

Voltage Detector IC Series

Counter Timer Built-in CMOS Voltage Detector IC



BD45xxx series BD46xxx series

●General Description

ROHM's BD45xxx and BD46xxx series are highly accurate, low current consumption Voltage Detector ICs. Because the counter timer delay circuit is built into these series, an external capacitor for the delay time setting is unnecessary. The lineup was established with low output types (Nch open drain and CMOS output) and detection voltages range from 2.3V to 4.8V in increments of 0.1V, so that the series may be selected according the application at hand.

●Features

- Counter Timer Built-in
- No delay time setting external capacitor required
- Ultra-low current consumption
- Two output types (Nch open drain and CMOS output)
- Package SSOP5 is similar to SOT-23-5 (JEDEC)

●Key Specifications

- Detection voltage: 2.3V to 4.8V (Typ.)
0.1V steps
- High accuracy detection voltage: ±1.0%
- Ultra-low current consumption: 0.85μA (Typ.)
- Operating temperature range: -40°C to +105°C
- Three internal, fixed delay time: 50ms
100ms
200ms

●Package

SSOP5



2.90mm x 2.80mm x 1.25mm

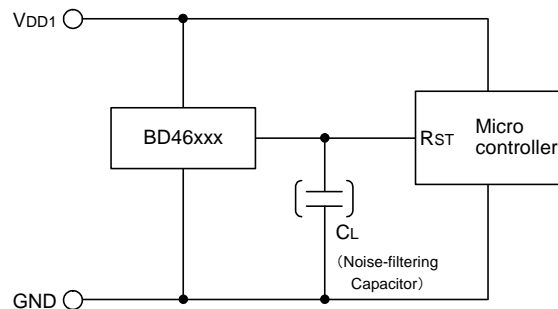
●Applications

Circuits using microcontrollers or logic circuits that require a reset.

●Typical Application Circuit



(Open Drain Output Type)
BD45xxx series



(CMOS Output Type)
BD46xxx series

●Connection Diagram

SSOP5



●Pin Descriptions

| PIN No. | Symbol | Function |
|---------|--------|----------------------|
| 1 | ER | Manual Reset |
| 2 | SUB | Substrate * |
| 3 | GND | GND |
| 4 | VOUT | Reset Output |
| 5 | VDD | Power Supply Voltage |

*Connect the substrate to GND.

●Ordering Information

| | | | | | | | | | | | | | | | | | | | |
|-------------|---|---|--|--|--|---|---|---|--|----------------------|--|--|--|---|--|---|--|---|--|
| B | | D | | X | | X | | X | | X | | X | | - | | T | | R | |
| Part Number | Output Type 45 : Open Drain 46 : CMOS | | | Reset Voltage Value 23 : 2.3V ↓ 0.1V step 48 : 4.8V | | | Counter Timer Delay Time Settings 5 : 50ms 1 : 100ms 2 : 200ms | | | Package G : SSOP5 | | Packaging and forming specification TR : Embossed tape and reel | | | | | | | |

