Technical Note

Class-AB Speaker Amplifiers

2W + 2W Stereo Speaker / Headphone Amplifier

BH7881EFV

No.10077EAT05

●Description

The BH7881EFV is a low voltage, low noise, high output speaker/headphone amplifier IC, in which a Bi-CMOS process is used. An on-chip speaker amplifier circuit that is capable of 2W+2W output can be used as a headphone amplifier by switching the operating mode. This makes it possible to configure an audio system using few external devices.
With a built-in, low saturation regulator with programmable output voltage and output current, clear tone quality is obtained even when directly connected to a digital power supply. A peripheral analog circuit can also be regulator driven. Furthermore, the BH7881EFV provides speaker output and VREG output short-circuit detection functions, a thermal shutdown function with hysteresis, and a speaker protection function.

●Features

1) Built-in low saturation type regulator (Digital power supply driver, voltage and current variable, short circuit detection)
2) Bass boost mode, gain switching functions
3) Speaker MUTE function (Headphone mode)
4) Built-in line amplifier output (gain adjustment, LPF setting) active/suspend function (TTL input control pin)
5) Hysteretic thermal shutdown function (Set for approximately 150℃ /90℃)
6) IC protection function (SP pin VCC/GND short circuit detection)
7) Speaker protection function (Output voltage amplitude control)

●Applications

Notebook computers, LCD TVs, etc.

●Absolute maximum ratings (Ta=25℃)

Parameter	Ratings	Unit
Supply voltage	+6.0	V
Power dissipation	1100 *1	mW
Storage temperature	-55～+125	℃
Operating temperature	-10～+70	℃

*1 Reduced by 11 mW/℃ at 25℃ or higher, when mounting on a 70mmX70mmX1.6mm PCB board).

●Operating Conditions (Ta=25℃)

Parameter	Ratings	Unit
Supply voltage	+3.3～+5.5	V

* This IC is not designed to be radiation-resistant.

●**Electrical characteristics** (Unless otherwise noted, VCC=3.3V,Ta=25℃,f=1kHz,R=4Ω,400Hz～30kHzBPF)

Parameter	Limits			Unit	Conditions
	Min.	Typ.	Max.		
■1CHIP					
Circuit current (ACTIVE)	-	18	30	mA	No signal
Circuit current(SUSPEND)	-	0	10	μA	No signal
■SP AMP					
Voltage gain1	8.5	11.0	13.5	dB	SE,Vin=-18dBV
Voltage gain 2	14.5	17.0	19.5	dB	BTL,Vin=-18dBV
Distortion	-	0.04	1.0	%	BTL,Vin=-18dBV
Maximum output level	1.5	4.5	-	dBV	BTL,DSTN=1%
Output noise level	-	-90	-80	dBV	SE,DIN-Audio
Cross talk	-	-85	-75	dBV	SE,DIN-Audio
Output level on mute	-	-110	-80	dBV	BTL,Vin=-18dBV
■HP AMP					
Voltage gain	3.0	5.5	8.0	dB	SE,Vin=-18dBV,R_L=32Ω
Distortion	-	0.02	1.0	%	SE,Vin=-18dBV,R_L=32Ω
Maximum output level	-1.6	1.4	-	dBV	SE,DSTN=1% ,R_L=10kΩ
Output noise level	-	-95	-80	dBV	SE,DIN-Audio ,R_L=32Ω
Cross talk	-	-90	-80	dBV	SE,DIN-Audio ,R_L=32Ω
Output level on mute	-	-105	-80	dBV	SE,Vin=-18dBV,R_L=32Ω
■BIAS					
Output voltage	1.40	1.65	1.90	V	No signal
■Regulator					
Output voltage	2.7	3.0	-	V	No signal
PSRR	-	-80	-	dBV	V_{IN}=0.28Vpp,1kHz
■CONTROL PIN					
ACTV/SPND CTRL 2PIN control pin					
SUSPEND mode	VCC/3+0.8	-	VCC	V	SP/HP&REG SUSPEND
ACTIVE mode	0	-	0.8	V	SP/HP&REG ACTIVE
SP/HP CTRL 12PIN control pin					
SP&HP mode	VCC/3+0.8	-	VCC	V	SP/HP ON
HP(SP MUTE) mode	0	-	0.8	V	SP OFF(SP MUTE),HP ON
BASSBOOST CTRL 11PIN control pin					
Bass-Boost mode	VCC/3+0.8	-	VCC	V	SP/HP gain UP
Non-Boost mode	0	-	0.8	V	SP/HP gain NORMAL

