### Serial-in / Parallel-out Driver Series

# 2-input I$^2$C-bus
# Serial in/Parallel out Drivers

## BU2098F

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### Description

BU2098F is an open drain output driver.It incorporates a built-in shift register and a latch circuit to control a maximum of 8 outputs by a 2-line interface, linked to a microcontroller.
An open drain output provides maximum 25mA current.

### Key Specifications

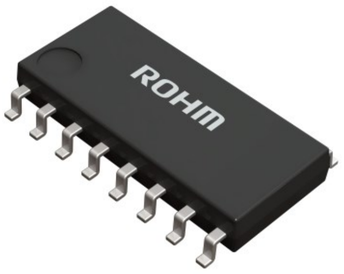
- Power supply voltage range: 2.7V to 5.5V
- Output voltage: 0V to 15V
- Operating temperature range: -40℃ to +85℃

### Features

- LED can be driven directly
- 8 Bit parallel output
- This product can be operated on low voltage
- Compatible with I$^2$C-bus
  *I$^2$C-bus is a trademark of NXP Semiconductors.

### Package

| | |
|---|---|
| | W(Typ) x D(Typ) x H(Max) |
| SOP16 | 10.00mm x 6.20mm x 1.71mm |

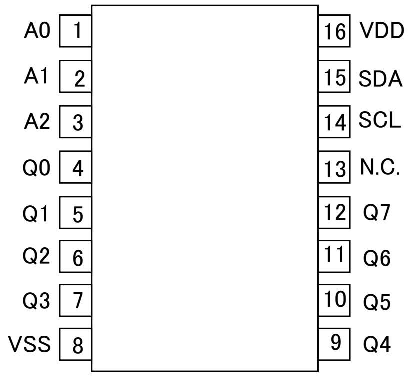


### Applications

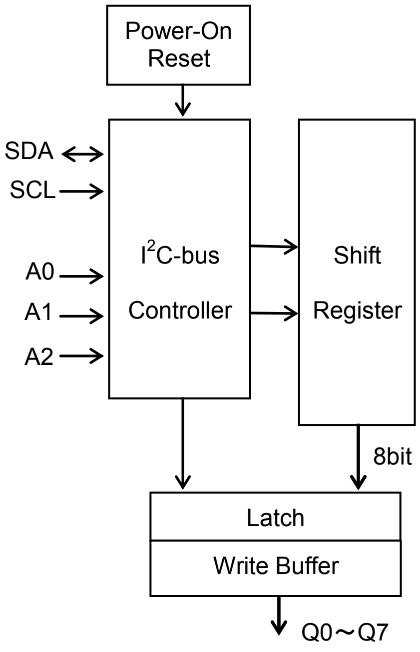
- Drive of LED
- Drive of Solenoid
- Drive of Relay

### Pin Configurations

(Top View)



### Block Diagrams



○Product structure：Silicon monolithic integrated circuit ○This product has no designed protection against radioactive rays

## Pin Descriptions

| Pin No. | Pin Name | I/O | Function |
|---|---|---|---|
| 1 | A0 | I | Address input (internally pull-up) |
| 2 | A1 | I | |
| 3 | A2 | I | |
| 4 | Q0 | O | Open drain output |
| 5 | Q1 | | |
| 6 | Q2 | | |
| 7 | Q3 | | |
| 8 | $V_{SS}$ | - | Ground |
| 9 | Q4 | O | Open drain output |
| 10 | Q5 | | |
| 11 | Q6 | | |
| 12 | Q7 | | |
| 13 | N.C. | - | Non connected |
| 14 | SCL | I | Serial clock input |
| 15 | SDA | I/O | Serial data input/output |
| 16 | $V_{DD}$ | - | Power supply |

## Absolute Maximum Ratings

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Power Supply Voltage | $V_{DD}$ | -0.5 to +7.0 | V |
| Input Voltage | $V_{IN}$ | -0.5 to $V_{DD}$+0.5 | V |
| Output Voltage | $V_O$ | $V_{SS}$ to +18.0 | V |
| Operating Temperature | $T_{opr}$ | -40 to +85 | °C |
| Storage Temperature | $T_{stg}$ | -55 to +125 | °C |
| Power Dissipation | $P_D$ | 0.30 (Note 1) | W |

(Note 1) Mounted on 70mm x 70mm x 1.6mm glass epoxy board. Reduce 3.0mW per 1°C above 25°C.