SSOP5



●Lineup

Table 1. Open Drain Output Type

| Detection Voltage | Counter Timer Delay Time Settings | | | | | |
|-------------------|-----------------------------------|-------------|---------|-------------|---------|-------------|
| | 50ms | | 100ms | | 200ms | |
| | Marking | Part Number | Marking | Part Number | Marking | Part Number |
| 4.8V | T0 | BD45485 | TS | BD45481 | UJ | BD45482 |
| 4.7V | T1 | BD45475 | TT | BD45471 | UK | BD45472 |
| 4.6V | T2 | BD45465 | TU | BD45461 | UL | BD45462 |
| 4.5V | T3 | BD45455 | TV | BD45451 | UM | BD45452 |
| 4.4V | T4 | BD45445 | TW | BD45441 | UN | BD45442 |
| 4.3V | T5 | BD45435 | TX | BD45431 | UP | BD45432 |
| 4.2V | T6 | BD45425 | TY | BD45421 | UQ | BD45422 |
| 4.1V | T7 | BD45415 | TZ | BD45411 | UR | BD45412 |
| 4.0V | T8 | BD45405 | U0 | BD45401 | US | BD45402 |
| 3.9V | T9 | BD45395 | U1 | BD45391 | UT | BD45392 |
| 3.8V | TA | BD45385 | U2 | BD45381 | UU | BD45382 |
| 3.7V | TB | BD45375 | U3 | BD45371 | UV | BD45372 |
| 3.6V | TC | BD45365 | U4 | BD45361 | UW | BD45362 |
| 3.5V | TD | BD45355 | U5 | BD45351 | UX | BD45352 |
| 3.4V | TE | BD45345 | U6 | BD45341 | UY | BD45342 |
| 3.3V | TF | BD45335 | U7 | BD45331 | UZ | BD45332 |
| 3.2V | TG | BD45325 | U8 | BD45321 | V0 | BD45322 |
| 3.1V | TH | BD45315 | U9 | BD45311 | V1 | BD45312 |
| 3.0V | TJ | BD45305 | UA | BD45301 | V2 | BD45302 |
| 2.9V | TK | BD45295 | UB | BD45291 | V3 | BD45292 |
| 2.8V | TL | BD45285 | UC | BD45281 | V4 | BD45282 |
| 2.7V | TM | BD45275 | UD | BD45271 | V5 | BD45272 |
| 2.6V | TN | BD45265 | UE | BD45261 | V6 | BD45262 |
| 2.5V | TP | BD45255 | UF | BD45251 | V7 | BD45252 |
| 2.4V | TQ | BD45245 | UG | BD45241 | V8 | BD45242 |
| 2.3V | TR | BD45235 | UH | BD45231 | V9 | BD45232 |

●Lineup - continued

Table 2. CMOS Output Type

| Detection Voltage | Counter Timer Delay Time Settings | | | | | |
|-------------------|-----------------------------------|-------------|---------|-------------|---------|-------------|
| | 50ms | | 100ms | | 200ms | |
| | Marking | Part Number | Marking | Part Number | Marking | Part Number |
| 4.8V | VA | BD46485 | W2 | BD46481 | WU | BD46482 |
| 4.7V | VB | BD46475 | W3 | BD46471 | WV | BD46472 |
| 4.6V | VC | BD46465 | W4 | BD46461 | WW | BD46462 |
| 4.5V | VD | BD46455 | W5 | BD46451 | WX | BD46452 |
| 4.4V | VE | BD46445 | W6 | BD46441 | WY | BD46442 |
| 4.3V | VF | BD46435 | W7 | BD46431 | WZ | BD46432 |
| 4.2V | VG | BD46425 | W8 | BD46421 | X0 | BD46422 |
| 4.1V | VH | BD46415 | W9 | BD46411 | X1 | BD46412 |
| 4.0V | VJ | BD46405 | WA | BD46401 | X2 | BD46402 |
| 3.9V | VK | BD46395 | WB | BD46391 | X3 | BD46392 |
| 3.8V | VL | BD46385 | WC | BD46381 | X4 | BD46382 |
| 3.7V | VM | BD46375 | WD | BD46371 | X5 | BD46372 |
| 3.6V | VN | BD46365 | WE | BD46361 | X6 | BD46362 |
| 3.5V | VP | BD46355 | WF | BD46351 | X7 | BD46352 |
| 3.4V | VQ | BD46345 | WG | BD46341 | X8 | BD46342 |
| 3.3V | VR | BD46335 | WH | BD46331 | X9 | BD46332 |
| 3.2V | VS | BD46325 | WJ | BD46321 | XA | BD46322 |
| 3.1V | VT | BD46315 | WK | BD46311 | XB | BD46312 |
| 3.0V | VU | BD46305 | WL | BD46301 | XC | BD46302 |
| 2.9V | VV | BD46295 | WM | BD46291 | XD | BD46292 |
| 2.8V | VW | BD46285 | WN | BD46281 | XE | BD46282 |
| 2.7V | VX | BD46275 | WP | BD46271 | XF | BD46272 |
| 2.6V | VY | BD46265 | WQ | BD46261 | XG | BD46262 |
| 2.5V | VZ | BD46255 | WR | BD46251 | XH | BD46252 |
| 2.4V | W0 | BD46245 | WS | BD46241 | XJ | BD46242 |
| 2.3V | W1 | BD46235 | WT | BD46231 | XK | BD46232 |