●Block diagram

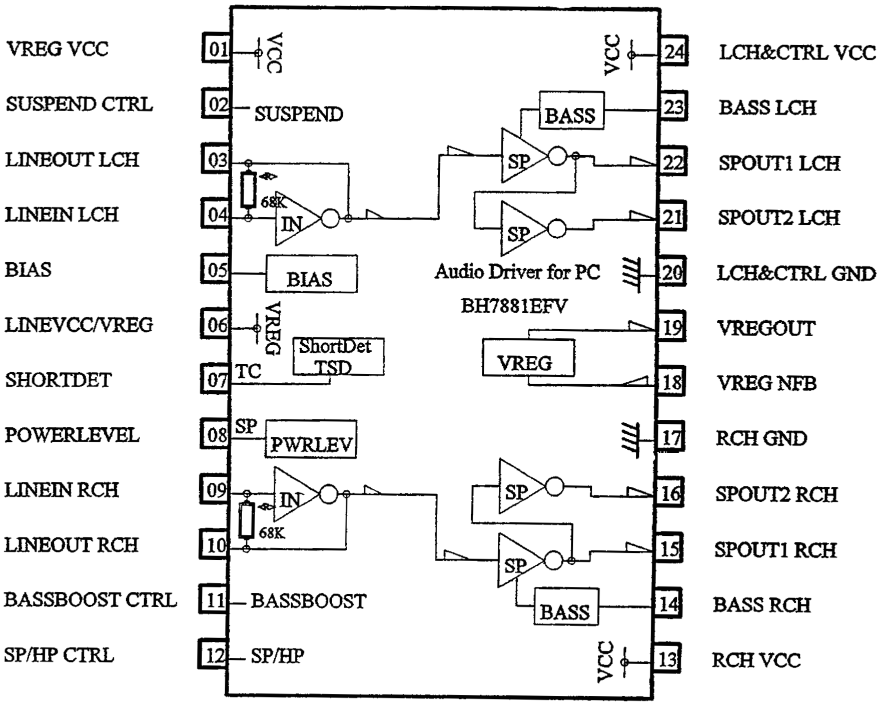


Fig.1

●Control pin descriptions

1. ACTIVE/SUSPEND:2PIN

Control input	Mode	Function
H	SUSPEND	Suspended state (Except REG)
L	ACTIVE	Active state

When suspended, the regulator (REG) is in an active state and the SP/HP/LINE amplifier is in a suspended state. Originally, signals from input resistance and feedback resistance leaked into the speaker output even when suspended, because of the series connection of an inverting amplifier. However, since the signals are cut off on their way in this IC, signal leaks do not occur in speaker output. (Signals due to feedback resistance are output in LINE amplifier output.)

2. POWER LEVEL:8PIN

Control input	Mode	Function
H	Limiter H	3Vf peak limiter ON (Output approx. 1.25 W)
OPEN	Limiter L	2Vf peak limiter ON(Output approx .0.70W)
L	Limiter OFF	limiter OFF

*VCC=5V,RL=4ohm,VIN=-8dBV

Since a limiter uses diode characteristics, it has temperature characteristics. On the high temperature side, amplitude tends to decrease, which is a characteristic that protects the IC. Since setting in speaker mode is assumed, it is ineffective (limiter OFF) in headphone mode. Moreover, precautions must be taken when input is so great, that output becomes a square wave, since this could cause local oscillation.

3. BASSBOOST ON/OFF:11PIN

Control input	Mode	Function
H	ON	BASSBOOST:ON
L	OFF	BASSBOOST:OFF

The capacitor that constitutes BASSBOOST is eliminated, and also functions as a gain switch.

