DACs for Electronic Adjustment

# High-precision 10bit 4ch/6ch D/A Converters

## BU2508FV, BU2507FV

No.11052ECT02

### ●Description

BU2508FV and BU2507FV ICs are high performance 10bit R-2R-type DACs with 4ch and 6ch outputs, respectively. Each channel incorporates a full swing output-type buffer amplifier with high speed output response characteristics, resulting in a greatly shortened wait time. The ICs also utilize the TTL level input method.

### ●Features

1) High performance, multi-channels R-2R-type 10bit D/A converter built-in (BU2508FV: 4 channels, BU2507FV: 6 channels)
2) Full swing output type buffer amplifier incorporated at each output channel
3) The RESET terminal can keep the voltage of all channels within the lower reference voltage range
4) Digital input compatible with TTL levels
5) 14bit 3-line serial data + RESET signal input (address 4bit + data 10bit)
6) Compact package: 14 pins, 0.65mm pitch (SSOP-B14)

### ●Applications

DVDs, CD-Rs, CD-RWs, digital cameras

### ●Lineup

| Parameter | BU2507FV | BU2508FV |
|---|---|---|
| Power source voltage range | 4.5 to 5.5V | 4.5 to 5.5V |
| Number of channels | 6ch | 4ch |
| Differential non linearity error | ±1.0LSB | ±1.0LSB |
| Integral non linearity error | ±3.5LSB | ±3.5LSB |
| Data transfer frequency | 10MHz | 10MHz |
| Package | SSOP-B14 | SSOP-B14 |

### ●Absolute Maximum Ratings (Ta=25℃)

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Power source voltage | VCC | -0.3 to 6.0 | V |
| D/A converter upper standard voltage | VDD | -0.3 to 6.0 | V |
| Input voltage | VIN | -0.3 to 6.0 | V |
| Output voltage | VOUT | -0.3 to 6.0 | V |
| Storage temperature range | $T_{stg}$ | -55 to 125 | ℃ |
| Power dissipation | Pd | 350 * | mW |

* Derated at 3.5mW/℃ at Ta>25℃, mounted on a 70x70x1.6mm FR4 glass epoxy board (copper foil area less than 3%)
Note: These products are not robust against radiation

### ●Recommended Operating Conditions (Ta=25℃)

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Power supply voltage range | VCC | 4.5 to 5.5 | V |
| Operating temperature range | Topr | -30 to 85 | ℃ |

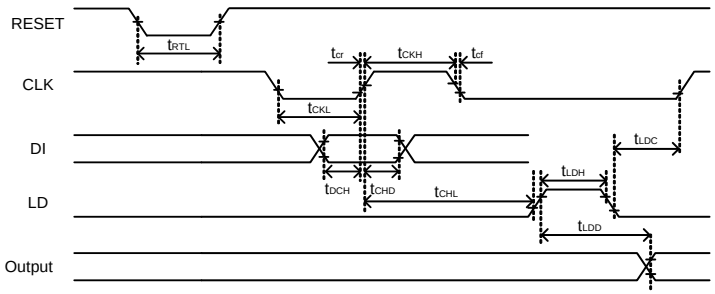
●**Electrical Characteristics** (Unless otherwise specified, VCC=5V, VrefH=5V, VrefL=0V, Ta=25℃)

