DATA SHEET

Part No.	AN12976A
Package Code No.	UBGA015-W-2020AEA

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AN12976A

Headphone amplifier IC with Charge pump

■ Overview

AN12976A is a headphone amplifier with charge pump driver which is not need output coupling capacitor. And the wafer level package is adopted, so it contributes to the miniaturization.

■ Features

- Need no output coupling capacitor
- Compact size
- Low RF noise affection

■ Applications

- Audio amplifier for mobile, such as a cellular phone

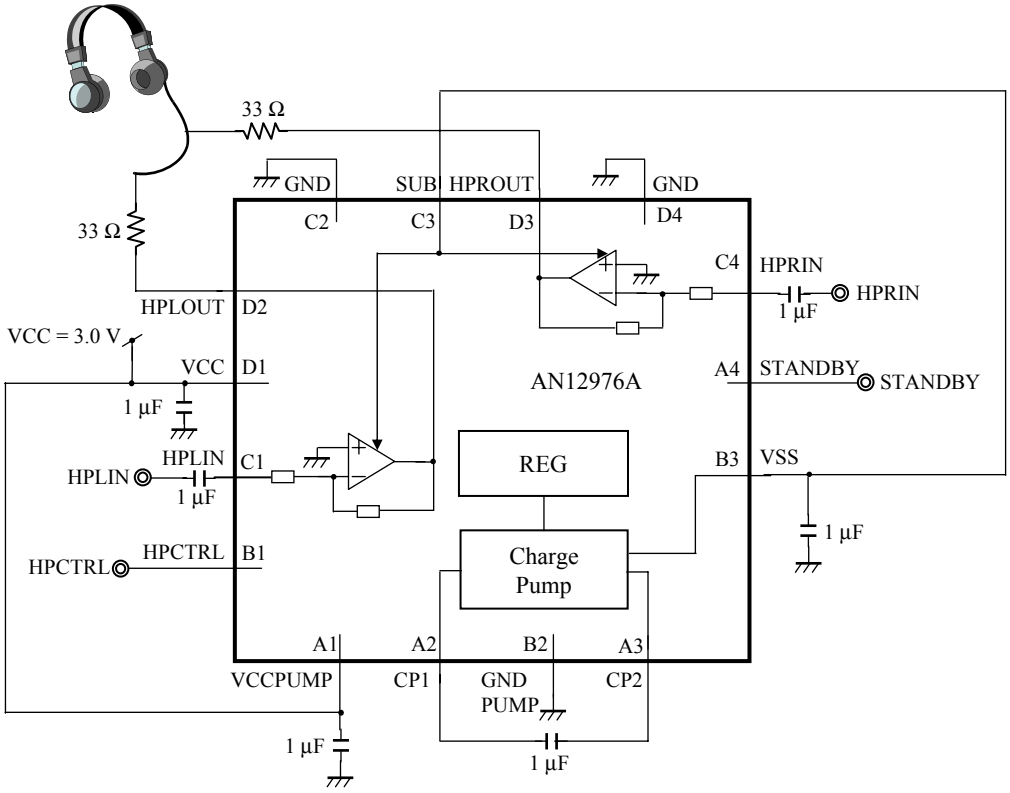
■ Package

- 15 pins wafer level chip size package (WLCSP Type)

■ Type

- Silicon monolithic Bi-CMOS IC

■ Application Circuit Example (Block Diagram)



Truth table for control pins

STANDBY (Pin A4)	HPCTRL (Pin B1)	Operation mode	
Low	Low	Standby mode	
Low	High	Use is prohibited	*1
High	Low	Headphone save mode	*2
High	High	Normal operation	

Notes) *1 : Although output state is the same as that of standby mode, VCC current of about 10 µA flows.
Use standby mode on the condition of STANDBY = Low, HPCTRL = Low as wherever possible.
*2 : This mode is that only charge pump operates and headphone output is turned OFF.

