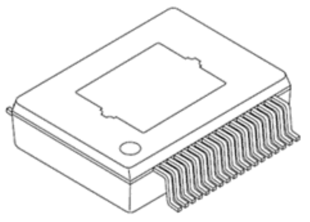
CDMOS Linear Integrated Circuit Silicon Monolithic

TCB701FNG

Maximum Power 49 W BTL × 4-ch Audio Power IC with Built-in Self-Diagnostics

1. Outline

The TCB701FNG is a power IC with built-in linear high efficiency 4-channel BTL amplifier developed for car audio applications.
The amplifier system uses our original high efficiency, class TB (Tied BTL), which enables saving heat generation to 1/5 (at P_{OUT} =0.8 W) as compared with conventional class AB amplifier, and realizes reducing internal temperature rise of car audio applications. The power loss with output power equivalent to a class D system (digital amplifier) in about 4 W or less is acquired. Additionally, this product can realize high efficiency system without peripheral parts (which are used for LPF and EMI protection) of class D system.
Built-in self-diagnostics allows the data reception and control through I^2C bus.
The maximum output power P_{OUT} is 49 W using a pure complementary Higher P-ch and Lower N-ch DMOS output stage. It also includes a standby function, a mute function, and each protection circuit necessary for car audio.



P-HSSOP36-1116-0.65-001

Weight: 1.28 g (typ.)

2. Applications

Power IC for car audio applications.

3. Features

- Our original high efficiency amplifier; class TB(Tied BTL)
- Built-in fulltime output offset detection
- Built-in +B low voltage detection (6 modes by I^2C control)
- Built-in standalone control mode (power ON / OFF and a mute control can be controlled without I^2C BUS)
- Built-in output clip detection
- Built-in cross output connection detection (Output short detection between different voltage)
- Built-in various mute functions (at low voltage, standby ON / OFF, fast, and I^2C control)
- 6 V operations (Engine idle reduction capability)
- Built-in hardware standby function
- Built-in various protection circuits (thermal shut down, over voltage, short to V_{CC}, short to GND, and output to output short)
  - ➢ The short-circuit protection can operate per channel.
- Control function via I^2C bus
  - ➢ Standby ON / OFF operation
  - ➢ Front / Rear separate mute operation and fast mute operation setting
  - ➢ Changing the time constants of mute (30 ms / 15 ms (typ.))
  - ➢ Front / Rear separate 2-step gain adjustment (26 dB / 16 dB)
  - ➢ Changing Power amplifier mode / Line driver mode
  - ➢ Changing clip detection (THD = 2% / 5 % / 10%)
  - ➢ Setting of output offset detection operation
  - ➢ Setting and startup of self-diagnostics
  - ➢ Setting parameters and startup of current detection
  - ➢ Setting rare short propriety
- Information capable to acquire via I^2C bus
  - ➢ Each output detection per channel (irregular connection, offset, and current detection for tweeter)
  - ➢ Information which is immediately before startup of over temperature protection, and acquisition of each setting state