| Parameter | | Symbol | Limits | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | | MIN. | TYP. | MAX. | | |
| <Digital unit> | | | | | | | |
| Power source current | | ICC | - | 0.85 | 2.8 | mA | At CLK = 10MHz, IAO = 0uA |
| Input leak current | | IILK | -5 | - | 5 | μA | VIN=0 to VCC |
| Input voltage L | | VIL | - | - | 0.8 | V | - |
| Input voltage H | | VIH | 2.0 | - | - | V | - |
| Output voltage L | | VOL | 0 | - | 0.4 | V | IOL=2.5mA |
| Output voltage H | | VOH | 4.6 | - | 5 | V | IOH=-2.5mA |
| <Analog unit> | | | | | | | |
| Consumption current | | IrefH | - | 4.5 | 7.5 | mA | Data condition : at maximum current |
| | | | - | 2.0 | 3.4 | mA(*1) | |
| D/A converter upper standard voltage setting range | | VrefH | 3.0 | - | 5 | V | Outputs does not necessarily take a value in standard voltage setting range. Value that output may take is in the buffer amplifier output voltage range (VO). |
| D/A converter lower standard voltage setting range | | VrefL | 0 | - | 1.5 | V | |
| Buffer amplifier output voltage range | | VO | 0.1 | - | 4.9 | V | IO=±100μA |
| | | | 0.2 | - | 4.75 | | IO=±1.0mA |
| Buffer amplifier output drive range | | IO | -2 | - | 2 | mA | Upper side saturation voltage =0.35V (on full scale setting, current sourcing ) Lower side saturation voltage =0.23V (on zero scale setting, current sinking ) |
| Precision | Differential non-linearity error | DNL | -1.0 | - | 1.0 | LSB | VrefH =4.796V VrefL=0.7V VCC=5.5V (4mV/LSB) No load (IO = +0mA) |
| | Integral non-linearity error | INL | -3.5 | - | 3.5 | | |
| | Zero point error | SZERO | -25 | - | 25 | mV | |
| | Full scale error | SFULL | -25 | - | 25 | | |
| Buffer amplifier output impedance | | RO | - | 5 | 15 | Ω | - |
| Pull-up I/O internal resistance value | | Rup | 12.5 | 25 | 37.5 | kΩ | Input voltage 0V (Resistance value changes according to voltage to be impressed.) |

*1: Value in the case where CH1 ~ CH4 are set to maximum current (after reset)

●**Timing Characteristics** (Unless otherwise specified, VCC=5V, VrefH=5V, VrefL=0V, Ta=25℃)

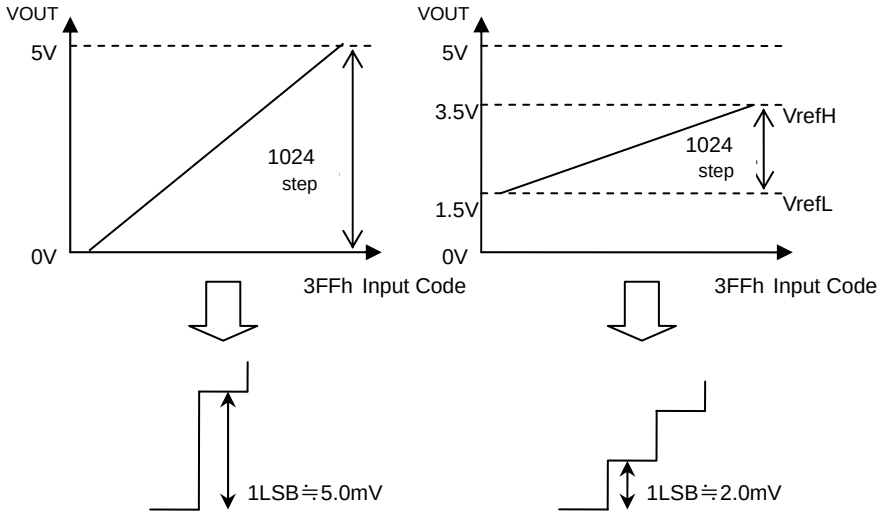
| Parameter | Symbol | Limits | | | Unit | Conditions |
|---|---|---|---|---|---|---|
| | | MIN. | TYP. | MAX. | | Judgment level is 80% / 20% of VCC. |
| Reset L pulse width | tRTL | 50 | - | - | nS | - |
| Clock L pulse width | tCKL | 50 | - | - | | - |
| Clock H pulse width | tCKH | 50 | - | - | | - |
| Clock rise time | tcr | - | - | 50 | | - |
| Clock fall time | tcf | - | - | 50 | | - |
| Data setup time | tDCH | 20 | - | - | | - |
| Data hold time | tCHD | 40 | - | - | | - |
| Load setup time | tCHL | 50 | - | - | | - |
| Load hold time | tLDC | 50 | - | - | | - |
| Load H pulse width | tLDH | 50 | - | - | | - |
| DA output settling time | tLDD | - | 7 | 20 | μS | CL≦100pF, VO:0.5V⇔4.5V . Until output value deference from final value becomes 1/2LSB |




(note) LD signal is level triggered. When LD input is on H level, internal shift-register state is loaded to DAC control latch. Clock transition during LD=H is inhibited.

