Bi-CMOS Linear Integrated Circuit Silicon Monolithic

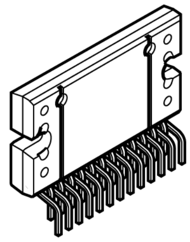
TB2996HQ

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, output offset voltage detector and various protection features are included.



HZIP25-P-1.00F

Weight: 7.7 g (typ.)

2. Applications

Power Amp IC developed for car audio applications.

3. Features

- High output power, low distortion, and low noise property (for details, refer to the Table 1 Typical Characteristics).
- Built-in detecting output offset voltage and shorted to GND (Pin25)
- Built-in muting function. (Pin22)
- Built-in auto muting functions (for low Vcc and stand-by sequence)
- Built-in standby switch. (Pin4)
- Built-in 6v operation and start stop cruising circuit
- Built-in various protection circuits (thermal shut down, over-voltage, short to GND, short to V_{CC}, and output to output short)

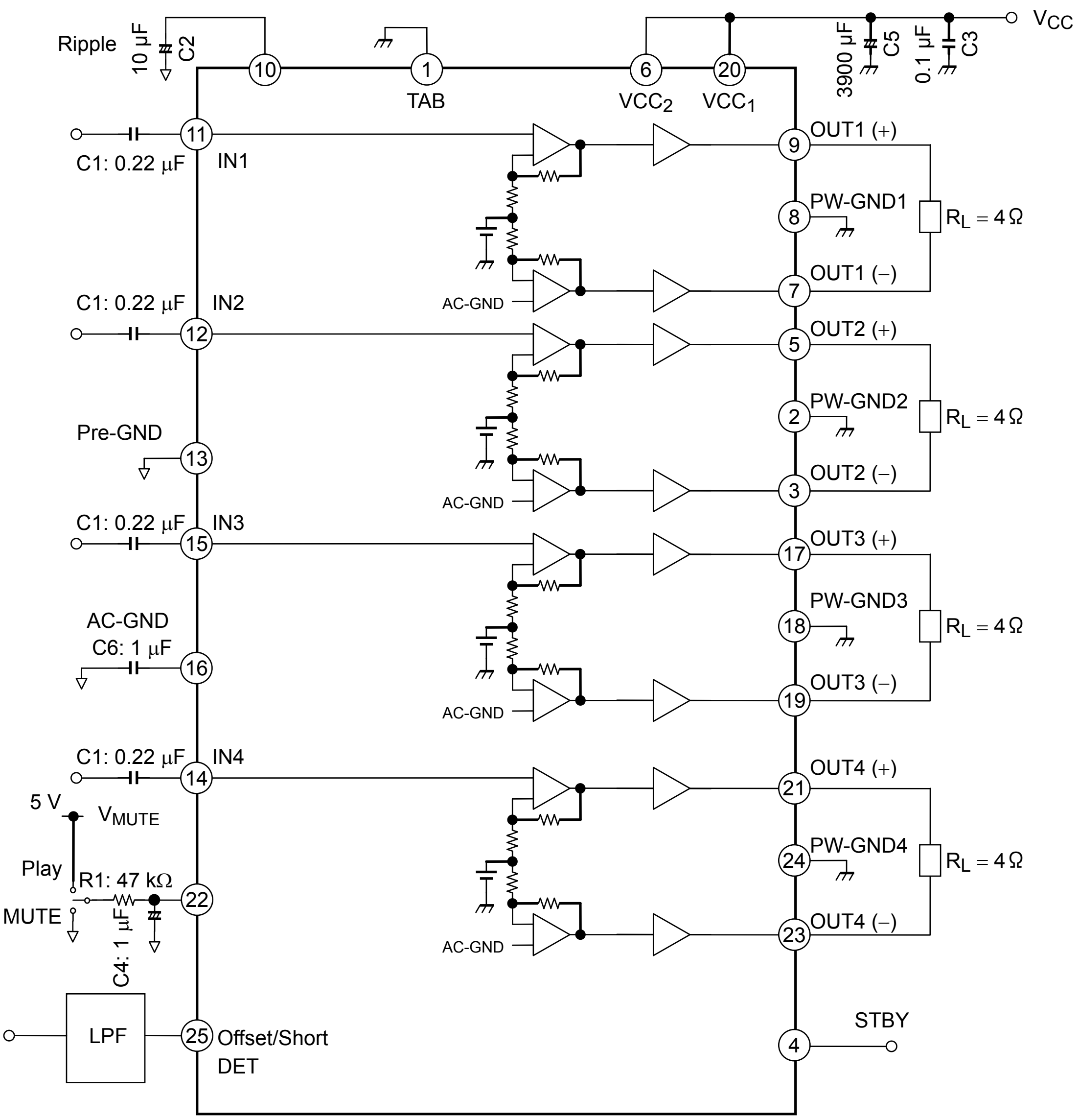
Table 1 Typical Characteristics (Note1)

Test condition	Typ.	Unit
Output power (P_{OUT})		
V_{CC} = 15.2 V, JEITA max	49	W
V_{CC} = 14.4V, JEITA max	44	
V_{CC} = 14.4V,THD = 10%	29	
THD = 10%	24	
Total harmonic distortion (THD)		
P_{OUT} = 4 W	0.006	%
Output noise voltage (V_{NO}) (Rg = 0 Ω)		
Filter : DIN AUDIO	50	μV
Operating Supply voltage range (V_{CC})		
R_L = 4 Ω	6～18	V
R_L = 2 Ω	6～16	

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

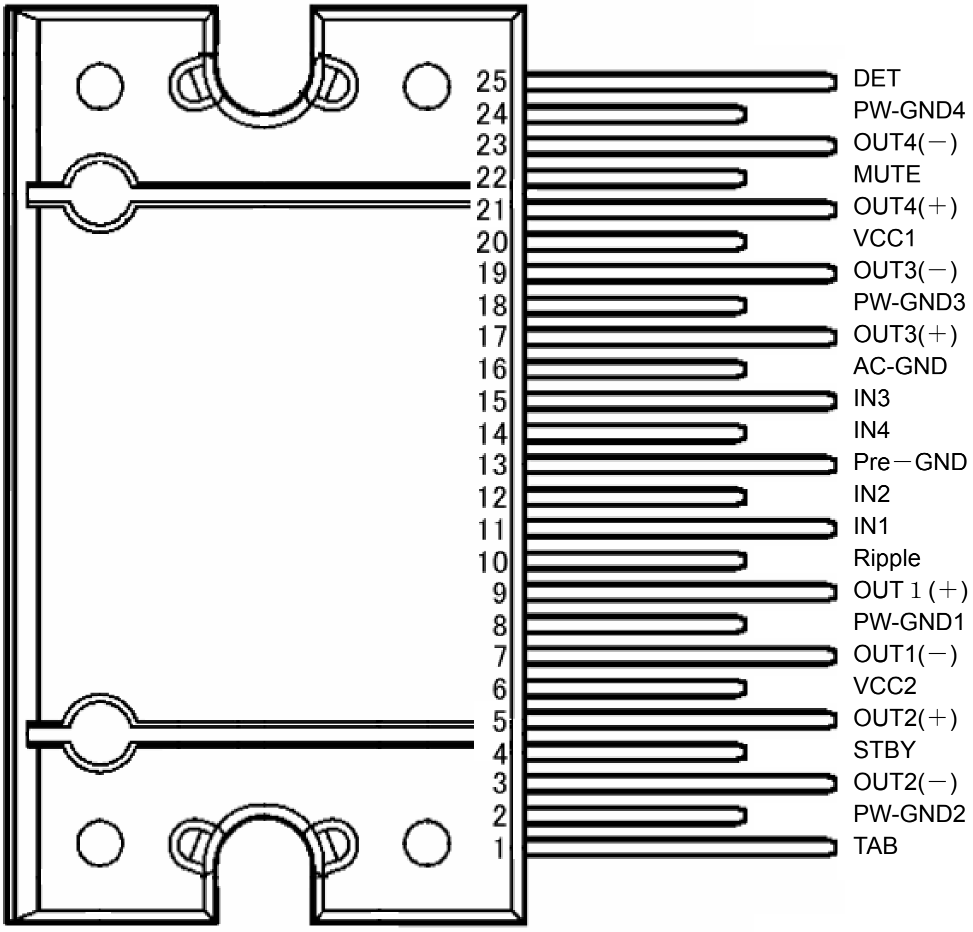


Some of the functional blocks, circuits or constants labels in the block diagram may have been omitted or simplified for clarity.