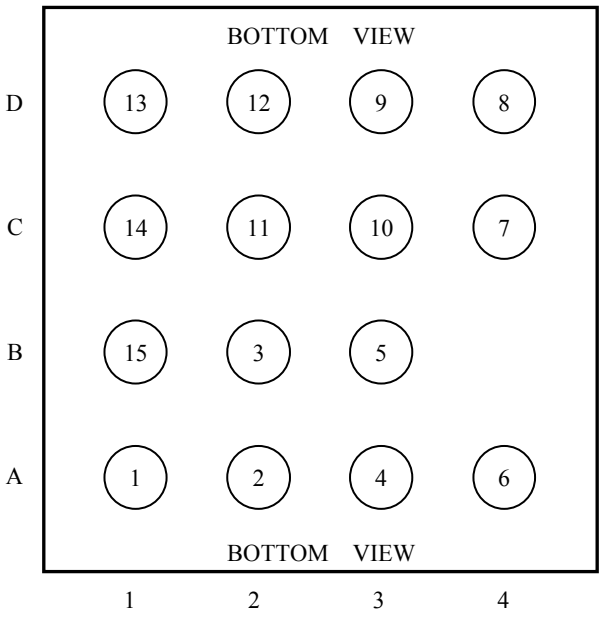
High and Low levels guaranteed voltage for control pins

	High-level	Low-level
STANDBY	1.7 V or more	0.3 V or less
HPCTRL	1.7 V or more	0.3 V or less

Notes)
- This application circuit is shown as an example but does not guarantee the design for mass production set.
- This block diagram is for explaining functions. The part of the block diagram may be omitted, or it may be simplified.

■ Pin Descriptions

Pin No.	Pad No.	Pin name	Type	Description
A1	1	VCCPUMP	Power Supply	Power Supply for charge pump
A2	2	CP1	Output	Cap1 for charge pump
B2	3	GNDPUMP	Ground	GND for charge pump
A3	4	CP2	Input	Cap2 for charge pump
B3	5	VSS	Output	Charge pump output
A4	6	STANDBY	Input	Standby control
C4	7	HPRIN	Input	Signal input R-channel
D4	8	GND	Input	GND
D3	9	HPROUT	Output	Headphone output R-channel
C3	10	SUB	Input	Substrate
C2	11	GND	Ground	GND
D2	12	HPLOUT	Output	Headphone output L-channel
D1	13	VCC	Power Supply	Power Supply
C1	14	HPLIN	Input	Signal input L-channel
B1	15	HPCTRL	Input	Headphone output control



■ Absolute Maximum Ratings

Note) Absolute maximum ratings are limit values which are not destructed, and are not the values to which operation is guaranteed.

A No.	Parameter	Symbol	Rating	Unit	Notes
1	Supply voltage	VCC	3.45	V	*1
2		VCCPUMP	3.45	V	*1
3	Supply current	I_{CC}	—	A	—
4	Power dissipation	P_D	58	mW	*2
5	Operating ambient temperature	T_{opr}	–30 to +85	°C	*3
6	Storage temperature	T_{stg}	–55 to +125	°C	

Notes) *1 :The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
*2 : The power dissipation shown is the value at T_a = 85°C for the independent (unmounted) IC package without a heat sink.
When using this IC, refer to the P_D-T_a diagram in the ■ Technical Data and design the heat radiation with sufficient margin so that the allowable value might not be exceeded based on the conditions of power supply voltage, load, and ambient temperature.
*3 :Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for T_a = 25°C.

■ Operating Supply Voltage Range

Parameter	Symbol	Range	Unit	Notes
Supply voltage range	VCC	2.7 to 3.3	V	*1
	VCCPUMP	2.7 to 3.3	V	*1

Note) *1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

■ Allowable Current and Voltage Range

Notes)
- Allowable current and voltage ranges are limit ranges which are not destructed, and are not the ranges to which operation is guaranteed.
- Voltage values, unless otherwise specified, are with respect to GND. GND is voltage for GND and GNDPUMP. GND = GNDPUMP
- VCC is voltage for VCC and VCCPUMP. VCC = VCCPUMP
- Do not apply external currents or voltages to any pin not specifically mentioned.
- For the circuit currents, "+" denotes current flowing into the IC, and "−" denotes current flowing out of the IC.

