BiCMOS Linear Integrated Circuit Silicon Monolithic

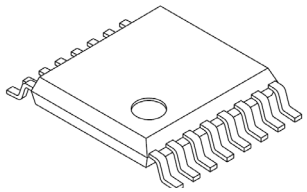
TB2909FNG

Maximum Power 3W SEPP × 1ch Audio Power IC

1. Description

The TB2909FNG is a one-channel SEPP power for engine sound applications.

It includes a standby switch, mute function and various protection features.



P-HTSSOP16-0505-0.65-001

Weight: 0.062g (typ.)

2. Applications

Power IC developed for engine sounds.

3. Features

- Built-in various mute function (low voltage, standby on/off)
- Built-in standby switch (pin7)
- Built-in mute functions (pin6)
- Built-in various protection circuits(short to GND,short to Vcc, outpin short,thermal shut down, over-voltage,)
- Built-in thermal detection (pin9)
- Built-in over-voltage detection (pin10)
- Built-in output short detection (pin11)
- Built-on speaker open detection (pin12)

Table1 Typical Characteristics

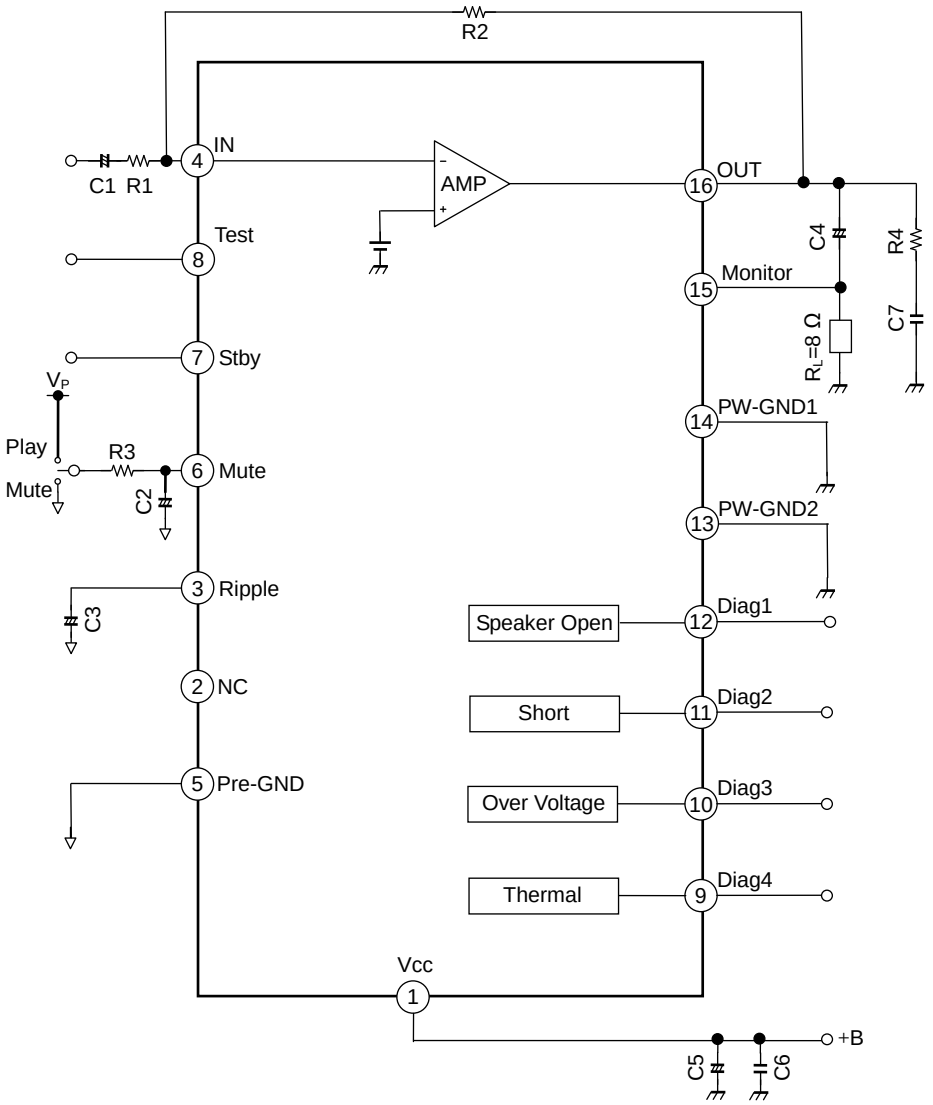
(Note1)

Condition	Typ.	Unit
Output power ($P_{OUT\ MAX}$)		
Vcc=16V MaxPower	5	W
MaxPower	3	W
THD=10%	2	W
Total harmonic distortion (THD)		
P_{OUT}=0.125W (Vout=1Vrms)	0.08	%
Output noise voltage (V_{NO})		
DIN_AUDIO, Rg = 620 Ω	50	μV
Operating Supply voltage range (V_{CC})		
RL=8 Ω	6 to16	V

Note1: Typical test Condition : V_{CC} = 12 V, f = 1 kHz, R_L = 8Ω, G_V = 20 dB, Ta = 25°C; unless otherwise specified

Rg: signal source resistance

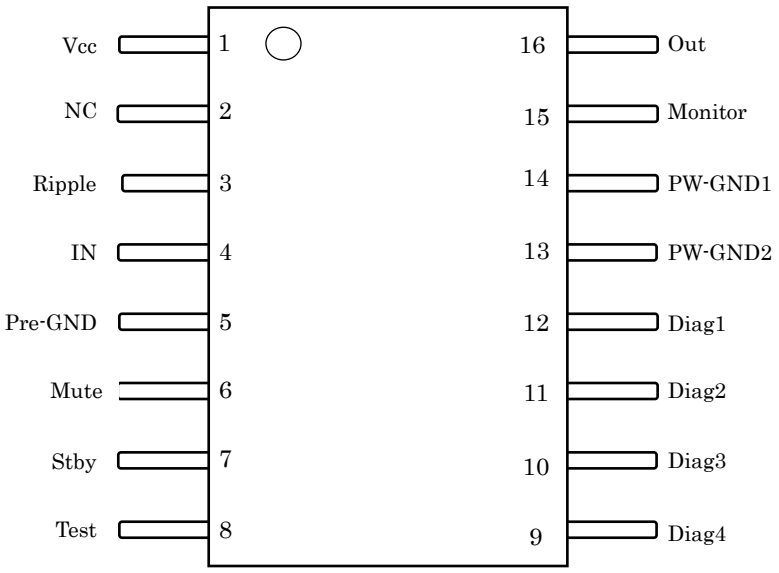
4. Block Diagram



Note2: Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes.

