

# Voltage Detector IC Series for Automotive

## Standard CMOS

## Voltage Detector IC

**BD48Exxx-M series    BD49Exxx-M series**

### ●General Description

ROHM's BD48Exxx-M and BD49Exxx-M series are highly accurate, low current consumption Voltage Detector IC series. The line up includes BD48xxx devices with N-channel open drain output and BD49xxx devices with CMOS output. The devices are available for specific detection voltages ranging from 2.3V to 6.0V in increments of 0.1V.

### ●Features

- High accuracy detection
- Ultra-low current consumption
- Two output types (N-ch open drain and CMOS output)
- Wide Operating temperature range
- Very small and low height package
- Package SSOP5 is similar to SOT-23-5(JEDEC)
- AEC-Q100 Qualified

### ●Key Specifications

- Detection voltage: 2.3V to 6.0V (Typ.), 0.1V steps
- High accuracy detection voltage:  $\pm 1.0\%$
- Ultra-low current consumption: 0.9 $\mu$ A (Typ.)
- Operating temperature range: -40°C to +105°C

### ●Package

SSOP5:

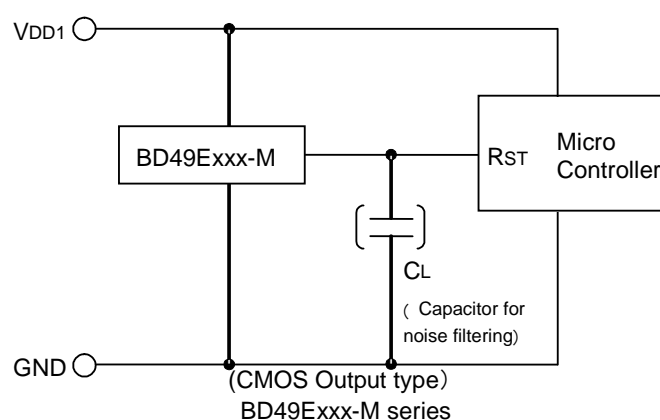
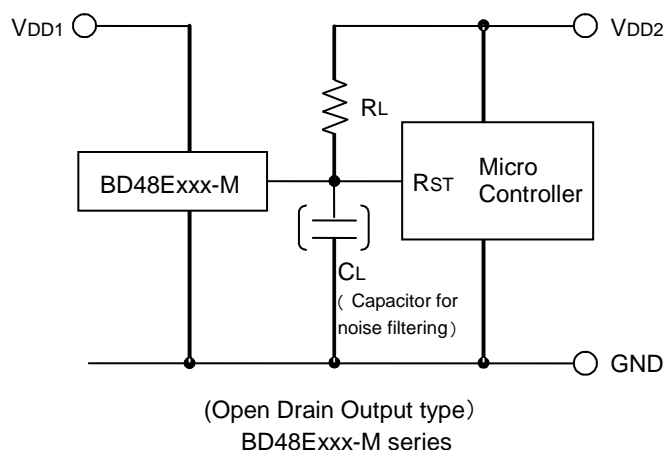


2.90mm x 2.80mm x 1.25mm

### ●Applications

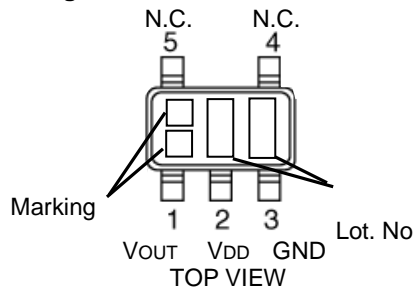
Circuits using microcontrollers or logic circuits that require a reset for automotive applications (car navigation, car audio, meter panel, exterior lamp etc.)

### ●Typical Application Circuit



## ● Connection Diagram

## SSOP5



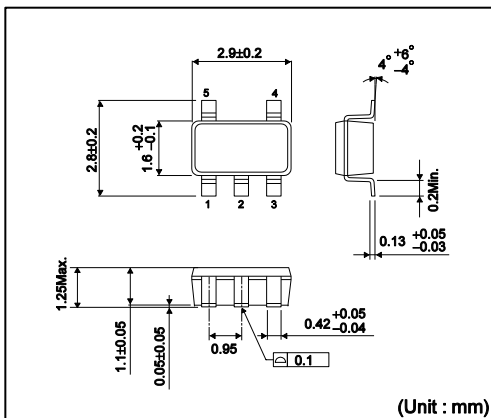
## ● Pin Descriptions

| SSOP5   |        |                      |
|---------|--------|----------------------|
| PIN No. | Symbol | Function             |
| 1       | VOUT   | Reset Output         |
| 2       | VDD    | Power Supply Voltage |
| 3       | GND    | GND                  |
| 4       | N.C.   | Unconnected Terminal |
| 5       | N.C.   | Unconnected Terminal |

## ● Ordering Information

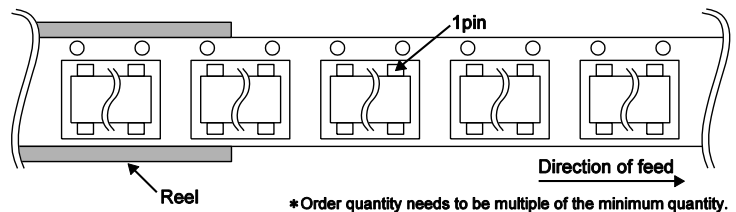
|                 |   |  |  |  |  |                      |  |   |       |  |  |
|-----------------|---|--|--|--|--|----------------------|--|---|-------|--|--|
| B D x x E x x x |   |  |  |  |  |                      |  | -   | M T R |  |  |
| Part Number     | Output Type<br>48 : Open Drain<br>49 : CMOS |  |  | Reset Voltage Value<br>23 : 2.3V<br>↓ 0.1V step<br>60 : 6.0V |  | Package<br>G : SSOP5 |  | Product Category<br>M : Automotive Category |       | Packaging and forming specification<br>TR : Embossed tape and reel |  |