**Caution:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

## Recommended Operating Conditions ($T_A$=25℃, $V_{SS}$=0V)

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Power Supply Voltage | $V_{DD}$ | +2.7 to +5.5 | V |
| Output Voltage | $V_O$ | 0 to +15 | V |

## Electrical Characteristics

(unless otherwise noted, $V_{DD}$=5V, $V_{SS}$=0V, $T_A$ =25℃)

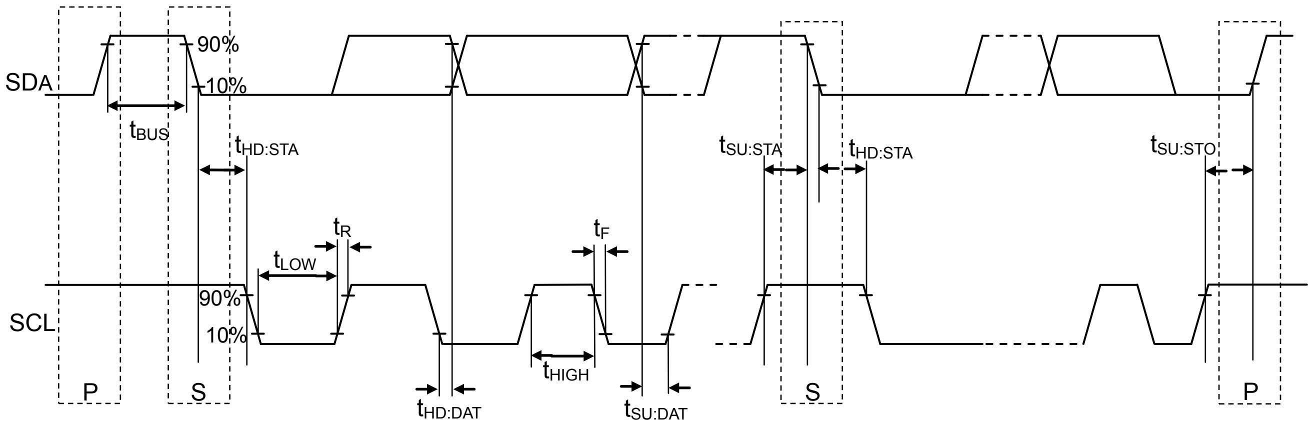
| Parameter | Symbol | Limits | | | Unit | Condition |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| Input High-level voltage | $V_{IH}$ | 0.7$V_{DD}$ | - | - | V | |
| Input Low-level voltage | $V_{IL}$ | - | - | 0.3$V_{DD}$ | V | |
| Output Low-level voltage | $V_{OL}$ | - | - | 0.4 | V | $I_{OUT}$=10mA |
| Input Low-level current | $I_{IL}$ | - | - | 2.0 | µA | $V_{IN}$=0 |
| Input High-level current | $I_{IH}$ | - | - | -2.0 | µA | $V_{IN}$=$V_{DD}$ |
| Output leakage current | $I_{OZ}$ | - | - | ±5.0 | µA | Output=High impedance<br>$V_{OUT}$=$V_{DD}$ |
| Static dissipation current | $I_{DD}$ | - | - | 2.0 | µA | |

Timing Characteristics

(Unless otherwise noted, $V_{DD}$=5V, $V_{SS}$=0V, $T_A$ =25℃)

| Parameter | Symbol | Fast mode $I^2C$-bus | | Standard mode $I^2C$-bus | | Unit |
|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | |
| SCL clock frequency | $f_{SCL}$ | 0 | 400 | 0 | 100 | kHz |
| Bus free time between start-stop condition | $t_{BUS}$ | 1.3 | - | 4.7 | - | µs |
| Hold time start condition | $t_{HD:STA}$ | 0.6 | - | 4.0 | - | µs |
| Low period of the SCL clock | $t_{LOW}$ | 1.3 | - | 4.7 | - | µs |
| High period of the SCL clock | $t_{HIGH}$ | 0.6 | - | 4.0 | - | µs |
| Set up time Re-start condition | $t_{SU:STA}$ | 0.6 | - | 4.7 | - | µs |
| Data hold time | $t_{HD:DAT}$ | 0 | - | 0 | - | µs |
| Data set up time | $t_{SU:DAT}$ | 100 | - | 250 | - | ns |
| Rise time of SDA and SCL | $t_R$ | 20+0.1×$C_b$ | 300 | - | 1000 | ns |
| Fall time of SDA and SCL | $t_F$ | 20+0.1×$C_b$ | 300 | - | 300 | ns |
| Set up time stop condition | $t_{SU:STO}$ | 0.6 | - | 4.0 | - | µs |
| Capacitive load for SDA line and SCL line | $C_b$ | - | 400 | - | 400 | pF |

Waveform of Timing Characteristics



S:Start Condition
P:Stop Condition

Figure 1. Timing chart (SDA, SCL)