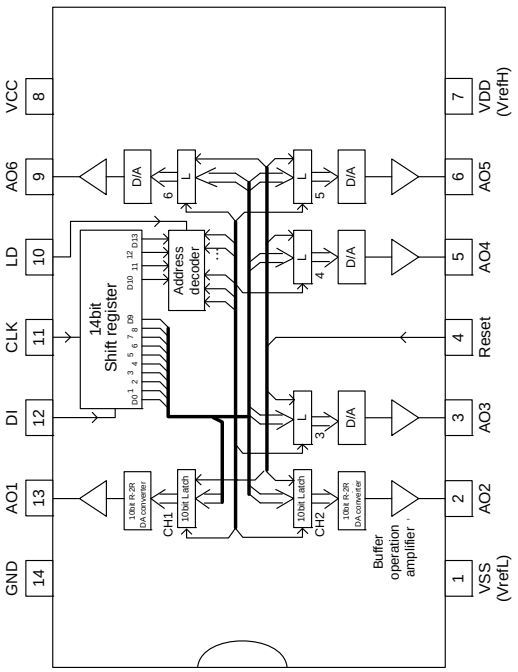
## ●DAC Variable Output Range Function

With the variable output range function, the upper / lower limits of the output voltage as well as the power supply voltage can be set. The upper limit value setting terminal VrefH is used as the power supply terminal, while the lower limit value setting terminal VrefL is used as the GND terminal (1LSB ≒ 5mV). In the example below, VrefH = 3.5V / VrefL = 1.5V. Further adjustments can be made in order to achieve greater accuracy (1LSB ≒ 2mV).

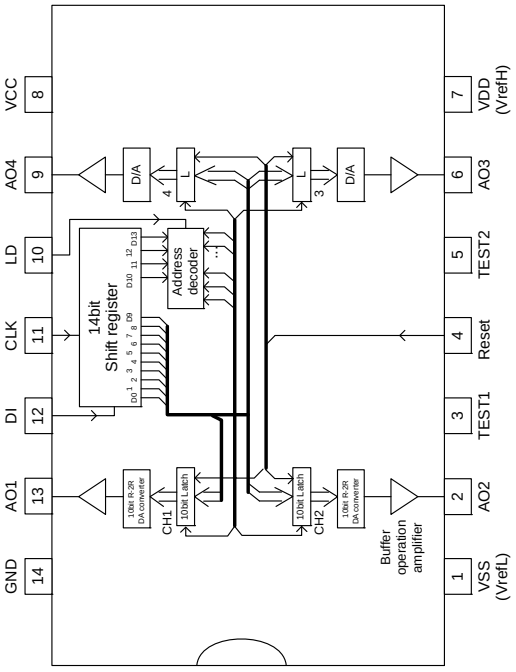



## ●Block Diagrams

BU2507FV




BU2508FV

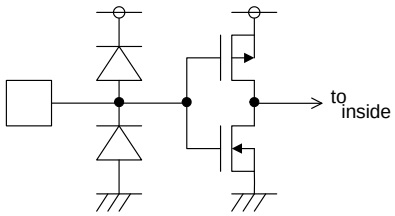
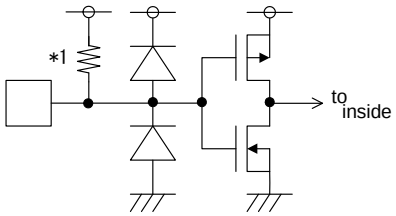
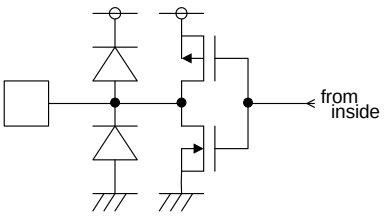
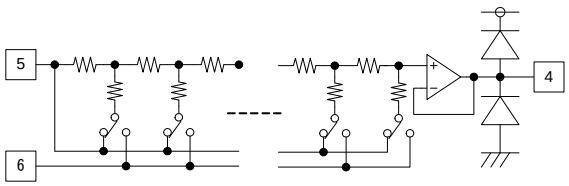