4. SP/HP:12PIN

Control input	Mode	Function
H	SP+HP	SP:ON, HP:ON
L	HP	SP:OFF,HP:ON

By using the headphone mode in a speaker MUTE mode, it is possible to completely cut off the pop noise when switching when VCC ON or OFF, or to ACTV or SPND. For control sequence and other information, see the following pages.

*Not all control pins have pull up or pull internal resistors. Therefore add pull up or pull down resistors, accordingly (PIN8 is an exception.)

●Description of operations

1. LINE Amplifier
   1) The voltage gain of the LINE amplifier is calculated by the following equations:
      GAIN = 20×LOG(68k/R4 +1k)) [dB]
      GAIN = 20×LOG(68k/R9 +1k)) [dB] R4 and R9 are resistances connected to PIN4 and PIN9

   2) In order to make it operable with mixing input, the LINE amplifier can be realized by connecting multiple resistors to PIN4 and PIN9. Since the input pin is also the feedback of an inverting differential amplifier, each individual signal is simply added.

   3) To configure LPF and remove unnecessary frequency components, the LINE amplifier can be realized by connecting capacitors between PIN3 and PIN4, and between PIN9 and PIN10. The LPF cut-off frequency at that time is calculated by the following equation:
      fc = 1/(2× π ×C×68k) [Hz]

2. SP Amplifier (HP Amplifier)
   1) The voltage gain of the SP amplifier for Non-Boost is about 12 [dB] (SE: Single end).

   2) The voltage gain of the SP amplifier for Bass-Boost is calculated by the following equations:
      GAIN = 20×LOG((40k+R22-23)/10k) [dB] Where R22-23 is the resistance connected between PIN22 and PIN23.
      GAIN = 20×LOG((40k+R14-15)/10k) [dB] Where R14-15 is the resistance connected between PIN14 and PIN15.

   3) The cut-off frequency for Bass-Boost is calculated by the following equations:
      fc = 1/(2× π ×C22-23×R22-23) [Hz] Where RC22-23 is connected between PIN22 and PIN23.
      fc = 1/(2× π ×C14-15×R14-15) [Hz] Where RC14-15 is connected between PIN14 and PIN15.

   4) Apply power to RCHVCC (PIN13), for MONO only.

3. Regulator
   1) The REG output voltage is calculated by the following equation, and numeric values are shown below:
      V = 1.15 [V]×(1+R(VLEV)/R(VREF)) [V]

REG setting voltage	3.0	3.3	3.6	4.0	4.6	V
Supply voltage(VCC)	3.3	3.6	4.0	5.0	5.0	V
R(VLEV)	30k	30k	30k	30k	30k	Ω
R(VREF)	18k	16k	14k	12k	10k	Ω

Use 1% resistors to eliminate errors in actual output voltages.

   2) The REG maximum output current is determined by the external Tr capability (hFE) of the IC. If more current is necessary, select one ICMAX with large hFE. Drive output current to the base is about 5 mA.

   3) When using the regulator, connect REG output to PIN6. The LINE amplifier, BIAS, and other sections essential to tone quality, are driven by the REG voltage. Clear sound output is obtained even if a digital power supply is the VCC.

   4) When using the regulator for an application, other than this IC, and driving the IC by VCC only, apply VCC at PIN6.

   5) When not using the regulator, it is set to OFF mode by connecting PIN 19 to OPEN and PIN18 to OPEN. Apply VCC at PIN6.

   6) Do not set a VCC applied voltage that is smaller than the set voltage of the regulator. Since the REG output transistor operates in a saturation region, an abnormal circuit current occurs.

   7) For the REG output transistor, Rohm transistors 2SA1900 and 2SA933 are recommended.

4. Short circuit detection
   1) Overview of SP amplifier VCC/GND short circuit detection.
      If the output pin of the SP amplifier is short circuited to VCC or GND, the detection function operates to suspend the output stage of the SP amplifier.
      If the SP output pin is short circuited to REG output, the detection function does not operate. It is configured so that it resets automatically if the short circuit is canceled. Moreover, although a short circuit is detected from the DC voltage of the output pin, and there is a short delay distinguishing it from maximum output amplitude, malfunction may occur due to factors such as power supply voltage and load. In this case, connect “PIN7” to GND. The short circuit function is set to the OFF mode.