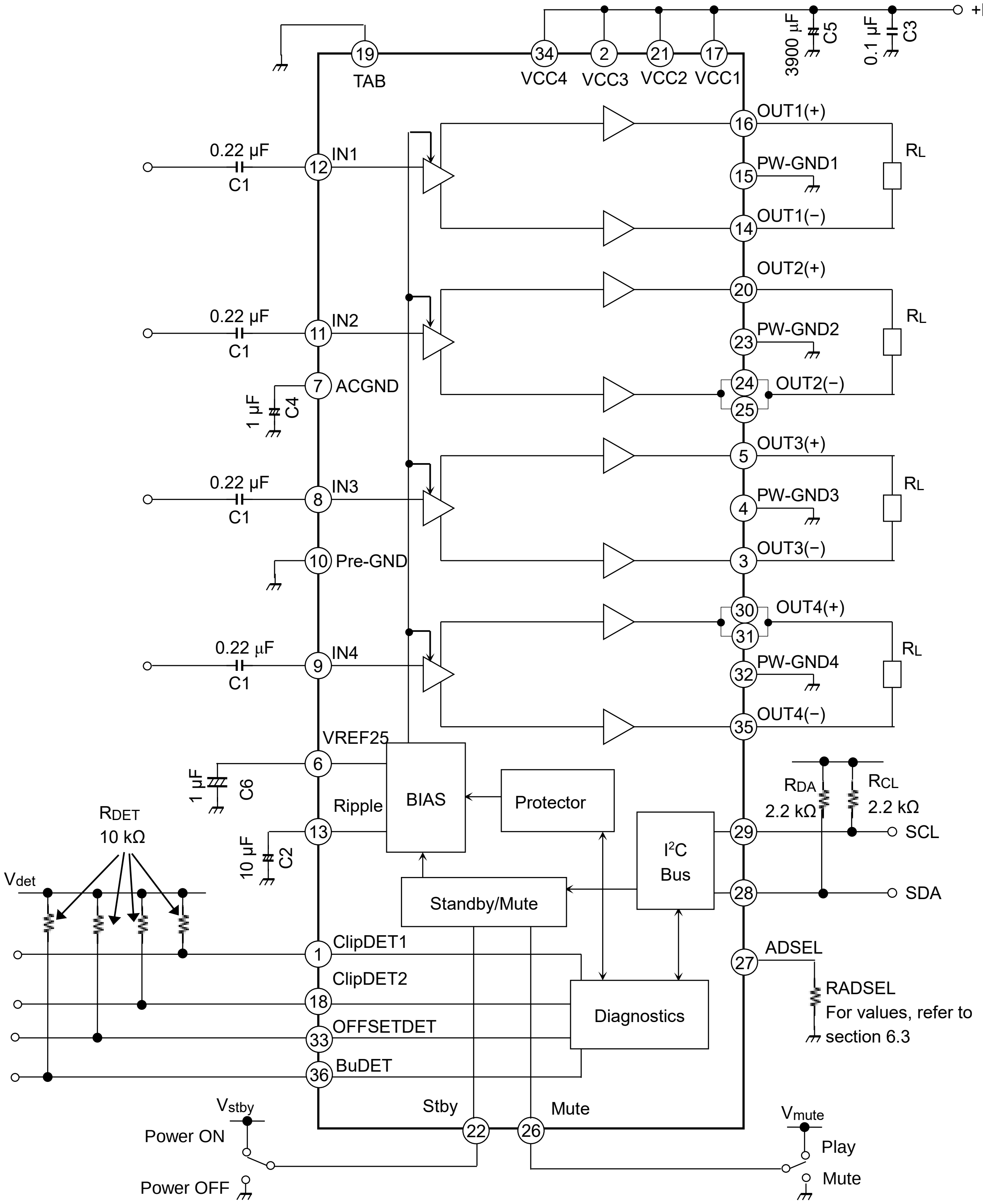
Table 3.1 Typical characteristics (Note)

Condition	Typ.	Unit
Output power (P_{OUT})		
V_{CC} = 15.2 V, Po max	49	W
V_{CC} = 14.4 V, Po max	45	W
V_{CC} = 14.4 V, THD = 10%	27	W
THD = 10%	25	W
Output power (P_{OUT}) (R_L = 2 Ω)		
V_{CC} = 14.4 V, Po max	70	W
V_{CC} = 14.4 V, THD = 10%	45	W
Total harmonic distortion (THD)		
P_{OUT} = 0.4 W	0.01	%
Output noise voltage (V_{NO}) (Rg = 600 Ω)		
BW = DINAUDIO	60	μVrms
Operating Supply voltage range ($V_{CC(opr)}$)		
Amplifier circuit (R_L = 4 Ω)	6 to 18	V
Amplifier circuit (R_L = 2 Ω)	6 to 16	V
Self-diagnostics circuit	7 to 18	V

Note: 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.