5. Pin Configuration and Function Descriptions

5.1 Pin Configuration (top view)

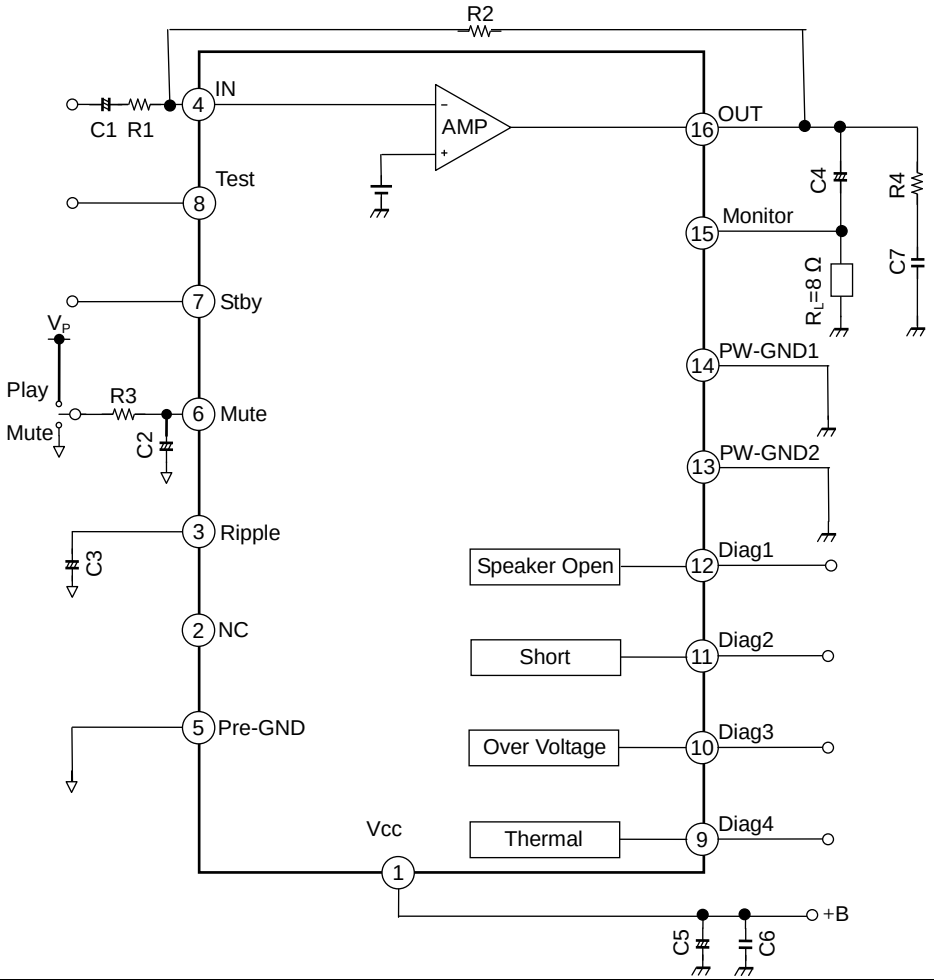


5.2 Pin Function Description

Pin	Symbol	I/O	Description
1	Vcc	V_{CC}-IN	Supply voltage
2	NC	—	Not connection
3	Ripple	—	Ripple voltage
4	IN	IN	Input
5	Pre-GND	—	Signal ground
6	Mute	V_{MUTE}-IN	Mute voltage input
7	Stby	V_{ST}-IN	Standby voltage input
8	Test	IN	Test
9	Diag4	OUT	Thermal mute detection
10	Diag3	OUT	Over-voltage detection
11	Diag2	OUT	Output short detection
12	Diag1	OUT	Speaker open detection
13	PW-GND2	—	Ground for output1
14	PW-GND1	—	Ground for output2
15	Monitor	IN	Monitor
16	OUT	OUT	Output

6. Detailed Description

6.1 External component specification



Component Name	Recommended Value	Pin	Purpose	Effect (Note3)	
				Lower than Recommended Value	Higher than Recommended Value
C1	4.7μF	IN	To eliminate DC	Cut-off frequency becomes higher	Cut-off frequency becomes lower
C2	1μF	Mute	To reduce pop noise	High pop noise. Duration until mute function turned on/off is short.	Low pop noise. Duration until mute function is turned on/off is long.
C3	4.7μF (Note4)	Ripple	Ripple filter	Turn on/off time is short	Turn on/off time is long
C4	1000 μF	OUT	To eliminate DC	Cut-off frequency becomes higher	Cut-off frequency becomes lower
C5	470 μF	Vcc	Ripple filter	Power supply ripple filtering	
C6	0.1 μF	Vcc	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin	
C7	0.22μF	OUT	To provide sufficient oscillation margin	Provides sufficient oscillation margin	
R1	2kΩ	IN	Setting of gain	–	
R2	20kΩ	IN, OUT	Setting of gain	–	
R3	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.
R4	2.2Ω	OUT	To provide sufficient oscillation margin	Provides sufficient oscillation margin	

Note3: When the unrecommended value is used, please examine it enough by system evaluation.

Note4: Please examine C3 over 4.7μF in consideration of POP sound.

6.2 Setting of Gain

This product can adjust the voltage gain of built-in amplifier with a setup of R1 and R2.
The voltage gain is determined by R1 and R2 as below expression.
It become Gv=20dB(typ.) when it is setting the R1:2kΩ and R2:20kΩ.

$$Gv(dB) = 20\log_{10}(R2 / R1)$$

6.3 Setting of Cut-off frequency

The lower cutoff frequency is determined by C1,R1 and C4,RL as below expression.

$$\text{Lower frequency cutoff (Hz)} \quad fcl = 1 / (2\pi C1 \times R1) \quad / \quad fcl = 1 / (2\pi C4 \times RL)$$

6.4 Standby Switch(Pin7)

The power supply can be turned on or off via pin 7 (Stby). The power supply current is about 0.01μA (typ.) in the standby state.

Table 2 Pin control volgate list(V_{SB})

Stand-by	Power	V_{SB} (V)
ON	OFF	0 to 0.8
OFF	ON	2.4 to V_{CC}

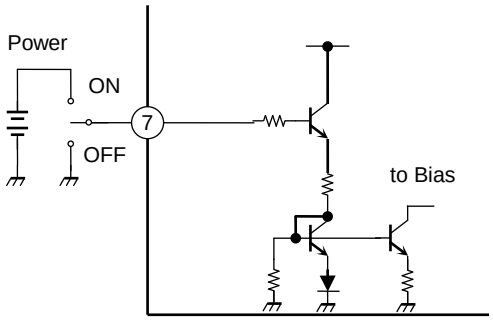


Figure1 The Schematic of Stby

Benefit of the standby switch, Vcc can be directly turned on or off by a microcontroller.

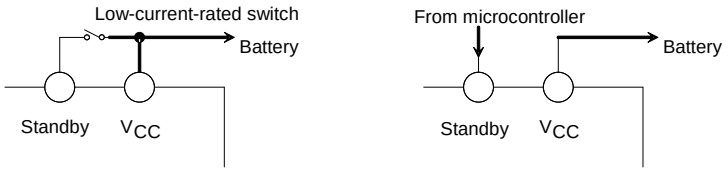


Figure 2 Standby Switch

6.5 Mute Switch(Pin6)

The mute mode in this product is a mute at standby on/off, an internal mute for low voltage. If the mute is turned off before charging R3 and C2 is finished, pop noise occurs because of input offset. Set "mute-off" with sufficient margin in considering a charge time. And this terminal is designed on the control voltage of 5 V.

For example, when the control voltage is changed from 5 V to 3.3 V, the pull-up resistor should be:

$$3.3\ V/5\ V \times 47\ k\Omega = 31\ k\Omega$$

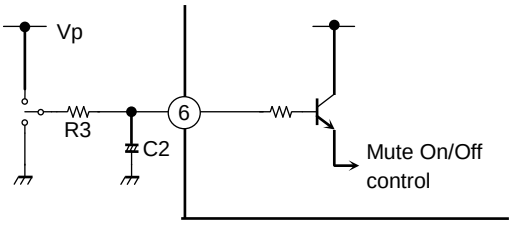


Figure 3 Mute Function

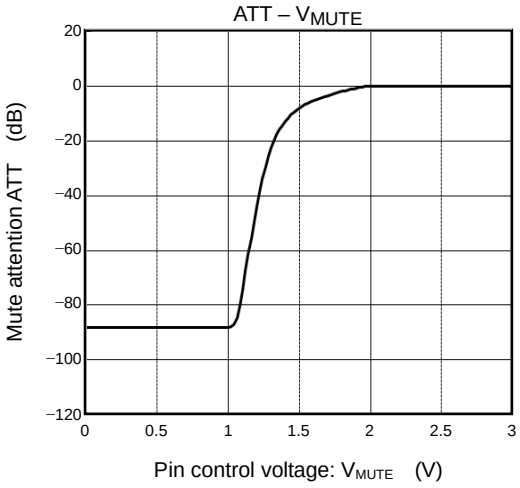


Figure4 Mute Attention − V_{MUTE} (V)

6.6 Speaker Open Detection(Pin12)

Speaker open detection can be detected in Diag1 for using Test terminal and monitor terminal.

At the time of startup, by setting speaker open detection mode for Test terminal applied over 2.4V, detect it by monitoring the voltage to occur on monitor terminal connected to a speaker between capacitor.(RL≧80 Ω (typ.))

At the speaker open detection, after the Test terminal high, it takes 100ms (typ.) at time to detect Diag1. After diagnostication,please set "Low" at Test terminal. When diagnostic at the time of the Stby-OFF, please use it in the condition of no inputting or Mute-on.

Since the current capability of the collector current of Q1 is set to about 1 mA, please use the pull-up resistor more than 4.7kΩ for Diag2 terminal by 5V at the time of a pull-up.