## ●Terminal Description

| No | Terminal name | Analog / Digital | I/O | Description of terminal | Equivalent circuit |
|---|---|---|---|---|---|
| 1 | VSS | Analog | - | DA converter lower standard voltage (VrefL) input terminal | 6 |
| 2 | AO2 | Analog | O | 10bit D/A output (CH2) | 4 |
| 3 | AO3(TEST1) | Analog | O | 10bit D/A output (CH3) (BU2508FV : test terminal) | 4 |
| 4 | Reset | Digital | I | All ch analog output L fixed | 2 |
| 5 | AO4(TEST2) | Digital | I | 10bit D/A output (CH4) (BU2508FV : test terminal) | 4 |
| 6 | AO5 (AO3) | Analog | O | 10bit D/A output (CH5) (BU2508FV : 10bit D/A output (CH3)) | 4 |
| 7 | VDD | Analog | - | DA converter upper standard voltage (VrefH) input terminal | 5 |
| 8 | VCC | - | - | Power source terminal | - |
| 9 | AO6 (AO4) | Analog | O | 10bit D/A output (CH6) (BU2508FV : 10bit D/A output (CH4)) | 4 |
| 10 | LD | Digital | I | When High level is input to LD terminal, the value of 14bit shift register is loaded to decoder and D/A output register. | 1 |
| 11 | CLK | Digital | I | Shift clock input terminal. At rise of shift clock, the signal from DI terminal is input to 14bit shift register. | 1 |
| 12 | DI | Digital | I | Serial data input terminal. Serial data whose data length is 14bit (address 4bit + data 10bit) is input. | 1 |
| 13 | AO1 | Analog | O | 10bit D/A output (CH1) | 4 |
| 14 | GND | - | - | GND terminal | - |

*In the case of BU2508FV, be sure to open TEST1 and TEST2 terminals.

## ●Equivalent Circuits

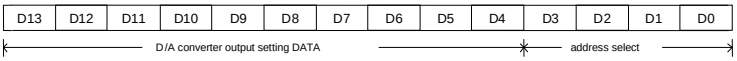
| | | | |
|---|---|---|---|
| 1 |  | 2 |  |
| 3 |  | 4・5・6 |  |

*1: 25kΩ at Vcc = 5.0V (changes according to voltage supplied)

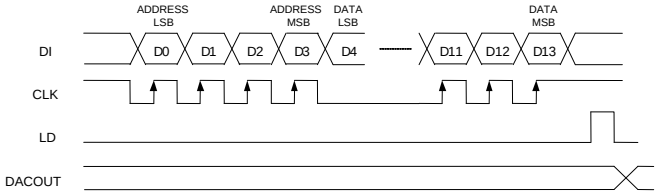
## ●Command Sending

1) In the case of BU2507FV

(1) Data format [data : LSB first]




(2) Data timing diagram

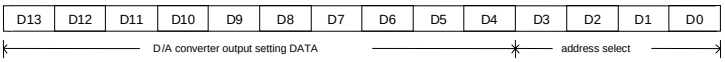



| D3 | D2 | D1 | D0 | Address selection |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Inconsequential |
| 0 | 0 | 0 | 1 | Inconsequential |
| 0 | 0 | 1 | 0 | AO1 selection |
| 0 | 0 | 1 | 1 | AO2 selection |
| 0 | 1 | 0 | 0 | Inconsequential |
| 0 | 1 | 0 | 1 | AO3 selection |
| 0 | 1 | 1 | 0 | AO4 selection |
| 0 | 1 | 1 | 1 | Inconsequential |
| 1 | 0 | 0 | 0 | AO5 selection |
| 1 | 0 | 0 | 1 | AO6 selection |
| 1 | 0 | 1 | 0 | Inconsequential |
| 1 | 0 | 1 | 1 | Inconsequential |
| 1 | 1 | 0 | 0 | Inconsequential |
| 1 | 1 | 0 | 1 | Inconsequential |
| 1 | 1 | 1 | 0 | Inconsequential |
| 1 | 1 | 1 | 1 | Inconsequential |