Pin No.	Pin name	Rating	Unit	Note
A2	CP1	—	—	—
A3	CP2	—	—	—
B3	VSS	—	—	—
A4	STANDBY	– 0.3 to VCC(D1) + 0.3	V	*1
C4	HPRIN	VSS(B3) to VCC(D1) + 0.3	V	*1
D3	HPROUT	VSS(B3) to VCC(D1) + 0.3	V	*1
C3	SUB	—	—	—
D2	HPLOUT	VSS(B3) to VCC(D1) + 0.3	V	*1
C1	HPLIN	VSS(B3) to VCC(D1) + 0.3	V	*1
B1	HPCTRL	– 0.3 to VCC(D1) + 0.3	V	*1

Note) *1 : (VCC(D1) + 0.3) V must not be exceeded 3.45 V.

■ Electrical Characteristics at VCC = 3.0 V, VCCPUMP = 3.0 V,
STBY ON : Pin A4 = Pin B1 = Low, STBY OFF : Pin A4 = Pin B1 = High

Note) T_a = 25°C±2°C unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
Circuit current								
1	Circuit current at non-signal 1 (VCC)	IVCC	VCC = 3.0 V, VCCPUMP = 3.0 V Non-signal, STBY = OFF	—	3	4.5	mA	—
2	Circuit current at non-signal 2 (VCCPUMP)	IVCCP	VCC = 3.0 V, VCCPUMP = 3.0 V Non-signal, STBY = OFF	—	5	7.5	mA	—
3	Circuit current at standby mode 1 (VCC)	IVCCST	VCC = 3.0 V, VCCPUMP = 3.0 V Non-signal, STBY = ON	—	0.01	1	µA	—
4	Circuit current at standby mode 2 (VCCPUMP)	IVCCPST	VCC = 3.0 V, VCCPUMP = 3.0 V Non-signal, STBY = ON	—	0.01	1	µA	—
Characteristics of headphone amplifier								
5	Reference output level of R-channel	VHPR	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω	–8.0	–7.0	–6.0	dBV	—
6	Reference output level of L-channel	VHPL	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω	–8.0	–7.0	–6.0	dBV	—
7	Reference output distortion of R-channel	THHPR	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω	—	0.025	0.1	%	—
8	Reference output distortion of L-channel	THHPL	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω	—	0.025	0.1	%	—
9	Reference output noise voltage of R-channel	VNHPR	Non-Signal STBY = OFF A-weighted, load = 32 Ω	—	–101	–95	dBV	—
10	Reference output noise voltage of L-channel	VNHPL	Non-Signal STBY = OFF A-weighted, load = 32 Ω	—	–101	–95	dBV	—
11	Maximum rating output of R-channel	PMHPR	THD = 1%, f = 1 kHz load = 32 Ω	7.5	15	—	mW	—
12	Maximum rating output of L-channel	PMHPL	THD = 1 %, f = 1 kHz load = 32 Ω	7.5	15	—	mW	—
13	Output level at standby mode	VSTHPR	Vin = –15 dBV, f = 1 kHz STBY = ON A-weighted, load = 32 Ω	—	–100	–90	dBV	—
14	Output level at standby mode	VSTHPL	Vin = –15 dBV, f = 1 kHz STBY = ON A-weighted, load = 32 Ω	—	–100	–90	dBV	—

■ Electrical Characteristics (continued) at VCC = 3.0 V, VCCPUMP = 3.0 V,
STBY ON : Pin A4 = Pin B1 = Low, STBY OFF : Pin A4 = Pin B1 = High

Note) T_a = 25°C±2°C unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
Characteristics of headphone amplifier								
15	Cross talk from R-channel to L-channel	CTHPR	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω A-weighted L/R differential	—	–70	–60	dB	—
16	Cross talk from L-channel to R-channel	CTHPL	Vin = –15 dBV, f = 1 kHz STBY = OFF, load = 32 Ω A-weighted L/R differential	—	–70	–60	dB	—
17	Standby control High voltage level	STBLVH	—	1.7	—	—	V	—
18	Standby control Low voltage level	STBLVL	—	—	—	0.3	V	—
19	Headphone control High voltage level	HPSLVH	—	1.7	—	—	V	—
20	Headphone control Low voltage level	HPSLVL	—	—	—	0.3	V	—

■ Electrical Characteristics (Reference values for design) at VCC = 3.0 V, VCCPUMP = 3.0 V,
STBY ON : Pin A4 = Pin B1 = Low, STBY OFF : Pin A4 = Pin B1 = High