   2) SP amplifier VCC/GND short circuit detection cautions
      When the output pin of the SP amplifier is short circuited with VCC or GND, excessive current flows in the IC and stress is applied to the chip. Accordingly, if it is shorted a number of times, the IC gradually deteriorates and is finally destroyed. The short circuit detection function does not guarantee operation after numerous shorts.

   3) Regulator short circuit detection
      If the output pin of the regulator is short circuited to GND, the detection function operates to suspend the output stage of the regulator. If the output pin of the regulator is short circuited to VCC, an abnormal current does not occur in any circuit. After the short circuit, the regulator resets automatically, due to the pull-up resistance (for example, 2.2 kΩ) connected to PIN1, as shown in the full option example of the sample application circuit.
      (Example: 3.9 kΩ is the resistance load for lowering the output impedance of the regulator when it is no load.)

5. Pop noise
   1) The following table shows the sequence for eliminating the pop noise that occurs from turning the power supply ON or OFF, or turning control pins ON or OFF.

Order	VCC	ACT/SPND	SP/HP	Conditions
1	OFF	SUSPEND	HP	Power Supply ON
2	ON	SUSPEND	HP	Turning on in the suspend
3	ON	ACTIVE	HP	SP MUTE～countermeasure
4	ON	ACTIVE	SP+HP	MUTE cancellation～operation
5	ON	ACTIVE	SP+HP	Operation
6	ON	ACTIVE	HP	SP MUTE～counter measure
7	ON	SUSPEND	HP	Turning off in the suspend
8	OFF	SUSPEND	HP	Power Supply OFF

   2) In speaker MUTE state, pop noise does not occur even when starting or changing modes. It is recommended to use speaker MUTE (headphone) mode during conditions where pop noise can occur.

   3) Any changes of the components values in the sample application circuit can the effect the pop noise cut-off function.

6. Bypass and bias capacitor
   1) Although this IC is designed so that bypass capacitors are not needed, when bypass capacitors are in fact necessary, place them close to the VCC~GND pins.

   2) Similarly, place a bias capacitor close to the GND pin.

7. Capacitive load drive
   1) Do not connect a capacitive load to the SP amplifier, HP amplifier, or IC pin. There is a possibility of oscillation.

   2) Adding RC to the HP amplifier output, as in the sample application circuit, makes the output noise, voltage, and distortion sensitive to oscillation.

8. Pop noise at start/end when switching ACTV/SPND
   Pop noise can be suppressed by mode transition due to software as in “Pop noise” above, or by hardware as shown below. This is realized (in SP mode) by forcibly setting HP mode temporarily, using the CR differential circuit.

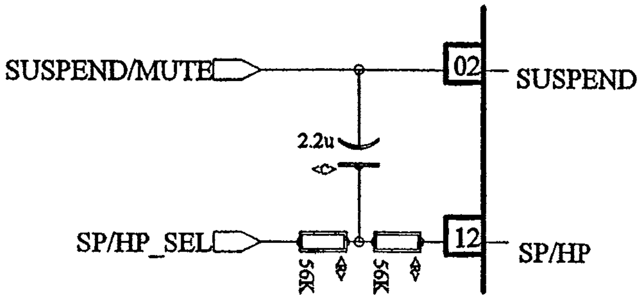


Fig.2

9. Power package
   1) In order to expand the power dissipation of the package, make the GND pattern, directly below the IC, as wide as possible and solder the GND pattern to the back of the IC.

   2) Power dissipation of the package varies greatly depending on factors such as the number of layers, area, film thickness, and material quality of the board used.