Note: Since static electricity serge intensity has a weak part according to conditions, please ask us with the detailed conditions of a static electricity serge examination.

4. Block Diagram

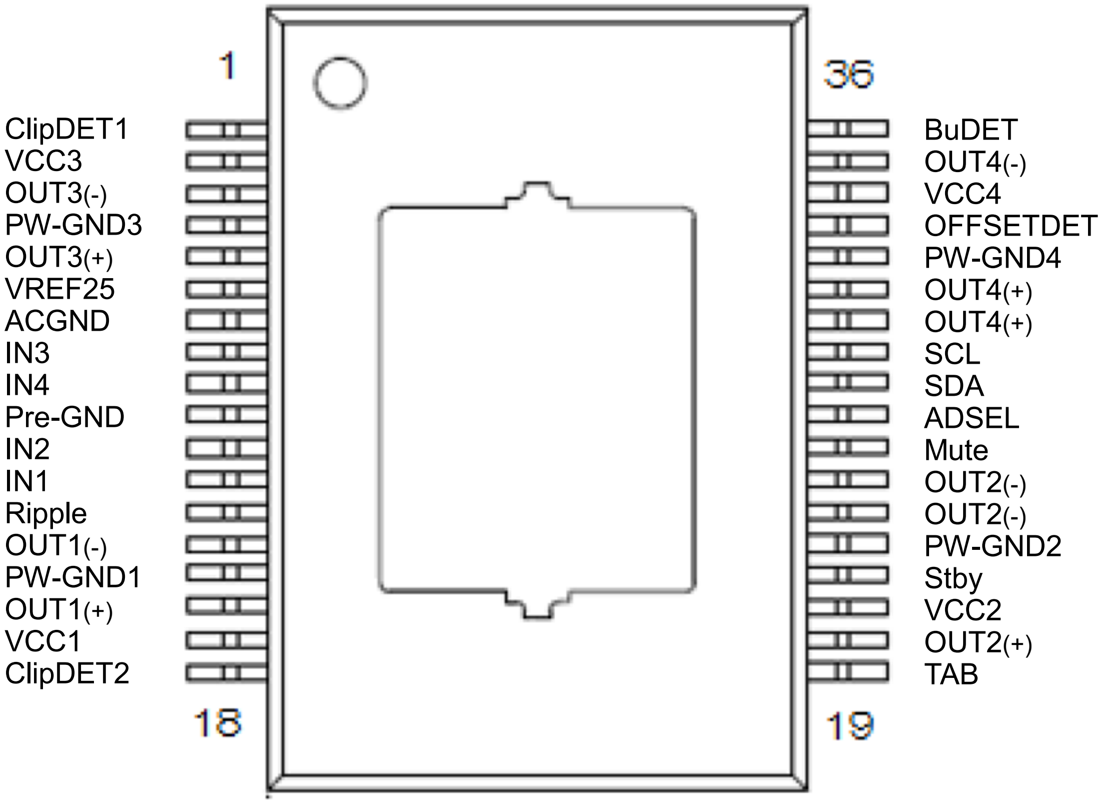


Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes.

