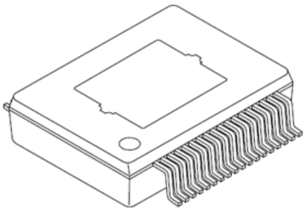
CDMOS Linear Integrated Circuit Silicon Monolithic

TCB001FNG

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

1. Outline

The TCB001FNG is a power IC with built-in four-channel BTL amplifier developed for car audio applications.
The maximum output power (P_{OUT} MAX) is 45W using a pure complementary P-ch and N-ch DMOS output stage.
It also includes a standby switch, mute function and various protection features.



P-HSSOP36-1116-0.65-001

Weight: 1.28 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.)
- Built-in various mute functions (At low voltage, standby on/off)
- Built-in standby switch (Pin 22)
- Built-in mute switch (Pin 33)
- Built-in various detection circuits (output offset voltage, output short, over voltage) (Pin 29)
- 6V operations (Engine idle reduction capability)
- Built-in various protection circuits (thermal shut down, over-voltage, short to GND, short to V_{DD}, load short, and prevention of speaker damage)

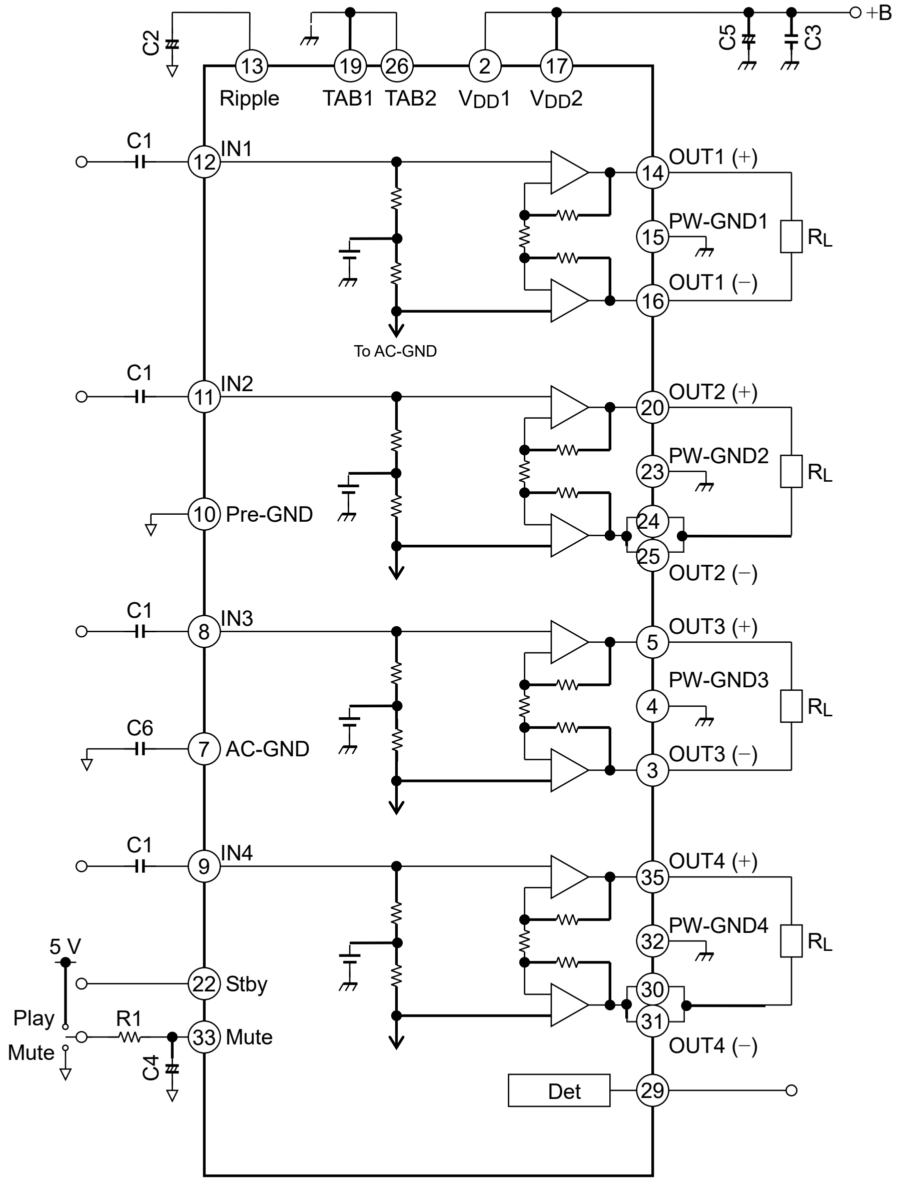
Table 3.1 Typical characteristics

(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.)

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}) (R_g = 0 Ω) (Note)		
BW = 20 Hz to 20 kHz	45	μV
Operating Supply voltage range (V_{DD})		
R_L = 4 Ω	6 to 18	V

Note: R_g: signal source resistance

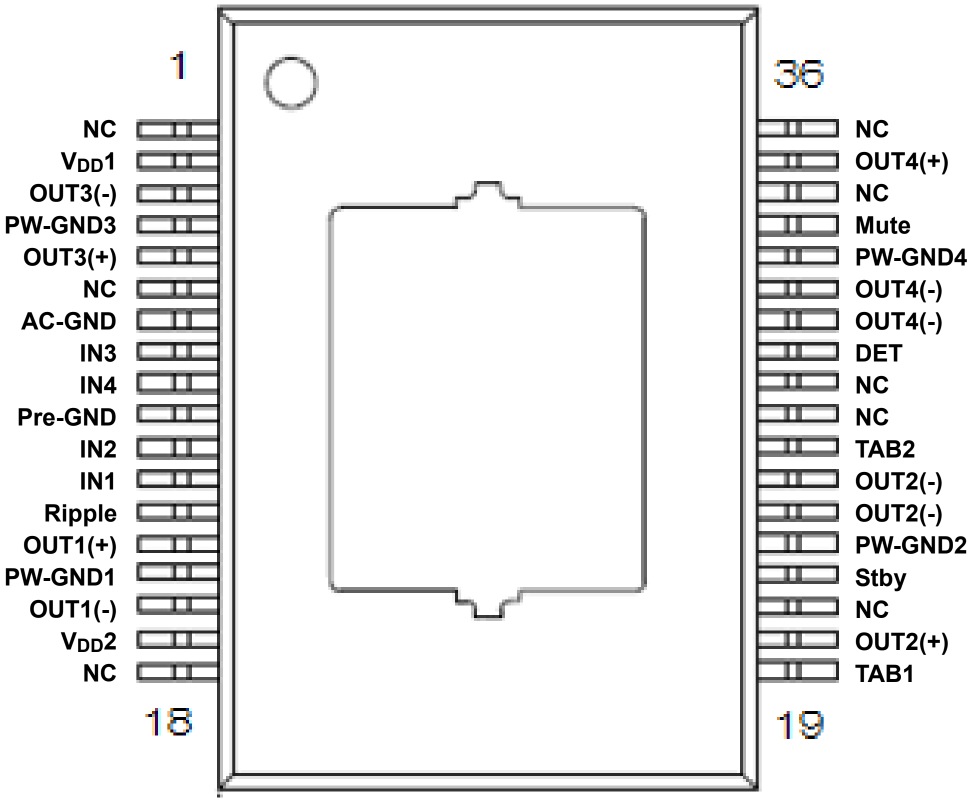
4. Block Diagram



Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes.

Note: A "channel" is a circuit which consists of INx, OUTx (+), OUTx (-), and PW-GNDx. (x: 1 to 4)