## Test Circuits

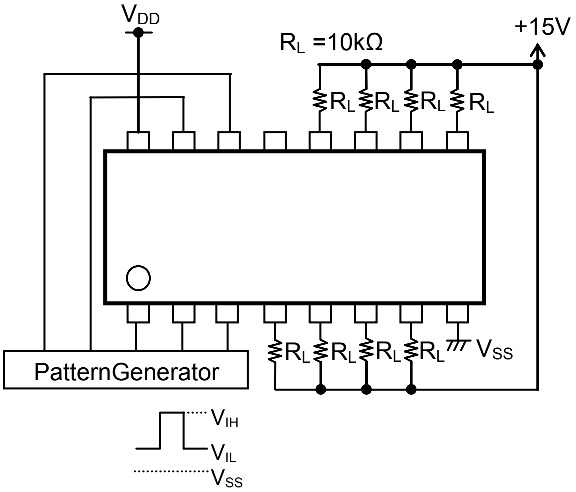


Figure 2. Test Circuit of Input H/LVoltage

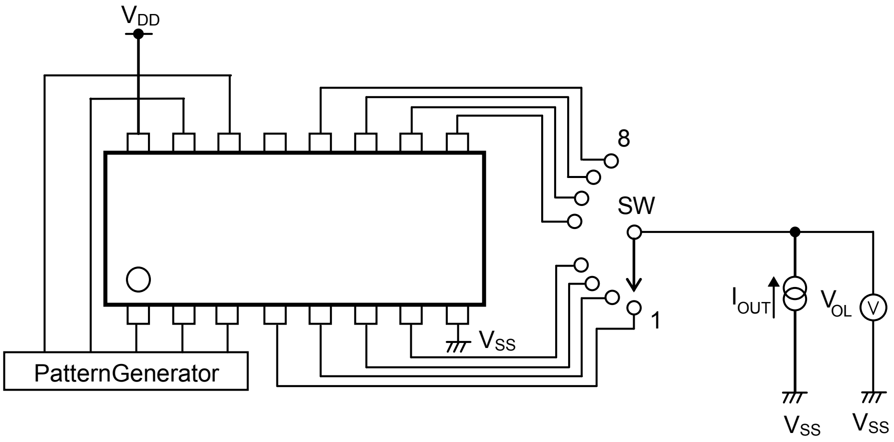


Figure 3. Test Circuit of Output L Voltage

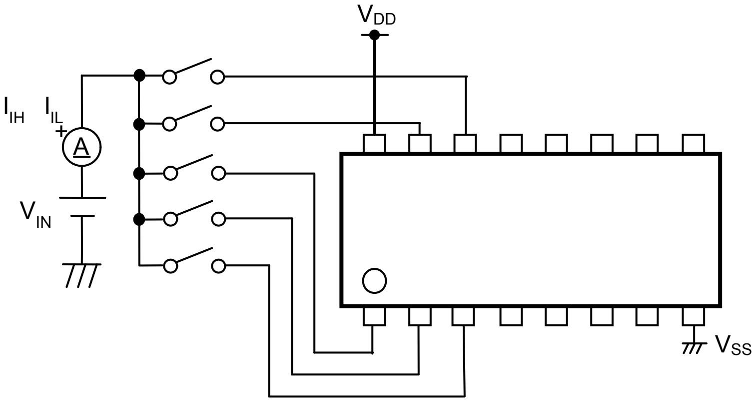


Figure 4. Test Circuit of Input H/LCurrent

## Test Circuit - continued

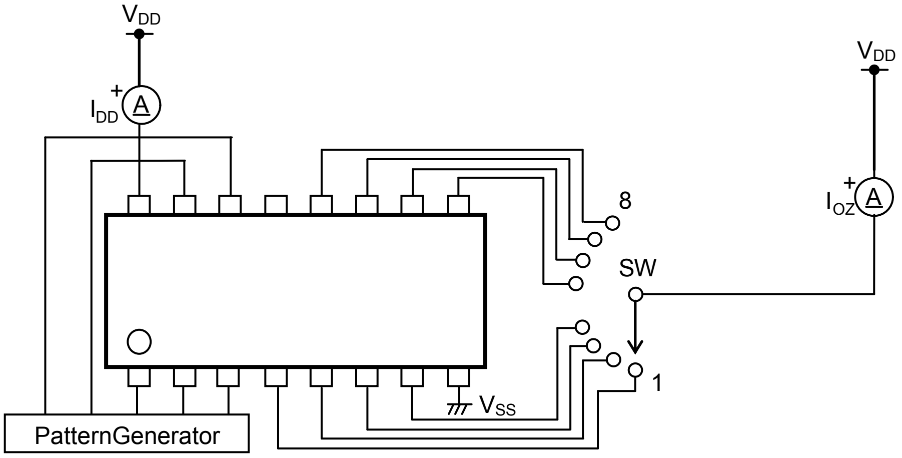


Figure 5. Test Circuit of Output Leak Current / Static Dissipation Current

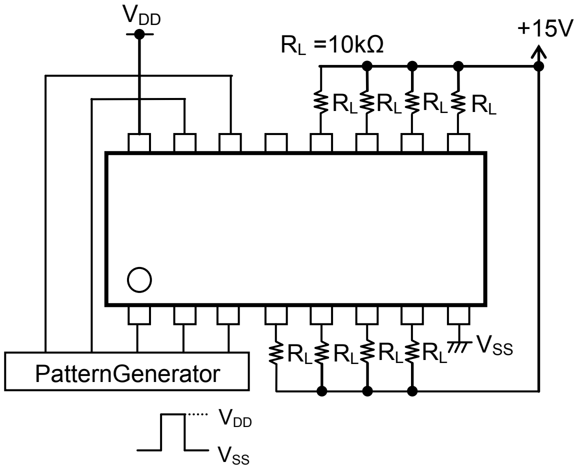


Figure 6. Test Circuit of Timing Characteristics

## Power Dissipation

Power dissipation(total loss) indicates the power that can be consumed by IC at $T_A$=25°C(normal temperature). IC is heated when it consumed power, and the temperature of IC chip becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing process, and consumable power is limited. Power dissipation is determined by the temperature allowed in IC chip(maximum junction temperature) and thermal resistance of package(heat dissipation capability). The maximum junction temperature is typically equal to the maximum value in the storage temperature range. Heat generated by consumed power of IC radiates from the mold resin or lead frame of the package. The parameter which indicates this heat dissipation capability(hardness of heat