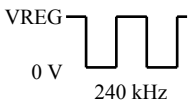
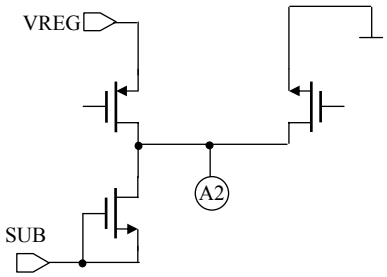
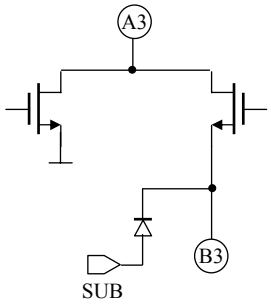
Note) T_a = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, we will respond in good faith to user concerns.

B No.	Parameter	Symbol	Conditions	Reference values			Unit	Notes
				Min	Typ	Max		
21	Output level of R-channel at power supply ripple input	VRHPR	Non-Signal VCC= –29 dBV, f = 1 kHz STBY = OFF, load = 32 Ω A-weighted	—	–90	—	dBV	—
22	Output level of L-channel at power supply ripple input	VRHPL	Non-Signal VCC = –29dBV, f = 1 kHz STBY = OFF, load = 32 Ω A-weighted	—	–90	—	dBV	—

■ Technical Data

- I/O block circuit diagrams and pin function descriptions

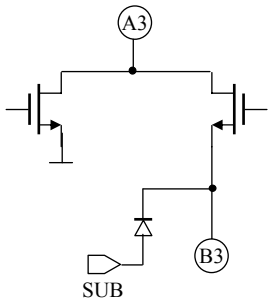
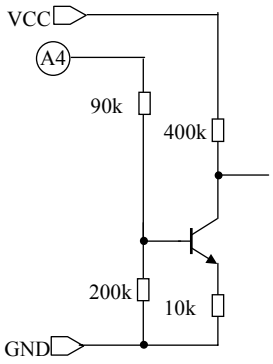
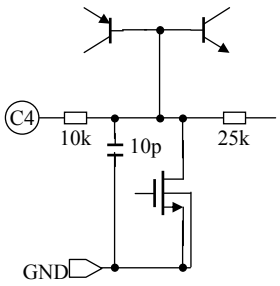
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
A1	VCCPUMP	—	—	Power supply for charge pump
A2	CP1 		—	Connecting terminal for charge pump flying capacitor (plus side)
B2	GNDPUMP	—	—	GND for charge pump
A3	CP2 		—	Connecting terminal for charge pump flying capacitor (minus side)

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

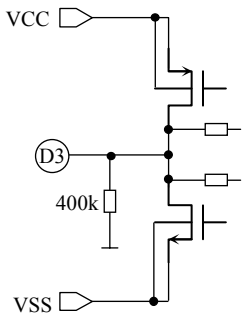
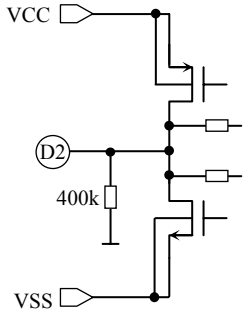
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
B3	VSS		—	Charge pump output
A4	STANDBY		Input Impedance ≅ 90 kΩ	Standby control
C4	HPRIN		Input Impedance ≅ 10 kΩ	Signal input R-channel
D4	GND	—	—	GND

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

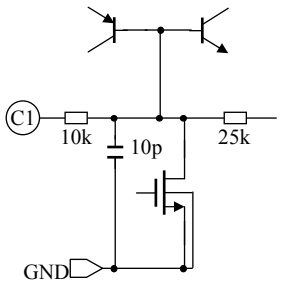
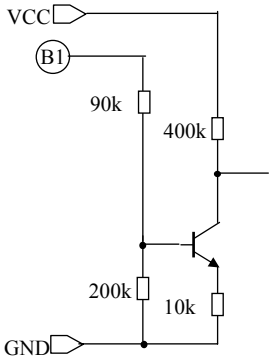
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
D3	HPROUT		Output Impedance ≤ 10 Ω	Headphone output R-channel
C3	SUB	—	—	Substrate level input
C2	GND	—	—	GND
D2	HPLOUT		Output Impedance ≤ 10 Ω	Headphone output L-channel