5. Pin Configuration (Top View)



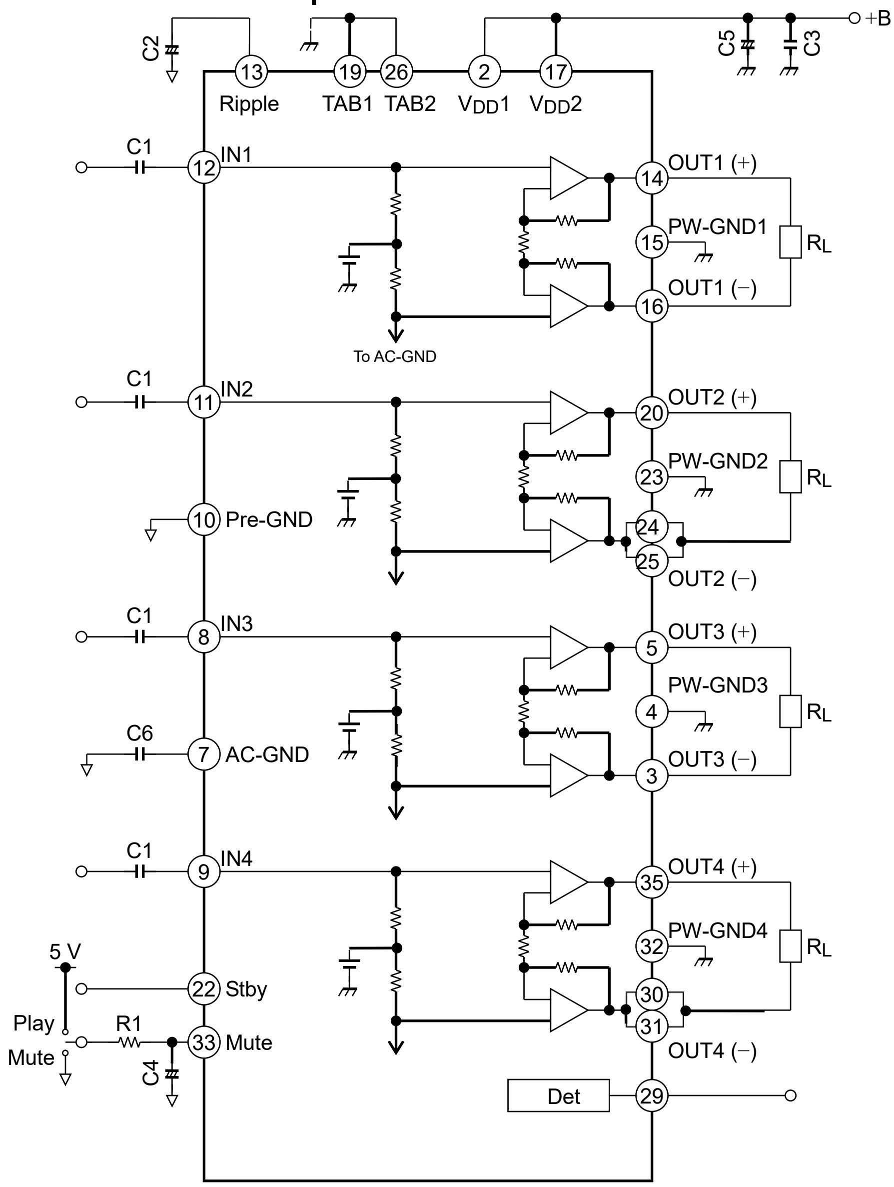
6. Pin Descriptions

Pin No.	Pin name	I/O	Description
1	NC	—	—
2	V_{DD}1	V_{DD}-IN	Supply voltage 1
3	OUT3(-)	OUT	3ch output-
4	PW-GND3	—	Ground for 3ch output
5	OUT3(+)	OUT	3ch output+
6	NC	—	—
7	AC-GND	—	Common reference voltage for all input
8	IN3	IN	3ch input
9	IN4	IN	4ch input
10	Pre-GND	—	Signal ground
11	IN2	IN	2ch input
12	IN1	IN	1ch input
13	Ripple	—	Ripple voltage
14	OUT1(+)	OUT	1ch output+
15	PW-GND1	—	Ground for 1ch output
16	OUT1(-)	OUT	1ch output-
17	V_{DD}2	V_{DD}-IN	Supply voltage 2
18	NC	—	—
19	TAB1	—	TAB (Always connect with GND)
20	OUT2(+)	OUT	2ch output+
21	NC	—	—
22	Stby	V_{ST}-IN	Standby voltage input
23	PW-GND2	—	Ground for 2ch output
24	OUT2(-)	OUT	2ch output-
25			
26	TAB2	—	TAB (Always connect with GND)
27	NC	NC	—
28			
29	DET	OD (Note)	Offset detector output / short detector / over voltage
30	OUT4(-)	OUT	4ch output-
31			
32	PW-GND4	—	Ground for 4ch output
33	Mute	V_{mute}IN	Mute voltage input
34	NC	—	—
35	OUT4(+)	OUT	4ch output+
36	NC	—	—

Note: OD: Open drain.

7. Detailed Description

7.1. Specifications of External Components



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 time shorter	Turn on time 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. Mute release time shorter	Low pop noise. Mute release time longer
C5	3900 μF	$V_{DD}1$, $V_{DD}2$	Ripple filter	For power supply hum and ripple filter	
C6	1 μF	AC-GND	Common reference voltage for all input	Pop noise is suppressed when C1: C6 = 1:4. (Note3)	
R1	47 kΩ	Mute	To reduce pop noise	High pop noise. Mute release time shorter	Low pop noise. Mute release 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: Please use the low leak current capacitor for C1 and C6.

7.2. Standby Switch Function

The power supply can be turned on or off by controlling Pin 22 (Standby voltage input pin) to High or Low. The threshold voltage of Pin 22 is shown in the following table. The power supply current is about 0.01 μA (typ.) in the standby state.

Table 7.1 Pin 22 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 22 is changed.

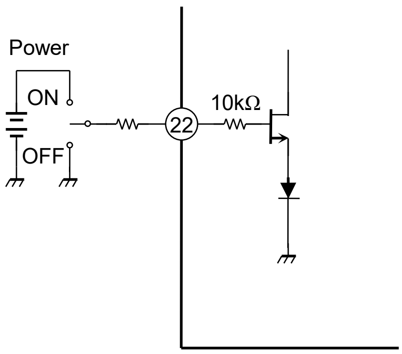


Figure 7.1 Standby circuit diagram

<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.

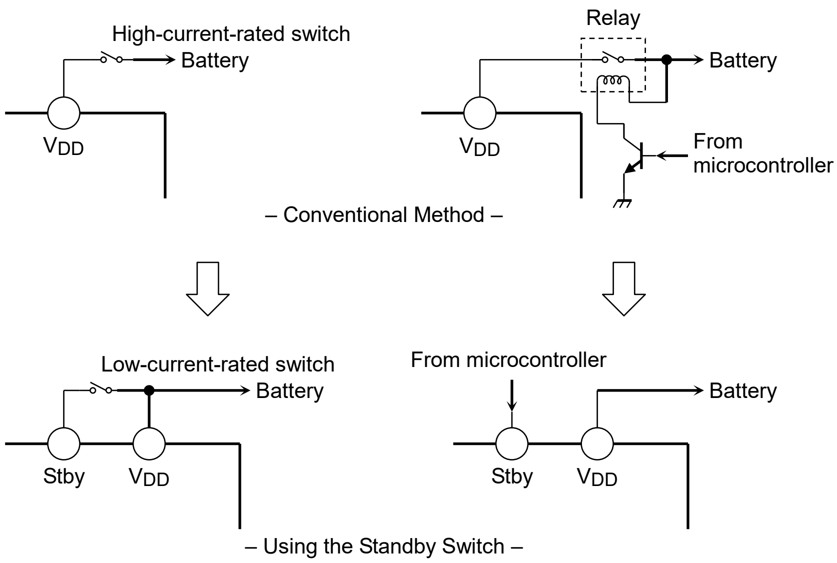


Figure 7.2 Standby switch

7.3. Mute Switch Function

The audio mute switch is enabled by setting Pin 33 to Low. R1 and C4 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 pin is designed on the control voltage of 5V. If it is used on voltage other than 5V, please set the constant of R1 after referring to the following formula.

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

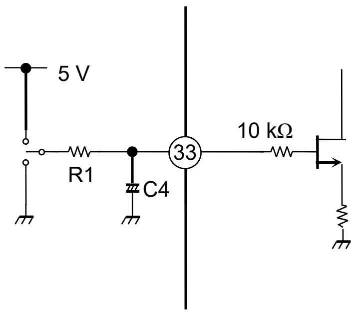


Figure 7.3 Mute Function

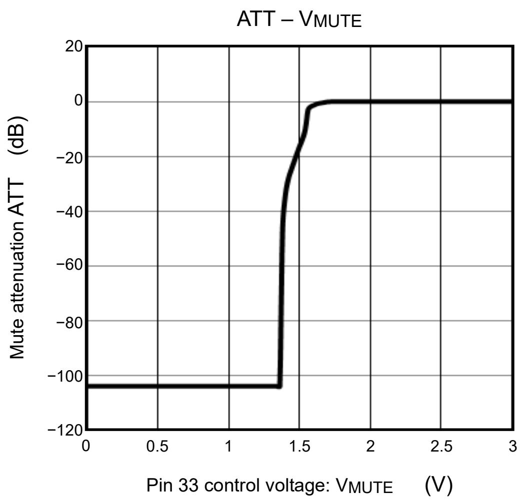


Figure 7.4 Mute Attenuation - V_{MUTE} (V)

7.4. Automatic Mute Function

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

7.4.1 Low Voltage Mute Function

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

7.4.2 Standby Off Mute Function

The standby off mute function is a function of which the mute operation when standby off, and keep it in a fixed period. This mute function is released after the ripple pin is charged and the voltage condition (Vripple ≥ 1/4V_{DD}) is filled.