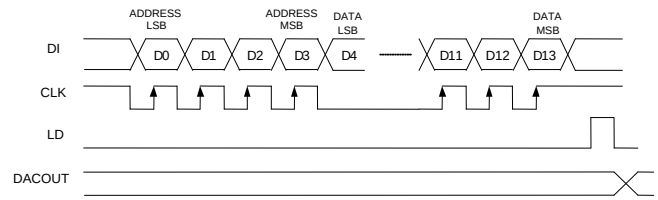
| D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D/A output (VrefH=VDD, VrefL=VSS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (VrefH-VrefL)/1024×1+VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | (VrefH-VrefL)/1024×2+VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | (VrefH-VrefL)/1024×3+VrefL |
| : | : | : | : | : | : | : | : | : | : | : |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | (VrefH-VrefL)/1024×1022+VrefL |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | (VrefH-VrefL)/1024×1023+VrefL |

2) In the case of BU2508FV

(1) Data format [Data: LSB first ]




(2) Data timing diagram




| D3 | D2 | D1 | D0 | Address selection |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Don't Care |
| 0 | 0 | 0 | 1 | Don't Care |
| 0 | 0 | 1 | 0 | AO1 selection |
| 0 | 0 | 1 | 1 | AO2 selection |
| 0 | 1 | 0 | 0 | Don't Care |
| 0 | 1 | 0 | 1 | Don't Care |
| 0 | 1 | 1 | 0 | Don't Care |
| 0 | 1 | 1 | 1 | Don't Care |
| 1 | 0 | 0 | 0 | AO3 selection |
| 1 | 0 | 0 | 1 | AO4 selection |
| 1 | 0 | 1 | 0 | Don't Care |
| 1 | 0 | 1 | 1 | Don't Care |
| 1 | 1 | 0 | 0 | Don't Care |
| 1 | 1 | 0 | 1 | Don't Care |
| 1 | 1 | 1 | 0 | Don't Care |
| 1 | 1 | 1 | 1 | Don't Care |

| D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D/A output (VrefH=VDD, VrefL=VSS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (VrefH-VrefL)/1024×1+VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | (VrefH-VrefL)/1024×2+VrefL |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | (VrefH-VrefL)/1024×3+VrefL |
| : | : | : | : | : | : | : | : | : | : | : |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | (VrefH-VrefL)/1024×1022+VrefL |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | (VrefH-VrefL)/1024×1023+VrefL |

## ●Electrical Characteristics Curves

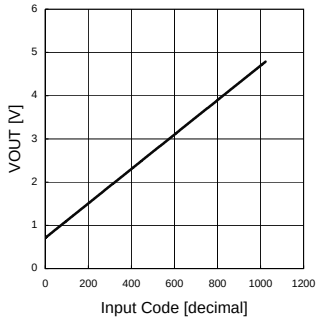



Fig.1 Output voltage linearity (-30℃)

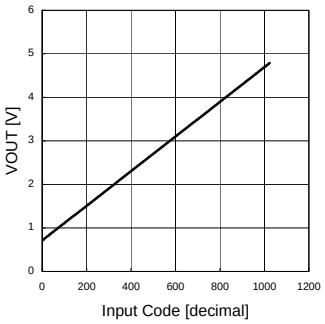



Fig.2 Output voltage linearity (25℃)

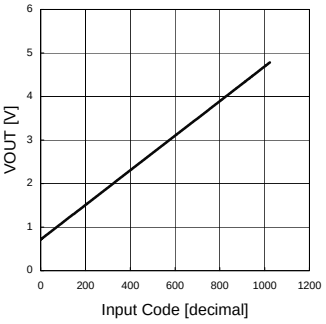



Fig.3 Output voltage linearity (85℃)

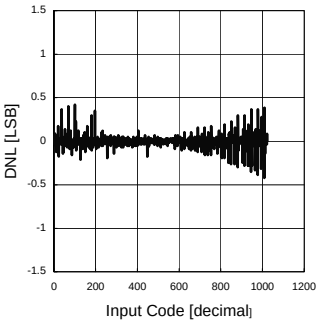



Fig.4 Differential linearity error (-30℃)