release)is called thermal resistance, represented by the symbol $\theta_{JA}$ (°C/W).The temperature of IC inside the package can be estimated by this thermal resistance. Figure 11 shows the model of thermal resistance of the package. Thermal resistance $\theta_{JA}$, ambient temperature $T_A$, maximum junction temperature $T_{Jmax}$, and power dissipation $P_D$ can be calculated by the equation below:

$$\theta_{JA} = (T_{Jmax} - T_A) / P_D \qquad (°C/W)$$

Derating curve in Figure 12 indicates power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient is determined by thermal resistance $\theta_{JA}$. Thermal resistance $\theta_{JA}$ depends on chip size, power consumption, package, ambient temperature, package condition, wind velocity, etc even when the same of package is used. Thermal reduction curve indicates a reference value measured at a specified condition.

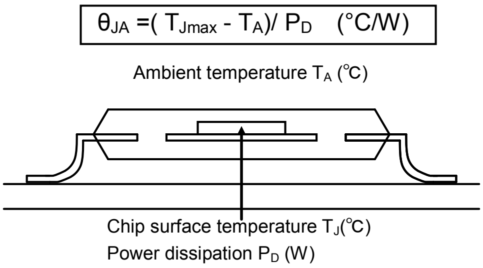


Figure 7. Thermal resistance

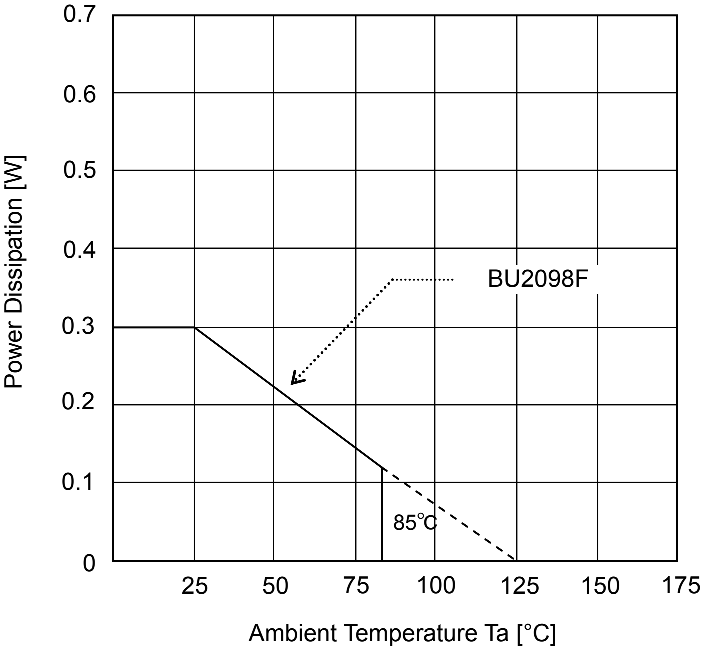


Figure 8. Derating Curve

## Function

1. Serial Interfacce

1.1 Start condition

The start condition is a “HIGH” to “LOW” transition of the SDA line while SCL is “HIGH”.

1.2 Stop condition

The stop condition is a “LOW” to “HIGH” transition of the SDA line while SCL is “HIGH”.