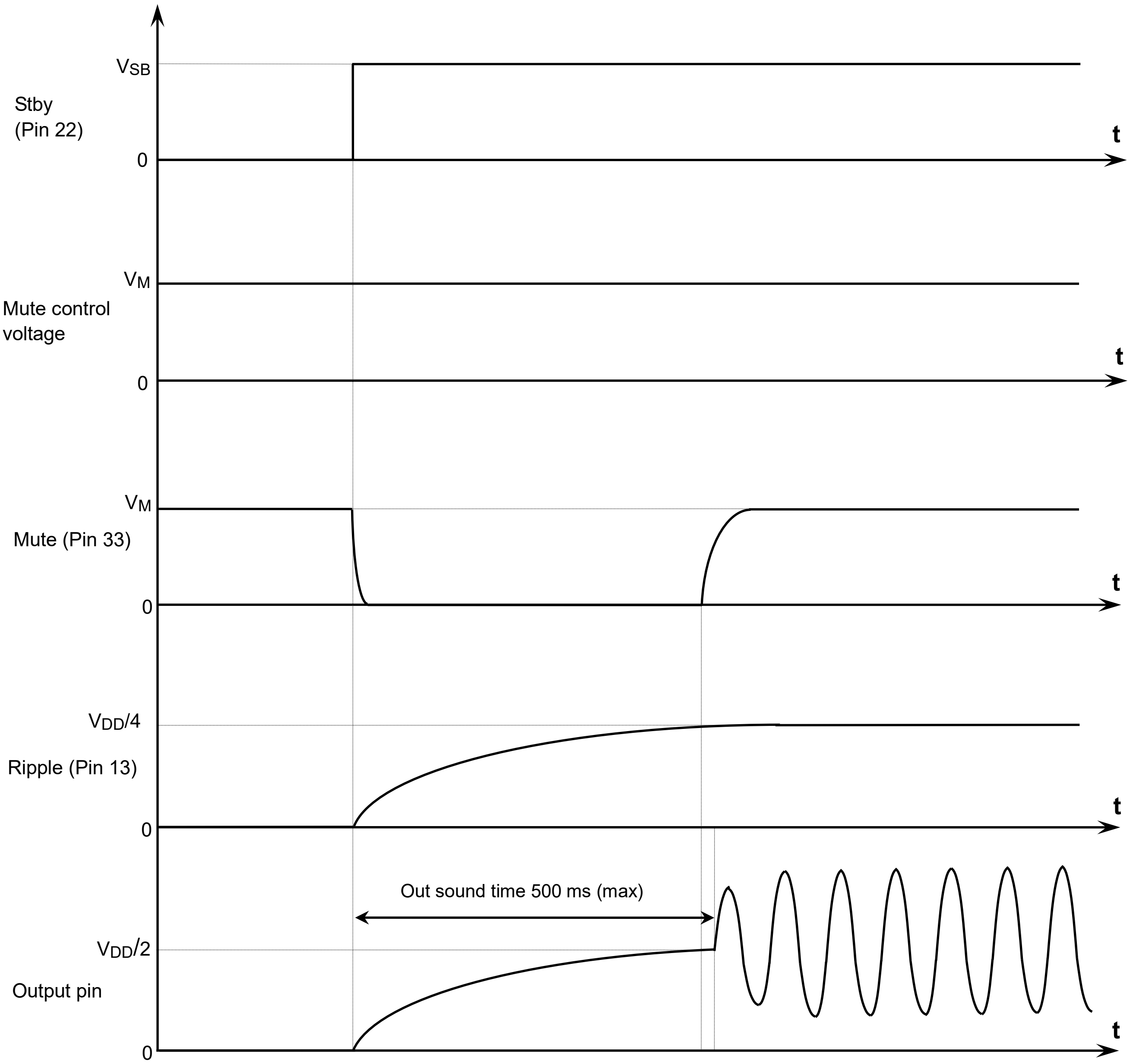


Figure 7.5 Sequence when standby-off

7.4.3 Mute off after standby off

After standby off, a pop noise is generated when the mute operation is turned off before capacitor of ripple, input, and AC-GND are finished to charge enough.
Please set “Mute-off” that it is sufficient margin in considering enough charge time after the middle point potential stable.

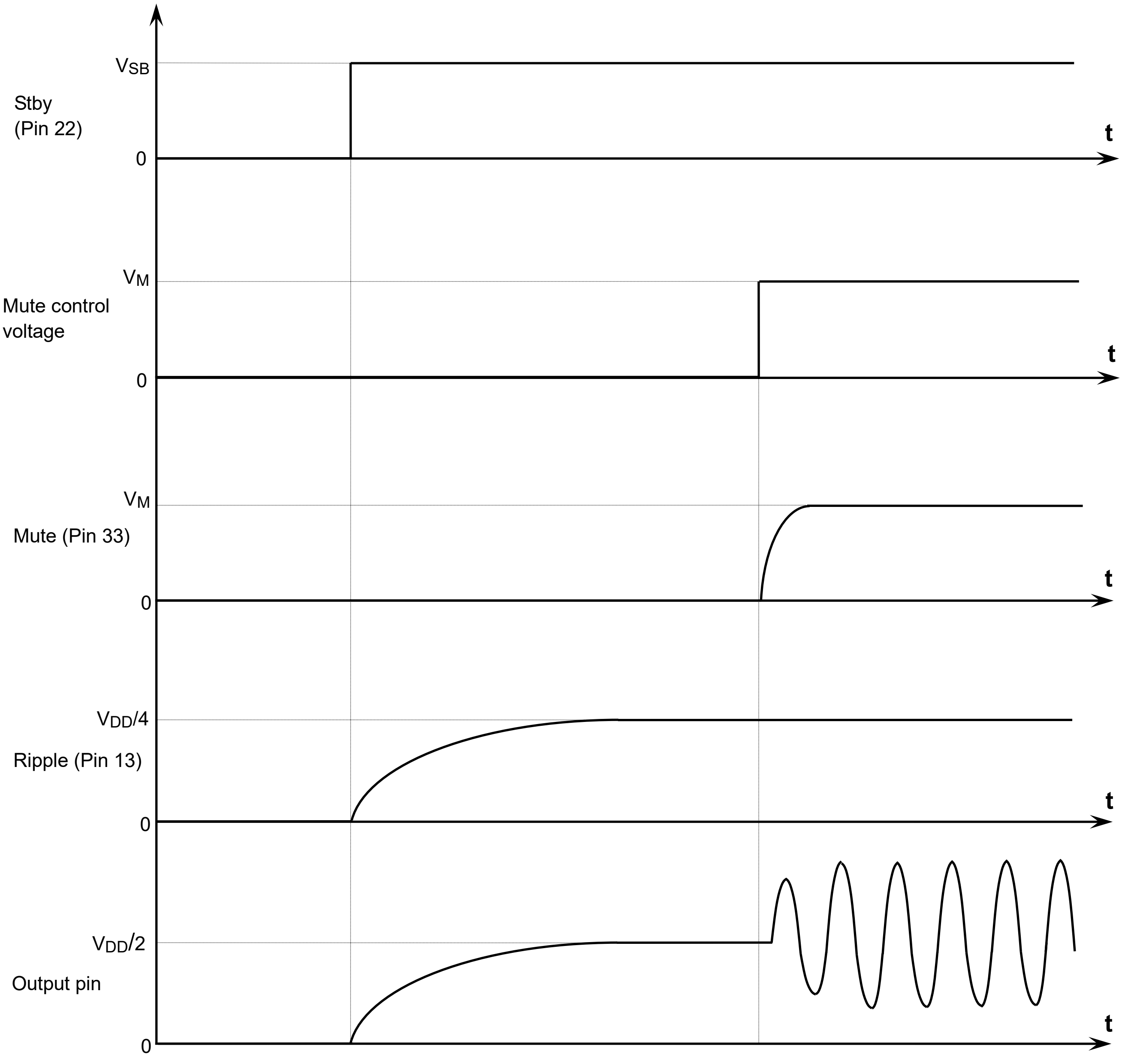


Figure 7.6 Mute off sequence after standby-off

7.5. Self-Diagnosis Detection (DET Pin)

Self-diagnosis detects various abnormal states in this IC-peripheral and the state is notified to outside of the IC by making a MOS transistor ON. This function makes it possible to achieve a high reliable set design, not only power IC but also overall device protection system. If this function is not used, use the Pin 29 (DET pin) to open.

7.5.1 DC Offset Detection Function

This function detects and notifies with Pin 29 an offset voltage to be generated in the amplifier output when an offset voltage exceeds the regulated threshold. When an abnormal offset voltage is generated in the output by leakage of input capacitor, the abnormal state is fed back to the circuit. Then, in order to perform safety operation, this function can be used as "(a) offset voltage detection" which is a part of the configured functions.

(a) Offset detection -> (b) Judgement Normal / Abnormal -> (c) To reduce the speaker stress (Standby-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.

