

## Voltage Detector (Reset) IC Series for Automotive Application

# Free Time Delay Setting

# CMOS Voltage Detector (Reset) IC

## BD52xx-2M Series and BD53xx-2M Series

### General Description

ROHM's BD52xx-2M and BD53xx-2M series are highly accurate, low current consumption Voltage Detector ICs with a capacitor controlled time delay. The lineup includes N-channel open drain output (BD52xx-2M) and CMOS output (BD53xx-2M) so that the users can select depending on the application. The devices are available for specific detection voltage ranging from 0.9V to 5.0V with 0.1V increment.

The time delay has  $\pm 30\%$  accuracy in the overall operating temperature range of  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ .

### Special Features

- AEC-Q100 Qualified (Note1)
- Nano Energy
- Delay Time Setting controlled by external capacitor
- Two output types (Nch open drain and CMOS output)
- Very small, lightweight and thin package
- Package SSOP5 is similar to SOT-23-5 (JEDEC) (Note1: Grade 1)

### Application Circuit

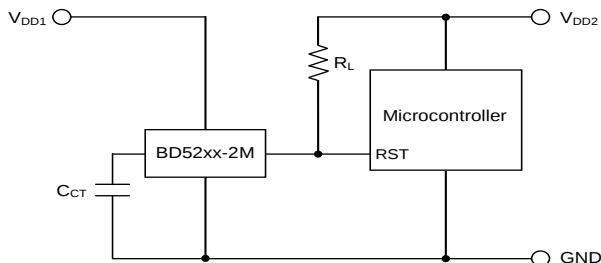


Figure 1. Open Drain Output Type  
BD52xx-2M Series

### Key Specifications

- Detection Voltage: 0.9V to 5.0V (Typ.)  
0.1V step
- Ultra-Low Current Consumption: 270nA (Typ.)
- Time Delay Accuracy:  $\pm 30\%$  ( $-40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$ , )  
(CT pin capacitor  $\geq 1\text{nF}$ )

### Special Characteristics

- Detection Voltage Accuracy:  
 $\pm 2.0\% \pm 12\text{mV}$  ( $V_{\text{DET}}=0.9\text{V}$  to  $1.6\text{V}$ )  
 $\pm 2.5\%$  ( $V_{\text{DET}}=1.7\text{V}$  to  $5.0\text{V}$ )

### Package

SSOP5:



W(typ) x D(typ) x H(max)  
2.90mm x 2.80mm x 1.25mm

### Application

- Automotive (audio system, navigation system, etc.)

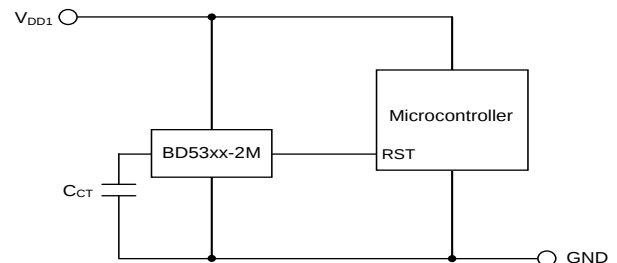
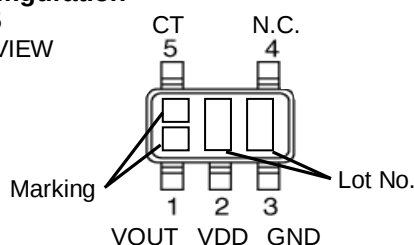


Figure 2. CMOS Output Type  
BD53xx-2M Series

### Pin Configuration

#### SSOP5

#### TOP VIEW



### Pin Description

| SSOP5   |        |                                                        |
|---------|--------|--------------------------------------------------------|
| PIN No. | Symbol | Function                                               |
| 1       | VOUT   | Output pin                                             |
| 2       | VDD    | Power supply voltage                                   |
| 3       | GND    | GND                                                    |
| 4       | N.C.   | No connection pin                                      |
| 5       | CT     | Capacitor connection pin for output delay time setting |

N.C. pin is electrically open and can be connected to either VDD or GND.

Nano Energy is a combination of technologies which realizes ultra low quiescent current operation.