## SSOP5



## &lt;Tape and Reel information&gt;

|                   |  |
|-------------------|--|
| Tape              | Embossed carrier tape  |
| Quantity          | 3000pcs  |
| Direction of feed | TR<br>(The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand) |



## ●Lineup

| Output Type       | Open Drain |             | CMOS    |             |
|-------------------|------------|-------------|---------|-------------|
| Detection Voltage | Marking    | Part Number | Marking | Part Number |
| 6.0V              | Cm         | BD48E60     | Ff      | BD49E60     |
| 5.9V              | Ck         | BD48E59     | Fe      | BD49E59     |
| 5.8V              | Ch         | BD48E58     | Fd      | BD49E58     |
| 5.7V              | Cg         | BD48E57     | Fc      | BD49E57     |
| 5.6V              | Cf         | BD48E56     | Fb      | BD49E56     |
| 5.5V              | Ce         | BD48E55     | Fa      | BD49E55     |
| 5.4V              | Cd         | BD48E54     | Ey      | BD49E54     |
| 5.3V              | Cc         | BD48E53     | Er      | BD49E53     |
| 5.2V              | Cb         | BD48E52     | Ep      | BD49E52     |
| 5.1V              | Ca         | BD48E51     | En      | BD49E51     |
| 5.0V              | By         | BD48E50     | Em      | BD49E50     |
| 4.9V              | Br         | BD48E49     | Ek      | BD49E49     |
| 4.8V              | Bp         | BD48E48     | Eh      | BD49E48     |
| 4.7V              | Bn         | BD48E47     | Eg      | BD49E47     |
| 4.6V              | Bm         | BD48E46     | Ef      | BD49E46     |
| 4.5V              | Bk         | BD48E45     | Ee      | BD49E45     |
| 4.4V              | Bh         | BD48E44     | Ed      | BD49E44     |
| 4.3V              | Bg         | BD48E43     | Ec      | BD49E43     |
| 4.2V              | Bf         | BD48E42     | Eb      | BD49E42     |
| 4.1V              | Be         | BD48E41     | Ea      | BD49E41     |
| 4.0V              | Bd         | BD48E40     | Dy      | BD49E40     |
| 3.9V              | Bc         | BD48E39     | Dr      | BD49E39     |
| 3.8V              | Bb         | BD48E38     | Dp      | BD49E38     |
| 3.7V              | Ba         | BD48E37     | Dn      | BD49E37     |
| 3.6V              | Ay         | BD48E36     | Dm      | BD49E36     |
| 3.5V              | Ar         | BD48E35     | Dk      | BD49E35     |
| 3.4V              | Ap         | BD48E34     | Dh      | BD49E34     |
| 3.3V              | An         | BD48E33     | Dg      | BD49E33     |
| 3.2V              | Am         | BD48E32     | Df      | BD49E32     |
| 3.1V              | Ak         | BD48E31     | De      | BD49E31     |
| 3.0V              | Ah         | BD48E30     | Dd      | BD49E30     |
| 2.9V              | Ag         | BD48E29     | Dc      | BD49E29     |
| 2.8V              | Af         | BD48E28     | Db      | BD49E28     |
| 2.7V              | Ae         | BD48E27     | Da      | BD49E27     |
| 2.6V              | Ad         | BD48E26     | Cy      | BD49E26     |
| 2.5V              | Ac         | BD48E25     | Cr      | BD49E25     |
| 2.4V              | Ab         | BD48E24     | Cp      | BD49E24     |
| 2.3V              | Aa         | BD48E23     | Cn      | BD49E23     |

## ●Absolute Maximum Ratings

| Parameter                   |                       | Symbol       | Limits                  | Unit |
|-----------------------------|-----------------------|--------------|-------------------------|------|
| Power Supply Voltage        |                       | $V_{DD-GND}$ | -0.3 to +10             | V    |
| Output Voltage              | Nch Open Drain Output | $V_{OUT}$    | GND-0.3 to +10          | V    |
|                             | CMOS Output           |              | GND-0.3 to $V_{DD}+0.3$ |      |
| Output Current              |                       | $I_o$        | 70                      | mA   |
| Power Dissipation           | SSOP5 *1*2            | $P_d$        | 540                     | mW   |
| Operating Temperature       |                       | $T_{opr}$    | -40 to +105             | °C   |
| Ambient Storage Temperature |                       | $T_{stg}$    | -55 to +125             | °C   |

\*1 Reduced by 5.4mW/°C when used over 25°C.

\*2 When mounted on ROHM standard circuit board (70mm×70mm×1.6mm, glass epoxy board).