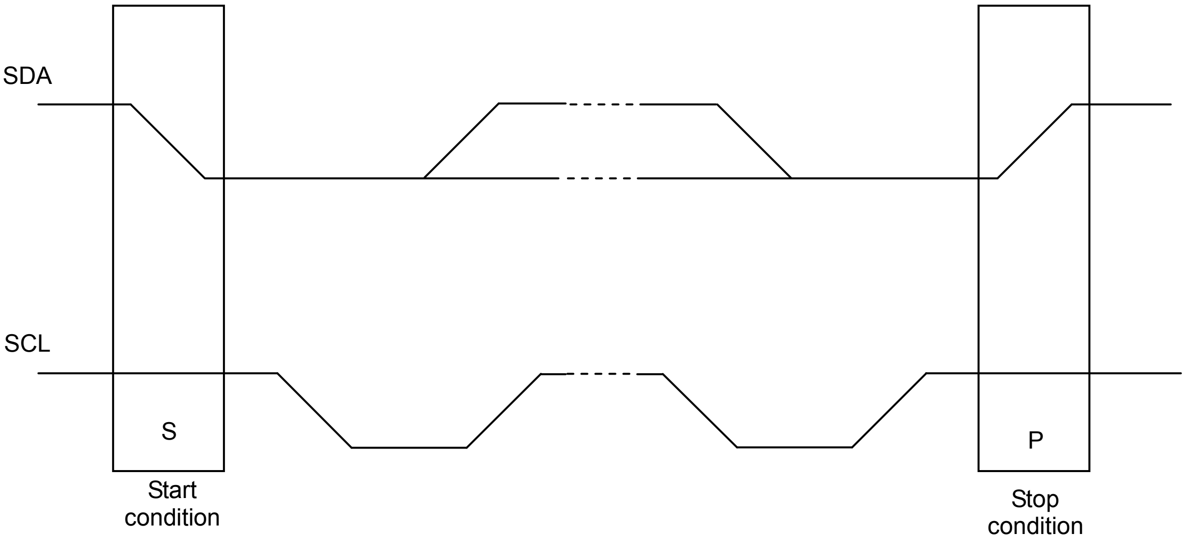


Figure 9. Start / Stop condition

1.3 Acknowledge

The master (μp) puts a resistive “HIGH” level on the SDA line during the acknowledge clock pulse. The peripheral (audio processor) that acknowledge has to pull-down (“LOW”) the SDA line during the acknowledge clock pulse, so that the SDA line is stable “LOW” during this clock pulse.

The slave which has been addressed has to generate an acknowledgement after the reception of each byte, otherwise the SDA line remains at the “HIGH” level during the ninth clock pulse time. In this case the master transmitter can generate the STOP information in order to abort the transfer.

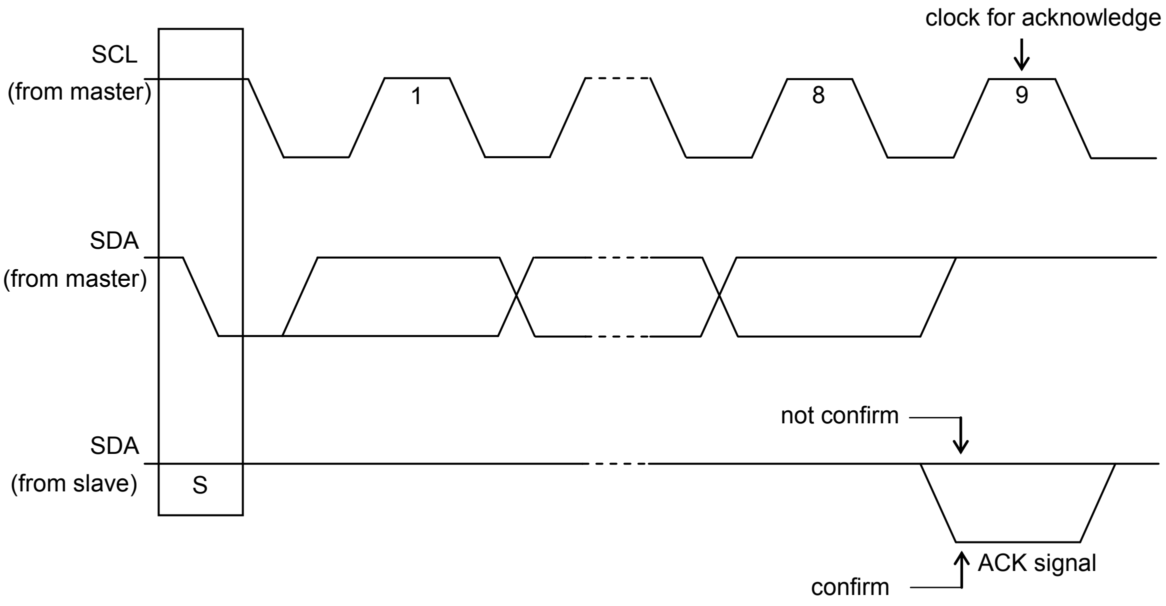


Figure 10. Acknowledge

## Function – continued

### 1.4 Write DATA

Send the stave address from master following the start condition (S). This address consists of 7 bits. The left 1 bit (the foot bit) is fixed “0”. The stop condition (P) is needed to finish the data transferred. But the re-send starting condition (Sr) enables to transfer the data without STOP (P).

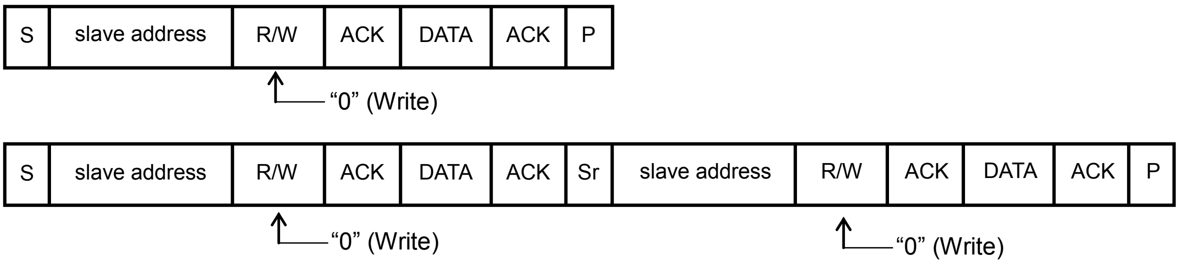


Figure 11. DATA transmit

### 1.5 Data format

The format is following.