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)

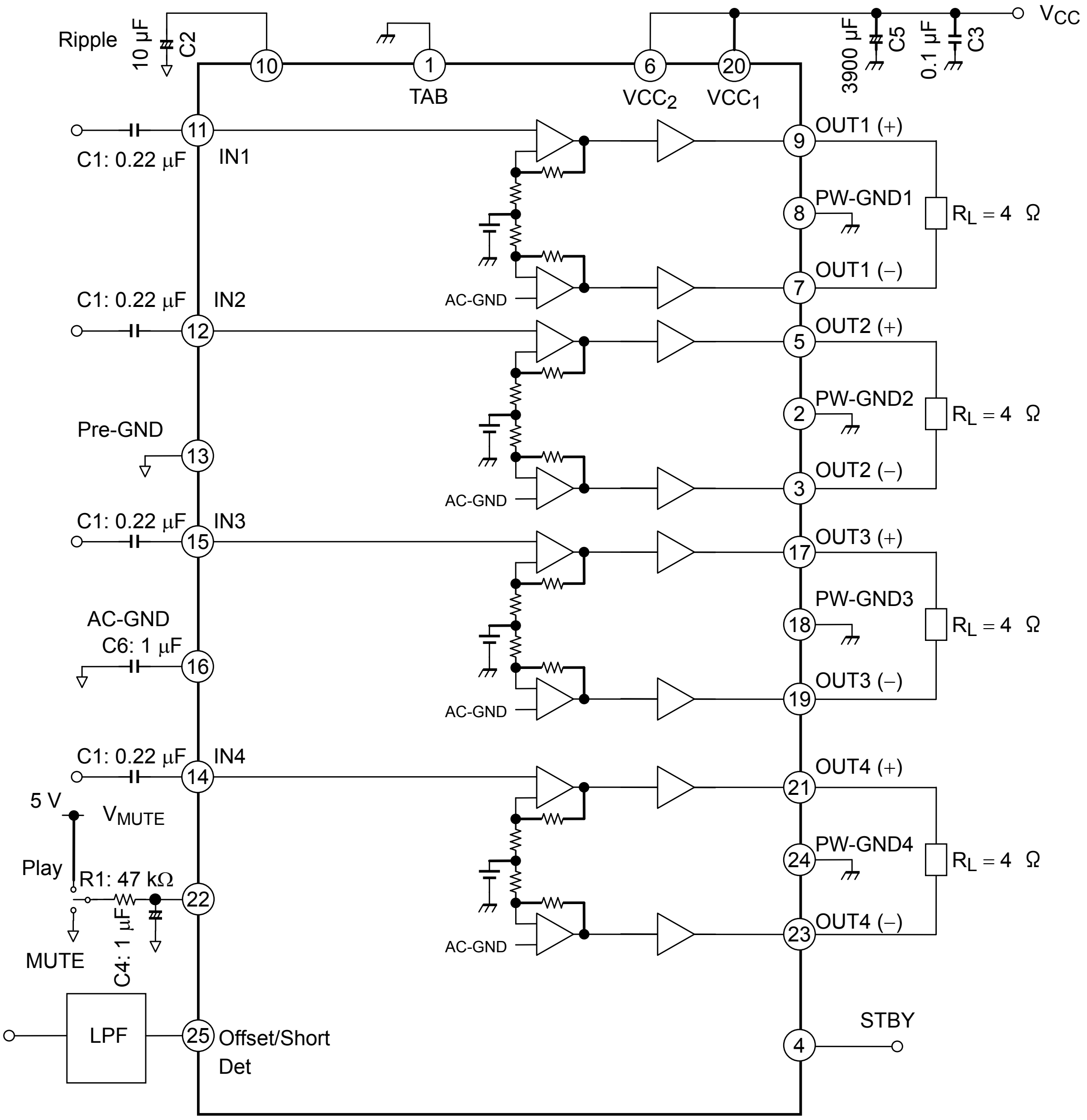


5.2 Pin Function Descriptions

Pin	Symbol	I/O	Description
1	TAB	—	Ground (TAB)
2	PW-GND2	—	Ground for OUT2
3	OUT2(-)	OUT	OUT2(-) output
4	STBY	V_{ST}-IN	Standby voltage input
5	OUT2(+)	OUT	OUT2(+) output
6	VCC_2	V_{CC}-IN	Supply voltage 2
7	OUT1(-)	OUT	OUT1(-) output
8	PW-GND1	—	Ground for OUT1
9	OUT1(+)	OUT	OUT1(+) output
10	Ripple	—	Ripple voltage
11	IN1	IN	OUT1 input
12	IN2	IN	OUT2 input
13	Pre-GND	—	Signal ground
14	IN4	IN	OUT4 input
15	IN3	IN	OUT3 input
16	AC-GND	—	Common reference voltage for all input
17	OUT3(+)	OUT	OUT3(+) output
18	PW-GND3	—	Ground for OUT3
19	OUT3(-)	OUT	OUT3(-) output
20	VCC_1	V_{CC}-IN	Supply voltage 1
21	OUT4(+)	OUT	OUT4(+) output
22	MUTE	V_{mute}IN	Mute voltage input
23	OUT4(-)	OUT	OUT4(-) output
24	PW-GND4	—	Ground for OUT4
25	DET	(OC) Note1	Offset detector output / Out to GND short detector

Note1 : OC means are open collector output

6. Functional 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 shorter	Turn on/off time longer
C3	0.1 μF	VCC_1, VCC_2	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin	
C6	1 μF	AC-GND	Common reference voltage for all input	Pop noise is suppressed when C1: C6 = 1:4. (Note2)	
C5	3900 μF	VCC_1, VCC_2	Ripple filter	Power supply ripple filtering	
R1 / C4	47kΩ / 1 μF	MUTE	Mute ON/OFF Smooth switching	Pop noise becomes larger	Switching time becomes 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.

7. Standby Function (Pin 4)

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.

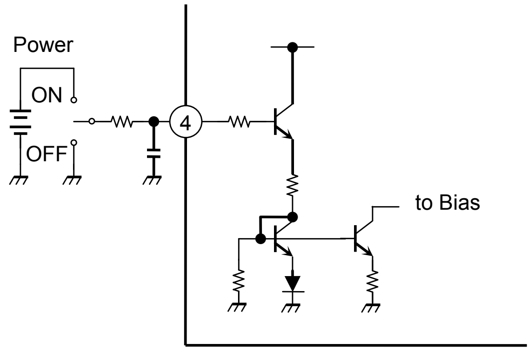


Figure 1 Internal circuit for standby

Standby Control Voltage (V_{SB}): Pin 4

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

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.

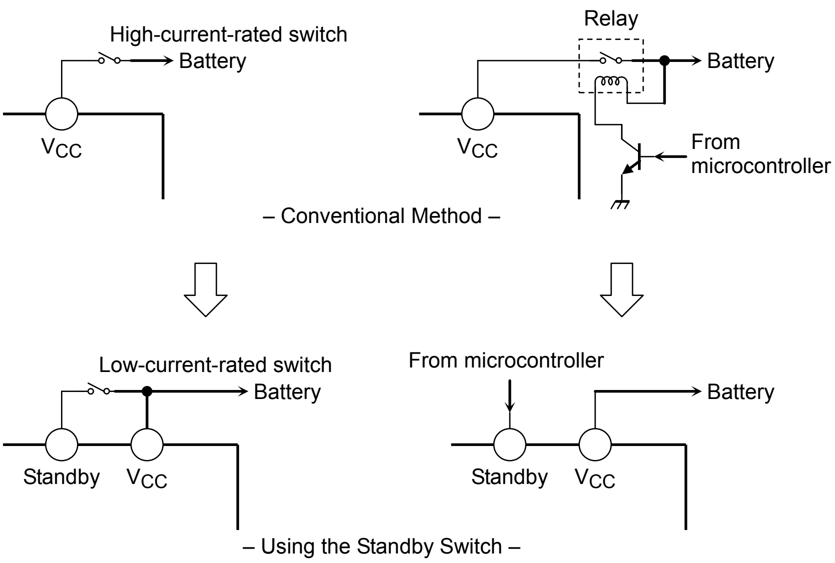


Figure 2 Standby Switch

8. Mute Function (pin 22)

The audio mute function is enabled by setting pin 22 Low. R_1 and C_4 determine the time constant of the mute function. The time constant affects pop noise generated when power or the mute function is turned on or off; thus, it must be determined on a per-application basis. (Refer to Figures 3 and 4.)
The value of the external pull-up resistor is determined, based on pop noise value.