●Electrical Characteristics (Unless Otherwise Specified  $T_a=-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ )

| Parameter                | Symbol    | Condition   | Limit   |              |                          | Unit          |
|--------------------------|-----------|---|---|--------------|--------------------------|---------------|
|                          |           |   | Min.  | Typ.         | Max.                     |               |
| Detection Voltage        | $V_{DET}$ | $R_L=470\text{k}\Omega$ , $V_{DD}=H \rightarrow L$ *1                                   | $V_{DET}(T) \times 0.99$                          | $V_{DET}(T)$ | $V_{DET}(T) \times 1.01$ | V             |
|                          |           | $V_{DET}=2.5\text{V}$   | $T_a=+25^{\circ}\text{C}$                         | 2.475        | 2.5                      | 2.525         |
|                          |           |   | $T_a=-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ | 2.418        | -                        | 2.584         |
|                          |           |   | $T_a=85^{\circ}\text{C}$ to $105^{\circ}\text{C}$ | 2.404        | -                        | 2.597         |
|                          |           | $V_{DET}=3.0\text{V}$   | $T_a=+25^{\circ}\text{C}$                         | 2.970        | 3.0                      | 3.030         |
|                          |           |   | $T_a=-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ | 2.901        | -                        | 3.100         |
|                          |           |   | $T_a=85^{\circ}\text{C}$ to $105^{\circ}\text{C}$ | 2.885        | -                        | 3.117         |
|                          |           | $V_{DET}=3.3\text{V}$   | $T_a=+25^{\circ}\text{C}$                         | 3.267        | 3.3                      | 3.333         |
|                          |           |   | $T_a=-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ | 3.191        | -                        | 3.410         |
|                          |           |   | $T_a=85^{\circ}\text{C}$ to $105^{\circ}\text{C}$ | 3.173        | -                        | 3.428         |
|                          |           | $V_{DET}=4.2\text{V}$   | $T_a=+25^{\circ}\text{C}$                         | 4.158        | 4.2                      | 4.242         |
|                          |           |   | $T_a=-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ | 4.061        | -                        | 4.341         |
|                          |           |   | $T_a=85^{\circ}\text{C}$ to $105^{\circ}\text{C}$ | 4.039        | -                        | 4.364         |
| Output Delay Time "L→H"  | $t_{PLH}$ | $C_L=100\text{pF}$ $R_L=100\text{k}\Omega$ $V_{out}=GND \rightarrow 50\%$ *2            | -   | -            | 100                      | $\mu\text{s}$ |
|                          |           |   |   |              |                          |               |
| Circuit Current when ON  | $I_{CC1}$ | $V_{DD}=V_{DET}-0.2\text{V}$ *1   | $V_{DET}=2.3-3.1\text{V}$                         | -            | 0.51                     | 1.53          |
|                          |           |   | $V_{DET}=3.2-4.2\text{V}$                         | -            | 0.56                     | 1.68          |
|                          |           |   | $V_{DET}=4.3-5.2\text{V}$                         | -            | 0.60                     | 1.80          |
|                          |           |   | $V_{DET}=5.3-6.0\text{V}$                         | -            | 0.66                     | 1.98          |
| Circuit Current when OFF | $I_{CC2}$ | $V_{DD}=V_{DET}+2.0\text{V}$ *1   | $V_{DET}=2.3-3.1\text{V}$                         | -            | 0.75                     | 2.25          |
|                          |           |   | $V_{DET}=3.2-4.2\text{V}$                         | -            | 0.80                     | 2.40          |
|                          |           |   | $V_{DET}=4.3-5.2\text{V}$                         | -            | 0.85                     | 2.55          |
|                          |           |   | $V_{DET}=5.3-6.0\text{V}$                         | -            | 0.90                     | 2.70          |
| Operating Voltage Range  | $V_{OPL}$ | $V_{OL} \leq 0.4\text{V}$ , $T_a=25$ to $105^{\circ}\text{C}$ , $R_L=470\text{k}\Omega$ | 0.95  | -            | -                        | V             |
|                          |           | $V_{OL} \leq 0.4\text{V}$ , $T_a=-40$ to $25^{\circ}\text{C}$ , $R_L=470\text{k}\Omega$ | 1.20  | -            | -                        |               |

 $V_{DET}(T)$ : Standard Detection Voltage(2.3V to 6.0V, 0.1V step) $R_L$ : Pull-up resistor to be connected between  $V_{OUT}$  and power supply. $C_L$ : Capacitor to be connected between  $V_{OUT}$  and GND.

Design Guarantee. (Outgoing inspection is not done on all products.)

\*1 Guarantee is  $T_a=25^{\circ}\text{C}$ .\*2  $t_{PLH}: V_{DD}=(V_{DET} \text{ typ.}-0.5\text{V}) \rightarrow (V_{DET} \text{ typ.}+0.5\text{V})$

## ●Electrical Characteristics (Unless Otherwise Specified Ta=-40°C to 105°C) - continued

| Parameter  | Symbol               | Condition                                    | Limit                  |                        |                        | Unit   |
|--|----------------------|--|------------------------|------------------------|------------------------|--------|
|  |                      |  | Min.                   | Typ.                   | Max.                   |        |
| 'Low' Output Voltage (Nch)                         | VOL                  | VDD=1.5V, ISINK = 0.4 mA, VDET=2.3-6.0V      | -                      | -                      | 0.5                    | V      |
|  |                      | VDD=2.4V, ISINK = 2.0 mA, VDET=2.7-6.0V      | -                      | -                      | 0.5                    |        |
| 'High' Output Voltage (Pch)<br>(BD49Exxx-M Series) | VOH                  | VDD=4.8V, ISOURCE=0.7 mA, VDET(2.3V to 4.2V) | VDD-0.5                | -                      | -                      | V      |
|  |                      | VDD=6.0V, ISOURCE=0.9 mA, VDET(4.3V to 5.2V) | VDD-0.5                | -                      | -                      |        |
|  |                      | VDD=8.0V, ISOURCE=1.1 mA, VDET(5.3V to 6.0V) | VDD-0.5                | -                      | -                      |        |
| Leak Current when OFF<br>(BD48Exxx-M Series)       | I <sub>leak</sub>    | VDD=VDS=10V *1                               | -                      | -                      | 0.1                    | μA     |
| Detection Voltage<br>Temperature coefficient       | V <sub>DET</sub> /ΔT | Ta=-40°C to 105°C<br>(Designed Guarantee)    | -                      | ±100                   | ±360                   | ppm/°C |
| Hysteresis Voltage                                 | ΔV <sub>DET</sub>    | VDD=L→H→L, RL=470kΩ                          | V <sub>DET</sub> ×0.03 | V <sub>DET</sub> ×0.05 | V <sub>DET</sub> ×0.08 | V      |

V<sub>DET</sub>(T) : Standard Detection Voltage(2.3V to 6.0V, 0.1V step)

R<sub>i</sub>: Pull-up resistor to be connected between Vout and power supply.