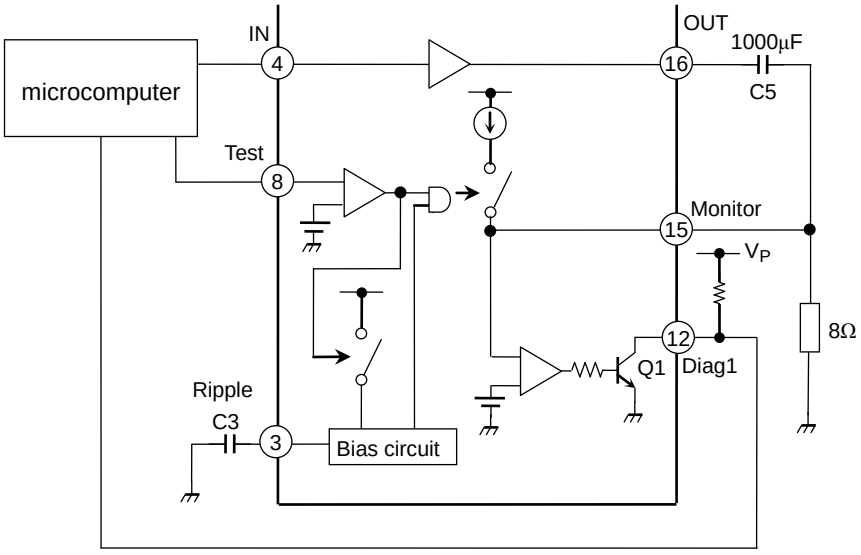


Figure 5 Speaker open detection

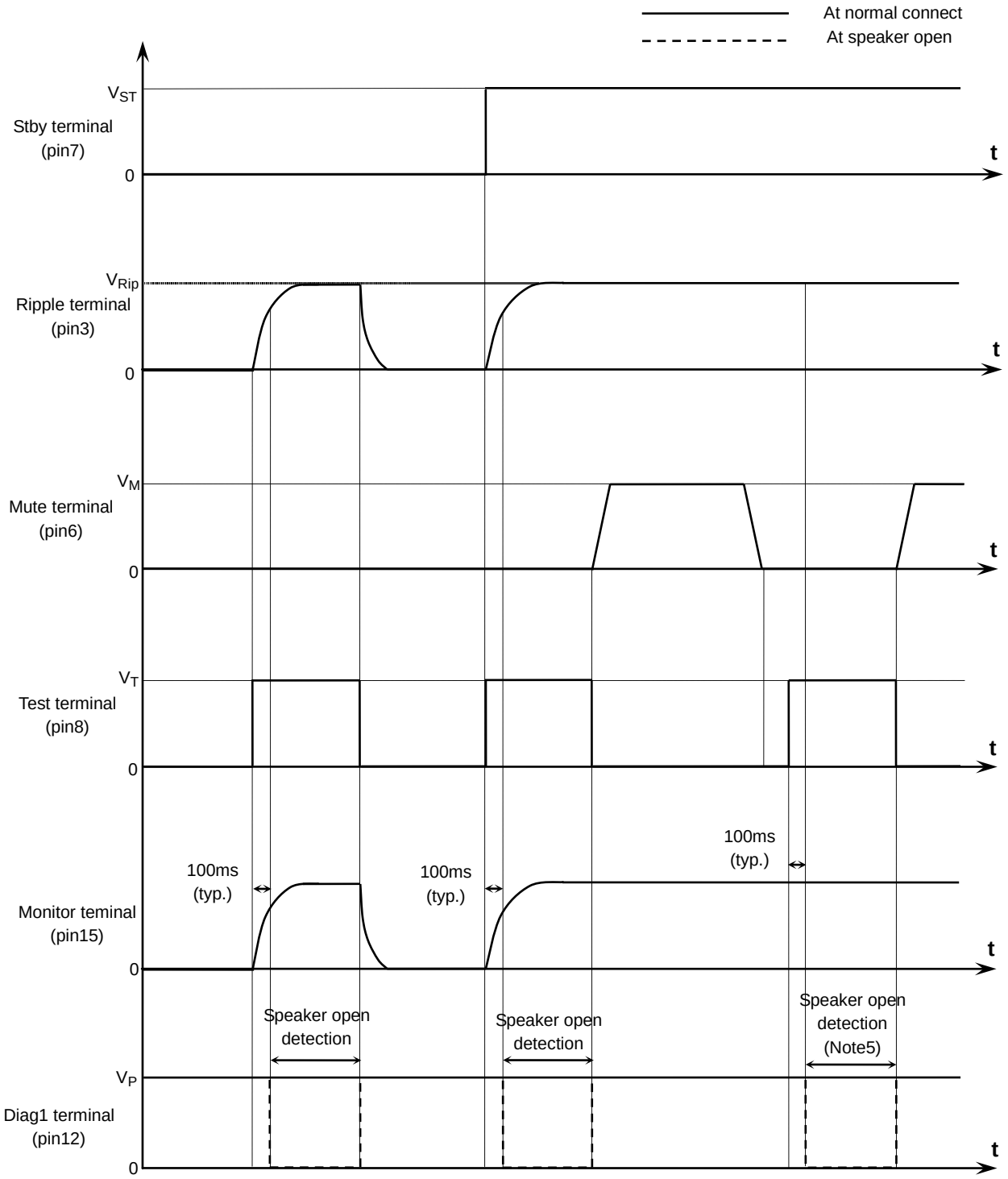


Figure6 Speaker open detection sequence

Table 3 Control list

Stby	Test	Condition
0	0	Stand-by ON
0	1	Speaker open detection
1	0	Stand-by OFF
1	1	Speaker open detection(Note5)

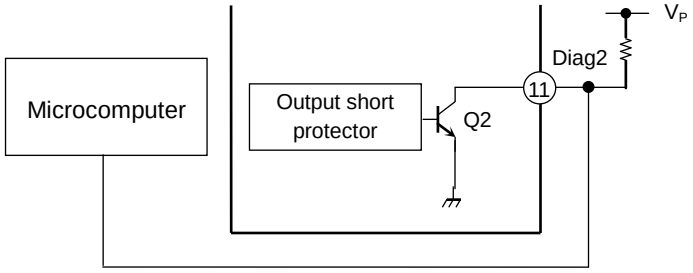
Note5: When diagnostic at the time of the Stby-OFF, please use it in the condition of no inputting or Mute-on.

6.7 Short Detection(Pin11)

In case of shorting output to Vcc/GND, NPN transistor (Q2) is turned on and can be detected in Diag2. (Reference: Figure 7)

In case of shorting output to GND, NPN transistor (Q2) is turned on and off in response to the input signal voltage. (Reference: Figure 8)

Since the current capability of the collector current of Q2 is set to about 1 mA, please use the pull-up resistor more than 4.7kΩ for terminal by 5V at the time of a pull-up.



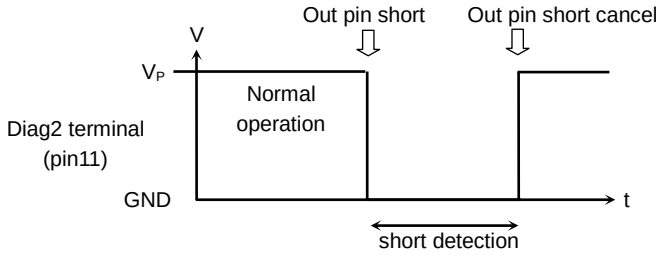


Figure 7 OUT pin short detection

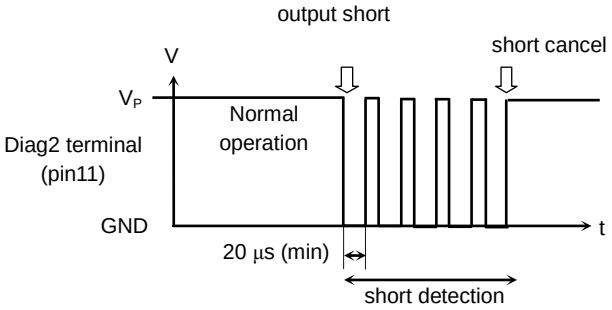


Figure 8 Out put to GND short detection

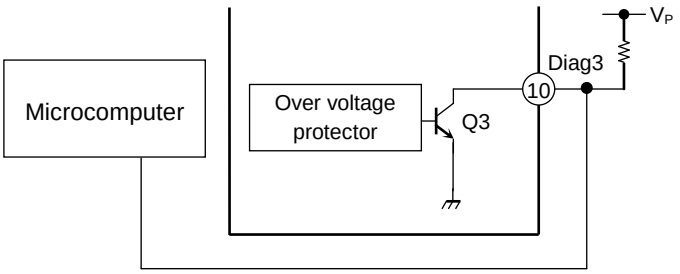
6.8 Overvoltage Detection(Pin10)

In case of over power supplied, NPN transistor (Q3) is turned on and can be detected in Diag4.