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

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## Ordering Information

|               |                                             |  |                                                            |  |                      |  |   |                                    |  |                                                                    |  |
|---------------|---------------------------------------------|--|------------------------------------------------------------|--|----------------------|--|---|------------------------------------|--|--------------------------------------------------------------------|--|
| B D x x x x x |                                             |  |                                                            |  |                      |  | - | 2 M T R                            |  |                                                                    |  |
| Part Number   | Output Type<br>52 : Open Drain<br>53 : CMOS |  | Detection Voltage<br>09 : 0.9V<br>↓ 0.1V step<br>50 : 5.0V |  | Package<br>G : SSOP5 |  |   | Product Rank<br>M : for Automotive |  | Packaging and forming specification<br>TR : Embossed tape and reel |  |

## Lineup

| Output Type       | Open Drain |             | CMOS    |             |
|-------------------|------------|-------------|---------|-------------|
| Detection Voltage | Marking    | Part Number | Marking | Part Number |
| 5.0V              | 1Z         | BD5250      | 90      | BD5350      |
| 4.9V              | 1Y         | BD5249      | 89      | BD5349      |
| 4.8V              | 1X         | BD5248      | 88      | BD5348      |
| 4.7V              | 1W         | BD5247      | 87      | BD5347      |
| 4.6V              | 1V         | BD5246      | 86      | BD5346      |
| 4.5V              | 1U         | BD5245      | 85      | BD5345      |
| 4.4V              | 1T         | BD5244      | 84      | BD5344      |
| 4.3V              | 1S         | BD5243      | 83      | BD5343      |
| 4.2V              | 1R         | BD5242      | 82      | BD5342      |
| 4.1V              | 1Q         | BD5241      | 81      | BD5341      |
| 4.0V              | 1P         | BD5240      | 80      | BD5340      |
| 3.9V              | 1N         | BD5239      | 79      | BD5339      |
| 3.8V              | 08         | BD5238      | 78      | BD5338      |
| 3.7V              | 07         | BD5237      | 77      | BD5337      |
| 3.6V              | 06         | BD5236      | 76      | BD5336      |
| 3.5V              | 05         | BD5235      | 75      | BD5335      |
| 3.4V              | 04         | BD5234      | 74      | BD5334      |
| 3.3V              | 03         | BD5233      | 73      | BD5333      |
| 3.2V              | 02         | BD5232      | 72      | BD5332      |
| 3.1V              | 01         | BD5231      | 71      | BD5331      |
| 3.0V              | 5G         | BD5230      | 70      | BD5330      |
| 2.9V              | Z9         | BD5229      | 69      | BD5329      |
| 2.8V              | Z8         | BD5228      | 68      | BD5328      |
| 2.7V              | Z7         | BD5227      | 67      | BD5327      |
| 2.6V              | XS         | BD5226      | 66      | BD5326      |
| 2.5V              | XR         | BD5225      | 65      | BD5325      |
| 2.4V              | 24         | BD5224      | 64      | BD5324      |
| 2.3V              | 23         | BD5223      | 63      | BD5323      |
| 2.2V              | 22         | BD5222      | 62      | BD5322      |
| 2.1V              | 21         | BD5221      | 61      | BD5321      |
| 2.0V              | 20         | BD5220      | 60      | BD5320      |
| 1.9V              | 19         | BD5219      | 59      | BD5319      |
| 1.8V              | 18         | BD5218      | 58      | BD5318      |
| 1.7V              | 17         | BD5217      | 57      | BD5317      |
| 1.6V              | 16         | BD5216      | 56      | BD5316      |
| 1.5V              | 15         | BD5215      | 55      | BD5315      |
| 1.4V              | 14         | BD5214      | 54      | BD5314      |
| 1.3V              | 13         | BD5213      | 53      | BD5313      |
| 1.2V              | 12         | BD5212      | 52      | BD5312      |
| 1.1V              | 11         | BD5211      | 51      | BD5311      |
| 1.0V              | 10         | BD5210      | 5F      | BD5310      |
| 0.9V              | 09         | BD5209      | 5E      | BD5309      |

## Absolute Maximum Ratings (Ta=+25°C)

| Parameter                    |                       | Symbol       | Limit                   | Unit |
|------------------------------|-----------------------|--------------|-------------------------|------|
| Power Supply Voltage         |                       | $V_{DD}-GND$ | -0.3 to +7              | V    |
| Output Voltage               | Nch Open Drain Output | $V_{OUT}$    | GND-0.3 to +7           | V    |
|                              | CMOS Output           |              | GND-0.3 to $V_{DD}+0.3$ |      |
| Output Current               |                       | $I_O$        | 70                      | mA   |
| Operating Temperature Range  |                       | $T_{opr}$    | -40 to +105             | °C   |
| Maximum Junction Temperature |                       | $T_{jmax}$   | +150                    | °C   |
| Storage Temperature Range    |                       | $T_{stg}$    | -55 to +150             | °C   |

**Caution 1:** 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.

**Caution 2:** Should by any chance the maximum junction temperature 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 maximum junction temperature rating.