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
D1	VCC	—	—	Power Supply
C1	HPLIN		Input Impedance ≅ 10 kΩ	Signal input L-channel
B1	HPCTRL		Input Impedance ≅ 90 kΩ	Headphone output control

■ Technical Data (continued)

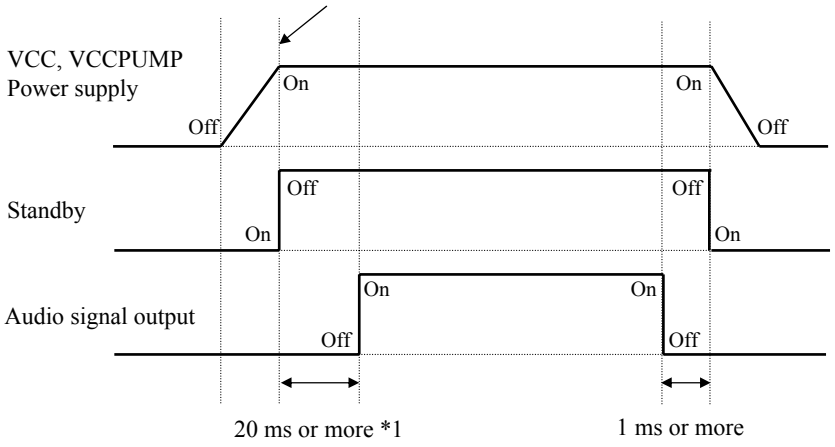
• Power supply sequence

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

The timing control of power On/Off and each logic according to the procedure below should be recommended for the best pop performance caused in switching.

1. The sequence of the power supply and standby

Please turn on the power supply first, and then get Standby Off.



Basic procedure at Power ON

1) Power Off condition
   Standby On
2) Power On
3) Standby Off

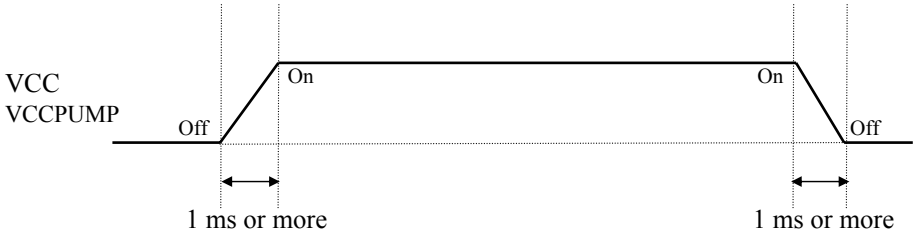
Basic procedure at Power Off

1) Power On condition
   Standby Off
2) Standby On
3) Power Off

Note) *1 : It takes about 20 ms from standby release to signal output.