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

5. Pin Configuration

5.1. Pin Configuration Diagram (Top View)



5.2. Pin Descriptions

Pin No.	Pin name	I/O	Description
1	ClipDET1	Vdet-OUT	Clip detection output (Front)
2	VCC3	VCC-IN	Power supply 3
3	OUT3(-)	OUT	OUT3 (-) output
4	PW-GND3	—	GND pin for OUT3
5	OUT3(+)	OUT	OUT3 (+) output
6	VREF25	—	Internal bias (2.5 V)
7	ACGND	—	Common reference voltage for all input
8	IN3	IN	OUT3 input
9	IN4	IN	OUT4 input
10	Pre-GND	—	Signal ground
11	IN2	IN	OUT2 input
12	IN1	IN	OUT1 input
13	Ripple	—	Ripple voltage
14	OUT1(-)	OUT	OUT1 (-) output
15	PW-GND1	—	GND pin for OUT1
16	OUT1(+)	OUT	OUT1 (+) output
17	VCC1	VCC-IN	Power supply 1
18	ClipDET2	Vdet-OUT	Clip detection output (Rear)
19	TAB	—	TAB (Always connect with GND)
20	OUT2(+)	OUT	OUT2 (+) output
21	VCC2	VCC-IN	Power supply 2
22	Stby	Vstby-IN	Standby voltage input
23	PW-GND2	—	GND pin for OUT2
24	OUT2(-)	OUT	OUT2 (-) output
25	OUT2(-)	OUT	OUT2 (-)output
26	Mute	Vmute-IN	Mute voltage input
27	ADSEL	—	Slave address selection
28	SDA	IN/OUT	I^2C serial data IO
29	SCL	IN	I^2C serial clock input
30	OUT4(+)	OUT	OUT4 (+) output
31	OUT4(+)	OUT	OUT4 (+) output
32	PW-GND4	—	GND pin for OUT4
33	OFFSETDET	Vdet-OUT	Offset detection output Short detection output (only for standalone control mode)
34	VCC4	VCC-IN	Power supply 4
35	OUT4(-)	OUT	OUT4 (-) output
36	BuDET	Vdet-OUT	+B voltage detection

6. Absolute Maximum Ratings

(Unless otherwise specified, Ta = 25 °C)

<table>
<tr><th colspan="2">Characteristics</th><th>Condition</th><th>Symbol</th><th>Rating</th><th>Unit</th></tr>
<tr><td colspan="2">Instantaneous power supply voltage</td><td>Within 0.2 s</td><td>$V_{CC\ (surge)}$</td><td>50</td><td>V</td></tr>
<tr><td colspan="2">Quiescent power supply voltage</td><td>—</td><td>$V_{CC\ (DC)}$</td><td>25</td><td>V</td></tr>
<tr><td colspan="2">Operating power supply voltage</td><td>—</td><td>$V_{CC\ (opr)}$</td><td>18</td><td>V</td></tr>
<tr><td colspan="2">Output current (peak)</td><td>—</td><td>$I_{O\ (peak)}$</td><td>9</td><td>A</td></tr>
<tr><td colspan="2">Power dissipation</td><td>(Note 1).</td><td>P_D</td><td>50</td><td>W</td></tr>
<tr><td colspan="2">Operating temperature</td><td>—</td><td>T_{opr}</td><td>-40 to 85</td><td>°C</td></tr>
<tr><td colspan="2">Storage temperature</td><td>—</td><td>T_{stg}</td><td>-55 to 150</td><td>°C</td></tr>
<tr><td colspan="2">Jumpstart</td><td>(Note 2).</td><td>V_{CC}-jump(DC)</td><td>28</td><td>V</td></tr>
<tr><td colspan="2">Junction temperature</td><td>—</td><td>T_j</td><td>150</td><td>°C</td></tr>
<tr><td rowspan="2">Voltage difference between pins</td><td>VCC1 to VCC2</td><td>∆VCC1-2</td><td>—</td><td>±0.3</td><td rowspan="13">V</td></tr>
<tr><td>Pre-GND to PW-GND</td><td>∆GNDPRE-PW</td><td>—</td><td>±0.3</td></tr>
<tr><td colspan="2" rowspan="11">Input pin voltage</td><td rowspan="11">—</td><td>Stby</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>Mute</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>IN(1 to 4)</td><td>Gnd-0.3 to 5.3</td></tr>
<tr><td>ACGND</td><td>Gnd-0.3 to 5.3</td></tr>
<tr><td>Ripple</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>ClipDET1/2</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>OFFSETDET</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>VREF25</td><td>Gnd-0.3 to 5.3</td></tr>
<tr><td>BuDET</td><td>Gnd-0.3 to V_{CC}(opr)</td></tr>
<tr><td>SCL/SDA</td><td>Gnd-0.3 to 5.3</td></tr>
<tr><td>ADSEL</td><td>Gnd-0.3 to 5.3</td></tr>
</table>

Note 1: Ta=25°C , Package thermal resistance under the infinite heat sinking use condition ($R_{th(j-t)}$ = 1.3 °C/W)
Note 2: +B (Battery) voltage is changed from 12 V to 28 V with rising SR 8.6 V/ms, Ta=25°C, for 1 minute applied.