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

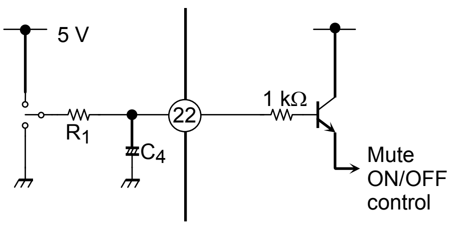


Figure 3 Mute Function

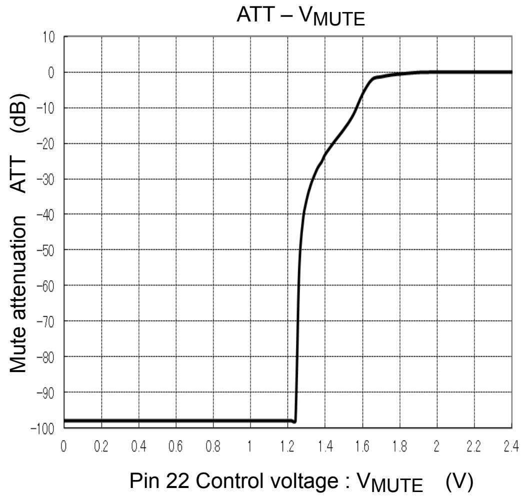


Figure 4 Mute Attenuation – V_{MUTE} (V)

9. Auto Muting Functions

The TB2996HQ has two automatic mute function.

a) Low Vcc Mute

b) Stand-by Off Mute.

9.1 Low Vcc Mute

When the supply voltage became lower than about 5.5V (Typ), The TB2996HQ operates the mute circuit automatically. This function prevents the large audible transient noise which is generated by low Vcc

9.2 Standby-Off Mute

The TB2996HQ operates the mute circuit during the standby-off transition. When the ripple voltage reached Vcc/5, the standby-off mute is terminated. The external mute has to be ON till the internal mute-OFF.

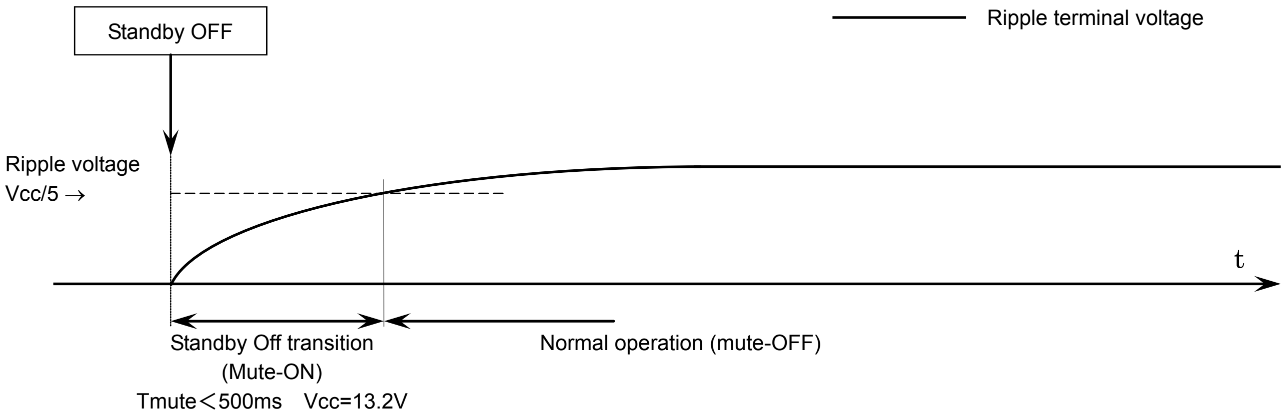


Figure 5 standby-Off Mute

10. Output DC Offset Detection

10.1 Offset circuit explanation

Offset Circuit This function detects the offset voltage between OUT(+) and OUT(-). The detection result is gotten by pin25.

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

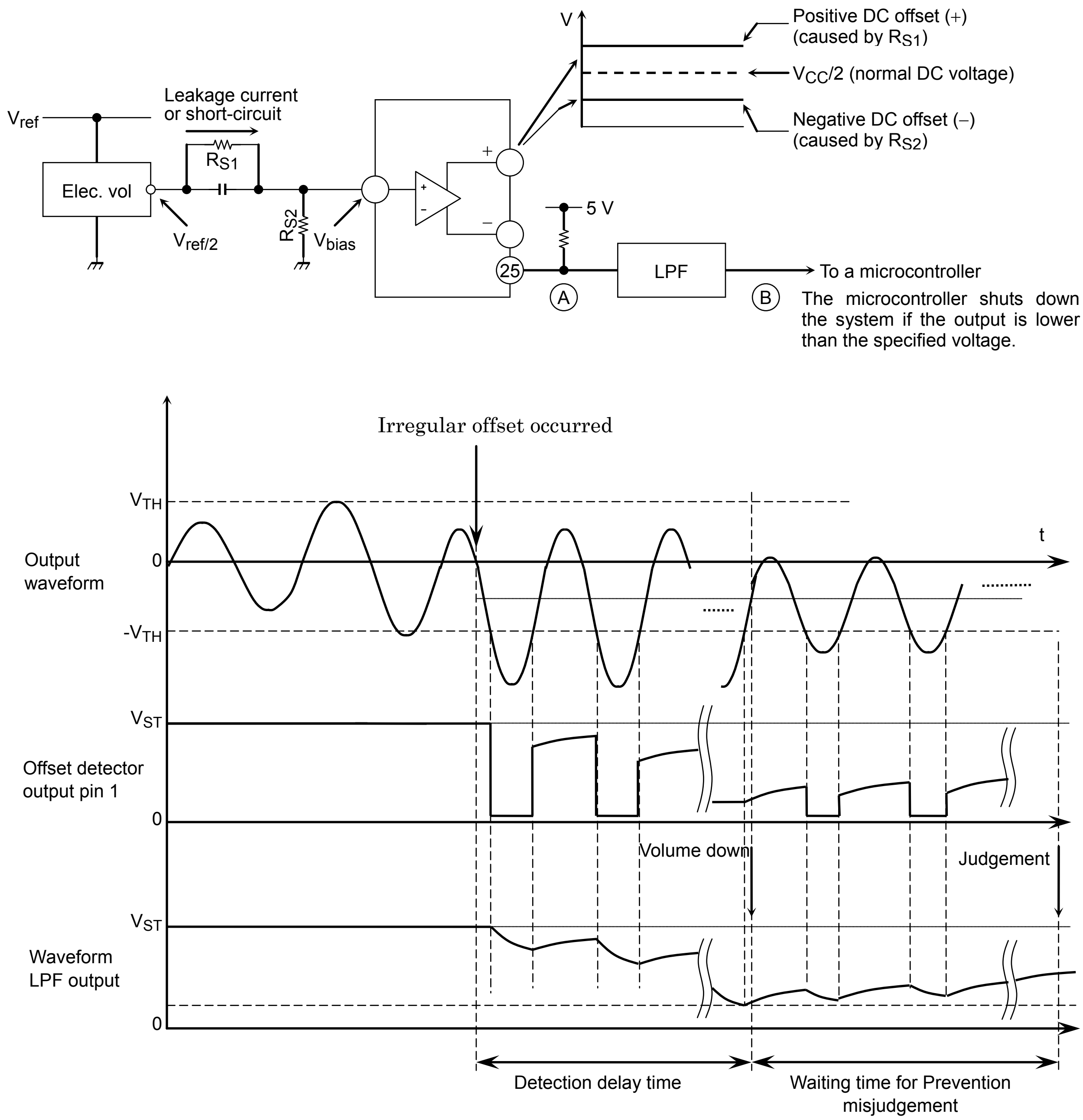


Figure 6 The detected result and audio output waveform

10.2 Outputshort detector

TB2996HQ has output shorting detector.

In case of shorting output to VCC/GND or over voltage power supplied, NPN transistor is turned on.

In case of shorting output to output NPN Tr. is turned on and off in response to the input signal voltage.

11. Protection Functions

This product has internal protection circuits such as thermal shut down, over-voltage, out to V_{CC}, 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 though 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_{CC} pin. If voltage falls, it will return automatically. When it operates, all outputs bias and high-side switch are turned off and all outputs are intercepted. Threshold voltage is 23V(Typ.)

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

It operates when each output pin is in irregular connection and the load line goes over the SOA of power transistor (DMOS). When it operates, all outputs bias circuits are turned off and all outputs are intercepted. If irregular connection is canceled, it will return automatically.

Note 1: When the current phase shifts widely, the protection will operate for the capacitor etc are connected with the output. Please confirmation to use enough by using your testing board etc.