● 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 | 60 | mA |
| ER pin Voltage | | V _{CT} | GND-0.3 to V _{DD} +0.3 | V |
| Power Dissipation ^{*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 (70mmx70mmx1.6mm, glass epoxy board).

● Electrical characteristics (Unless Otherwise Specified Ta=-40 to 105°C)

| Parameter | Symbol | Condition | Limit | | | Unit | |
|---|-------------------------------|---|-------------------------------|-------------------------------|-------------------------------|--------|-------|
| | | | Min. | Typ. | Max. | | |
| Detection Voltage | V _{DET} | V _{DD} =H→L, R _L =470kΩ ^{*1} | V _{DET} (T) x0.99 | V _{DET} (T) | V _{DET} (T) x1.01 | V | |
| | | V _{DET} =2.5V | T _a =+25°C | 2.475 | 2.5 | | 2.525 |
| | | | T _a =-40°C to 85°C | 2.418 | - | | 2.584 |
| | | | T _a =85°C to 105°C | 2.404 | - | | 2.597 |
| | | V _{DET} =3.0V | T _a =+25°C | 2.970 | 3.0 | | 3.030 |
| | | | T _a =-40°C to 85°C | 2.901 | - | | 3.100 |
| | | | T _a =85°C to 105°C | 2.885 | - | | 3.117 |
| | | V _{DET} =3.3V | T _a =+25°C | 3.267 | 3.3 | | 3.333 |
| | | | T _a =-40°C to 85°C | 3.191 | - | | 3.410 |
| | | | T _a =85°C to 105°C | 3.173 | - | | 3.428 |
| | | V _{DET} =4.2V | T _a =+25°C | 4.158 | 4.2 | | 4.242 |
| | | | T _a =-40°C to 85°C | 4.061 | - | | 4.341 |
| T _a =85°C to 105°C | 4.039 | | - | 4.364 | | | |
| V _{DET} =4.8V | T _a =+25°C | 4.752 | 4.8 | 4.848 | | | |
| | T _a =-40°C to 85°C | 4.641 | - | 4.961 | | | |
| | T _a =85°C to 105°C | 4.616 | - | 4.987 | | | |
| Detection Voltage Temperature coefficient | V _{DET} /ΔT | -40°C to +105°C | - | ±100 | ±360 | ppm/°C | |
| Hysteresis Voltage | ΔV _{DET} | V _{DD} =L→H→L, R _L =470kΩ | V _{DET} (T) x0.03 | V _{DET} (T) x0.05 | V _{DET} (T) x0.08 | V | |
| 'High' Output Delay time | t _{PLH} | C _L =100pF, R _L =100kΩ ^{*1, *2, *3} | BD45xx5, BD46xx5 | 45 | 50 | 55 | ms |
| | | | BD45xx1, BD46xx1 | 90 | 100 | 110 | |
| | | | BD45xx2, BD46xx2 | 180 | 200 | 220 | |
| Circuit Current when ON | I _{DD1} | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =2.3V to 3.1V ^{*1} | - | 0.70 | 2.10 | μA | |
| | | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =2.3V to 3.1V | - | 0.70 | 2.85 | | |
| | | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =3.2V to 4.2V ^{*1} | - | 0.75 | 2.25 | | |
| | | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =3.2V to 4.2V | - | 0.75 | 3.00 | | |
| | | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =4.3V to 4.8V ^{*1} | - | 0.80 | 2.40 | | |
| | | V _{DD} =V _{DET} -0.2V, V _{ER} =0V V _{DET} =4.3V to 4.8V | - | 0.80 | 3.15 | | |
| Circuit Current when OFF | I _{DD2} | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =2.3V to 3.1V ^{*1} | - | 0.75 | 2.25 | μA | |
| | | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =2.3V to 3.1V | - | 0.75 | 4.28 | | |
| | | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =3.2V to 4.2V ^{*1} | - | 0.80 | 2.40 | | |
| | | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =3.2V to 4.2V | - | 0.80 | 4.50 | | |
| | | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =4.3V to 4.8V ^{*1} | - | 0.85 | 2.55 | | |
| | | V _{DD} =V _{DET} +0.2V, V _{ER} =0V V _{DET} =4.3V to 4.8V | - | 0.85 | 4.73 | | |