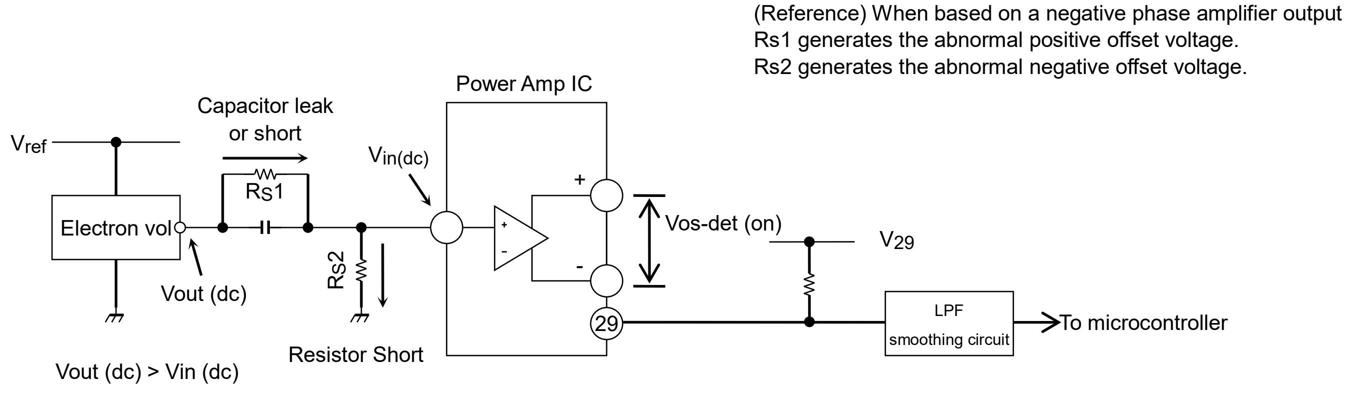


Figure 7.7 Generating mechanism of abnormal output offset voltage

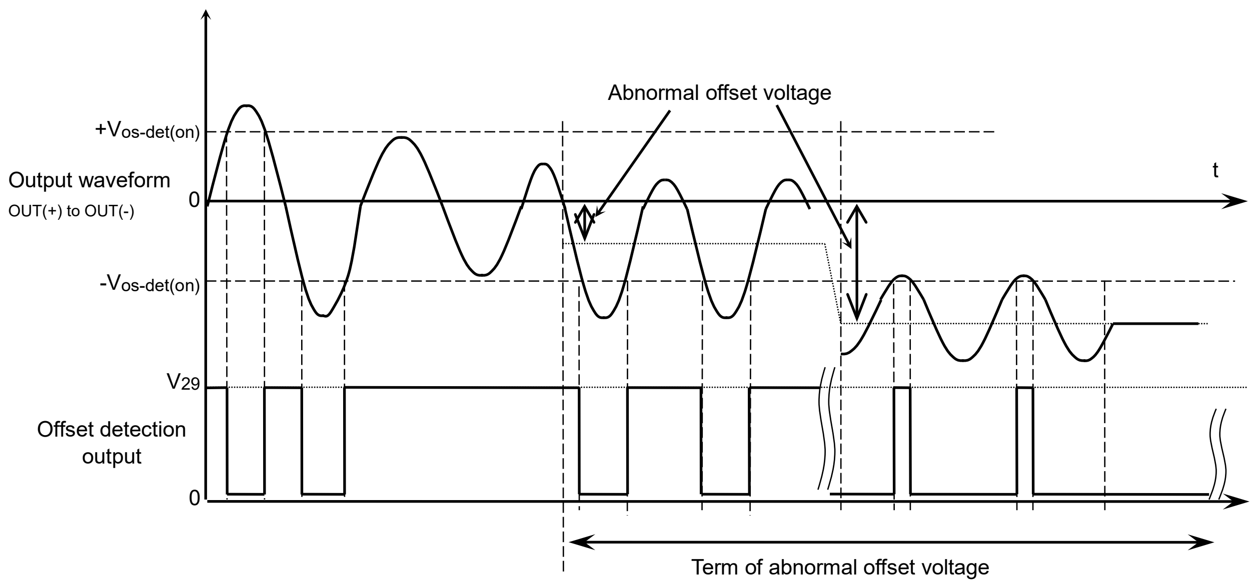


Figure 7.8 Output waveform of Pin 29

7.5.2 Output Short Detection Function

In case of shorting output to V_{DD}/GND or supplying over voltage, the MOS transistor is turned on and can be detected. (Refer to Figure 7.10.) Threshold of over voltage protection: V_{DD}=23 V(typ.).
And in the case of load short, the MOS transistor repeats turning on and off corresponding to the output signal. (Refer to Figure 7.11.) Please set a pull-up resistor so that the Io is 500 μA or less.

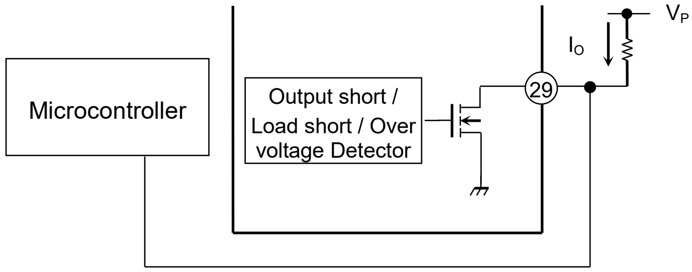


Figure 7.9 Generating mechanism of output short detection

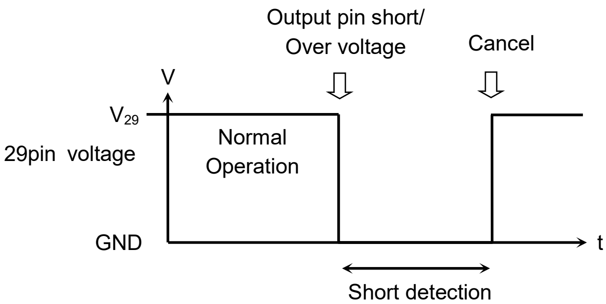


Figure 7.10 Pin 29 output waveform

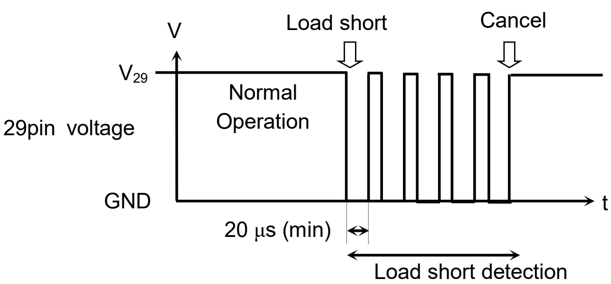


Figure 7.11 Pin 29 output waveform at load short

7.6. Reduction Capability of Sound Cutting and Pop Sound by Lowered V_{DD} Voltage

This IC has an amplifier circuit to reduce a sound cutting and a pop sound when the V_{DD} voltage is lowered. This function can reduce the sound cutting and the pop sound which have been generated in the conventional IC by switching the middle point potential to 1/4V_{DD} at lowered voltage momentary.

7.7. Protection Functions

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

(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, and load short

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

(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(Typ.). 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 A is applied to the speaker pins due to an external circuit failure (Note).
(Abnormal DC output offset)

↓

The speaker impedance becomes 1 Ω or less due to a layer short.

↓

A current of over 4 A (Typ.) flows into the speaker, damaging the speaker.

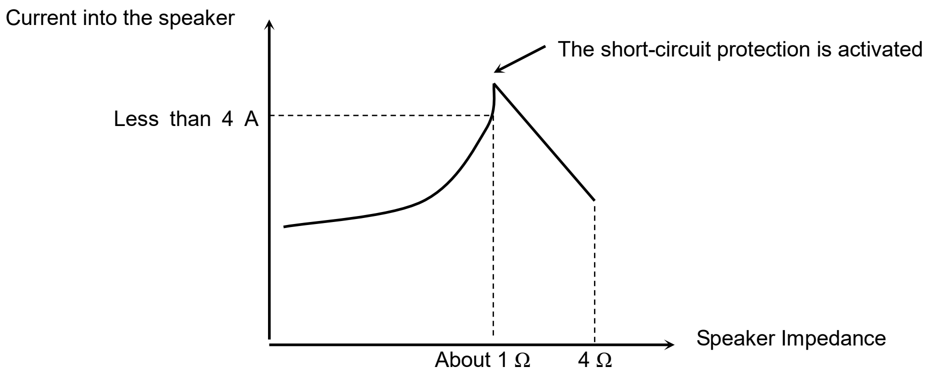


Figure 7.12 Prevention of speaker damage

Note: 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.