12. Absolute Maximum Ratings

(Ta = 25°C unless otherwise specified)

Characteristics	Condition	Symbol	Rating	Unit
supply voltage (surge)	max0.2s	$V_{CC\ (surge)}$	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

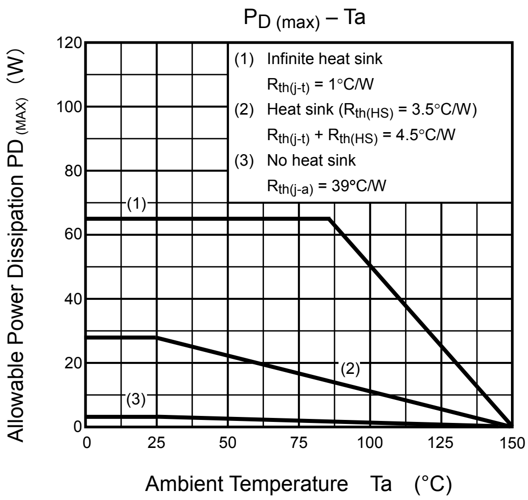
Note: Package thermal resistance $R_{th(j-t)}$ = 1°C/W (typ.) (Ta = 25°C, with infinite heat sink)

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.

12.1 Power Dissipation



13. Operating Ranges

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

14. Electrical Characteristics

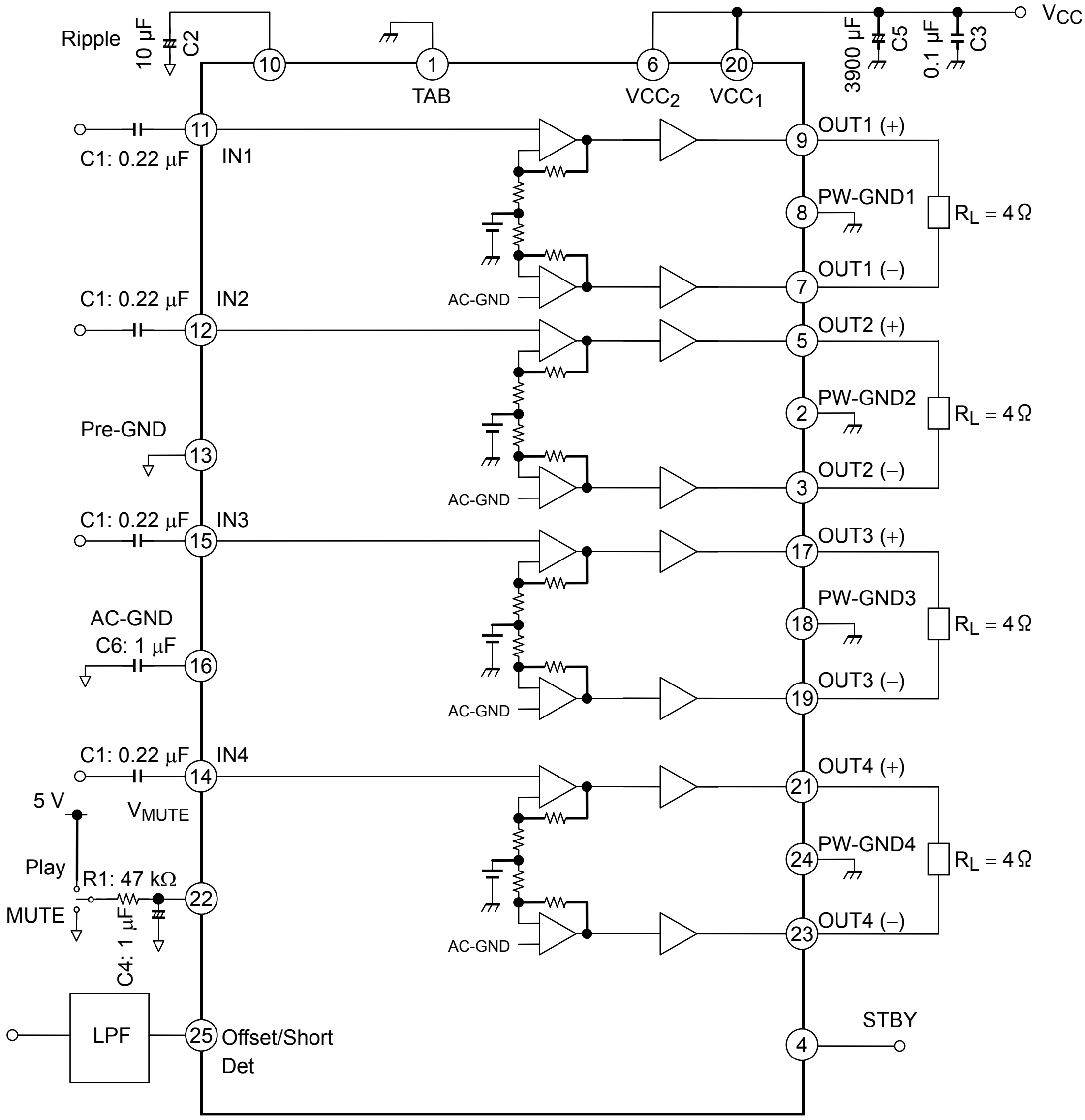
(V_{CC} = 13.2 V, f = 1 kHz, R_L = 4 Ω, Ta = 25°C unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I_{CCQ}	V_{IN} = 0	—	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=2Ω)	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=20Hz to 20KHz	—	50	70	μV
Ripple rejection ratio	R.R.	f_{RIP} = 100 Hz, Rg = 620 Ω (note1) V_{RIP} = 0.775 Vrms	60	70	—	dB
Crosstalk	C.T.	Po = 4W, R_g = 620 Ω,	—	80	—	dB
Output offset voltage	V_{OFFSET}	—	−90	0	90	mV
Input resistance	R_{IN}	—	—	90	—	kΩ
Standby current	I_{STBY}	V_{STB} = 0V,V22=0	—	0.01	1	μA
Mute attenuation	ATT M	MUTE: ON V_{OUT} = 7.75 Vrms → MUTE: OFF	85	100	—	dB
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 , R_1 = 47 kΩ	0	—	0.9	
Offset detection threthold voltage	Vos_{det}	Rpull-up = 47 kΩ, +V= 5.0 V Reference of Vout DC voltage	±1.0	±1.5	±2.0	V
Terminal 25 saturation voltage	P25-Sat	Rpull-up = 10 kΩ, +V = 5.0 V P25 is LOW at the detective.	—	100	500	mV

Note 1 : f_{RIP} : repple frequency

Note2 : V_{RIP} : Ripple signal voltage (AC fluctuations in the power supply)