Threshold of over voltage protection: Vcc=22V(typ.) Overvoltage detection has hysteresis.

And it will be detected off under 18V(typ.) since it has hysteresis.

The current capability of the collector current of Q3 is set to about 1 mA, please use the pull-up resistor more than 4.7kΩ for terminal by 5V at the time of a pull-up



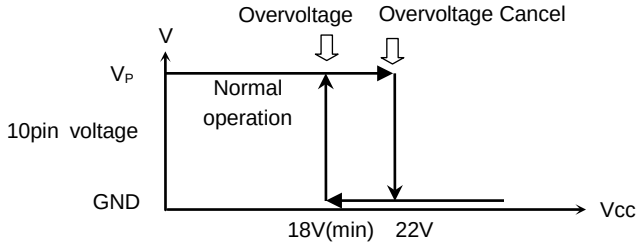


Figure 9 Overvoltage Detection

Note6: The supply voltage (operation) of absolute maximum ratings is 16V. Please use less than 16V.

6.9 Thermal Detection(Pin9)

In case of rising the junction temperature over 165°C (typ.), NPN transistor (Q4) is turned on and can be detected in Diag4.

Since the current capability of the collector current of Q4 is set to about 1 mA, please use the pull-up resistor more than 4.7kΩ for Diag1 terminal by 5V at the time of a pull-up

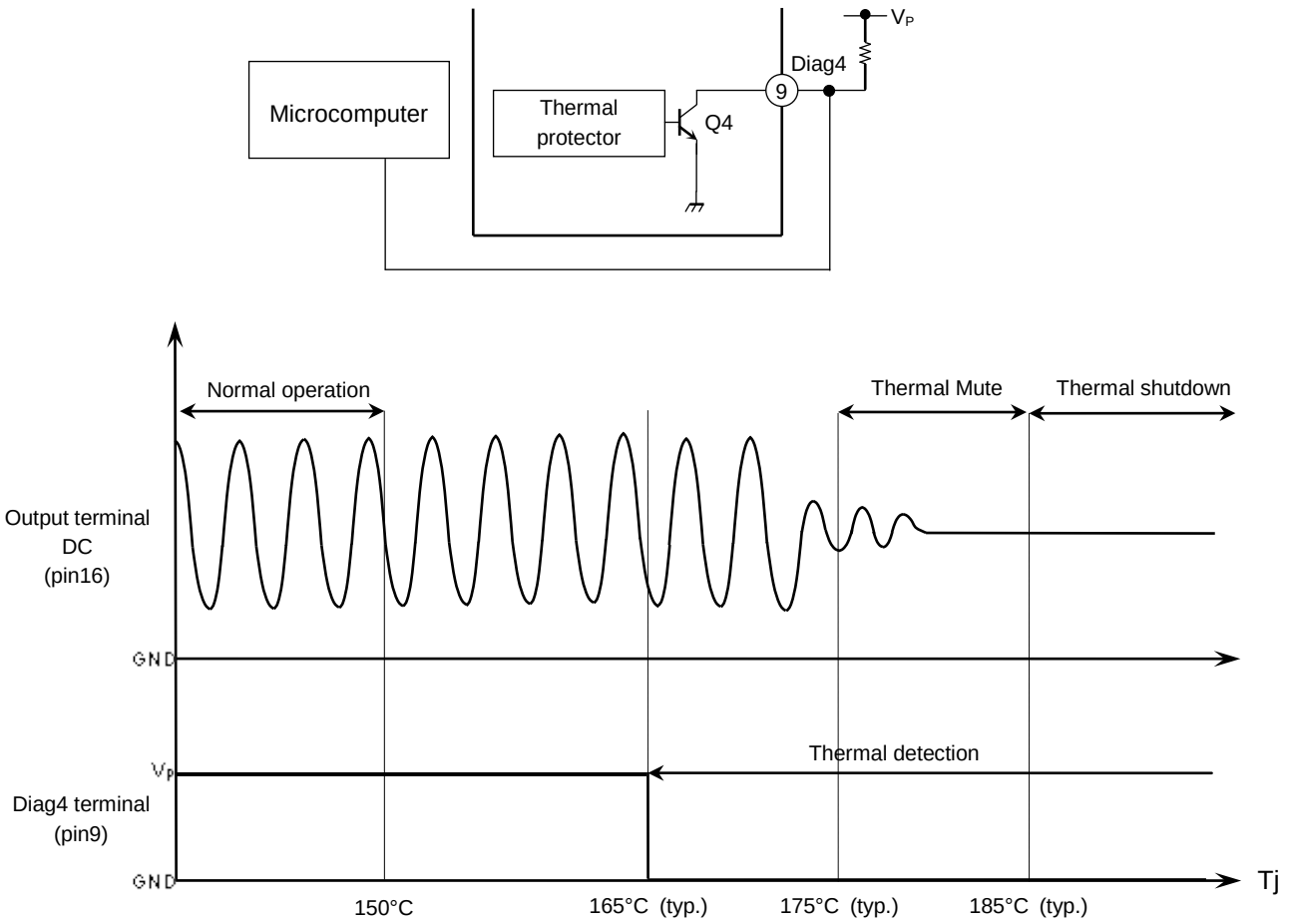


Figure10 Thermal Detection

Note7:The junction temperature of absolute maximum ratings is 150°C. Please use less than 150°C.
Note8:If it is over 185°C (typ.),Diag4 and Daig2 become "Low".

6.10 Mute Function

The mute mode in this product is a mute at standby on/off, an internal mute for low voltage.

6.10.1 Low Voltage Mute

When the supply voltage became lower than about 5.5V, it operates the mute circuit automatically.

And when the Vcc voltage reached about 5.7V, this mute is turned off, it has the hysteresis.

6.10.2 Standby ON→OFF Mute

After pin4(the standby voltage input terminal) is turned "Low", until the ripple terminal voltage became about 1/2Vcc+1.4V.

it operates the mute circuit automatically.