C<sub>i</sub>: Capacitor to be connected between Vout and GND.

Design Guarantee. (Outgoing inspection is not done on all products.)

\*1 Guarantee is Ta=25°C.

●Block Diagrams

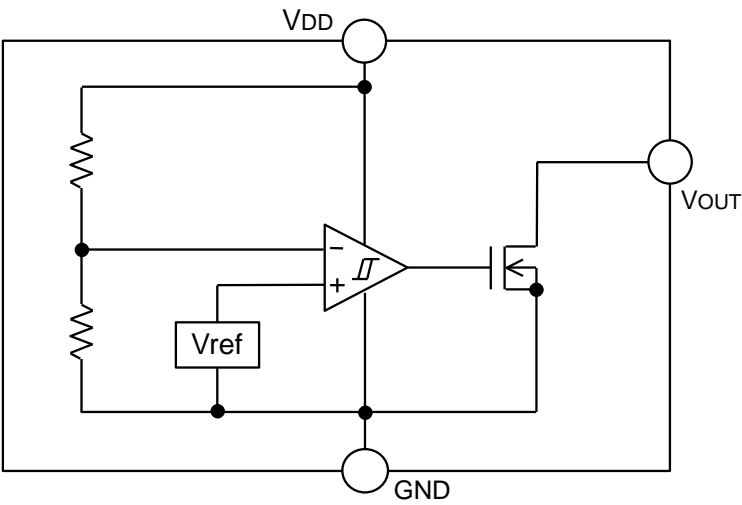


Fig.1 BD48Exxx-M series

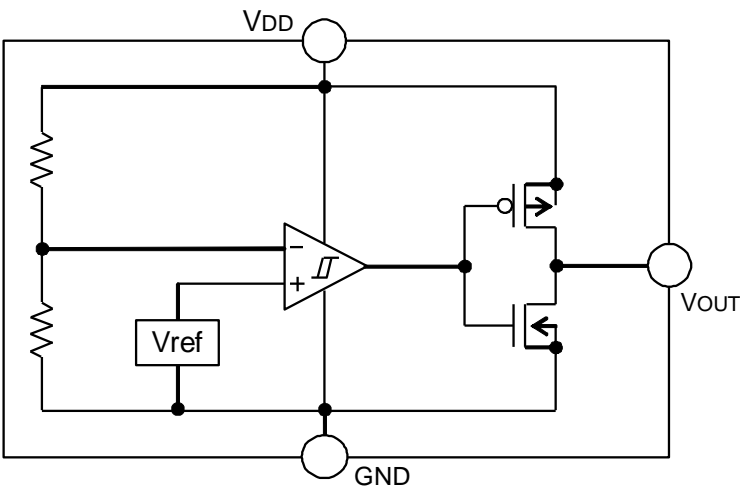
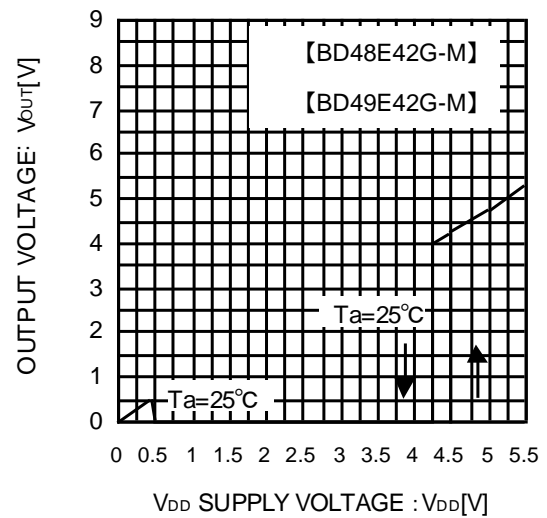