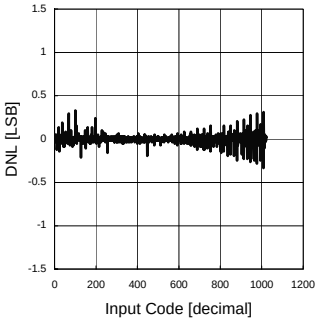



Fig.5 Differential linearity error (25℃)

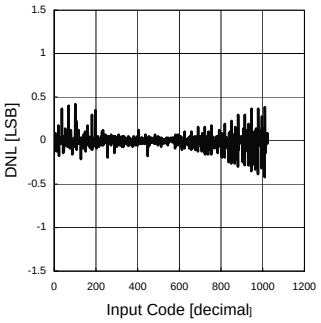



Fig.6 Differential linearity error (85℃)

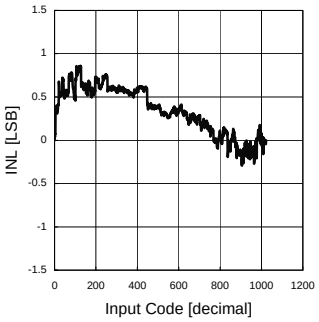



Fig.7 Integral linearity error (-30℃)

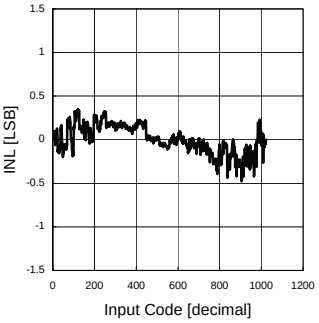



Fig.8 Integral linearity error (25℃)

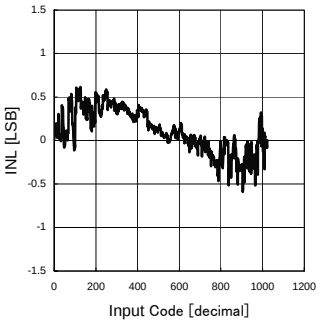



Fig.9 Integral linearity error (85℃)

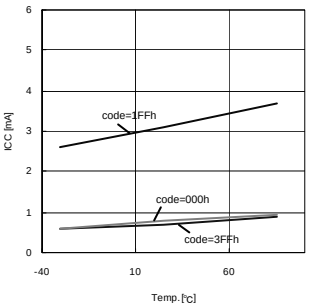



Fig.10 Circuit current temperature characteristic

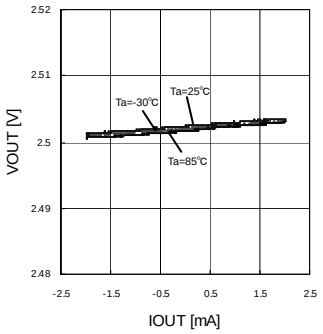



Fig.11 Output load fluctuation characteristic (input code : 1FFh)

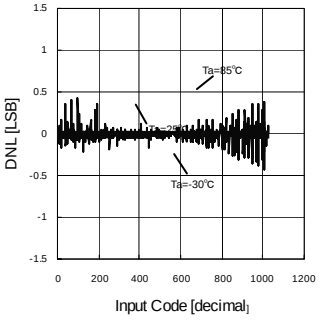
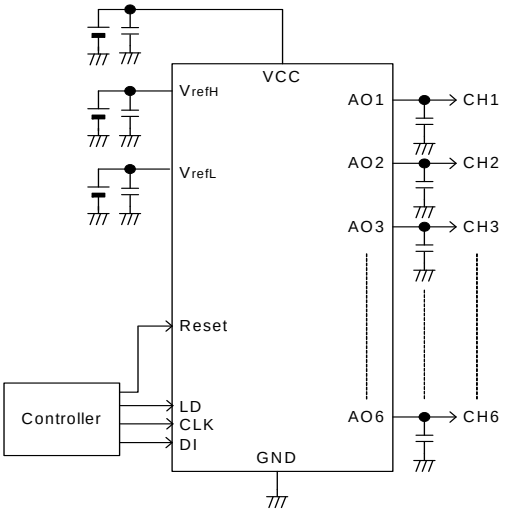



Fig.12 Pull-up built in resistance characteristic

●Standard Example Application Circuit




●Notes for use

(1) The electrical characteristic and data on graphs for this datasheet, are typically evaluated value, and not guaranteed.