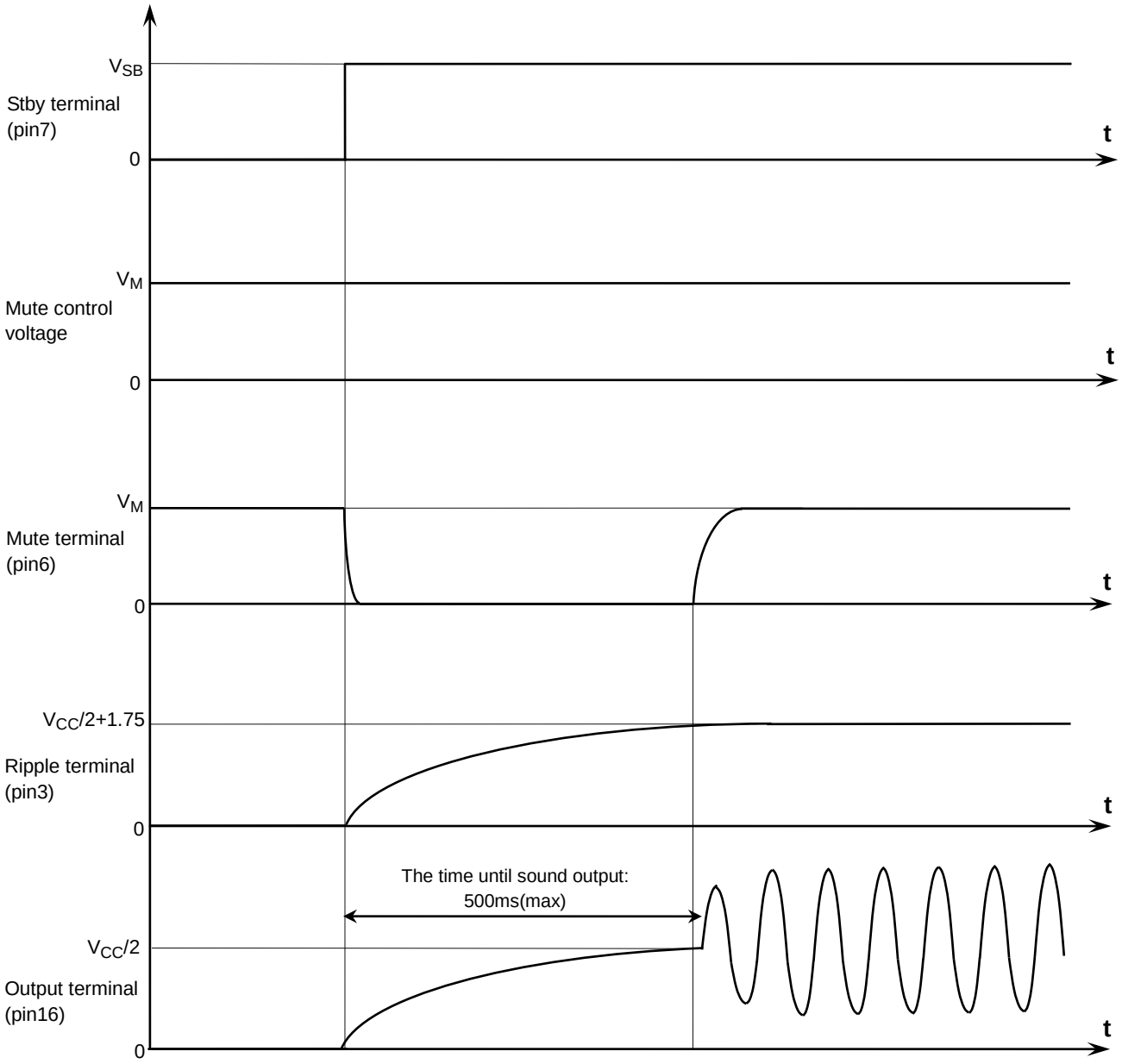


Figure11 The timing chart at the time of a standup1

6.10.3 Mute off sequence after stby off

If the mute is turned off before charging C4 is finished, pop noise occurs. Please set "Mute-off" with sufficient margin in considering a enough charge time after the middle point potential stable.

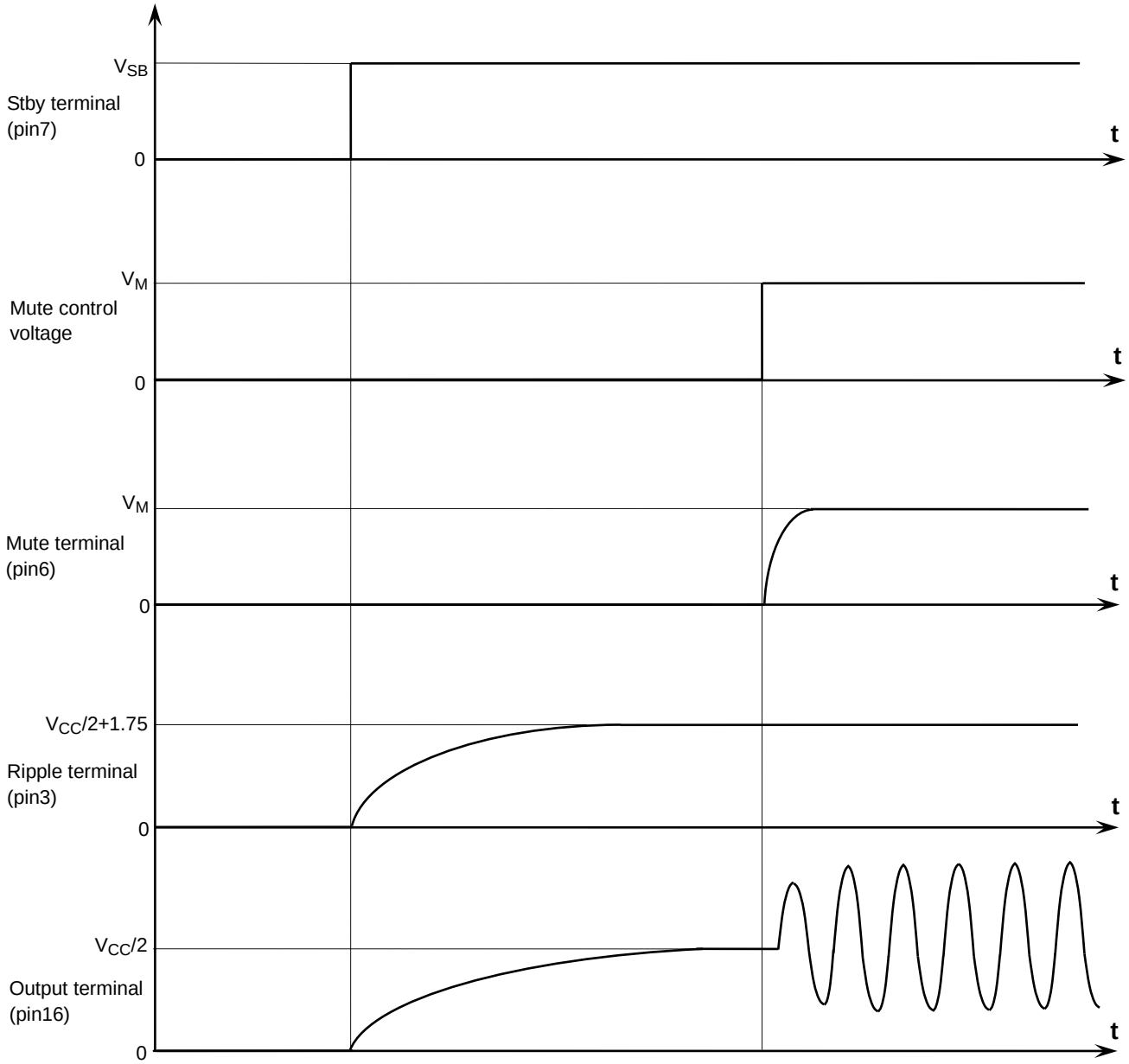


Figure12 The timing chart at the time of a standup2

6.11 Protection Functions

This product has internal protection circuits such as thermal shut down, over-voltage, out to Vcc, and Outpin short circuit protections.

(1) Thermal shut down

It operates when junction temperature exceeds 165°C. (Note9)
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.

(2) Over-voltage (Note10)

It operates when voltage exceeding operating range is supplied to Vcc pin. If voltage falls, it will return automatically. When it operates, output bias is turned off.

(3) Short to Vcc, Outpin short

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

Note9: This function does not recommend to use over the absolute maximum ratings. Applications using the device should be designed under absolute maximum ratings.

Note10: In the case of applies over the operating supply voltage range before stby off, it will be operated the protection function.

7. Absolute Maximum Ratings

(Ta = 25°C unless otherwise specified)

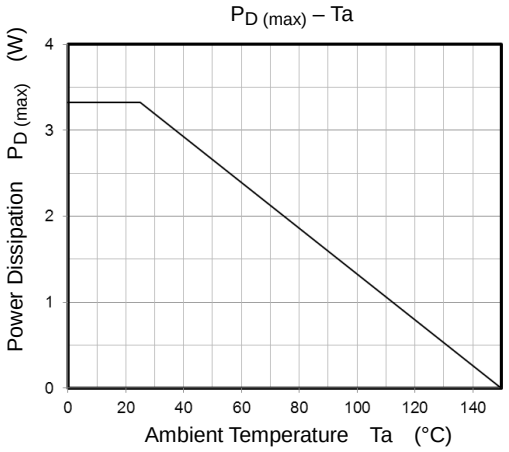
Characteristics	Condition	Symbol	Rating	Unit
Supply voltage (surge)	Max0.2s	$V_{CC\ (surge)}$	40	V
Supply voltage (DC)		$V_{CC\ (DC)}$	25	V
Supply voltage (operation)		$V_{CC\ (opr)}$	16	V
Output current (peak)		$I_{O\ (peak)}$	2.5	A
Power dissipation	(Note11)	P_D	3.3	W
Operating temperature range		T_{opr}	−40 to 110	°C
Storage temperature		T_{stg}	−55 to 150	°C
Junction temperature		Tj	150	°C

Note11: Ta = 25°C, Package thermal resistance $\theta_{j\text{-}a}$ = 37.6°C /W

Note12: 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.

Note13: Before using, creating, and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

7.1 Power Dissipation



・Package thermal resistance $\theta_{j\text{-}a}$ = 37.6°C/W

・Condition board material : FR-4 (JEDCE4layer)

board area : 114.3x76.2mm t=1.6mm

1-layer (surface layer) Cu-are:45x70mm Cu-surface:12% Cu-thickness:70μm

2-layer (inner layer) Cu-are:74x74mm Cu-surface:100% Cu-thickness:35μm

16-Thermal via connected to 1-layer and 2-layer.

Connect to the back of package e-pad and Cu of 1-layer by solder.

Note14: This package thermal resistance is the evaluation result at board included in chip, package and Substrate, the power dissipation is calculated from thermal resistance. Regarning to using this product, please use the low resistance board and give a margin to the power dissipation.