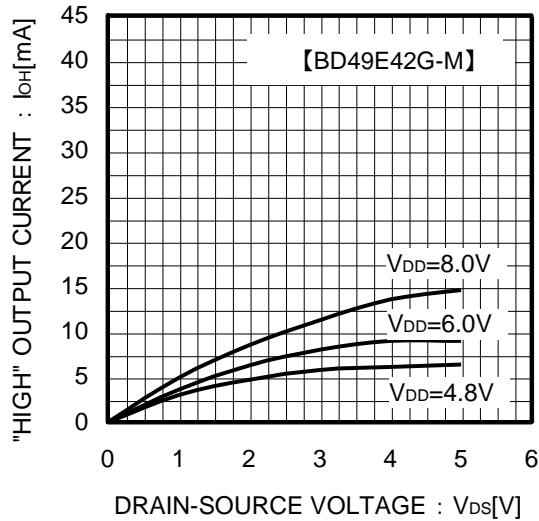
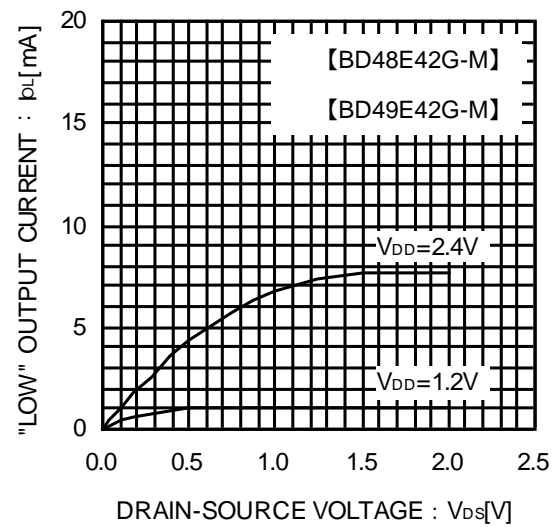
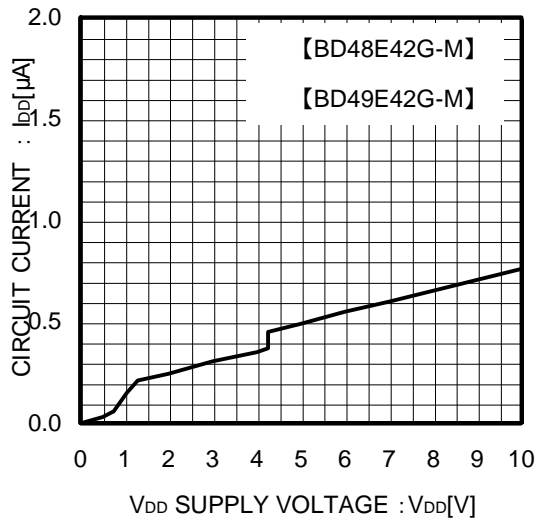
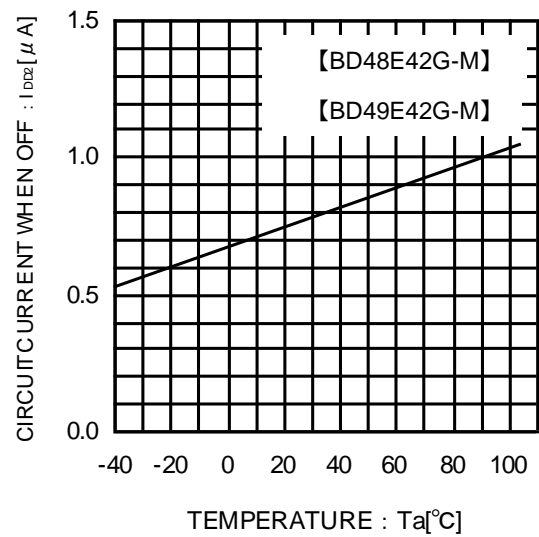
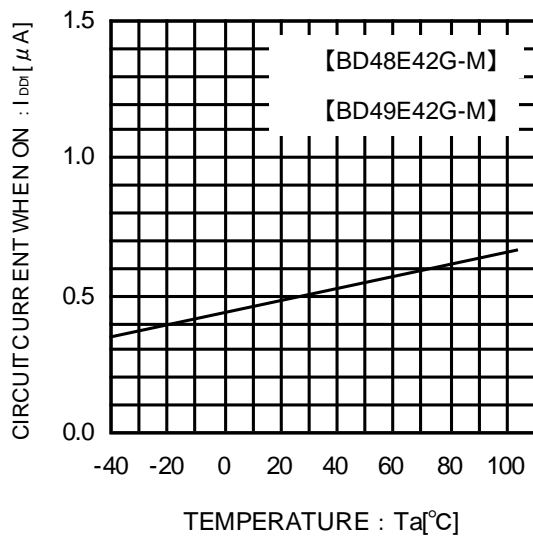
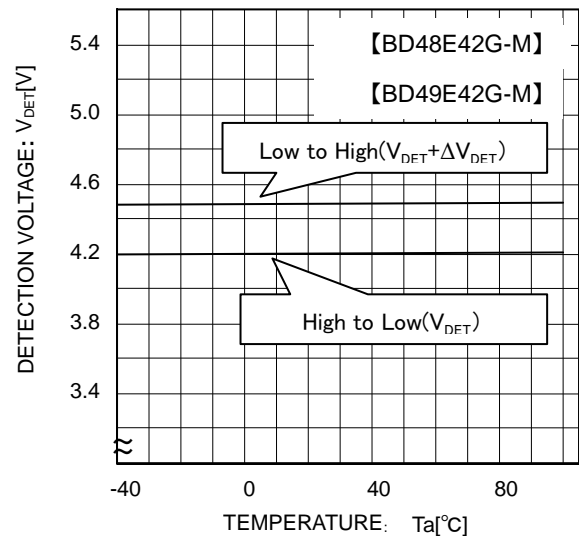
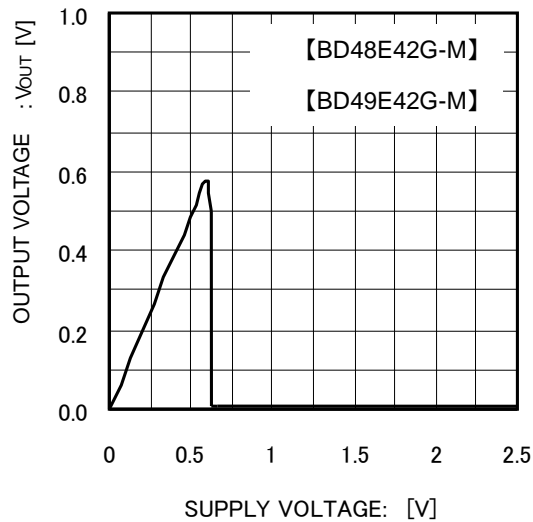