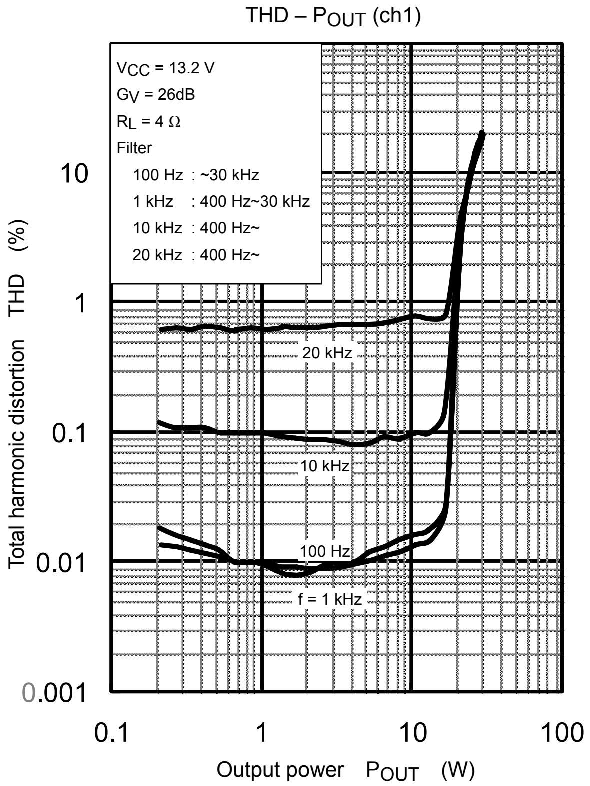
15. Test Circuit

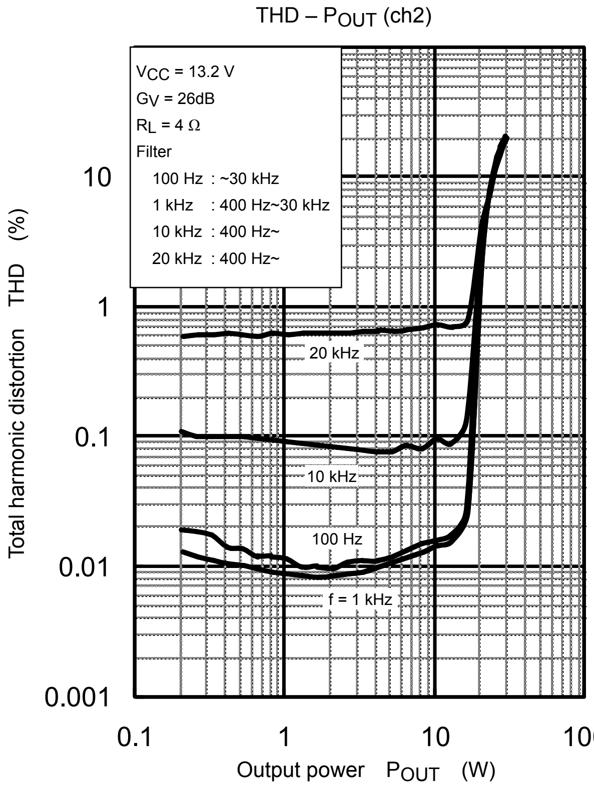


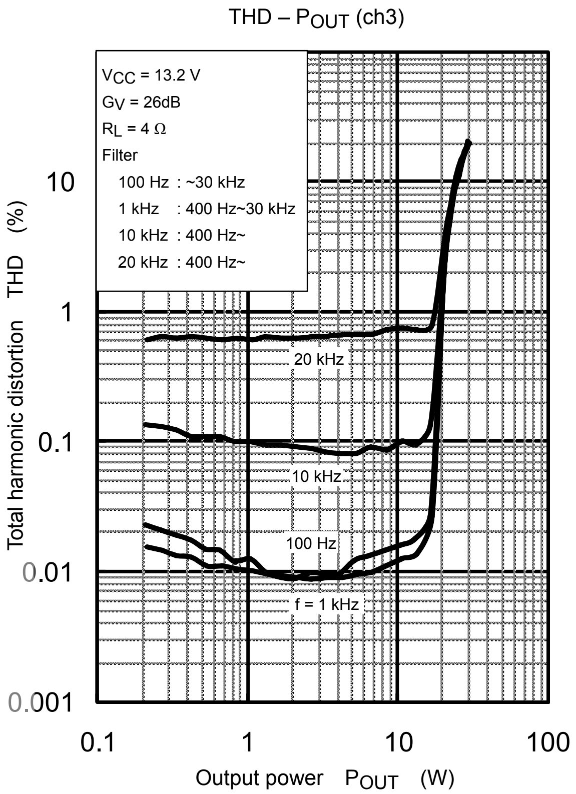
components in the test circuit are only used to determine the device characteristics.
It is not guaranteed that the system will work properly with these components.

16. Electrical characteristics

16.1 Total Harmonic Distortion vs. Output Power







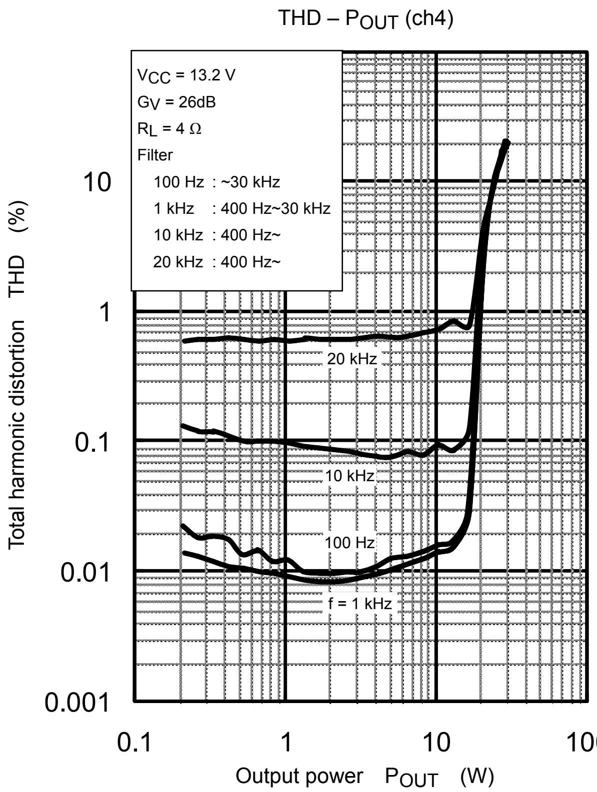
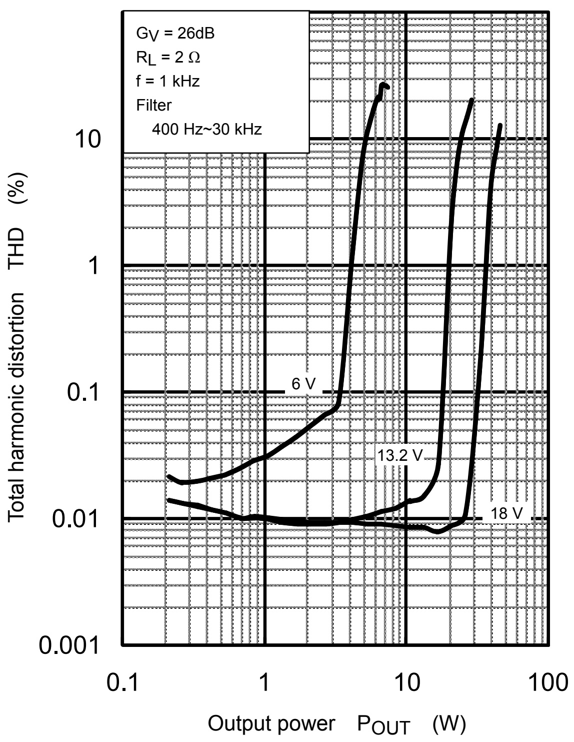
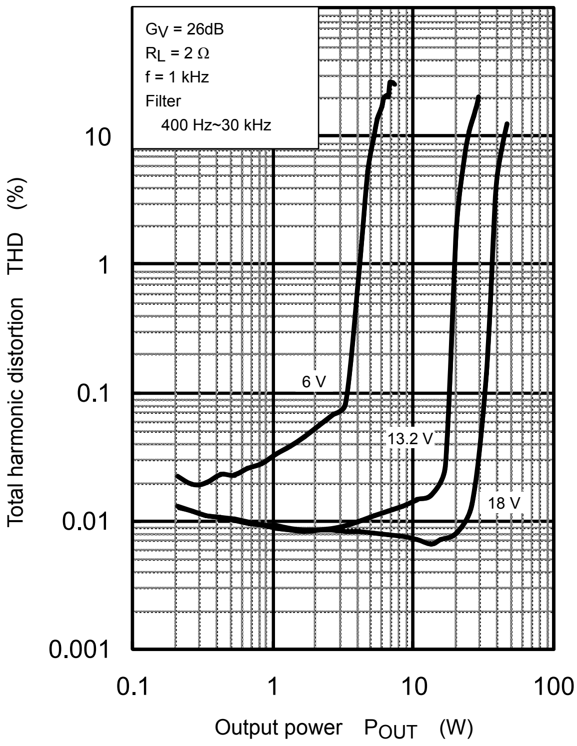


Fig. 7-1 Total Harmonic Distortion of Each Frequency (R_L=4Ω)

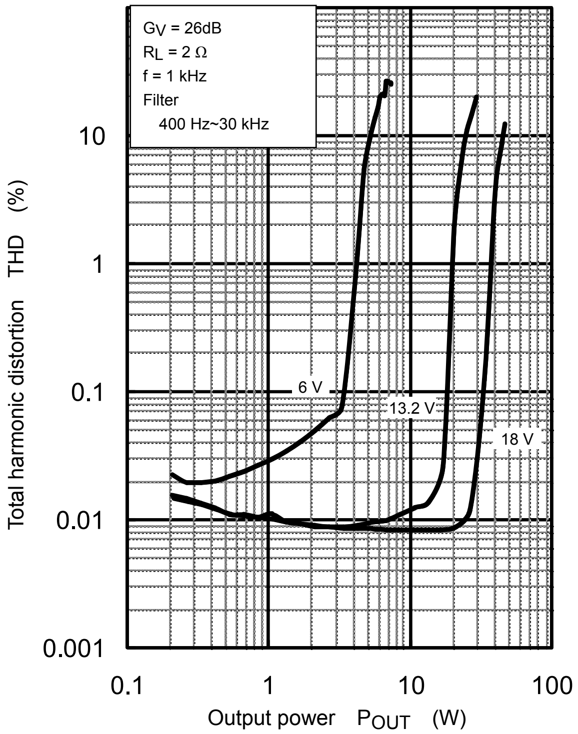
THD – P_{OUT} (ch1)



THD – P_{OUT} (ch2)



THD – P_{OUT} (ch3)



THD – P_{OUT} (ch4)