8. Operating Ranges

Characteristics	Symbol	Test Circuit	Min	Typ.	Max	Unit
Supply voltage	V_{CC}	R_L=8Ω	6	—	16	V

9. Electrical Characteristics

VCC = 12 V, f = 1 kHz, RL = 8 Ω, Gv=20dB,Ta = 25°C unless otherwise specified

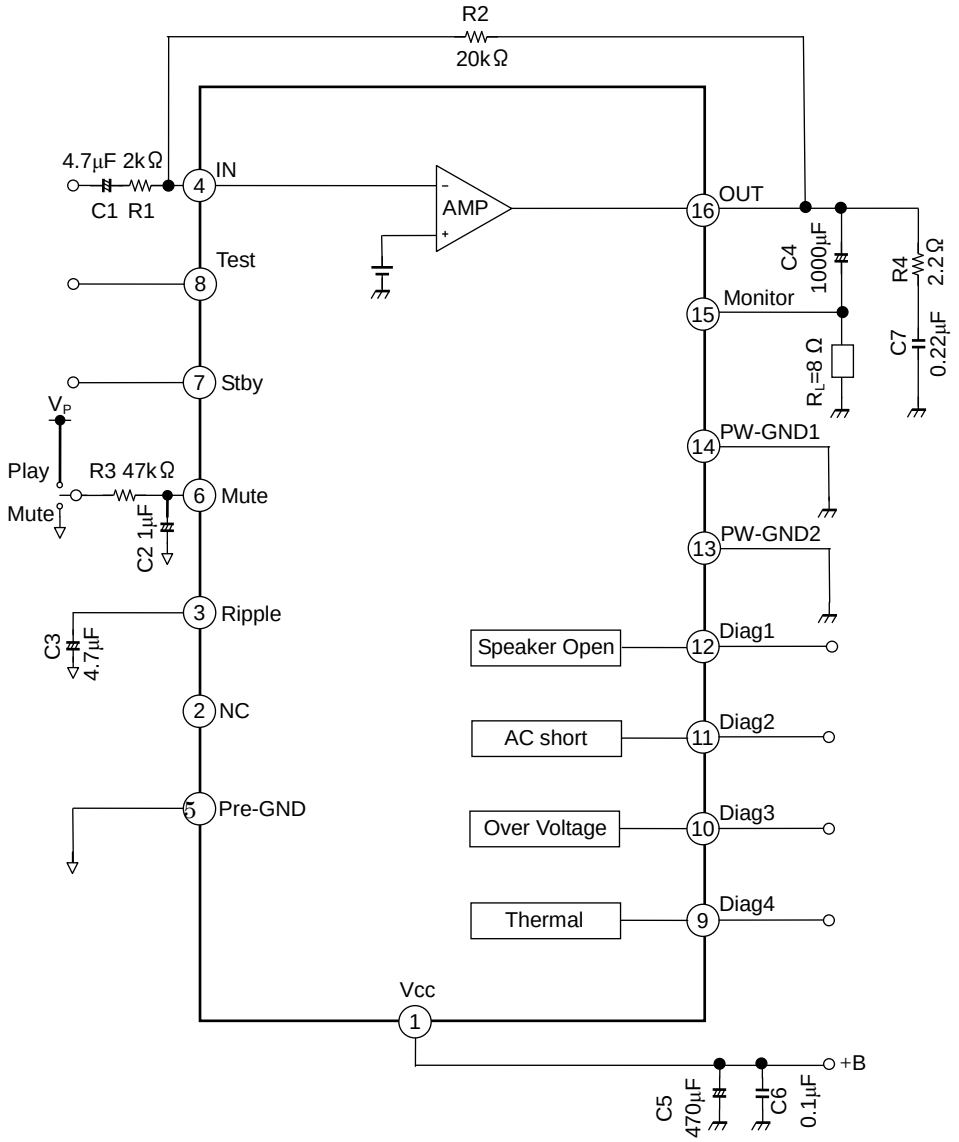
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unite
Quiescent supply current	I_{CCQ}	—	VIN = 0V	—	7	—	mA
Output power	P_{OUT} MAX1	—	max POWER	—	3	—	W
	P_{OUT}	—	THD = 10%	—	2	—	
	P_{OUT} MAX2	—	Vcc=16V,max POWER	—	5	—	
Total harmonic distortion	THD	—	Pout= 0.125 W(Vout=1Vrms) Filter=400Hz-30kHz	—	0.08	—	%
Voltage gain	G_V	—	Vout = 0.775 Vrms Input resistance(±1%)	19	20	21	dB
Output noise voltage	V_{NO}	—	Rg = 0 Ω, DIN_AUDIO	—	50	—	μVrms
Ripple rejection ration	R.R.	—	frip = 100 Hz, Rg = 620 Ω(Note15) Vrip = 0.775Vrms	—	50	—	dB
Standby current	I_{SB}	—	Standby condition	—	0.01	9	μA
Standby control voltage	V_{SB} H	—	POWER: ON	2.4	—	Vcc	V
	V_{SB} L	—	POWER: OFF	0	—	0.8	
Mute control voltage	V_M H	—	MUTE: OFF	2.4	—	Vcc	
	V_M L	—	MUTE: ON	0	—	0.8	
Test control voltage	V_T H	—	Test: ON	2.4	—	Vcc	
	V_T L	—	Test: OFF	0	—	0.8	
Mute attenuation	ATT M	—	Vout =0.775 Vrms → Mute: ON DIN_AUDIO	—	85	—	dB
Pin x1-x4 saturation voltage	Pxx -Sat	—	Rpull-up = 10 kΩ, +V_{SB}= 5.0 V When detect(pin Low)	—	100	500	mV

Note15: f_{RIP}: Ripple frequency

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

Note16: V_{SB}H、V_MH、V_TH : 16V(max)