Fig.2 BD49Exxx-M series

## ● Typical Performance Curves



## ●Typical Performance Curves – continued





●Typical Performance Curves – continued

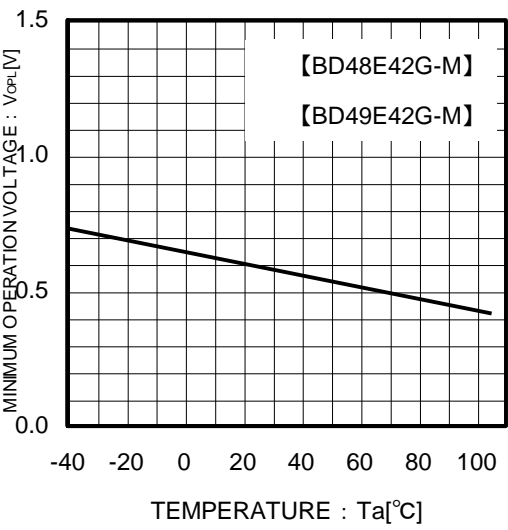


Fig.11 Operating Limit Voltage

## ●Application Information

### Explanation of Operation

For both the open drain type (Fig.12) and the CMOS output type (Fig.13), the detection and release voltages are used as threshold voltages. When the voltage applied to the  $V_{DD}$  pins reaches the applicable threshold voltage, the  $V_{OUT}$  terminal voltage switches from either “High” to “Low” or from “Low” to “High”. Please refer to the Timing Waveform and Electrical Characteristics for information on hysteresis. Because the BD48Exxx-M series uses an open drain output type, it is necessary to connect a pull-up resistor to  $V_{DD}$  or another power supply if needed [The output “High” voltage ( $V_{OUT}$ ) in this case becomes  $V_{DD}$  or the voltage of the other power supply].

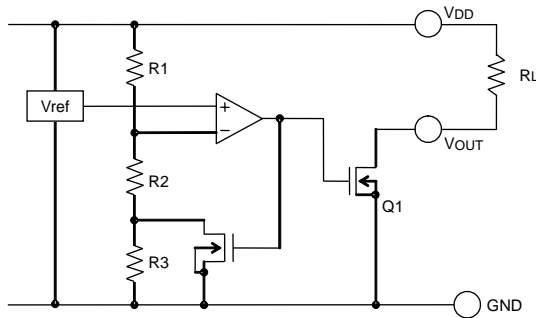


Fig.12 (BD48Exxx-M series Internal Block Diagram)

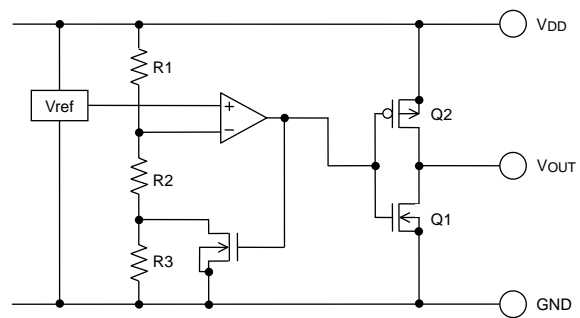


Fig.13 (BD49Exxx-M series Internal Block Diagram)

## Reference Data

Examples of Leading ( $t_{PLH}$ ) and Falling ( $t_{PHL}$ ) Output

| Part Number | $t_{PLH}$ ( $\mu s$ ) | $t_{PHL}$ ( $\mu s$ ) |
|-------------|-----------------------|-----------------------|
| BD48E45G-M  | 39.5                  | 87.8                  |
| BD49E45G-M  | 32.4                  | 52.4                  |

$V_{DD}=4.3V \rightarrow 5.1V$

$V_{DD}=5.1V \rightarrow 4.3V$

\*This data is for reference only.

The figures will vary with the application, so please confirm actual operating conditions before use.

## Timing Waveform

Example: the following shows the relationship between the input voltages  $V_{DD}$  and the output voltage  $V_{OUT}$  when the input power supply voltage  $V_{DD}$  is made to sweep up and sweep down (the circuits are those in Fig.12 and 13).

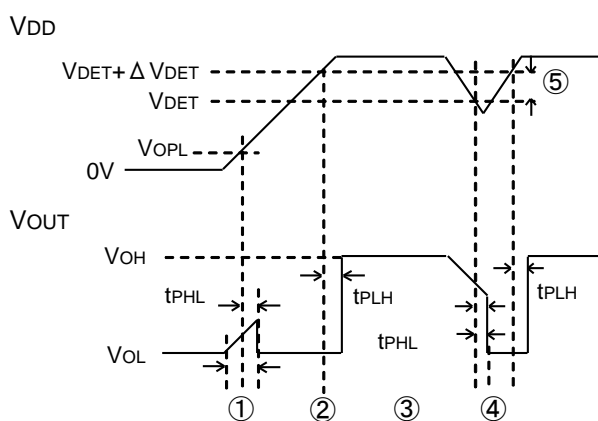


Fig.14 Timing Waveform

- ① When the power supply is turned on, the output is unstable from after over the operating limit voltage ( $V_{OPL}$ ) until  $t_{PHL}$ . Therefore it is possible that the reset signal is not valid when the rise time of  $V_{DD}$  is faster than  $t_{PHL}$ .
- ② When  $V_{DD}$  is greater than  $V_{OPL}$ , but less than the reset release voltage ( $V_{DET} + \Delta V_{DET}$ ), the output voltages will switch to Low.
- ③ If  $V_{DD}$  exceeds the reset release voltage ( $V_{DET} + \Delta V_{DET}$ ), then,  $V_{OUT}$  switches from L to H.
- ④ If  $V_{DD}$  drops below the detection voltage ( $V_{DET}$ ) when the power supply is powered down or when there is a power supply fluctuation,  $V_{OUT}$  switches to L (with a delay of  $t_{PHL}$ ).
- ⑤ The potential difference between the detection voltage and the release voltage is known as the hysteresis width ( $\Delta V_{DET}$ ). The system is designed such that the output does not toggle with power supply fluctuations within this hysteresis width, preventing the malfunctions due to noise.