## Thermal Resistance (Note 1)

| Parameter                                                      | Symbol          | Thermal Resistance (Typ) |                          | Unit |
|----------------------------------------------------------------|-----------------|--------------------------|--------------------------|------|
|                                                                |                 | 1s <sup>(Note 3)</sup>   | 2s2p <sup>(Note 4)</sup> |      |
| SSOP5                                                          |                 |                          |                          |      |
| Junction to Ambient                                            | θ <sub>JA</sub> | 376.5                    | 185.4                    | °C/W |
| Junction to Top Characterization Parameter <sup>(Note 2)</sup> | Ψ <sub>JT</sub> | 40                       | 30                       | °C/W |

(Note 1)Based on JESD51-2A(Still-Air).

(Note 2)The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 3)Using a PCB board based on JESD51-3.

| Layer Number of Measurement Board | Material  | Board Size                 |
|-----------------------------------|-----------|----------------------------|
| Single                            | FR-4      | 114.3mm x 76.2mm x 1.57mmt |
| Top                               |           |                            |
| Copper Pattern                    | Thickness |                            |
| Footprints and Traces             | 70μm      |                            |

(Note 4)Using a PCB board based on JESD51-7.

| Layer Number of Measurement Board | Material  | Board Size                |           |                 |           |
|-----------------------------------|-----------|---------------------------|-----------|-----------------|-----------|
| 4 Layers                          | FR-4      | 114.3mm x 76.2mm x 1.6mmt |           |                 |           |
| Top                               |           | 2 Internal Layers         |           | Bottom          |           |
| Copper Pattern                    | Thickness | Copper Pattern            | Thickness | Copper Pattern  | Thickness |
| Footprints and Traces             | 70μm      | 74.2mm x 74.2mm           | 35μm      | 74.2mm x 74.2mm | 70μm      |

**Electrical Characteristics (Unless otherwise specified Ta=-40°C to +105°C, VDD=0.8V to 6V)**

| Parameter                      | Symbol           | Condition                                                              | Limit                                |                       |                                      | Unit    |
|--------------------------------|------------------|------------------------------------------------------------------------|--------------------------------------|-----------------------|--------------------------------------|---------|
|                                |                  |                                                                        | Min                                  | Typ                   | Max                                  |         |
| Detection Voltage              | $V_{DET}$        | $V_{DET}=0.9V$ to $1.6V$ , $V_{DD}=H \rightarrow L$ , $R_L=100k\Omega$ | $V_{DET}(T) \times 0.98$<br>$-0.012$ | $V_{DET}(T)$          | $V_{DET}(T) \times 1.02$<br>$+0.012$ | V       |
|                                |                  | $V_{DET}=1.7V$ to $5.0V$ , $V_{DD}=H \rightarrow L$ , $R_L=100k\Omega$ | $V_{DET}(T) \times 0.975$            | $V_{DET}(T)$          | $V_{DET}(T) \times 1.025$            |         |
| Hysteresis Voltage             | $\Delta V_{DET}$ | $V_{DD}=L \rightarrow H \rightarrow L$ , $R_L=100k\Omega$              | $V_{DET} \times 0.03$                | $V_{DET} \times 0.05$ | $V_{DET} \times 0.07$                | V       |
| Circuit Current when ON        | $I_{DD1}$        | $V_{DD}=V_{DET}-0.2V$                                                  | -                                    | 0.23                  | 1.00                                 | $\mu A$ |
| Circuit Current when OFF       | $I_{DD2}$        | $V_{DD}=V_{DET}+0.5V$                                                  | -                                    | 0.27                  | 1.10                                 | $\mu A$ |
| Operating Voltage Range        | $V_{OPL}$        | $V_{OL} \leq 0.4V$ , Ta=-40°C to 105°C, $R_L=100k\Omega$               | 0.80                                 | -                     | -                                    | V       |
| “Low” Output Voltage (Nch)     | $V_{OL}$         | $V_{DD}=0.8V$ , ISINK = 0.17mA, $V_{DET}=0.9V$ to $1.6V$               | -                                    | -                     | 0.4                                  | V       |
|                                |                  | $V_{DD}=1.2V$ , ISINK = 1.0mA, $V_{DET}=1.7V$ to $5.0V$                | -                                    | -                     | 0.4                                  |         |
|                                |                  | $V_{DD}=2.4V$ , ISINK = 2.0mA, $V_{DET}=2.7V$ to $5.0V$                | -                                    | -                     | 0.4                                  |         |
| “High” Output Voltage (Pch)    | $V_{OH}$         | $V_{DD}=4.8V$ , ISOURCE=2.0mA, $V_{DET}(0.9V$ to $4.2V)$               | $V_{DD}-0.4$                         | -                     | -                                    | V       |
|                                |                  | $V_{DD}=6.0V$ , ISOURCE=2.5mA, $V_{DET}(0.9V$ to $5.0V)$               | $V_{DD}-0.4$                         | -                     | -                                    |         |
| Output Leak Current (BD52xx)   | $I_{LEAK}$       | $V_{DD}=V_{DS}=6V$                                                     | -                                    | -                     | 1.0                                  | $\mu A$ |
| Delay Time (L $\rightarrow$ H) | $t_{PLH}$        | $V_{OUT}=GND \rightarrow 50\%$ , CT=0.01 $\mu F$<br>Note 1 Note 2      | 38.9                                 | 55.5                  | 72.1                                 | ms      |