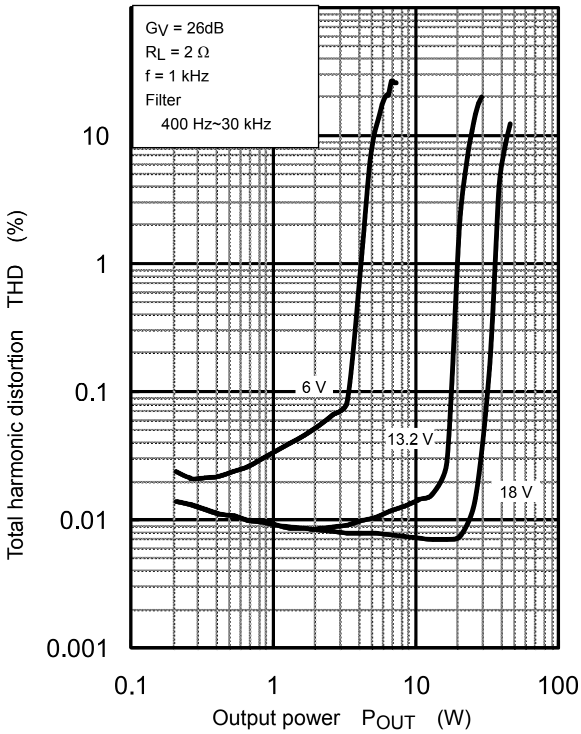
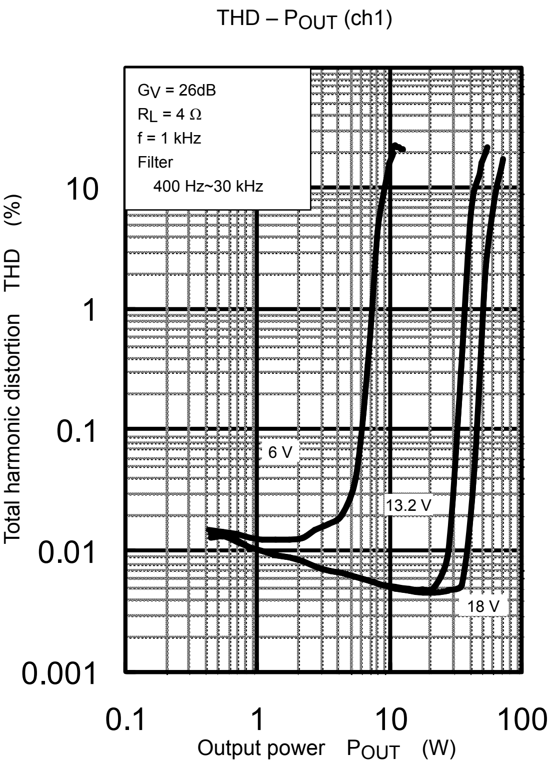
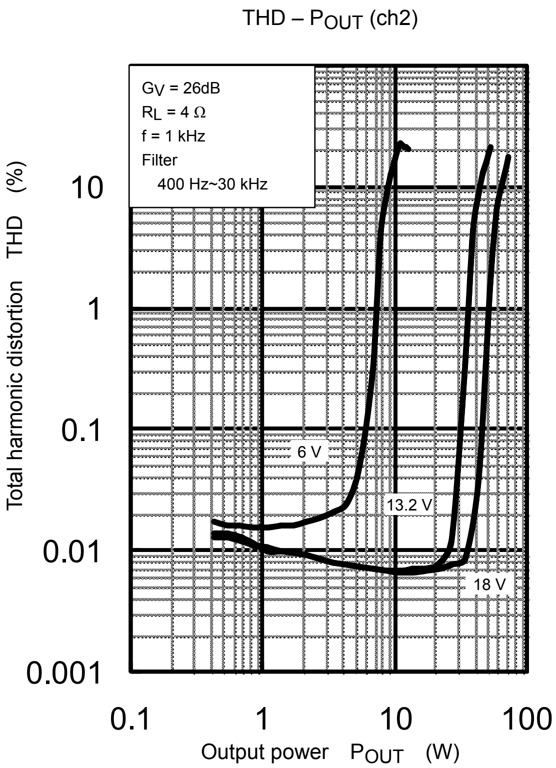
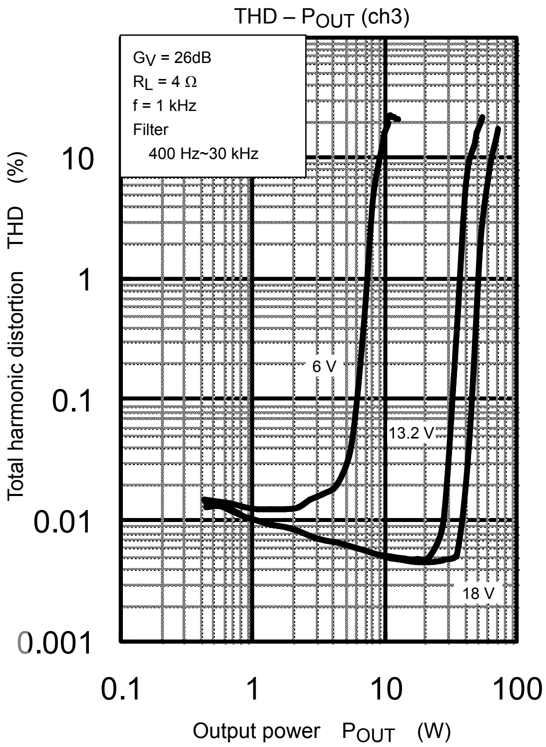


Fig.7-2 Total Harmonic Distortion by Power-supply Voltage (R_L=4Ω)







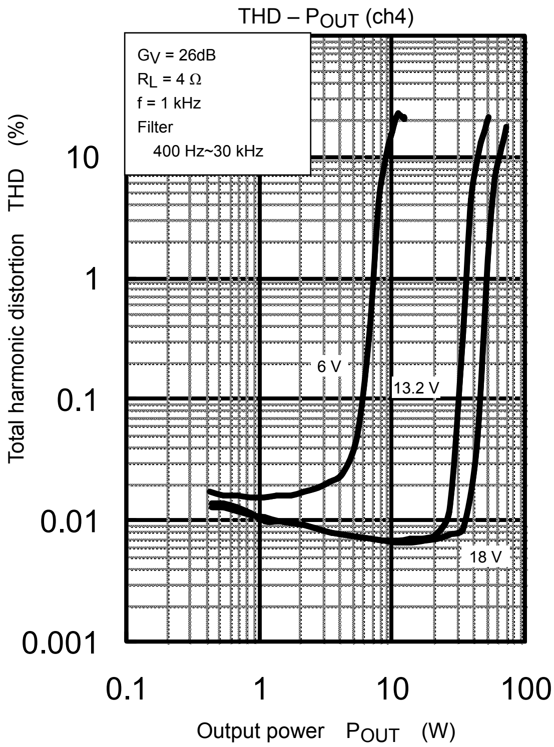


Fig.7-3 Total Harmonic Distortion by Power-supply Voltage (R_L=4Ω)

16.2 Various Frequency Characteristics

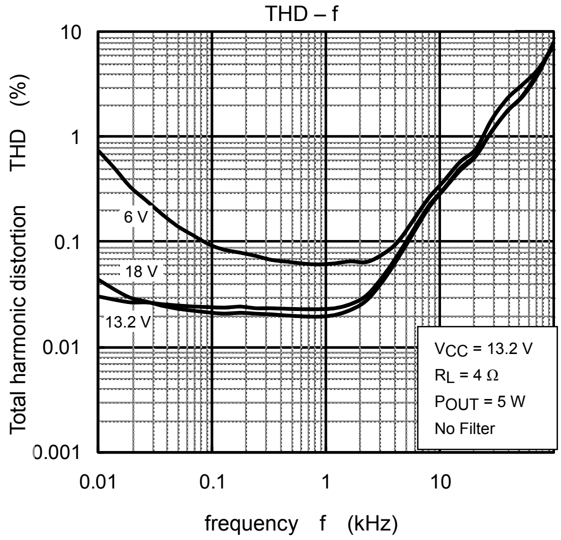
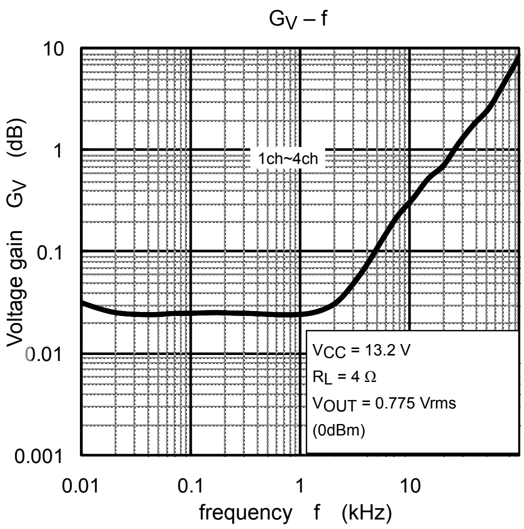