## ●Circuit Applications

1) Examples of a common power supply detection reset circuit.

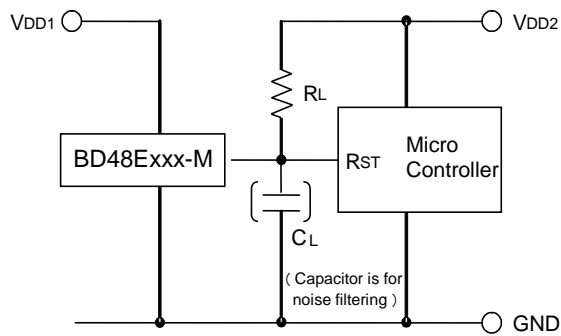


Fig.15 Open Drain Output Type

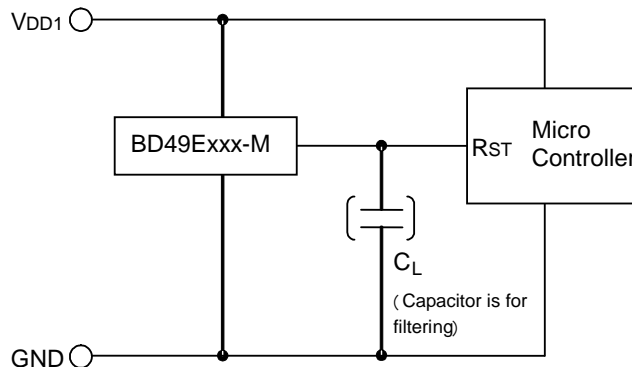


Fig.16 CMOS Output Type

Application examples of BD48Exxx-M series (Open Drain output type) and BD49Exxx-M series (CMOS output type) are shown on the left.

CASE1: Power supply of the microcontroller ( $V_{DD2}$ ) differs from the power supply of the reset detection ( $V_{DD1}$ ).

Use an open drain output type (BD48xxx-M) device with a load resistance  $R_L$  attached as shown in figure 15.

CASE2: Power supply of the microcontroller ( $V_{DD1}$ ) is same as the power supply of the reset detection ( $V_{DD1}$ ).

Use a CMOS output type (BD49xxx-M) device or an open drain device with a pull up resistor between output and  $V_{DD1}$ .

When a capacitance  $C_L$  for noise filtering is connected to the  $V_{OUT}$  pin (the reset signal input terminal of the microcontroller), please take into account the waveform of the rise and fall of the output voltage ( $V_{OUT}$ ).

The Electrical characteristics were measured using  $R_L = 470k\Omega$  and  $C_L = 100pF$ .

2) The following is an example of a circuit application in which an OR connection between two types of detection voltage resets the microcontroller.

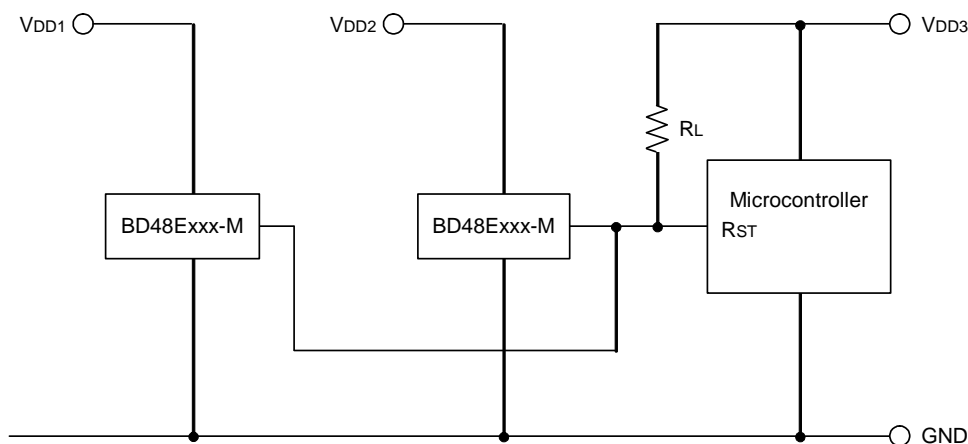


Fig.17

To reset the microcontroller when many independent power supplies are used in the system, OR connect an open drain output type (BD48Exxx-M series) to the microcontroller's input with pull-up resistor to the supply voltage of the microcontroller ( $V_{DD3}$ ) as shown in Fig. 17. By pulling-up to  $V_{DD3}$ , output "High" voltage of micro-controller power supply is possible.

## 3) Examples of the power supply with resistor dividers

In applications wherein the power supply voltage of an IC comes from a resistor divider circuit, an in-rush current will flow into the circuit when the output level switches from “High” to “Low” or vice versa. In-rush current is a sudden surge of current that flows from the power supply (VDD) to ground (GND) as the output logic changes its state. This current flow may cause malfunction in the systems operation such as output oscillations, etc.