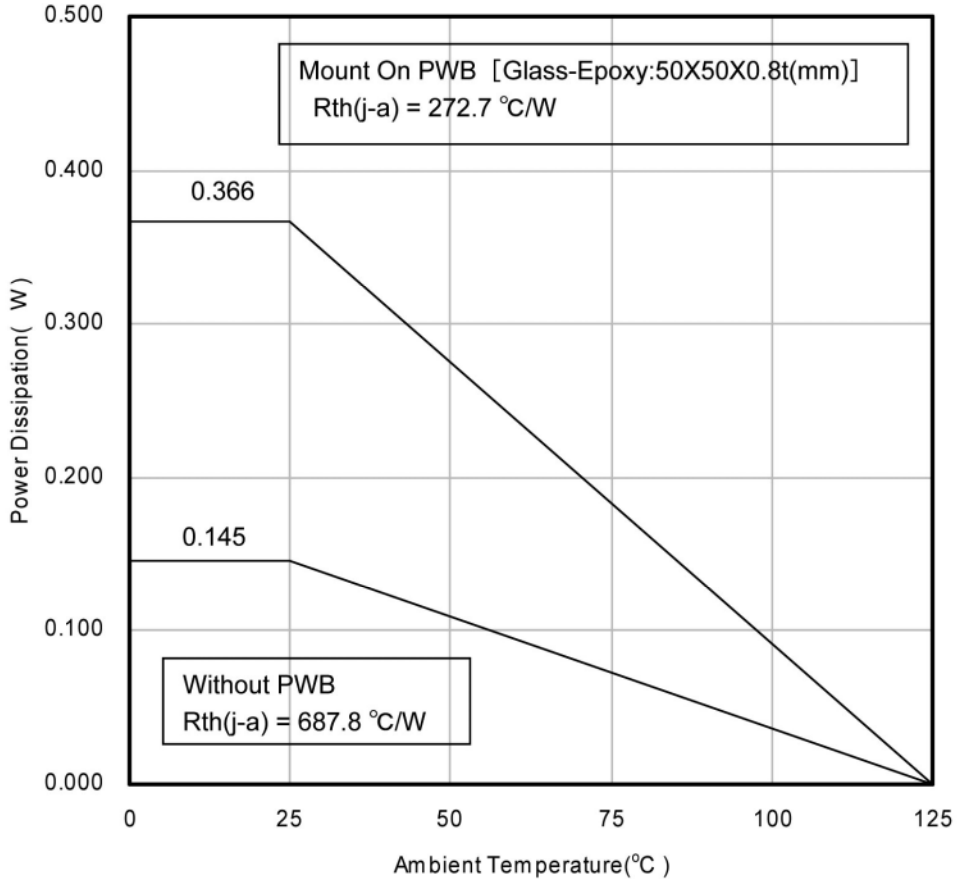
2. Sequence of VCC and VCCPUMP

This IC does not have a rising and falling order in VCC and VCCPUMP. Rising and falling times of them are recommended 1 ms or more.



■ Technical Data (continued)

• P_D — T_a diagram



■ Usage Notes

• Special attention and precaution in using

1. This IC is intended to be used for general electronic equipment [cam corder].
   Consult our sales staff in advance for information on the following applications:
   Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   Any applications other than the standard applications intended.
   (1) Space appliance (such as artificial satellite, and rocket)
   (2) Traffic control equipment (such as for automobile, airplane, train, and ship)
   (3) Medical equipment for life support
   (4) Submarine transponder
   (5) Control equipment for power plant
   (6) Disaster prevention and security device
   (7) Weapon
   (8) Others : Applications of which reliability equivalent to (1) to (7) is required

2. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.

3. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.

4. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.

5. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-V_{CC} short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .
   And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.

6. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
   Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

7. When using the LSI for new models, verify the safety including the long-term reliability for each product.

8. When the application system is designed by using this LSI, be sure to confirm notes in this book.
   Be sure to read the notes to descriptions and the usage notes in the book.

9. Pay attention not to apply any voltage and current to Pins B3(VSS), Pin C3(SUB), Pin A2(capacitor 1 for charge pump) and Pin A3(capacitor 2 for charge pump) from circuits except for the recommended circuit, which might cause breakage and smoke.

10. Please carry out the thermal design with sufficient margin such that the power dissipation will not be exceeded, based on the conditions of power supply, load and ambient temperature. Although indicated also in the column of the maximum rating, the maximum rating becomes an instant and the marginal value which must not exceed. It sufficiently evaluates and I use-wish-do so that it may not exceed certainly. Moreover, do not impress neither voltage nor current to Pin which is not indicated. It may destroy in both cases.

11. For The orders of power-on and power-off, the IC does not have any restrictions on operation. For power-on, Satisfy the waveforms described in Technical Data and Power supply sequence.

■ Usage Notes (continued)

• Special attention and precaution in using (continued)

12. Due to unshielded structure of this IC, under exposure of light, function and characteristic of the product cannot be guaranteed. During normal operation or even under testing condition, please ensure that IC is not exposed to light.

13. Basically, chip surface is ground potential. Please design to ensure no contact between chip surface and metal shielding.

Request for your special attention and precautions in using the technical information and semiconductors described in this book

(1) If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.

(2) The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this book.

(3) The products described in this book are intended to be used for general applications (such as office equipment, communications equipment, measuring instruments and household appliances), or for specific applications as expressly stated in this book.
Consult our sales staff in advance for information on the following applications:
- Special applications (such as for airplanes, aerospace, automotive equipment, traffic signaling equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.

It is to be understood that our company shall not be held responsible for any damage incurred as a result of or in connection with your using the products described in this book for any special application, unless our company agrees to your using the products in this book for any special application.

(4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.

(5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

(6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

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