V_{DET}(T): Standard Detection Voltage (2.3V to 4.8V, 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.

*1 Guarantee is Ta=25°C.

*2 t_{PLH}: V_{DD}=(V_{DET}(T)-0.5V)→(V_{DET}(T)+0.5V)

*3 t_{PLH}: V_{DD}=Please set the rise up time between V_{DD}=0→V_{DET} to more than 100μs.

Attention: Please connect the GND when you don't use 'ER'

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

| Parameter | Symbol | Condition | Limit | | | Unit |
|-----------------------------|-------------------|---|---------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Operating Voltage Range | VOPL | VOL≤0.4V, RL=470kΩ, Ta=25 to 105°C | 0.95 | - | - | V |
| | | VOL≤0.4V, RL=470kΩ, Ta=-40 to 25°C | 1.20 | - | - | |
| 'High' Output Voltage (Pch) | VOH | VDD=4.8V, ISOURCE= 1.0 mA, VDET(2.3V to 4.2V) | VDD-0.5 | - | - | V |
| | | VDD=6.0V, ISOURCE= 1.2 mA, VDET(4.3V to 4.8V) | VDD-0.5 | - | - | |
| 'Low' Output Voltage (Nch) | VOL | VDD=1.2V, ISINK = 0.45 mA | - | - | 0.3 | V |
| | | VDD=2.4V, ISINK = 1.3 mA, VDET(2.7V to 4.8V) | - | - | 0.3 | |
| Leak Current when OFF | I _{leak} | VDD=VDS=10V | - | - | 0.1 | μA |
| ER Pin 'H' Voltage | VEH | | 2.0 | - | - | V |
| ER Pin 'L' Voltage | VEL | | - | - | 0.8 | V |
| ER Pin Input Current | IEL | | - | 1 | 10 | μA |

VDET(T):Standard Detection Voltage (2.3V to 4.8V, 0.1V step)

RL :Pull-up resistor to be connected between VOUT and power supply.

CL :Capacitor to be connected between VOUT and GND.

*1 Guarantee is Ta=25°C.

Attention: Please connect the GND when you don't use 'ER'

●Block Diagrams



Fig.1 BD45xxx Series



Fig.2 BD46xxx Series

● Typical Performance Curves



Fig.3 Circuit Current



Fig.4 "Low" Output Current



Fig.5 "High" Output Current



Fig.6 I/O Characteristics

● Typical Performance Curves – continued



Fig.7 ER Terminal Threshold Voltage



Fig.8 ER Terminal Input Current



Fig.9 Detection Voltage Release Voltage



Fig.10 Circuit Current when ON (VDET-0.2V)

● Typical Performance Curves – continued



Fig.11 Circuit Current when OFF



Fig.12 Operating Limit Voltage



Fig.13 Output Delay Time
"Low" → "High"



Fig.14 Output Delay Time
"High" → "Low"