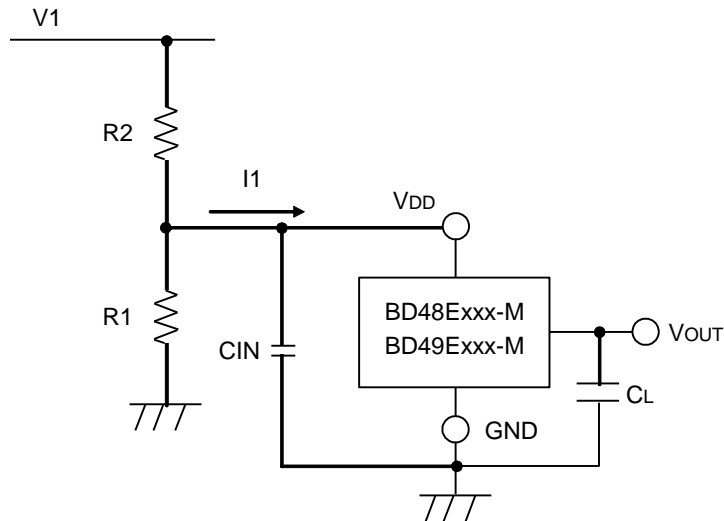


Fig.18

When an in-rush current ( $I_1$ ) flows into the circuit (Refer to Fig. 18) at the time when output switches from “Low” to “High”, a voltage drop of  $I_1 \times R_2$  (input resistor) will occur in the circuit causing the VDD supply voltage to decrease. When the VDD voltage drops below the detection voltage, the output will switch from “High” to “Low”. While the output voltage is at “Low” condition, in-rush current will stop flowing and the voltage drop will be reduced. As a result, the output voltage will switch again from “Low” to “High” which causes an in-rush current and a voltage drop. This operation repeats and will result to oscillation.

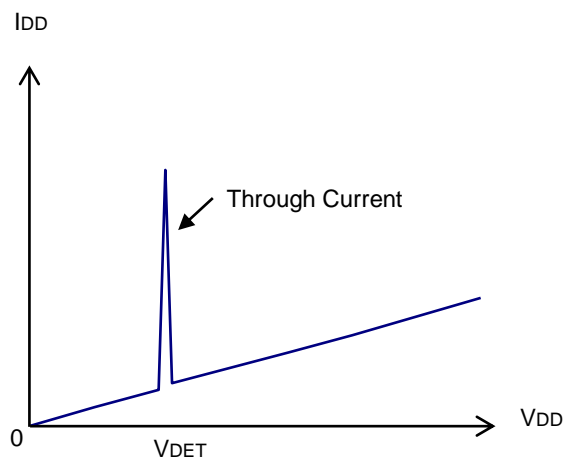


Fig.19 Current Consumption vs. Power Supply Voltage

**●Operational Notes**

- 1) Absolute maximum ratings  
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. 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.
- 2) Ground Voltage  
The voltage of the ground pin must be the lowest voltage of all pins of the IC at all operating conditions. Ensure that no pins are at a voltage below the ground pin at any time, even during transient condition.
- 3) 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.
- 4) Bypass Capacitor for Noise Rejection  
To help reject noise, put a 1 $\mu$ F capacitor between V<sub>DD</sub> pin and GND and 1000pF capacitor between V<sub>OUT</sub> pin and GND. Be careful when using extremely big capacitor as transient response will be affected.
- 5) Short between pins and mounting errors  
Be careful when mounting the IC on printed circuit boards. The IC may be damaged if it is mounted in a wrong orientation or if pins are shorted together. Short circuit may be caused by conductive particles caught between the pins.
- 6) Operation under strong electromagnetic field  
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.
- 7) The V<sub>DD</sub> line impedance might cause oscillation because of the detection current.
- 8) A V<sub>DD</sub> to GND capacitor (as close connection as possible) should be used in high V<sub>DD</sub> line impedance condition.
- 9) Lower than the minimum input voltage puts the V<sub>OUT</sub> in high impedance state, and it must be V<sub>DD</sub> in pull up (V<sub>DD</sub>) condition.
- 10) External parameters  
The recommended parameter range for R<sub>L</sub> is 10k $\Omega$  to 1M $\Omega$ . There are many factors (board layout, etc) that can affect characteristics. Please verify and confirm using practical applications.
- 11) Power on reset operation  
Please note that the power on reset output varies with the V<sub>DD</sub> rise time. Please verify the behavior in the actual operation.
- 12) 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.
- 13) Rush current  
When power is first supplied to the IC, rush current may flow instantaneously. It is possible that the charge current to the parasitic capacitance of internal photo diode or the internal logic may be unstable. Therefore, give special consideration to power coupling capacitance, power wiring, width of GND wiring, and routing of connections.
- 14) This IC has extremely high impedance terminals. Small leak current due to the uncleanness of PCB surface might cause unexpected operations. Application values in these conditions should be selected carefully. If 10M $\Omega$  leakage is assumed between the C<sub>T</sub> terminal and the GND terminal, 1M $\Omega$  connection between the CT terminal and the V<sub>DD</sub> terminal would be recommended. Also, if the leakage is assumed between the V<sub>out</sub> terminal and the GND terminal, the pull up resistor should be less than 1/10 of the assumed leak resistance.

## ●Revision History

| Date        | Revision | Changes   |
|-------------|----------|---|
| 30.Mar.2012 | 001      | New Release   |
| 14.Dec.2012 | 002      | Updated General Description, Features, Applications, Absolute maximum ratings, Explanation of Operation, Timing Waveform, Circuit Applications, and Operational Notes.<br>Changed Lineup table format.<br>Add I <sub>o</sub> in Absolute Maximum Rating table<br>Add limits for V <sub>DET</sub> specifically at V <sub>DET</sub> =2.5V,3.0V,3.3V,4.2V,4.8V<br>Change parameter in electrical characteristics from IOL to VOL and IOH to VOH<br>Add circuits application numbers 2 and 3<br>Added Revision History. |
| 22.May.2013 | 003      | Change limits for V <sub>DET</sub> at V <sub>DET</sub> =2.5V,3.0V,3.3V,4.2V,4.8V  |
| 27.Aug.2013 | 004      | Update the applications and features on page 1 and ordering information on page 2   |

# Notice

## Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, aircraft/spacecraft, nuclear power controllers, 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     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

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 not designed 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:
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  - [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<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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 Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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.

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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

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