$V_{DET}(T)$ : Standard Detection Voltage(0.9V to 5.0V, 0.1V step)

$R_L$ : Pull-up resistor to be connected between  $V_{OUT}$  and power supply.

Note 1  $t_{PLH}$ :  $V_{DD}=(V_{DET}(T)-0.1V) \rightarrow (V_{DET}(T)+0.5V)$  for  $V_{DET}=0.9V$  to  $1.2V$

$t_{PLH}$ :  $V_{DD}=(V_{DET}(T)-0.5V) \rightarrow (V_{DET}(T)+0.5V)$  for  $V_{DET}=1.3V$  to  $5.0V$

Note 2 CT delay capacitor range: open to 4.7 $\mu F$ .

## Block Diagram

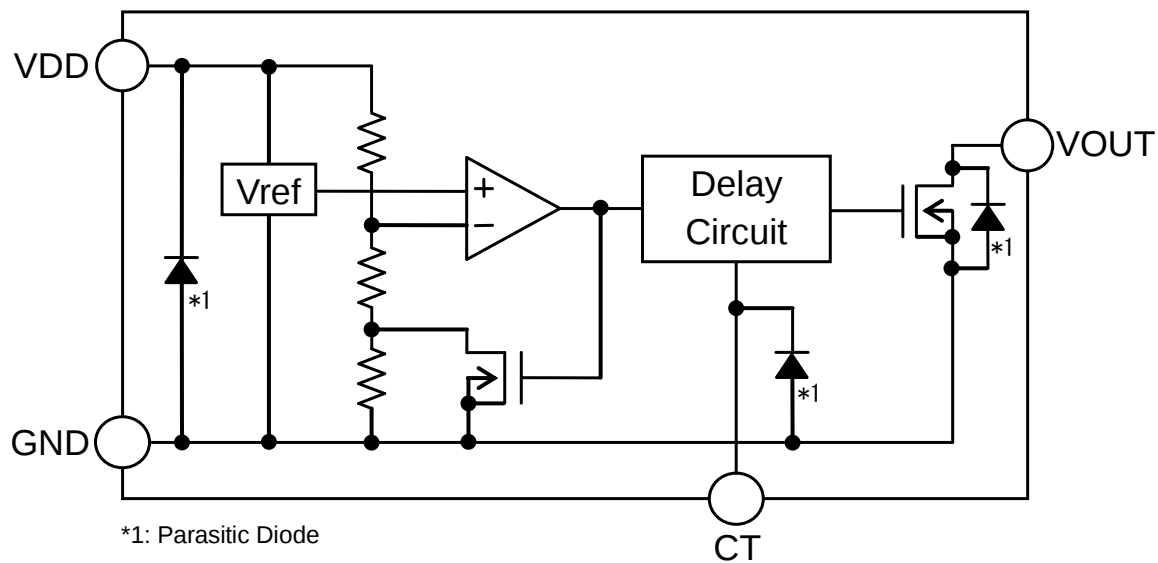


Figure 3. BD52xx-2M Series

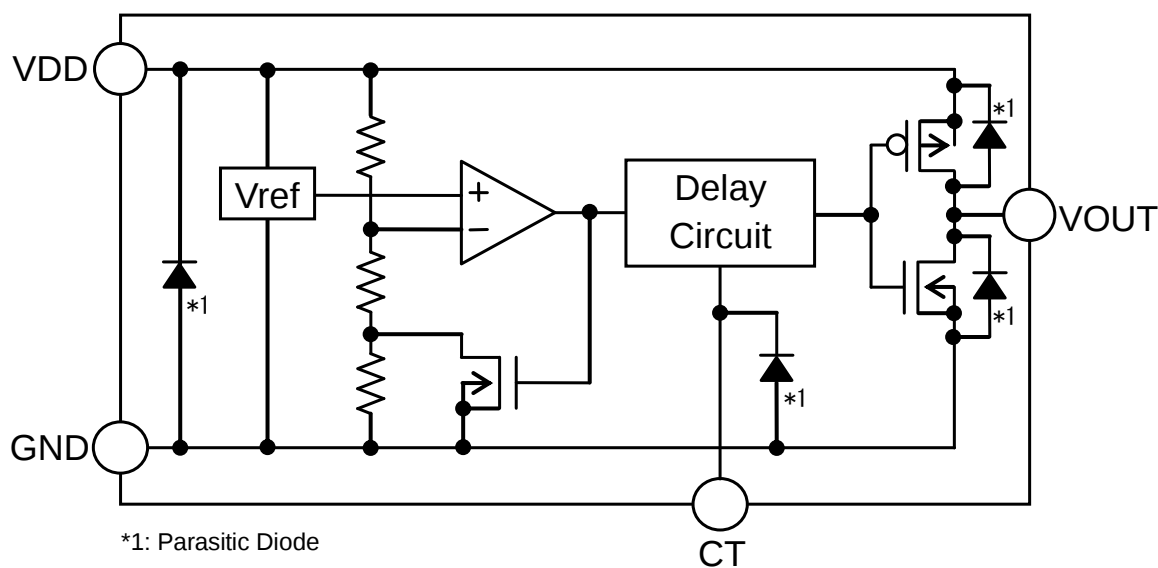


Figure 4. BD53xx-2M Series

## Typical Performance Curves

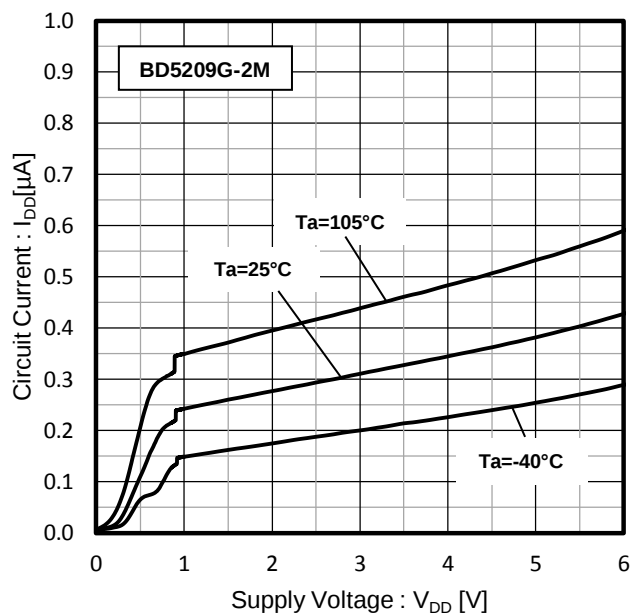
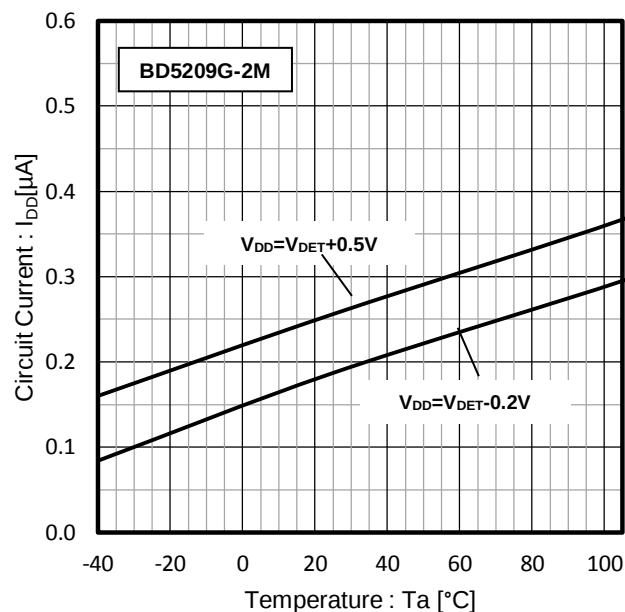
Figure 5. Circuit Current vs.  $V_{DD}$ 