8. Absolute Maximum Ratings

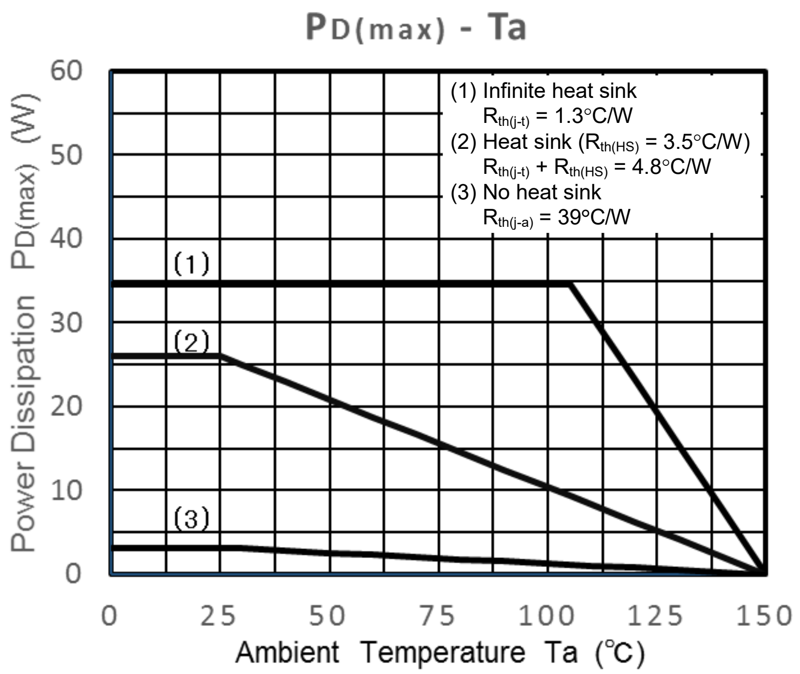
(Ta = 25°C unless otherwise specified)

Characteristics	Condition	Symbol	Rating	Unit
Supply voltage (surge)	Max 0.2 s	$V_{DD\ (surge)}$	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/Junction temperature	—	T_{stg}/T_j	-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 $R_{th(j-t)}$ = 1.3°C/W (typ.) (Ta = 25°C, 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.

9. Power Dissipation



10. Operating Ranges

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

11. Electrical Characteristics

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

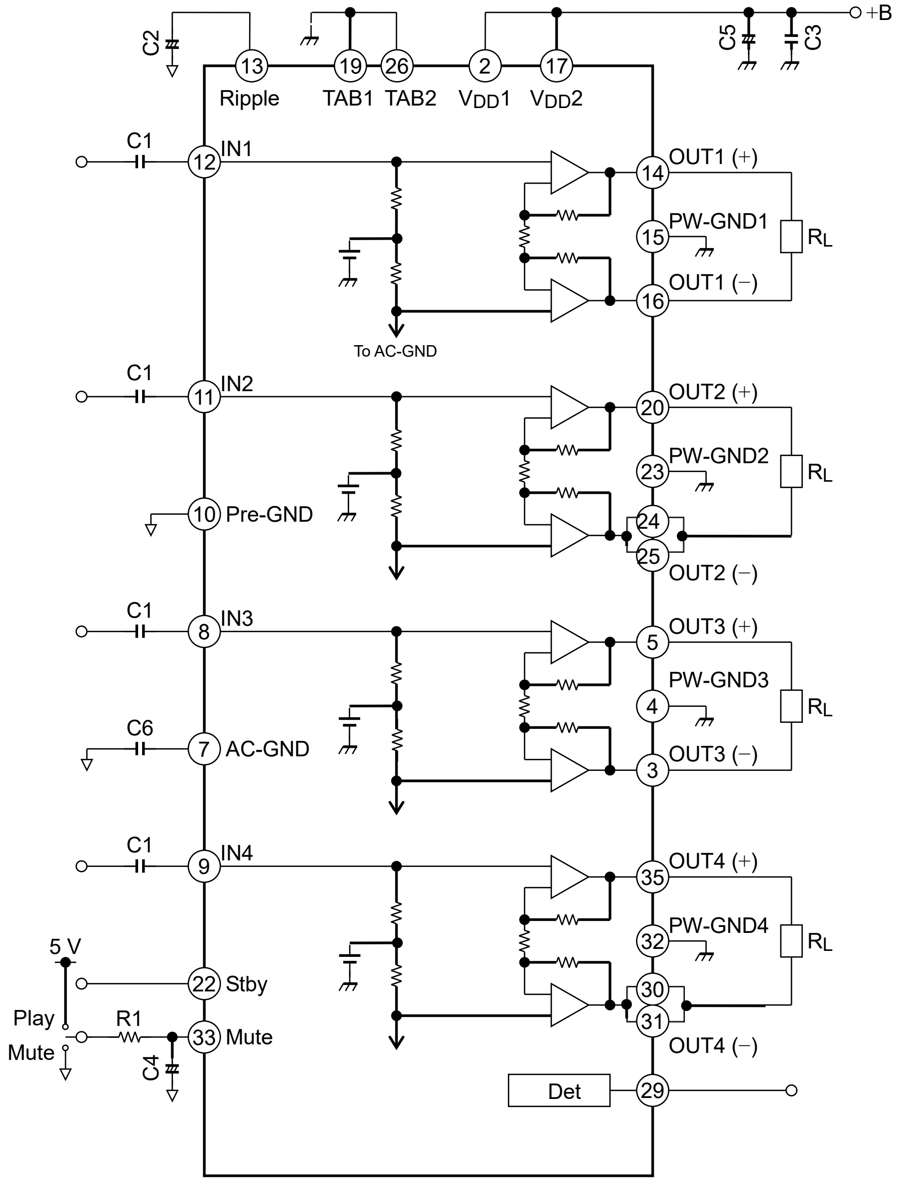
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I_{CCQ}	V_{IN} = 0 Vrms	—	200	300	mA
Output power	P_{OUT} MAX (1)	V_{DD} = 15.2 V, max POWER	—	45	—	W
	P_{OUT} MAX (2)	V_{DD} = 14.4 V, max POWER	—	40	—	
	P_{OUT} (1)	V_{DD} = 14.4 V, THD = 10%	—	26	—	
	P_{OUT} (2)	THD = 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, V4 = 0, V22 = 0	—	0.01	1	μA
Standby control voltage	V_{SB} H	POWER: ON	2.2	—	V_{DD}	V
	V_{SB} L	POWER: OFF	0	—	0.8	
Mute control voltage	V_M H	Mute: OFF	2.2	—	V_{DD}	V
	V_M L	Mute: ON, R1 = 47 kΩ	0	—	0.8	
Mute attenuation	ATT M	Mute: ON, V_{OUT} = 7.75 Vrms → Mute: OFF	85	100	—	dB
DC offset threshold voltage	$V_{off\text{-}set}$	Io=500 μA, Out(+) - Out(-)	±1.0	±1.5	±2.0	V
Voltage at each detection ON condition	P29-Det	Io=500 μA, (Pin 29 = low) at detection	—	100	500	mV

Note: V_{SB}H, V_MH, P29-Det should be used with less than 18 V.

Note1: f_{rip}: Ripple frequency

V_{rip}: Ripple signal voltage (Superimposes on a V_{DD} power supply)