● Application Information

Explanation of Operation

For both the open drain type (Fig.15) and the CMOS output type (Fig.16), 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”. Because the BD45xxx series uses an open drain output type, it is necessary to connect either 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.15 (BD45xxx Type Internal Block Diagram)



Fig.16 (BD46xxx Type Internal Block Diagram)

Reference Data

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

| Part Number | t _{PLH} [ms] | t _{PHL} [μs] |
|-------------|-----------------------|-----------------------|
| BD45275G | 50 | 18 |
| BD46275G | 50 | 18 |

V_{DD}=2.2V→3.2V

V_{DD}=3.2V→2.2V

*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}, the output voltage V_{OUT} and ER terminal 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.17 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 outputted 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} + ΔV_{DET}), the output voltages will switch to Low.
- ③ If V_{DD} exceeds the reset release voltage (V_{DET} + ΔV_{DET}), the counter timer start and V_{OUT} switches from L to H.
- ④ When more than the high level voltage is supplied to the ER terminal, V_{OUT} comes to “L” after t_{PLH} delay time. Therefore, a time when ER terminal is “H” is necessary for 100μsec or more.
- ⑤ When the ER terminal switches to Low, the counter timer starts to operate, a delay of t_{PLH} occurs, and V_{OUT} switches from “L” to “H”.
- ⑥ 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}).
- ⑦ The potential difference between the detection voltage and the release voltage is known as the hysteresis width (ΔV_{DET}). The system is designed such that the output does not toggle with power supply fluctuations within this hysteresis width, preventing malfunctions due to noise.

These time changes by the application and use it, please verify and confirm using practical applications.

●Circuit Applications

1) Examples of common power supply detection reset circuits.



Fig.18 Open Drain Output Type



Fig.19 CMOS Output Type

Application examples of BD45xxx series (Open Drain output type) and BD46xxx series (CMOS output type) are shown below.

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 (BD45xxx) with a load resistance R_L as shown Fig.18.

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 (BD46xxx) device or an open drain output type (BD45xxx) device with a pull up resistor between the 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}).

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. 20

To reset the microcontroller when many independent power supplies are used in the system, OR connect an open drain output type (BD45xxx series) to the microcontroller's input with pull-up resistor to the supply voltage of the microcontroller (V_{DD3}) as shown in Fig. 20. 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. 21

When an in-rush current (I1) flows into the circuit (Refer to Fig. 21) at the time when output switches from “Low” to “High”, a voltage drop of $I1 \times R2$ (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. 22 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 μ F capacitor between V_{DD} pin and GND and 1000pF capacitor between V_{OUT} 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_{DD} line impedance might cause oscillation because of the detection current.
- 8) A V_{DD} to GND capacitor (as close connection as possible) should be used in high V_{DD} line impedance condition.
- 9) Lower than the minimum input voltage puts the V_{OUT} in high impedance state, and it must be V_{DD} in pull up (V_{DD}) condition.
- 10) 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 the leakage of about 1M Ω is assumed between the ER terminal and the GND terminal, 100k Ω connection between the ER terminal and the V_{DD} terminal would be recommended. If the leakage is assumed between the V_{OUT} terminal and the GND terminal, the pull-up resistor should be less than 1/10 of the assumed leak resistance.
- 11) External parameters
The recommended parameter range for R_L is 50k Ω to 1M Ω . There are many factors (board layout, etc) that can affect characteristics. Please verify and confirm using practical applications.
- 12) Power on reset operation
Please note that the power on reset output varies with the V_{DD} rise time. Please verify the behavior in the actual operation.
- 13) 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.
- 14) 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.

Notice

Precaution on using ROHM Products

- 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 |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV | | CLASS III | |

- 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:
 - Installation of protection circuits or other protective devices to improve system safety
 - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- 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:
 - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
 - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
 - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - Sealing or coating our Products with resin or other coating materials
 - 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
 - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- 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.
- De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- 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

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

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General Precaution

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