Figure 6. Circuit Current vs. Temp

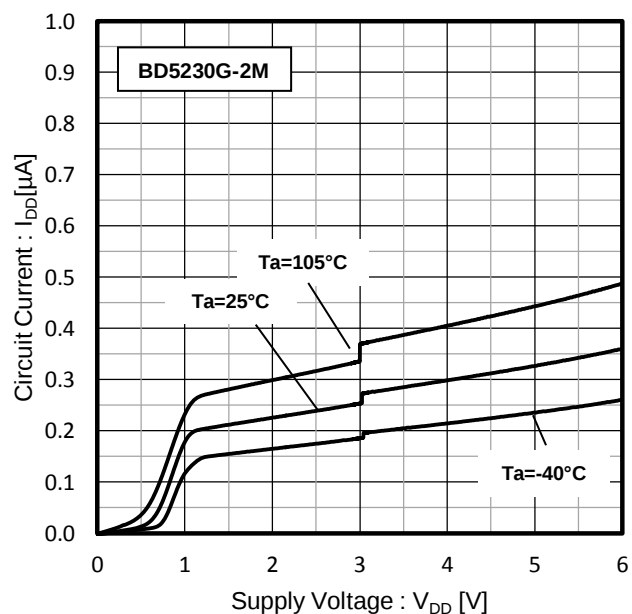
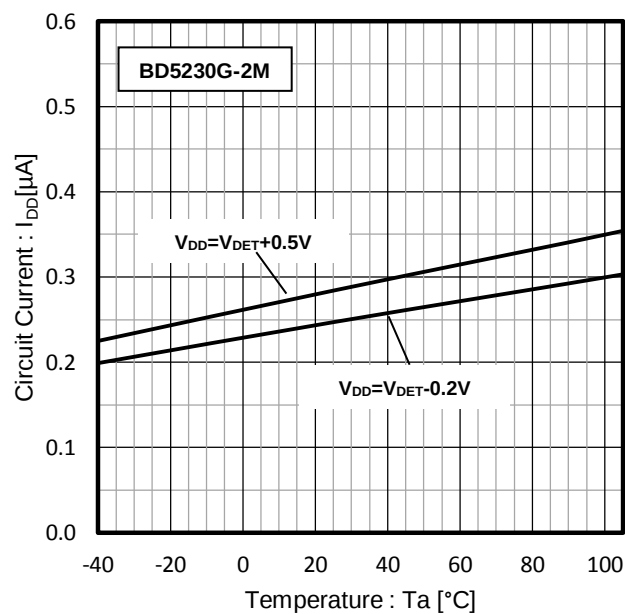
Figure 7. Circuit Current vs.  $V_{DD}$ 