12. Test Circuit



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

13. Characteristic Chart (Reference)

13.1. Total Harmonic Distortion vs. Output Power

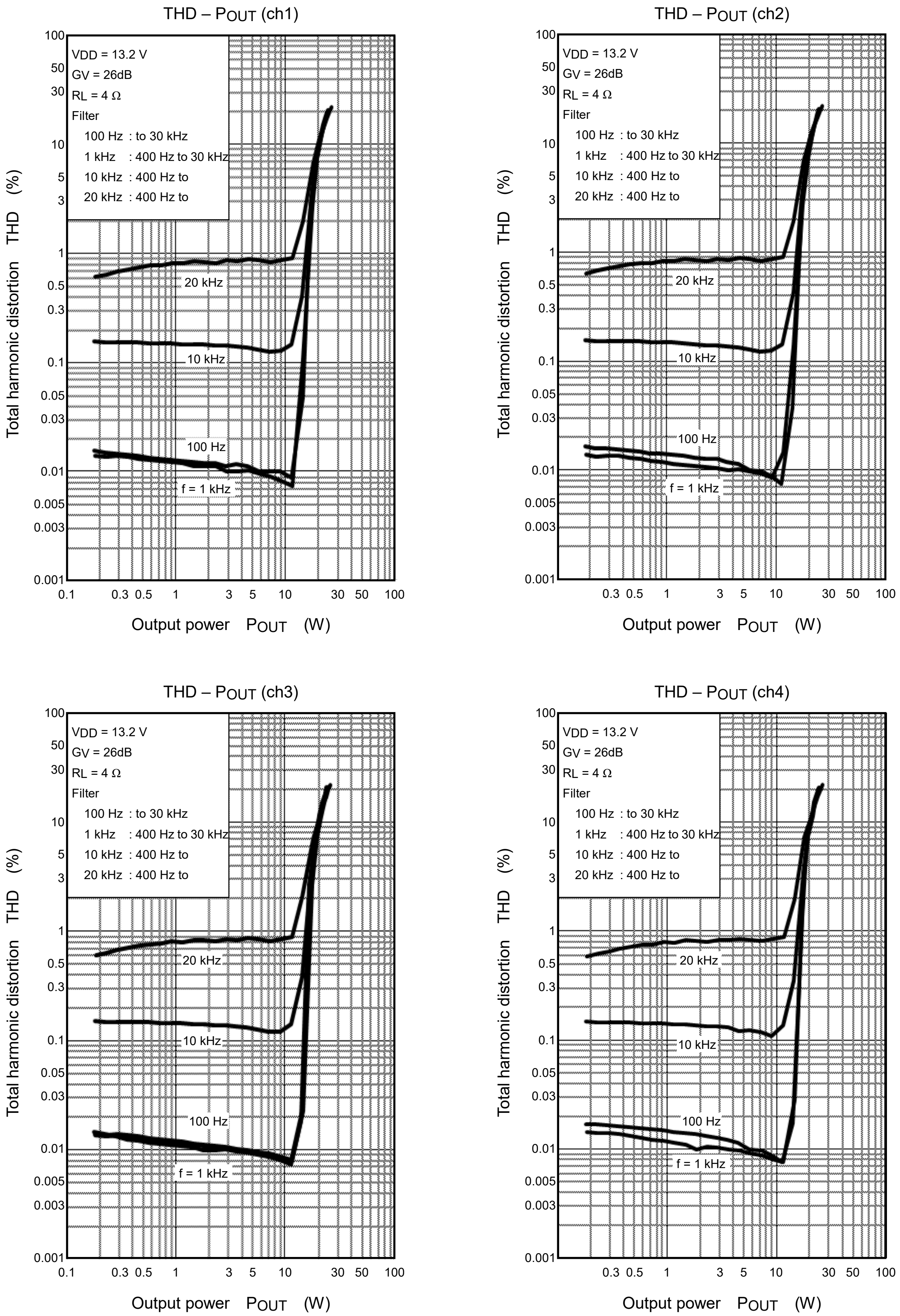


Figure 13.1 Total Harmonic Distortion of Each Frequency (R_L = 4 Ω)

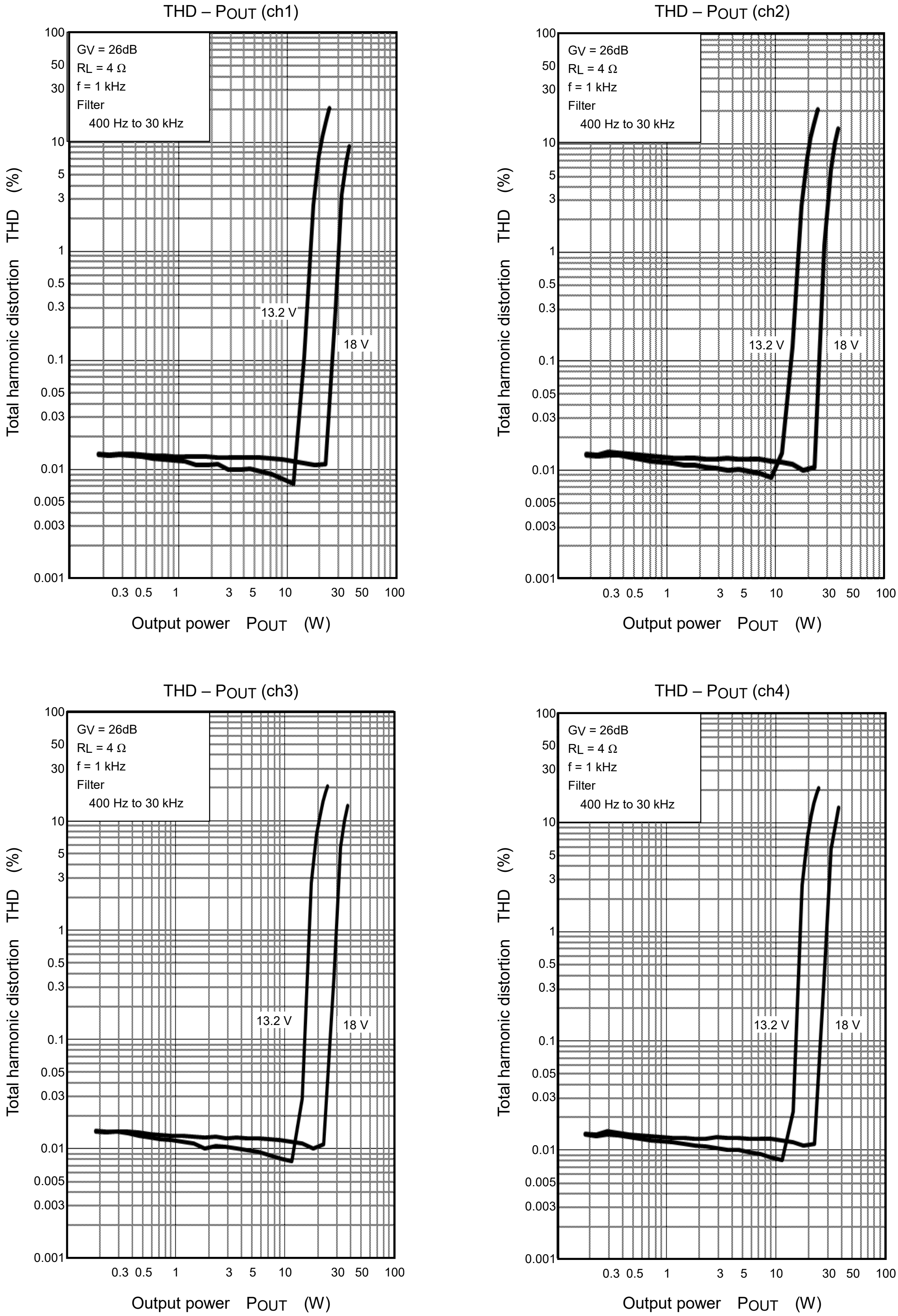


Figure 13.2 Total Harmonic Distortion by Power-supply Voltage (R_L = 4 Ω)

13.2. Various Frequency Characteristics

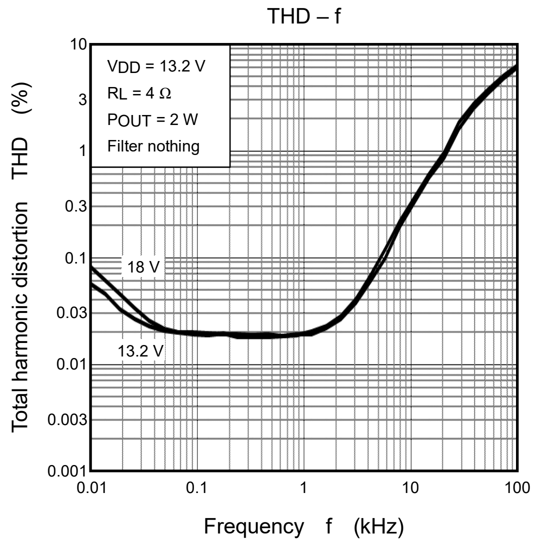
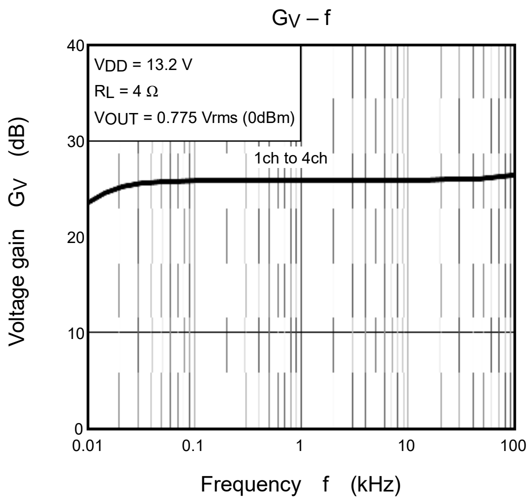