Fig.7-4 Frequency Characteristics of Total Harmonic Distortion



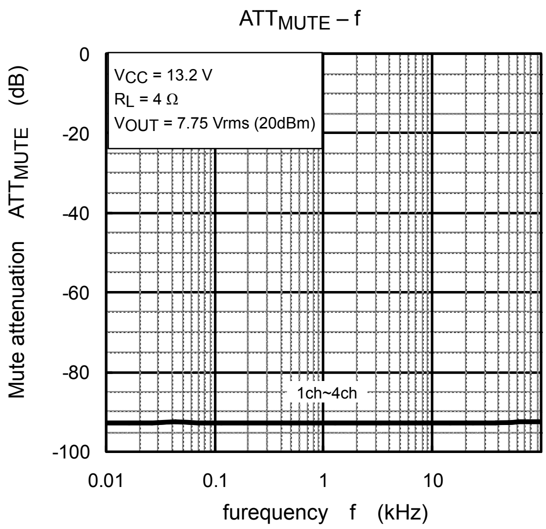


Fig. 7-5 Frequency Characteristics of Voltage Gain and Mute Attenuation

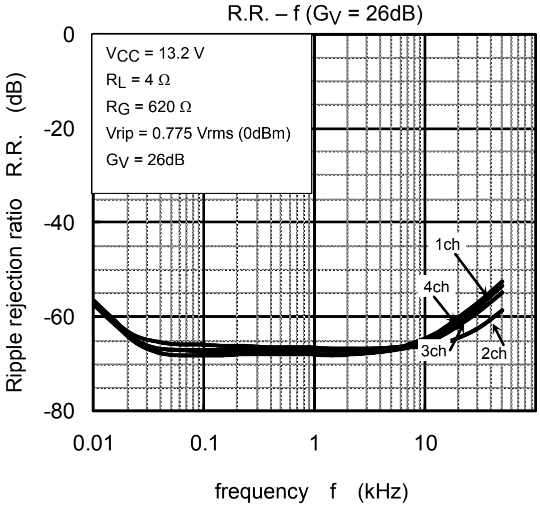


Fig. 7-6 Frequency Characteristics of Ripple Rejection Rate

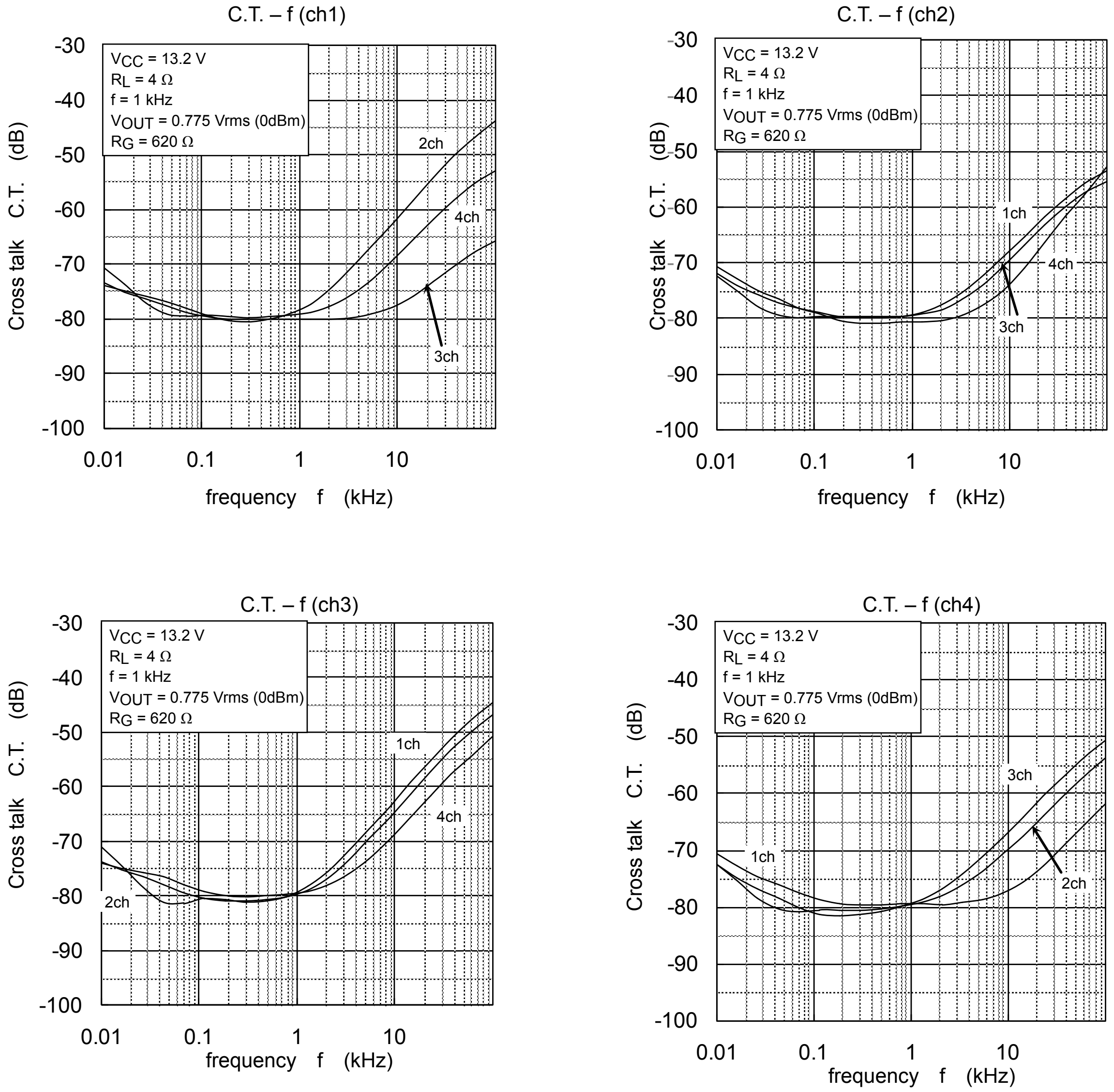
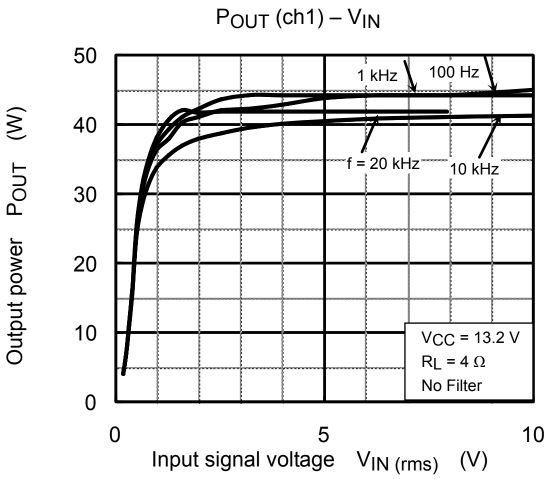
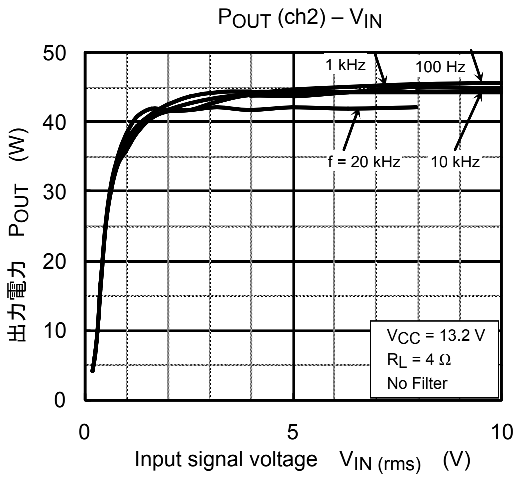
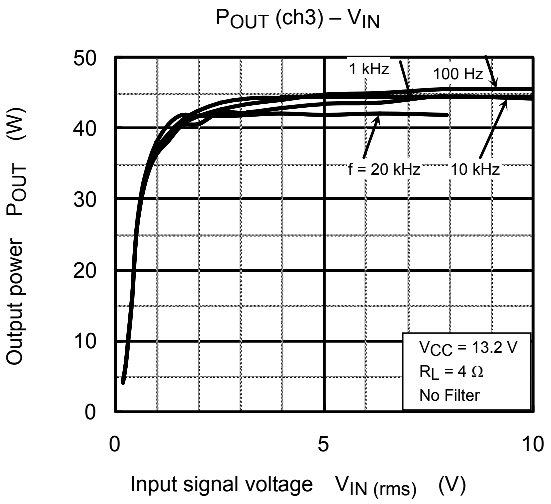