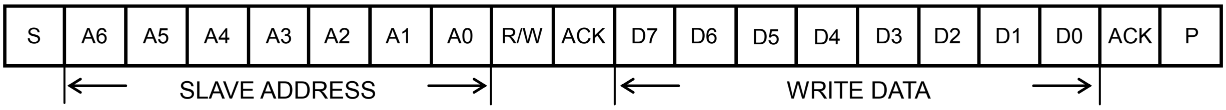


Figure 12. Data format

Table 1. for WRITE format

| | | |
|---|---|---|
| Slave address | A0 to A2 | Each bit can be defined by the input levels of pins A0 to A3. |
| | A3 to A6 | These 4 bits are fixed. |
| | R/W | “0” |
| Write Data | D0 to D7 | Write “1” to D0 makes Q0 pin High-impedance. And write “0” makes Q0 pin LOW. D[1:7] and Q[1:7] are same as D0 and Q0. |

Table 2. for (A2, A1, A0) to SLAVE ADDRESS

| A6 | A5 | A4 | A3 | A2 | A1 | A0 | Slave address |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 38H |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 39H |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 3AH |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 | 3BH |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 3CH |
| 0 | 1 | 1 | 1 | 1 | 0 | 1 | 3DH |
| 0 | 1 | 1 | 1 | 1 | 1 | 0 | 3EH |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3FH |

Fixed for BU2098F ←→ (A6–A3)

Defined by external pin A0～A2 ←→ (A2–A0)

### Function – continued

2. Function of Power Supply is turning ON

2.1 Reset Condition

After power on reset, open drain outputs of Q0 to Q7 pins are ON condition.
Then, the outputs becomes Low voltage when pull-up resistor is connected .

2.2 Rising Time of Power Supply

$V_{DD}$ must rise within 10ms. ($t_{START}$)
If the rise time would exceed 10ms, it is afraid not to reset .