10. Other
    Beween voltages of VCC=1.4～1.6 V, momentary oscillation sometimes is observed at the SPOUT pin. Nevertheless, this occurrence is not reproduced on a momentary rise or fall of VCC. When slowly raising VCC pay attention to transient voltage. In order to avoid such occurrences, a sample circuit is illustrated below:

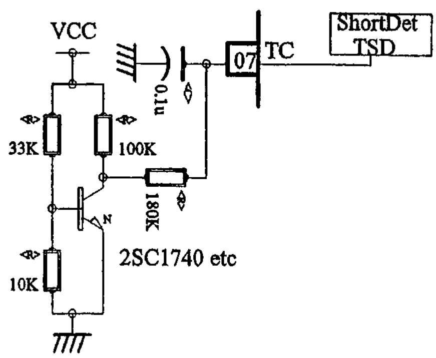


Fig.3

●**Application circuit**

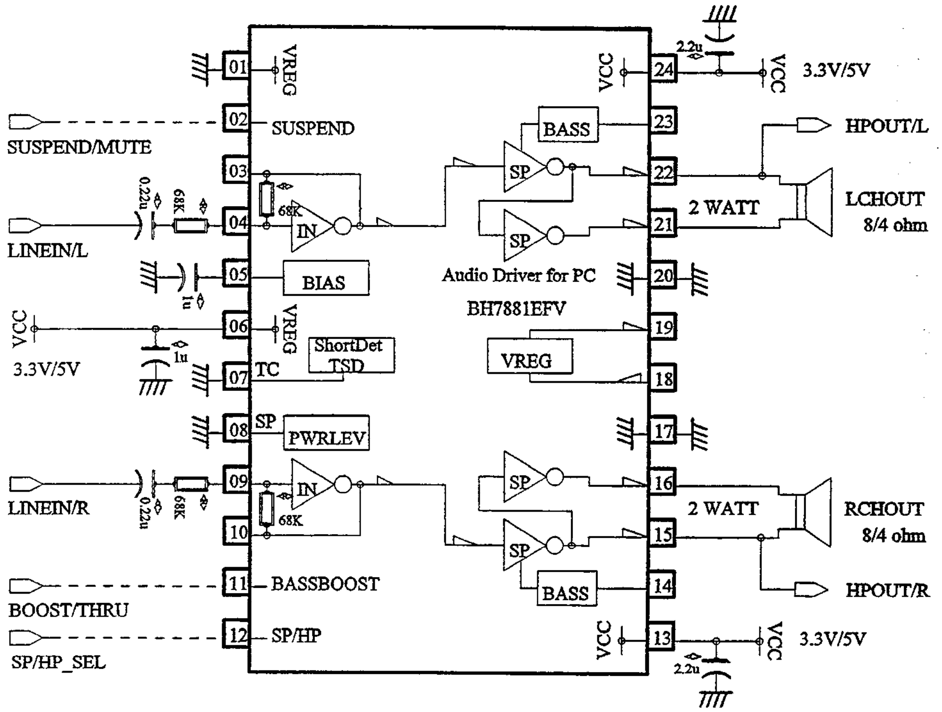


Fig.4 Minimum external components example

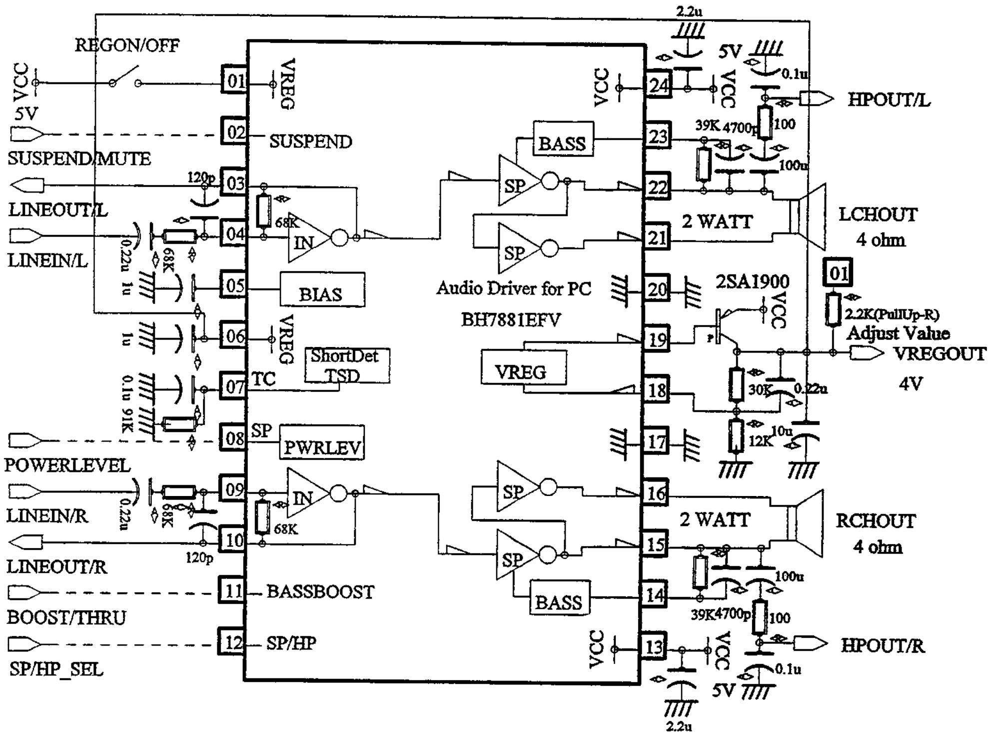


Fig.5 Maximum external components example

●**Operation Notes**

1. Numbers and data in entries are representative design values and are not guaranteed values of the items.

2. Although ROHM is confident that the example application circuit reflects the best possible recommendations, be sure to verify circuit characteristics for your particular application. Modification of constants for other externally connected circuits may cause variations in both static and transient characteristics for external components as well as this Rohm IC. Allow for sufficient margins when determining circuit constants.

3. Absolute maximum ratings
   Use of the IC in excess of absolute maximum ratings, such as the applied voltage or operating temperature range (Topr), may result in IC damage. Assumptions should not be made regarding the state of the IC (short mode or open mode) when such damage is suffered. A physical safety measure, such as a fuse, should be implemented when using the IC at times where the absolute maximum ratings may be exceeded.

4. GND potential