(2) We suppose that application circuits are recommendable, but please make sufficient check for characteristics with the actual application. In case that value of external component for this IC is changed, please check characteristic, not only static but also transient.

(3) About absolute maximum ratings
If operation condition is over the absolute maximum ratings, supply voltage or other operation range, IC will be broken. Please don't apply any voltage or temperature over the absolute maximum ratings. If application have possibilities of become over the absolute maximum ratings, please take safety measures by using fuse and so on. Not to over absolute maximum ratings of IC.

(4) GND voltage
Please keep GND voltage lowest of any other terminal of this IC. Please confirm other terminal voltages is not lower than GND.

(5) Thermal design
Please making a thermal design that allows for a sufficient margin in light of the power dissipation in actual operating condition.

(6) About terminals short and wrong mounting
Please pay full attention to the IC direction and displacement when mounting IC on PCB. If you assemble them by mistake and electrify it, IC might be destroyed. And it is happen to short among IC terminals or terminals and power supply, by foreign substance.

(7) About operation in strong electromagnetic field
If you use it in strong electromagnetic field, please evaluate fully as there is a possibility of malfunction.

(8) Place a bypass capacitor as close as possible between each power supply terminal and ground in order to prevent deterioration of the D/A conversion accuracy due to ripple and noise signals from power supply or GND.

(9) A capacitor should be inserted between the analog output and ground in order to eliminate noise.
A capacitance up to 100pF is recommended (including the capacitance of the wire).

●Ordering part number

| B | U | 2 | 5 | 0 | 8 | F | V | - | E | 2 |
|---|---|---|---|---|---|---|---|---|---|---|

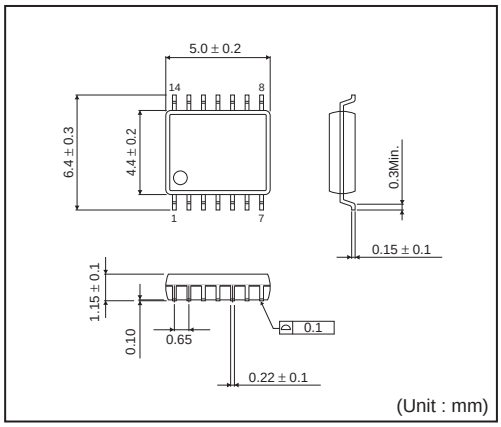
Part No.

Part No.
2507
2508

Package
FV: SSOP-B14

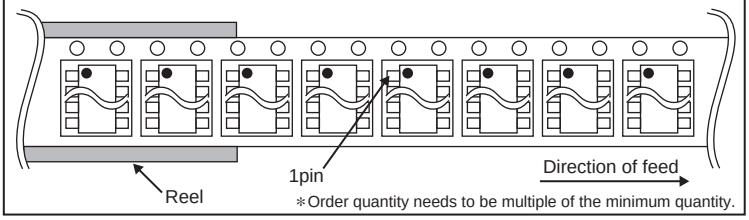
Packaging and forming specification
E2: Embossed tape and reel

**SSOP-B14**




<Tape and Reel information>

| | |
|---|---|
| Tape | Embossed carrier tape |
| Quantity | 2500pcs |
| Direction of feed | E2<br>( 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.

# Notice

## Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN | USA | EU | CHINA |
|---|---|---|---|
| CLASSⅢ | CLASSⅢ | CLASSⅡb | CLASSⅢ |
| CLASSⅣ | | CLASSⅢ | |

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including $Cl_2$, $H_2S$, $NH_3$, $SO_2$, and $NO_2$
   [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

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

### Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

### Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

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.

### Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

### Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

### Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

### Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data. ROHM shall not be in any way responsible or liable for infringement of any intellectual property rights or other damages arising from use of such information or data.:

2. No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the information contained in this document.

### Other Precaution

1. This document may not be reprinted or reproduced, in whole or in part, without prior written consent of ROHM.

2. The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.

3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.

4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

## General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

3. The information contained in this document is provided on an "as is" basis and ROHM does not warrant that all information contained in this document is accurate and/or error-free. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties resulting from inaccuracy or errors of or concerning such information.