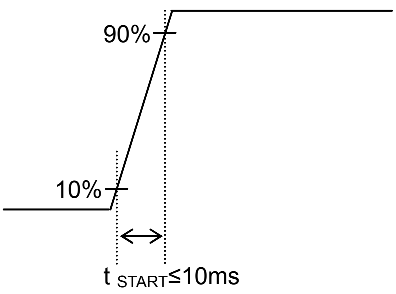


Figure 13. Rising time of power supply

### Timing Chart

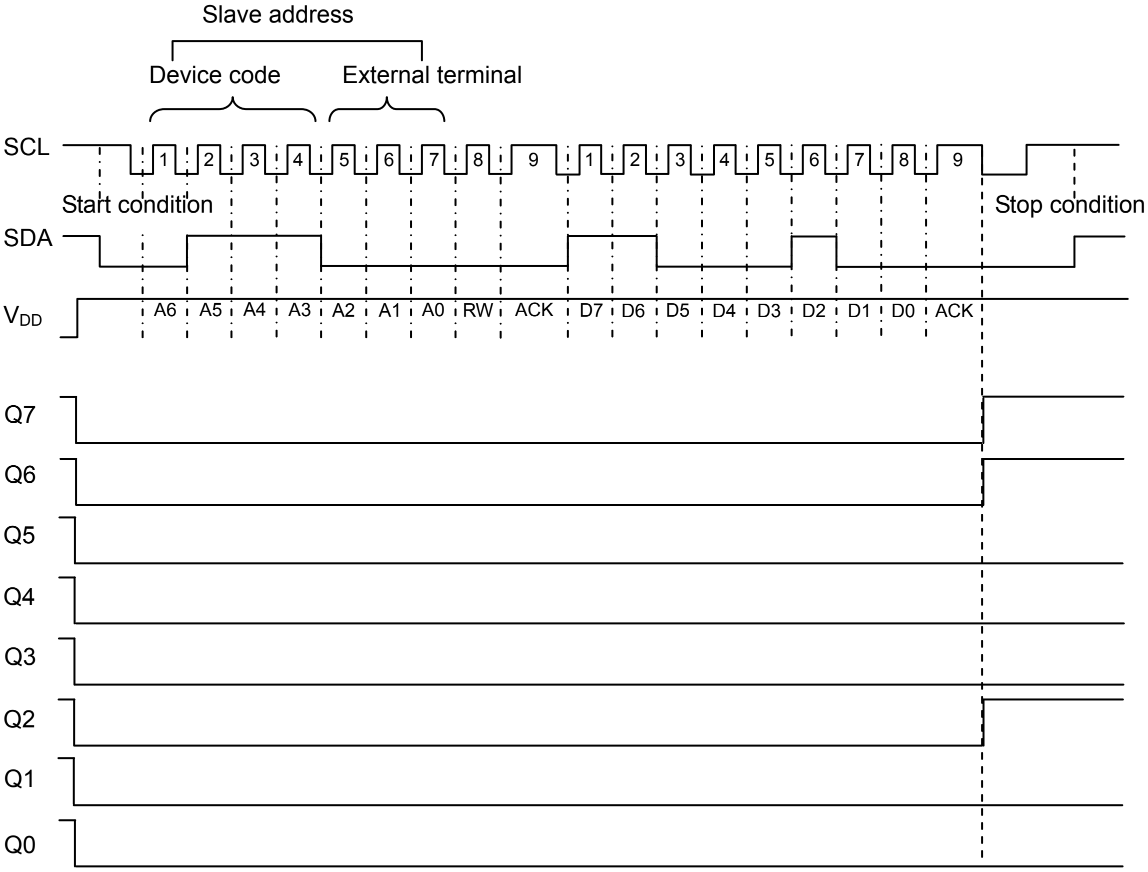
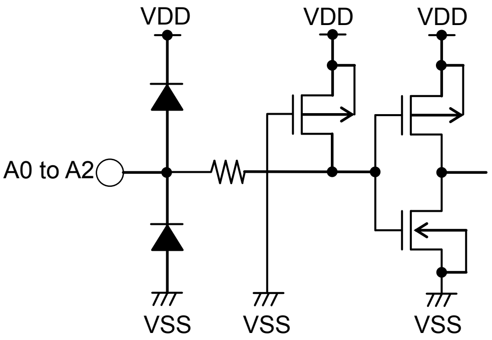
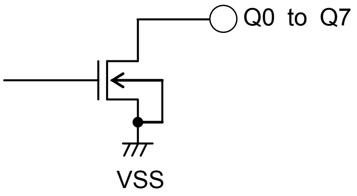
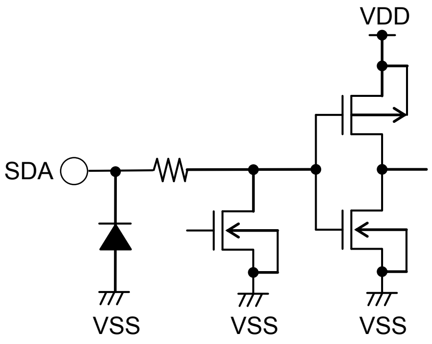
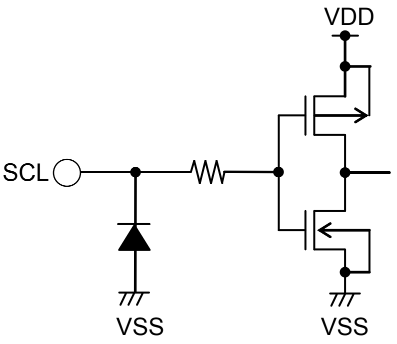


Diagram shows a status where a pull-up resistor is connected to open drain output.

Figure 14. Timing chart

## I/O Equivalence Circuits

| A0 to A2 | Q0 to Q7 |
|---|---|
|  |  |
| SDA | SCL |
|  |  |

## Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Thermal Consideration**
   Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the $P_D$ rating.

6. **Recommended Operating Conditions**
   These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. **Operation Under Strong Electromagnetic Field**
   Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. **Inter-pin Short and Mounting Errors**
    Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

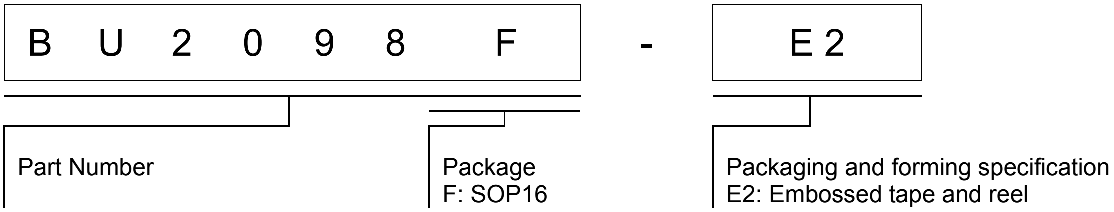
11. **Unused Input Pins**
    Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

## Operational Notes - continued

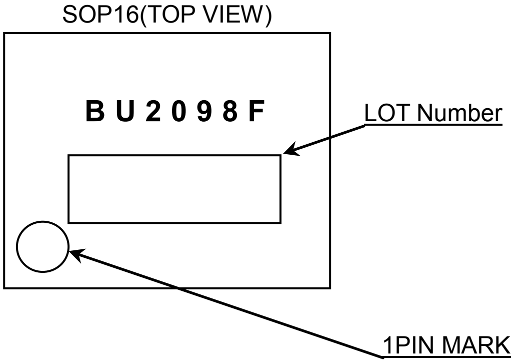
12. **Regarding the Input Pin of the IC**
    In the construction of this IC, P-N junctions are inevitably formed creating parasitic diodes or transistors. The operation of these parasitic elements can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions which cause these parasitic elements to operate, such as applying a voltage to an input pin lower than the ground voltage should be avoided. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. Even if the power supply voltage is applied, make sure that the input pins have voltages within the values specified in the electrical characteristics of this IC.