   Ensure a minimum GND pin potential in all operating conditions. Make sure that no pins are at a voltage below the GND at any time, regardless of whether it is a transient signal or not.

5. Thermal design
   Perform thermal design, in which there are adequate margins, by taking into account the permissible dissipation (Pd) in actual states of use.

6. Short circuit between terminals and erroneous mounting
   Pay attention to the assembly direction of the ICs. Wrong mounting direction or shorts between terminals, GND, or other components on the circuits, can damage the IC.

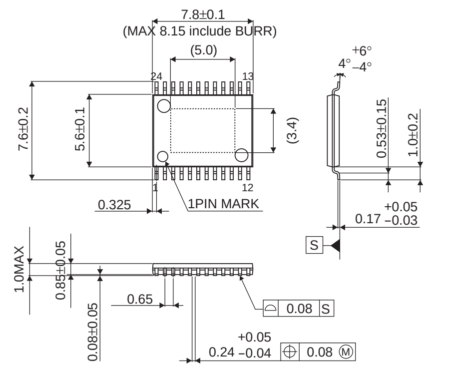
7. Operation in strong electromagnetic field
   Using the ICs in a strong electromagnetic field can cause operation malfunction.

●**Ordering part number**

B	H	7	8	8	1	E	F	V	-	E	2

- B H: Part No.
- 7 8 8 1: Part No.
- E F V: Package
  EFV: HTSSOP-B24
- E 2: Packaging and forming specification
  E2: Embossed tape and reel

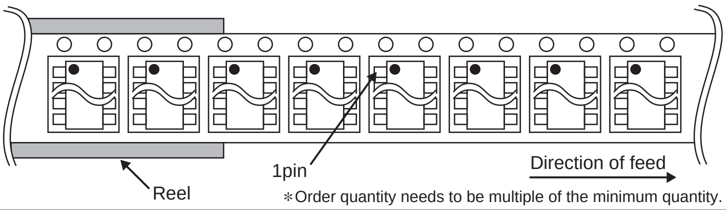
HTSSOP-B24



(Unit : mm)

<Tape and Reel information>

Tape	Embossed carrier tape (with dry pack)
Quantity	2000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



※Order quantity needs to be multiple of the minimum quantity.

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JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

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1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
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   [c] the Products are exposed to direct sunshine or condensation
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2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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