Figure 13.3 Frequency Characteristics of Total Harmonic Distortion



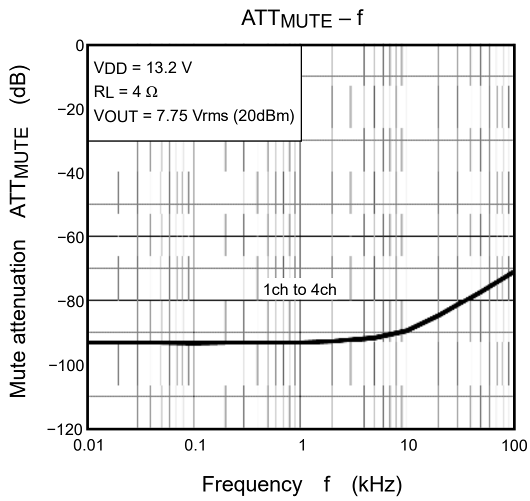


Figure 13.4 Frequency Characteristics of Voltage Gain and Mute Attenuation

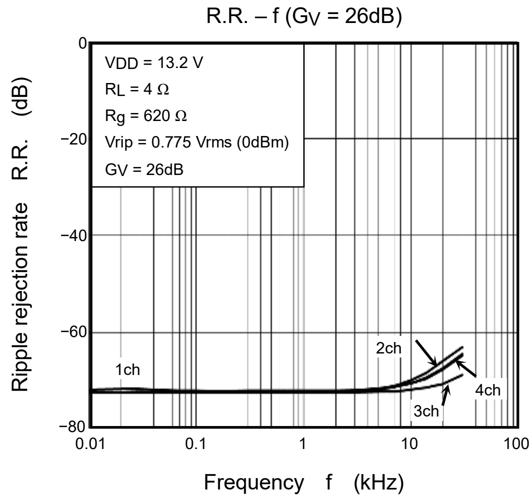


Figure 13.5 Frequency Characteristics of Ripple Rejection Rate

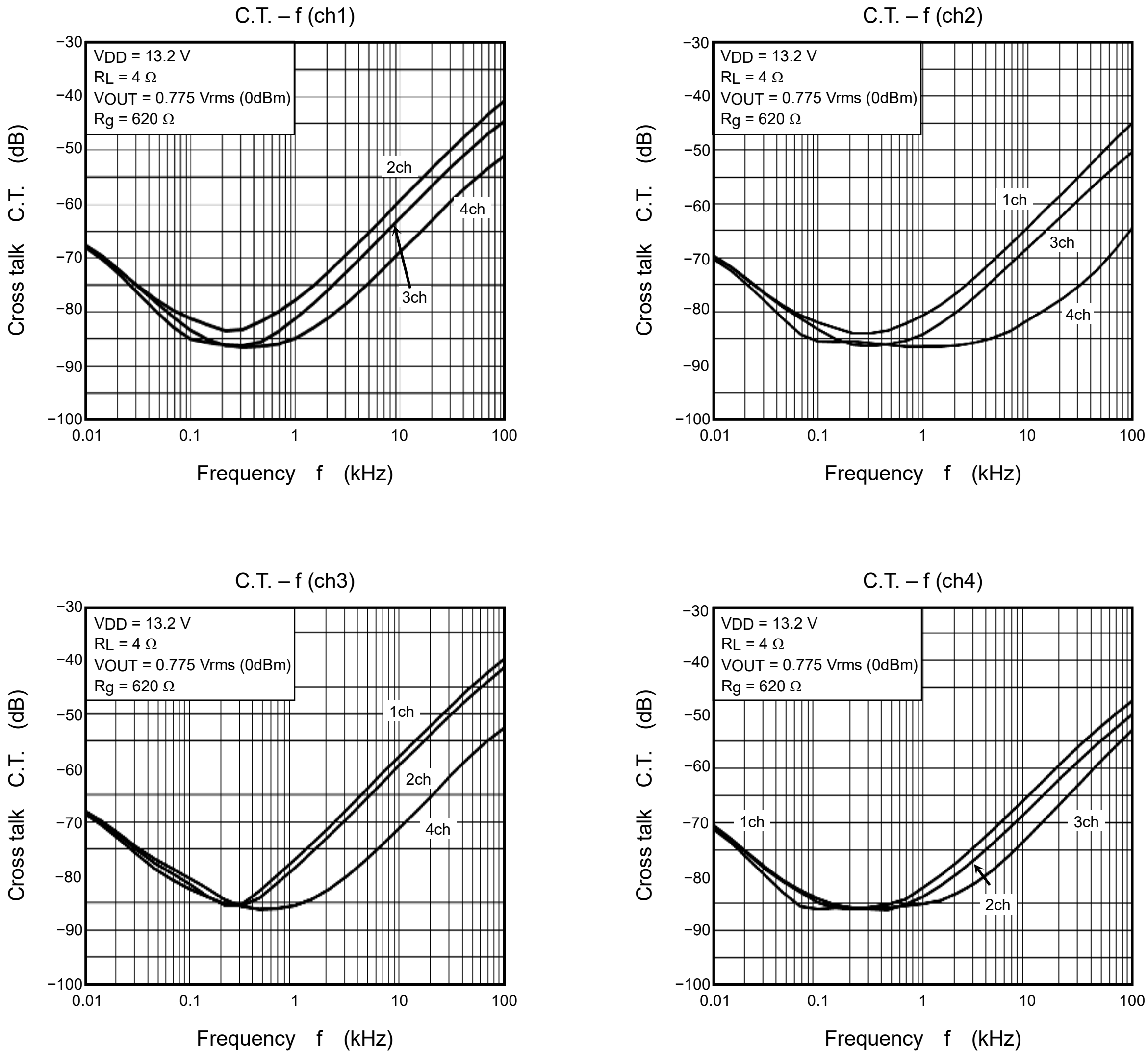


Figure 13.6 Frequency Characteristics of Cross Talk

13.3. Output Power Characteristics to Input Voltage

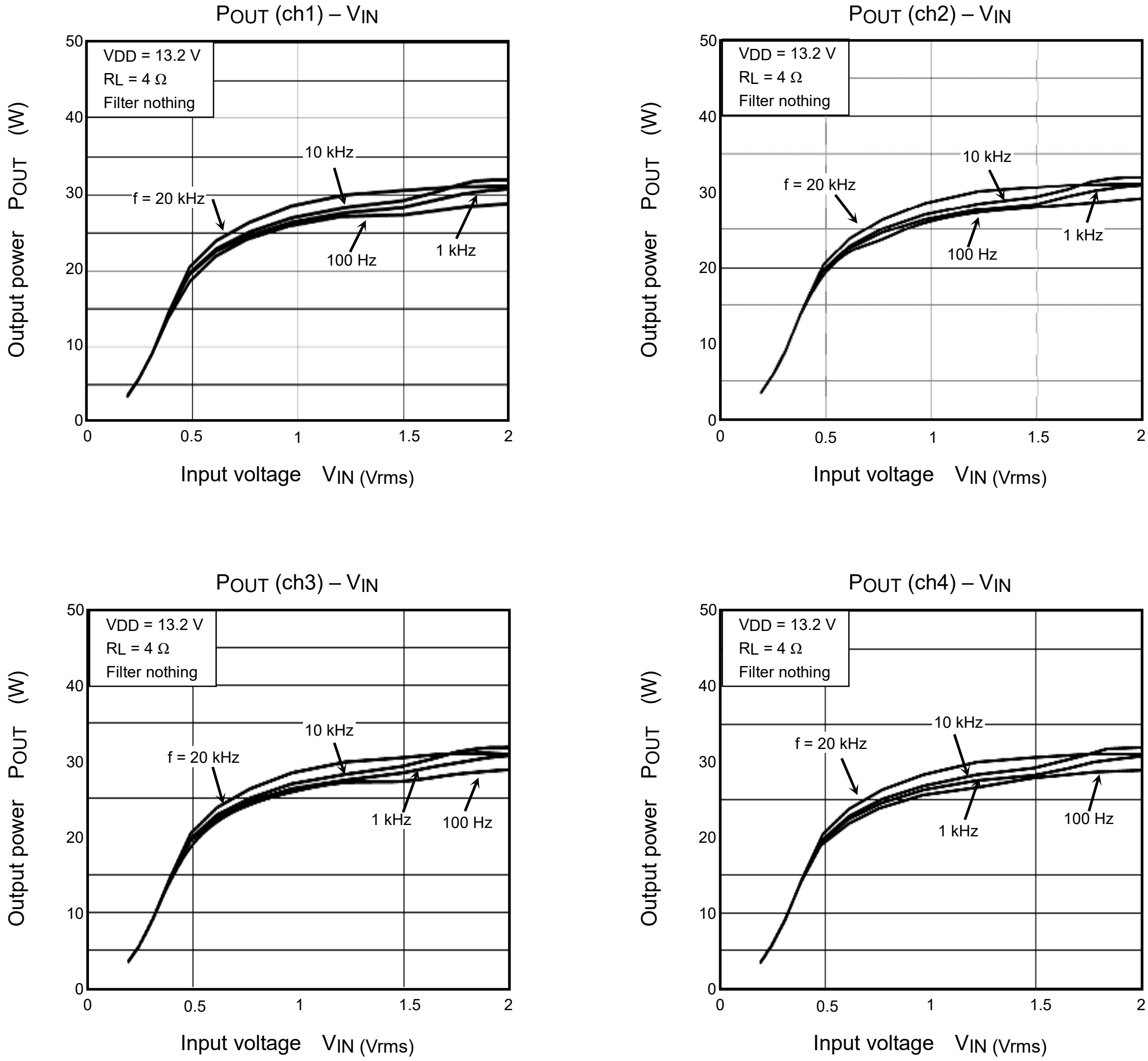


Figure 13.7 Frequency Characteristics of Ripple Rejection

13.4. Power Dissipation vs. Output Power

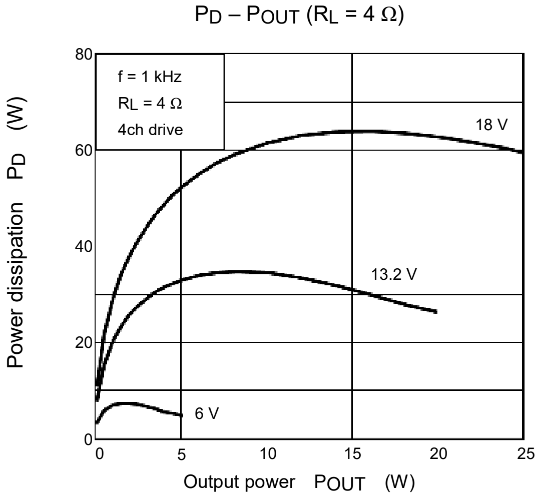
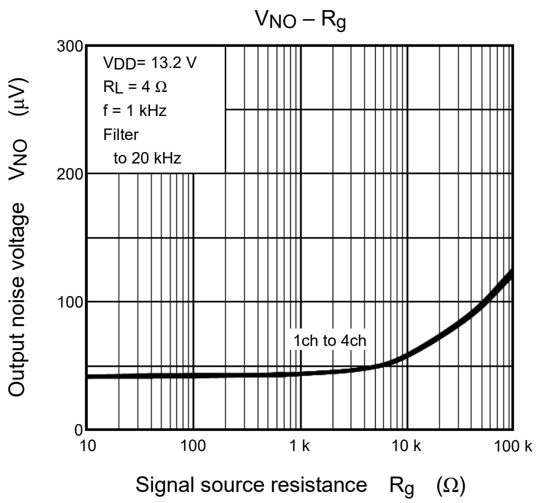


Figure 13.8 Power Dissipation vs. Output Power

13.5. Other Characteristics



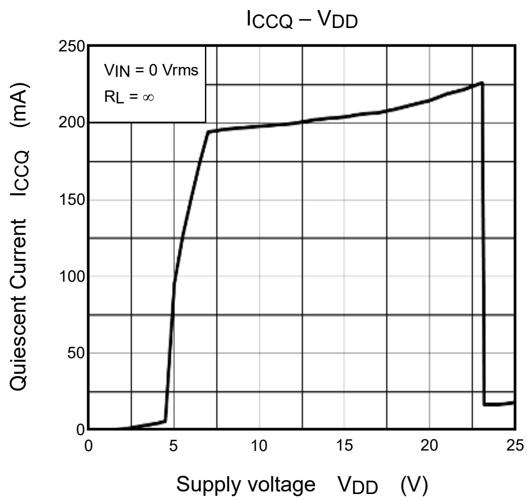
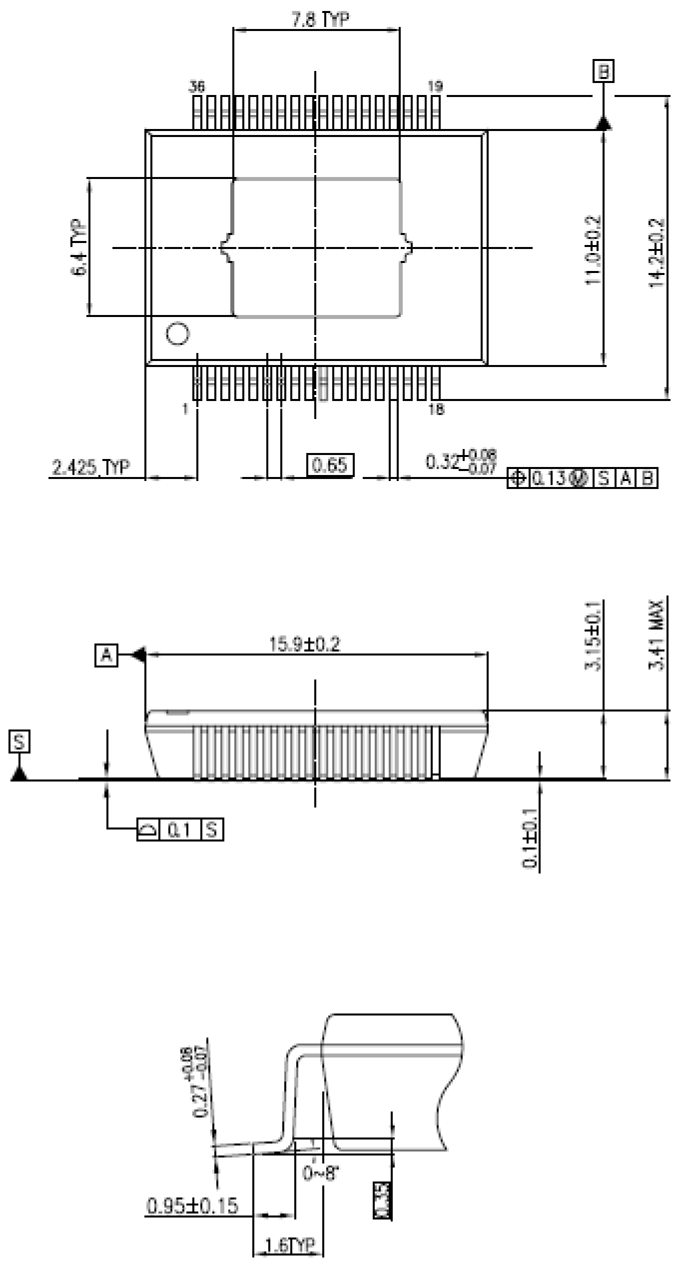


Figure 13.9 Other Characteristics

14. Package Dimensions

P−HSSOP36−1116−0.65−001 "Unit:mm"

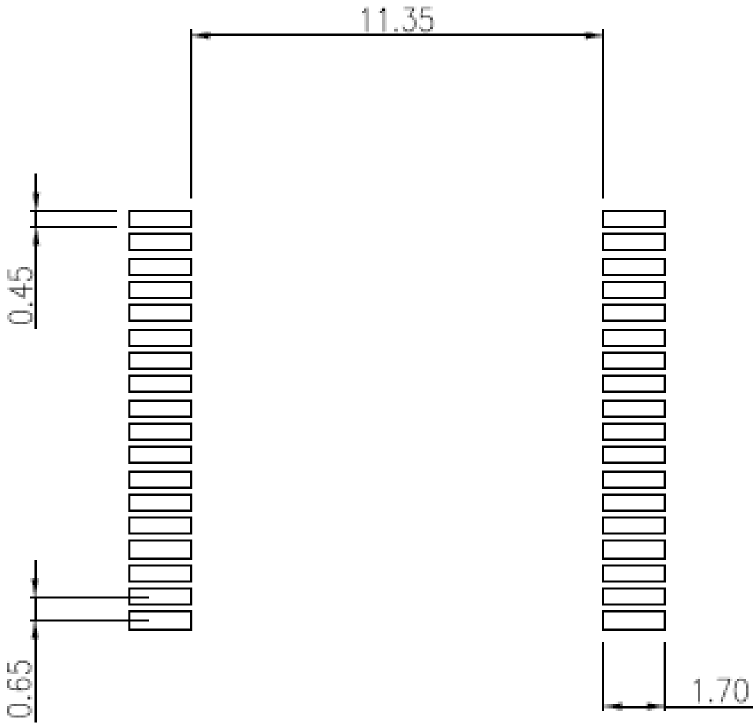


Weight: 1.28g (typ.)

15. Land pattern dimensions (Reference)

P-HSSOP36-1116-0.65-001

"Unit: mm"



NOTES

- All linear dimensions are given in millimeters unless otherwise specified.
- This drawing is based on JEITA ET-7501 Level3 and should be treated as a reference only.TOSHIBA Electronic Devices & Storage Corporation is not responsible for any incorrect or incomplete drawings and information.
- You are solely responsible for all aspects of your own land pattern, including but not limited to soldering processes.
- The drawing shown may not accurately represent the actual shape or dimensions.
- Before creating and producing designs and using, customers must also refer to and comply with the latest versions of all relevant TOSHIBA Electronic Devices &Storage Corporation information and the instructions for the application that Product will be used with or for.

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.

(6) Characteristic Chart
This data is provided for reference only. Thorough evaluation and testing should be implemented when designing your application's mass production design.

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 reverses the rotation 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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