13. **Ceramic Capacitor**
    When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

## Ordering Information

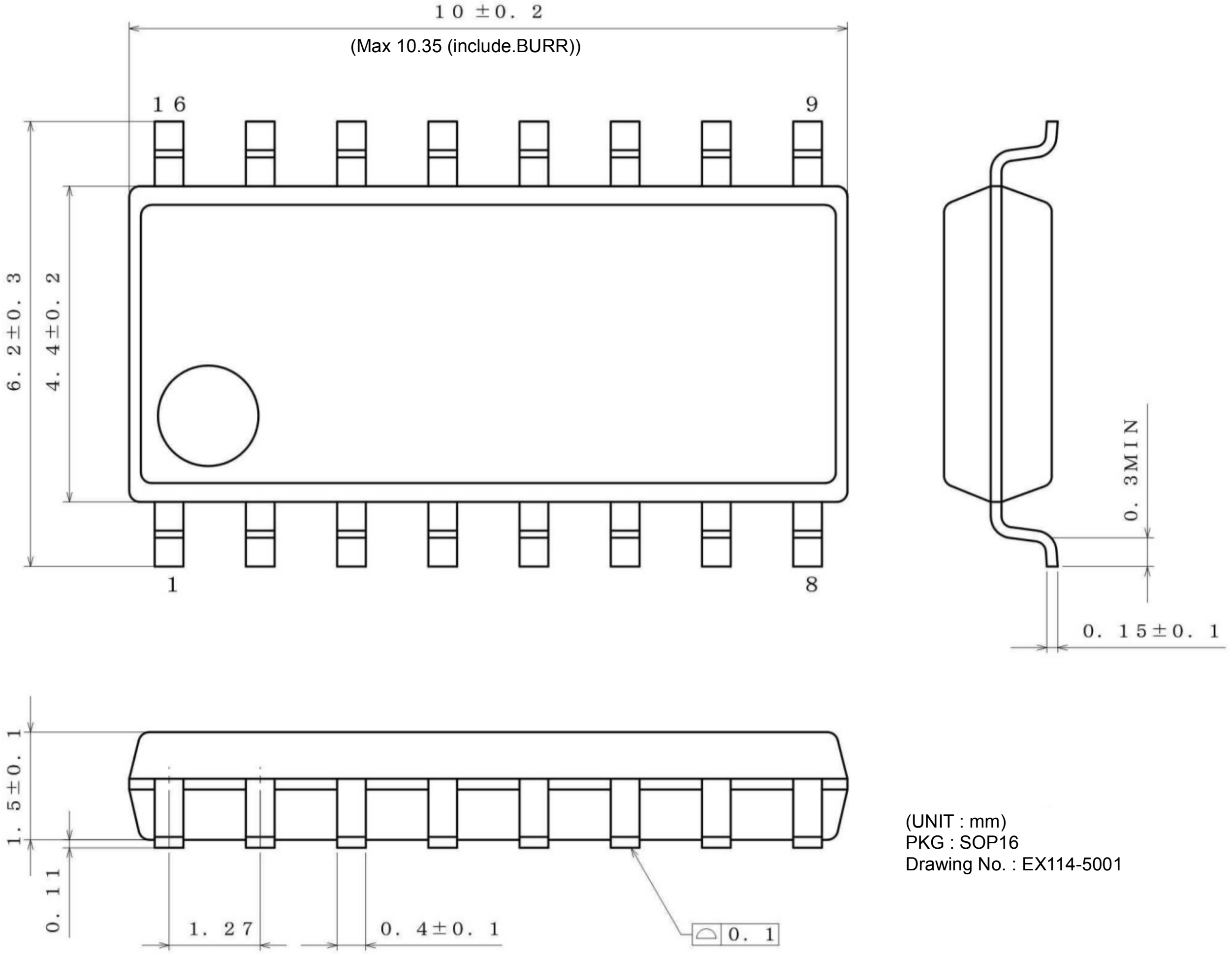


## Marking Diagrams



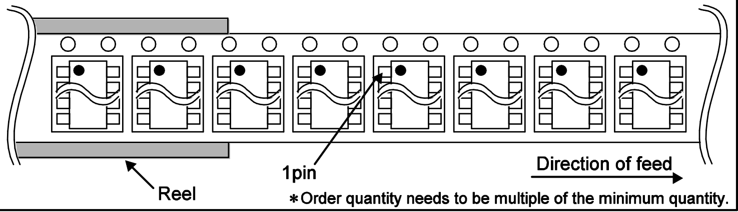
## Physical Dimension, Tape and Reel Information

| | |
|---|---|
| Package Name | SOP16 |



<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.

## Revision History

| Date | Revision | Changes |
|---|---|---|
| 11.Oct.2013 | 001 | New Release |
| 01.Sep.2015 | 002 | Page.9 Function：2.1 Reset Condition<br>（Open drain outputs after reset：Hi-z Condition→ON Condition）<br>Page.9 Timing Chart：Open drain outputs after $V_{DD}$ is ON<br>（Outputs condition：All High → All Low） |

# 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 on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, 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 concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

## Precaution Regarding Intellectual Property Rights

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## General Precaution

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