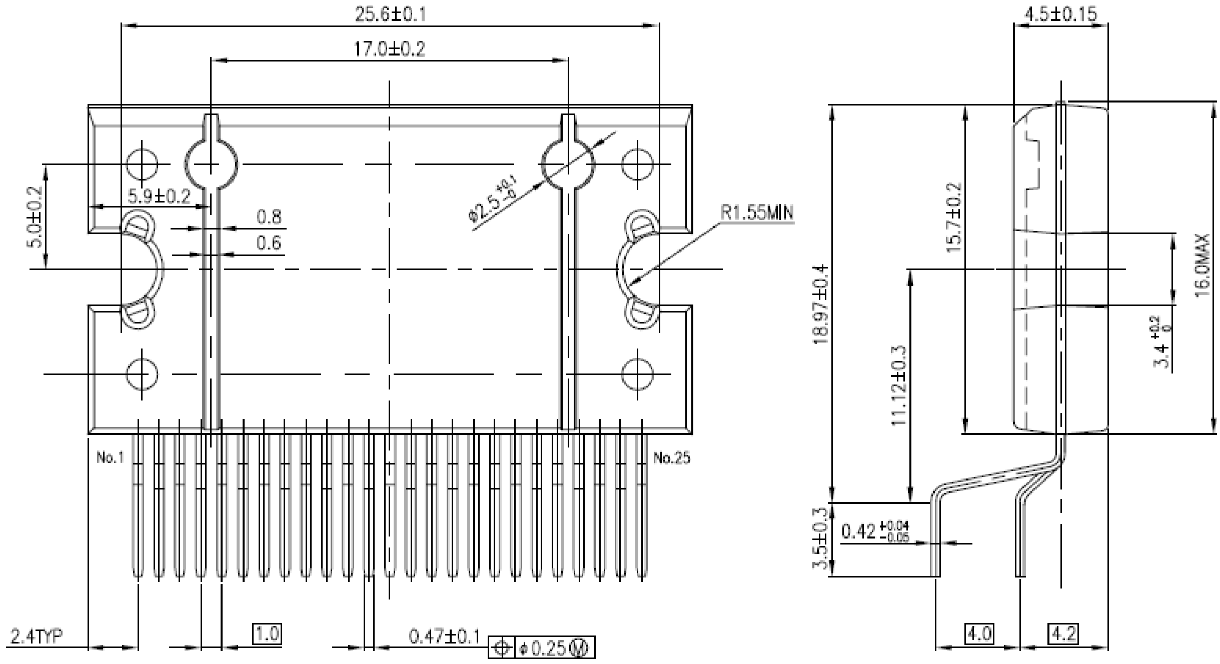


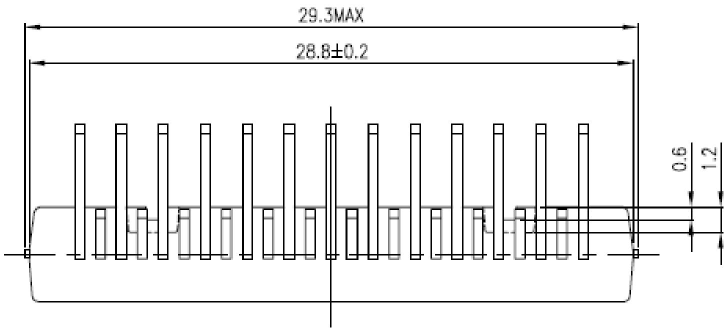
Figure 11.10 Other Characteristics

12. Package Dimensions

HZIP25-P-1.00F

Unit: mm





Weight: 7.7 g (typ.)

13. 4ch Power IC Evaluation Board Diagram

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

Note 1: This board can be shared with some other products.
Please confirm external parts of the evaluated product beforehand when you unite the evaluation board.

Note 2: Since this board is a shared board, some wiring patterns may need to cut.

- Component Side

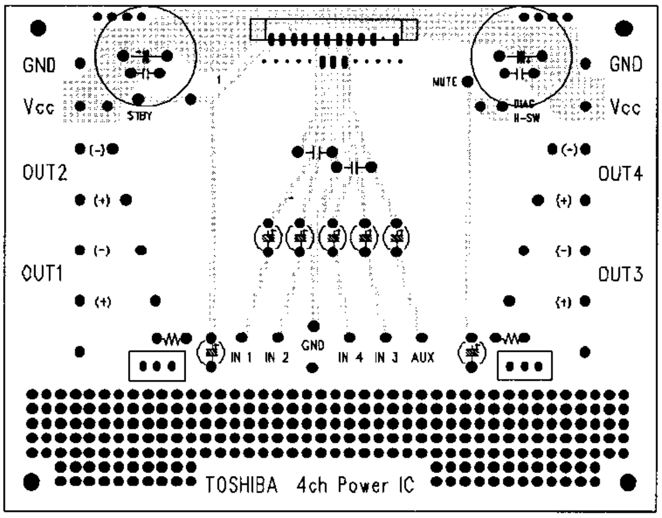


Figure 13.1 Pattern of Evaluation Board (component side)

- Solder Side

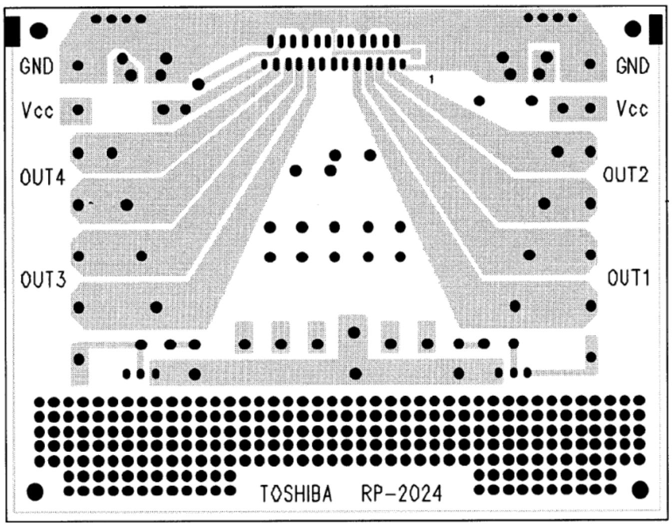


Figure 13.2 Pattern of Evaluation Board (solder side)

Notes on Contents

(1) Block Diagrams
Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

(2) Equivalent Circuits
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

(3) Timing Charts
Timing charts may be simplified for explanatory purposes.

(4) Application Circuits
The application circuits shown in this document are provided for reference purposes only.
Thorough evaluation is required, especially at the mass production design stage.
Providing these application circuit examples does not grant a license for industrial property rights.

(5) Test Circuits
Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on handling of ICs

[1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

[2] 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.

[3] 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. 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.

[4] Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

[5] 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.

Points to remember on handling of ICs

(1) 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.

(2) 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.

(3) Heat Radiation Design

In 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 (T_j) 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.

(4) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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