10. Test Circuit



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

11. Characteristic Chart

11.1 Total Harmonic Distortion vs. Output Power

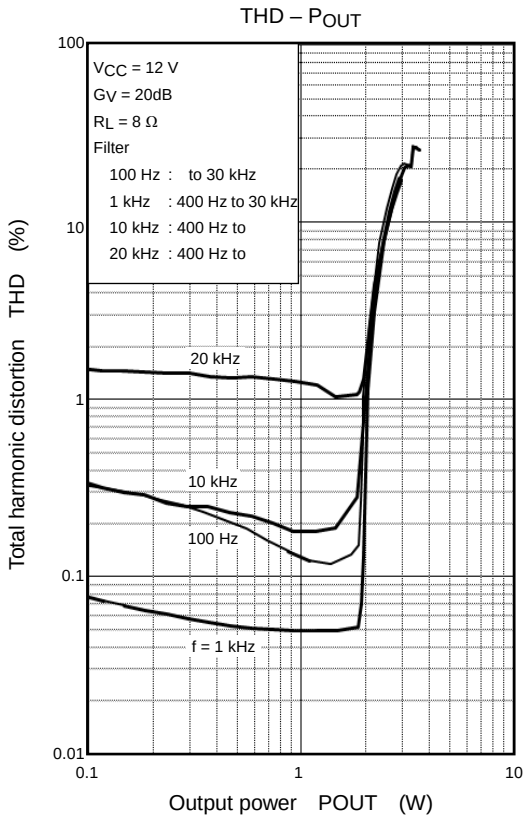


Figure 8 Total Harmonic Distortion of Each Frequency

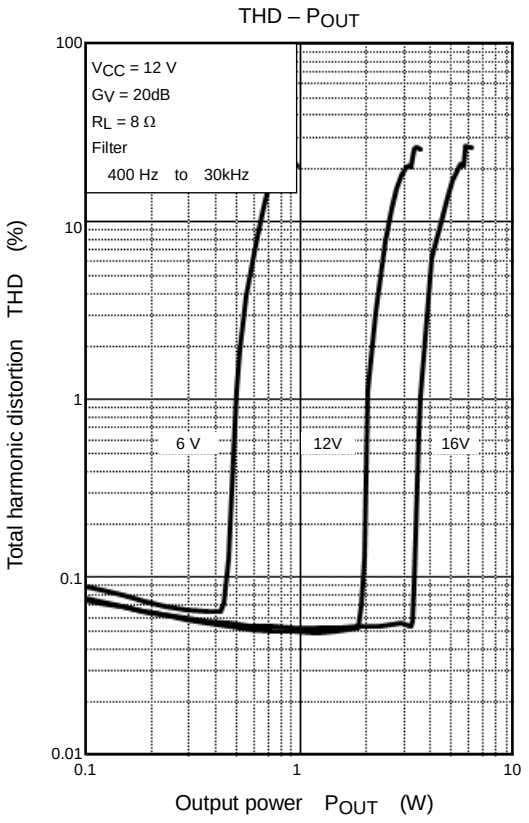


Figure 9 Total Harmonic Distortion by Power-supply Voltage

11.2 Various Frequency Characteristics

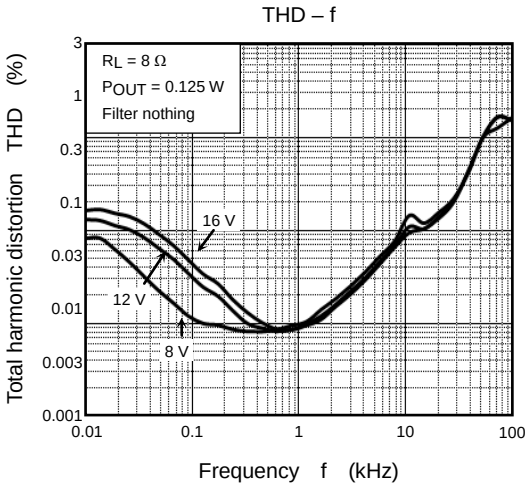


Figure 10 Frequency Characteristics of Total Harmonic Distortion

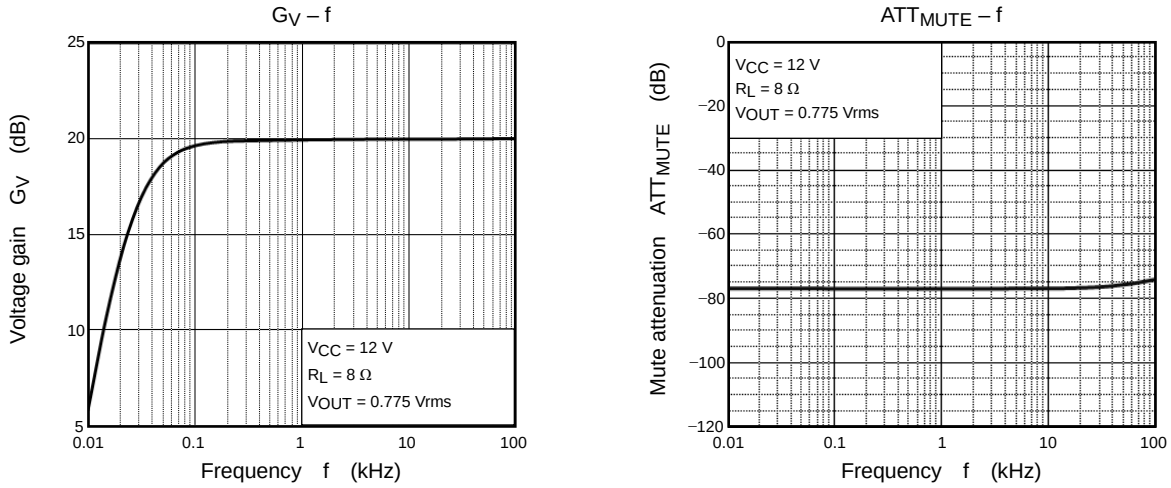


Figure 11 Frequency Characteristics of Voltage Gain and Mute Attenuation

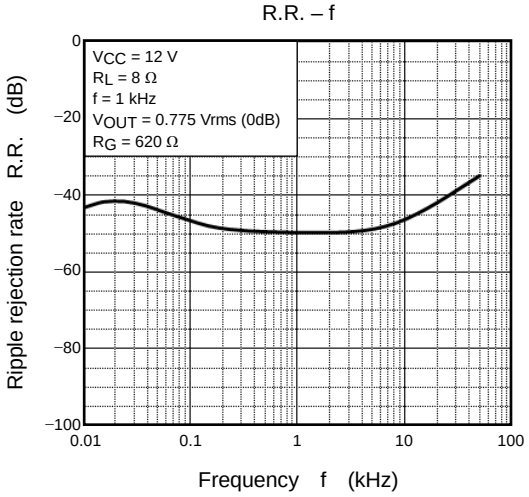
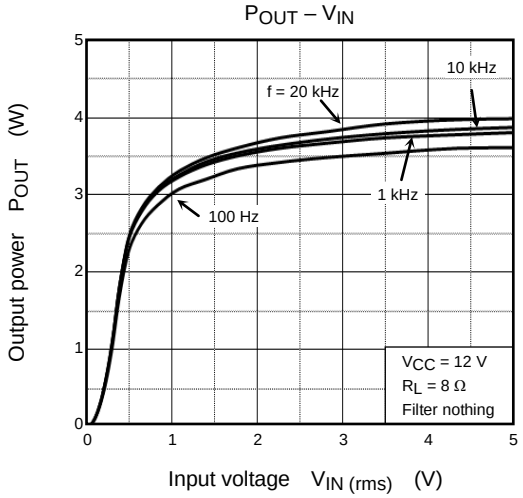
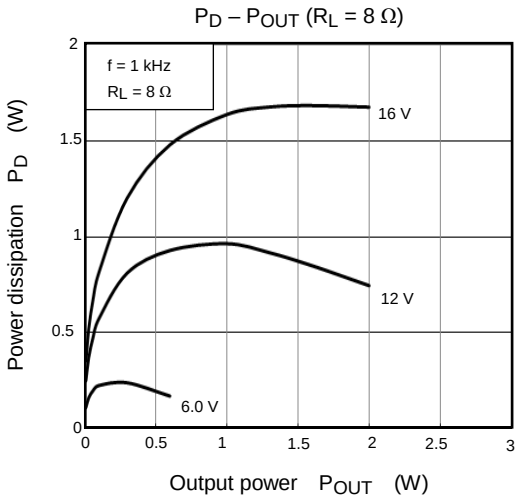


Figure 12 Frequency Characteristics of Ripple Rejection Rate

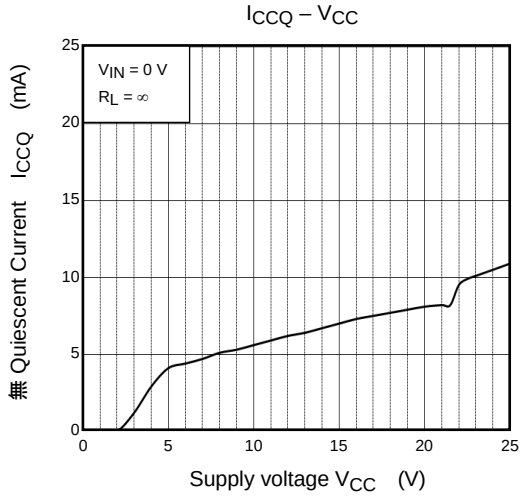
11.3 Output Power Characteristics to Input Voltage