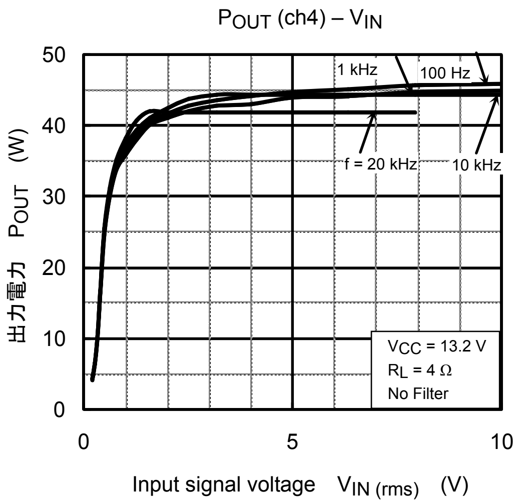
Fig. 7-7 Frequency Characteristics of Cross Talk

16.3 Output Power vs Input Voltage

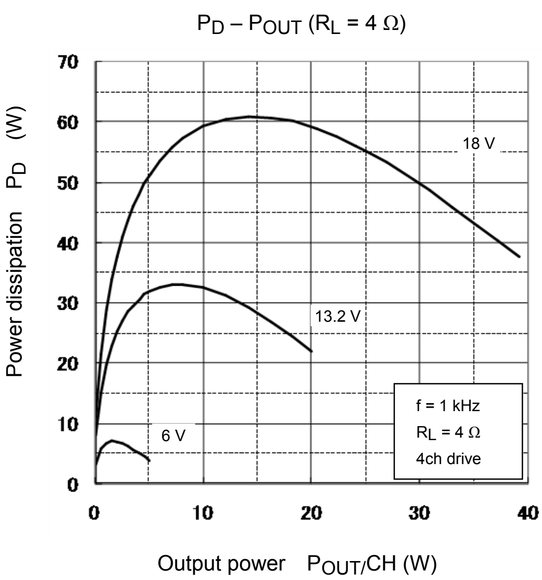




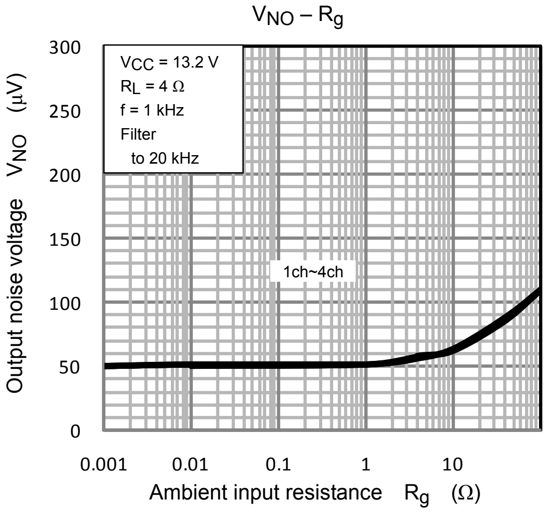


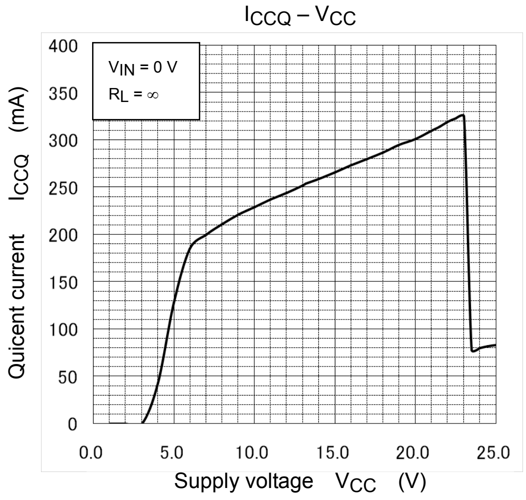


16.4 Power Dissipation vs. Output Power



16.5 Other characteristics

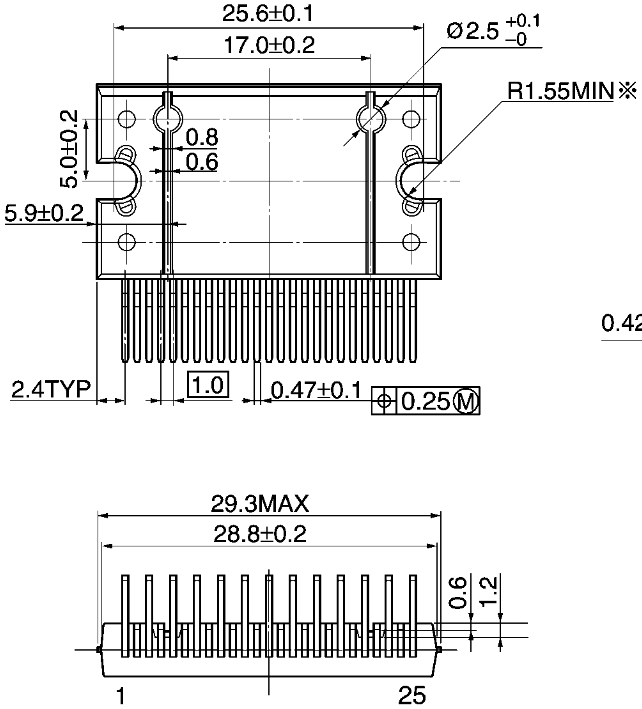




17. Package Dimensions

HZIP25-P-1.00F

Unit: mm



* From center to parting line.

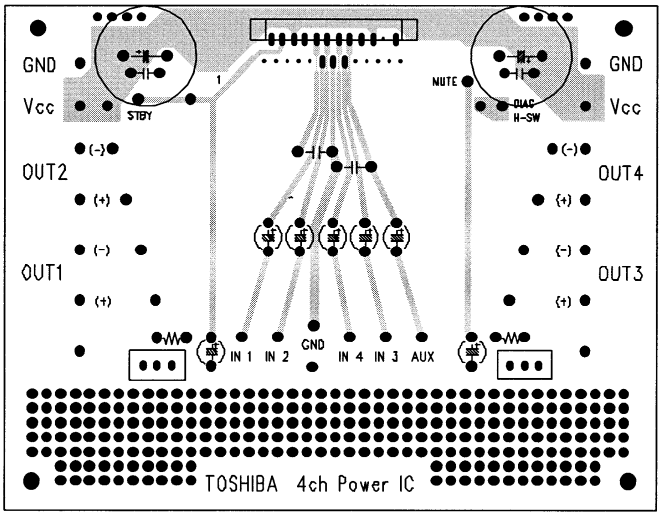
Weight : 7.7 g (typ.)

18. Board Layout for TOSHIBA 4-Channel Power Circuitry

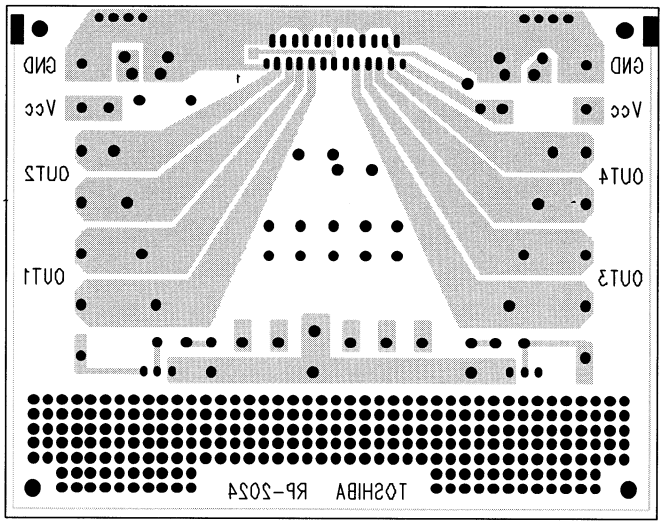
The layout diagrams below illustrate the front and back sides of the test board “RP-2024” for testing Toshiba’s 4-channel power circuitry, which is housed in a HZIP25-P-1.00F (SPP25) package.

Note 1: This test board is designed to be used for several power amplifiers. Therefore, devices that are externally connected to the power amplifier to be tested must be checked before setting up the test board.

Front Side



Back Side



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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