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.

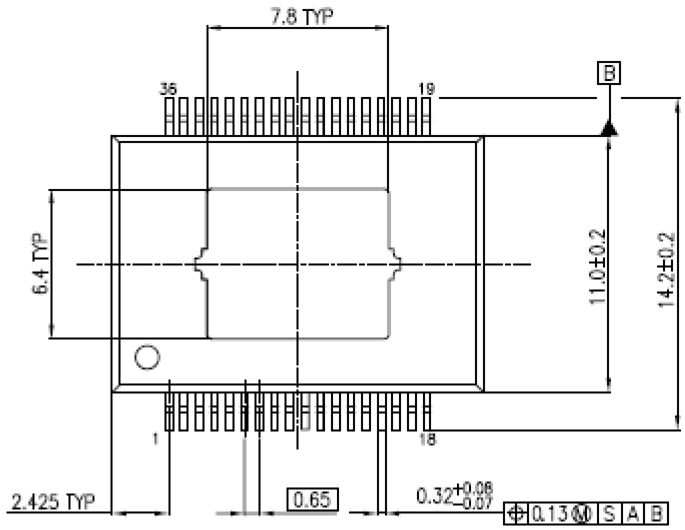
7. Operating Range

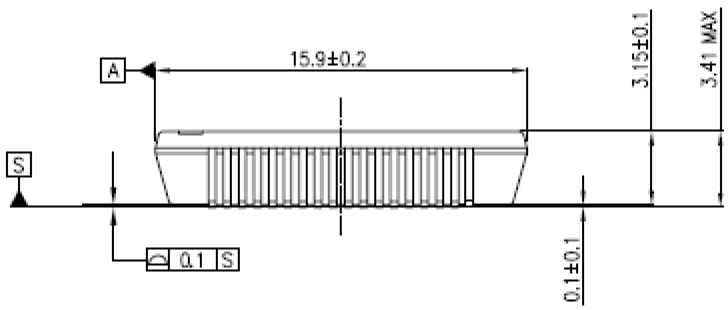
Characteristics		Symbol	Condition	Min	Typ.	Max	Unit
Operating voltage range	Amplifier circuit	V_{CC}	R_L=4 Ω (Note 1)	6	—	18	V
			R_L=2 Ω (Note 1)	6	—	16	V
	Self-diagnostic circuit	V_{CC} (SD)	—	7	—	18	V
Connected load range	Power amplifier mode 1	R_L1	V_{CC} = 6 to 18 V	4	—	—	Ω
	Power amplifier mode 2	R_L2	V_{CC} = 6 to 16 V	2	—	—	Ω
	Line driver mode	R_L3	IB2-D3=1	8	—	—	Ω

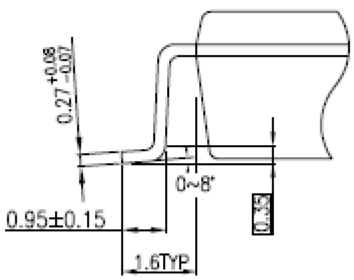
Note 1: When the low voltage mute is operating, the operation starts from 7.5 V.

8. Package Dimension

P-HSSOP36-1116-0.65-001 “Unit : mm”







Weight: 1.28g (typ.)

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) Customer inquiries:
Automotive Marketing Group I
Tel: +81-3-3457-3361
https://toshiba.semicon-storage.com/ap-en/contact.html

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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