11.4 Power Dissipation vs. Output Power

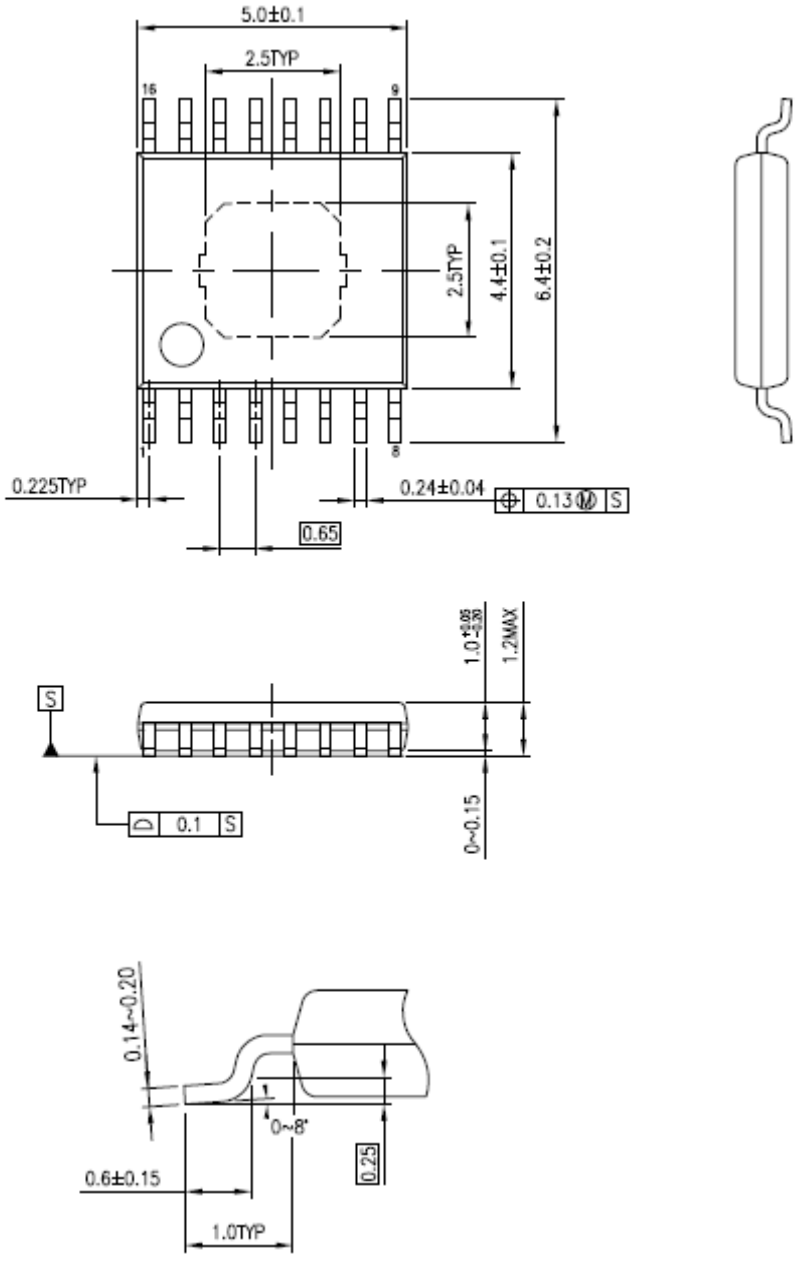


11.5 Other Characteristic



12. Package Dimensions

Package:P-HTSSOP16-0505-0.65-001 Unit:mm



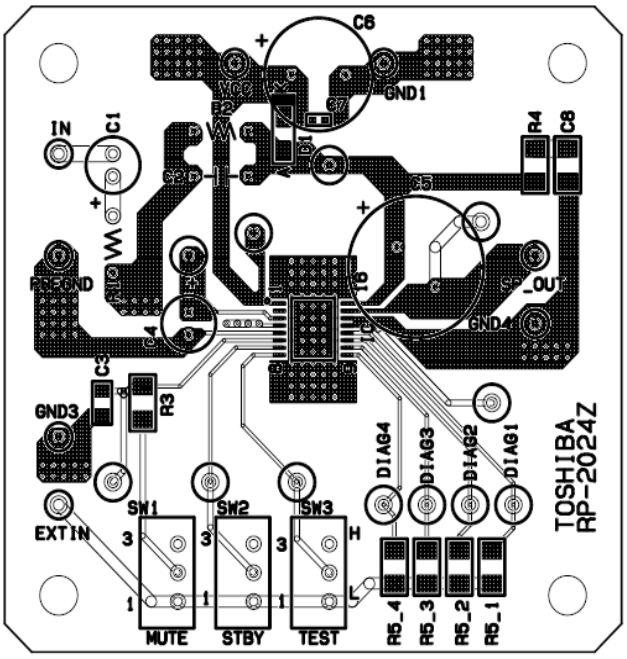
Weight: 0.062 g (typ.)

13. Package Dimensions

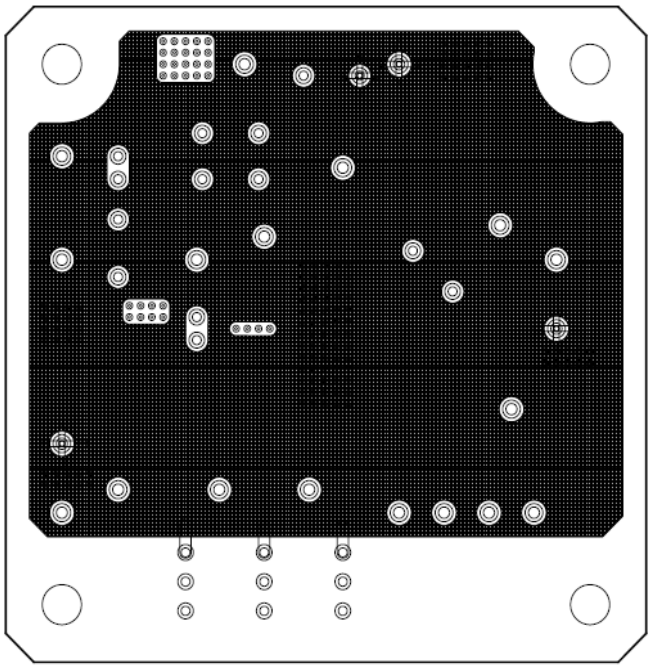
This dimension is the pattern layer "RP-2024Z" for Toshiba 1ch power IC evaluation board using P-HTSSOP16-0505-0.65-001. This product evaluate below board.

1-layer : (surface layer) Cu-area ; 57x57mm Cu-surface ; about 20% Cu-thickness ; 35μm
2-layer : (inner layer) Cu-area ; 57x57mm Cu-surface ; about 80% Cu-thickness ; 70μm
3-layer : (inner layer) Cu-area ; 57x57mm Cu-surface ; about 80% Cu-thickness ; 70μm
4-layer : (solder layer) Cu-area ; 57x57mm Cu-surface ; about 20% Cu-thickness ; 35μm

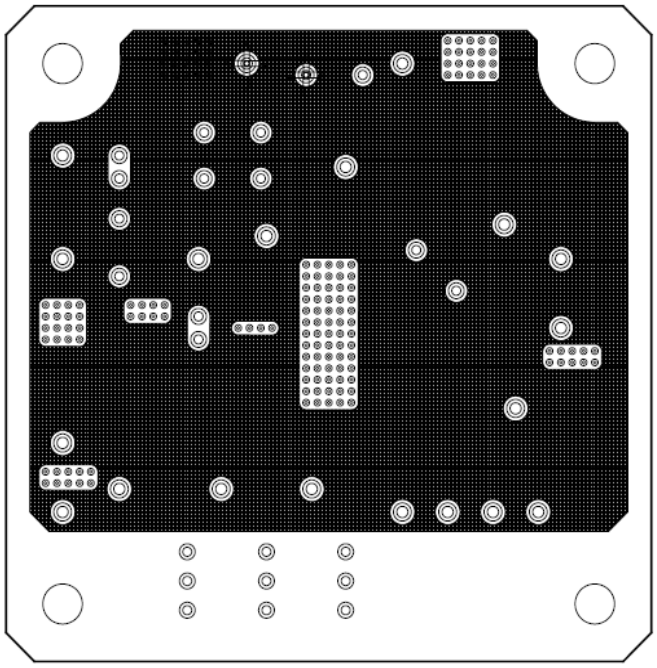
- Component part(1-layer)



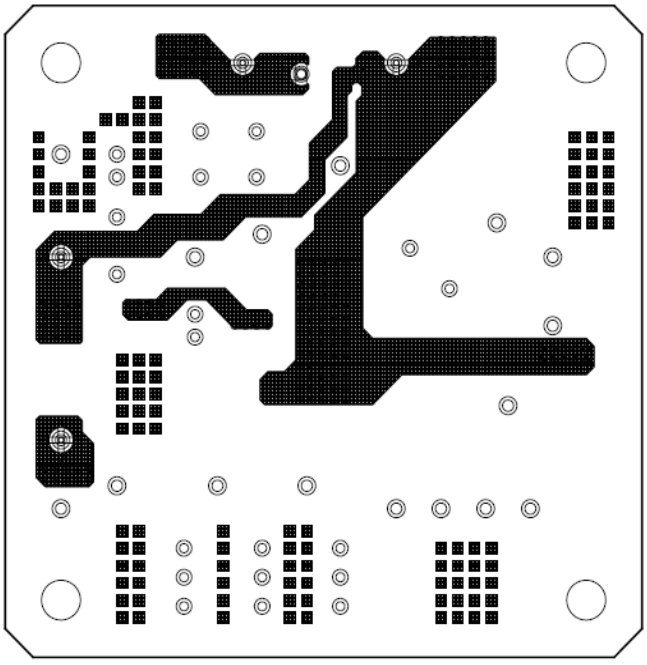
- GND layer(2-layer)



- Vcc layer(3-layer)



- Solder layer(4-layer)



Note17: This board can share some product, for that it does not accord the part od silk and part number.In case of make the board, please confirm the external component of evaluation product.

14. 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

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