Figure 8. Circuit Current vs. Temp

## Typical Performance Curves - continued

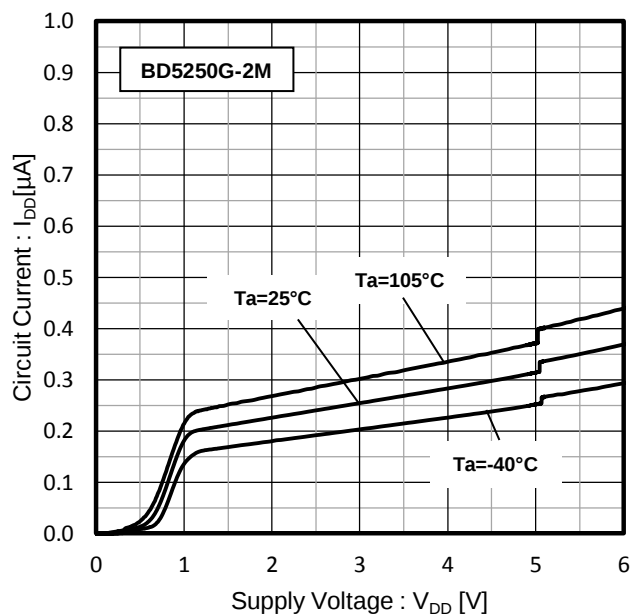
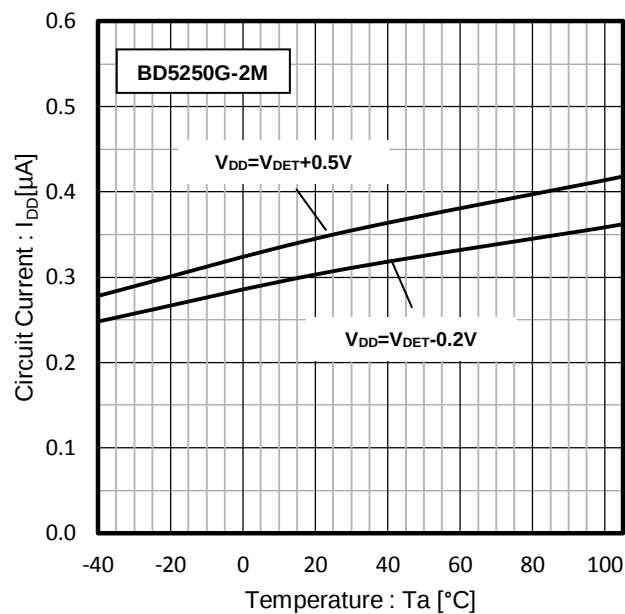
Figure 9. Circuit Current vs.  $V_{DD}$ 

Figure 10. Circuit Current vs. Temp

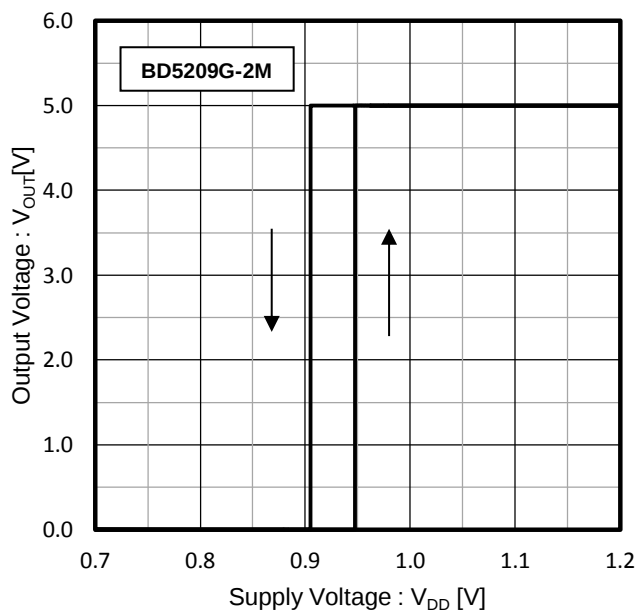


Figure 11. Detection Voltage

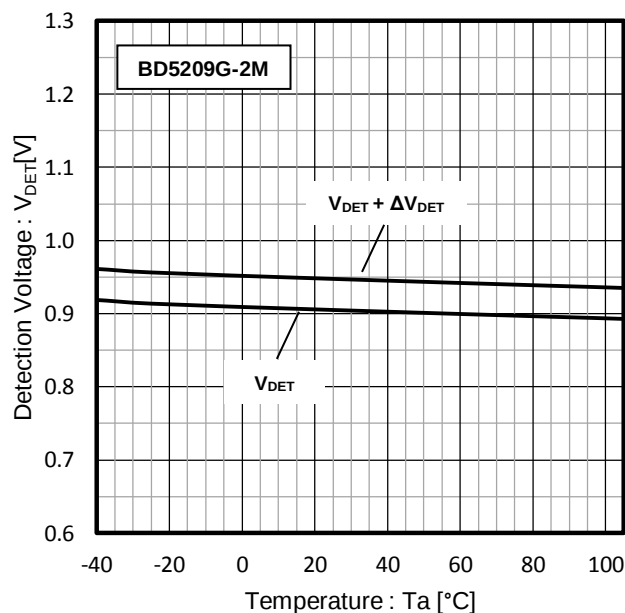


Figure 12. Detection Voltage and Release Voltage

## Typical Performance Curves - continued

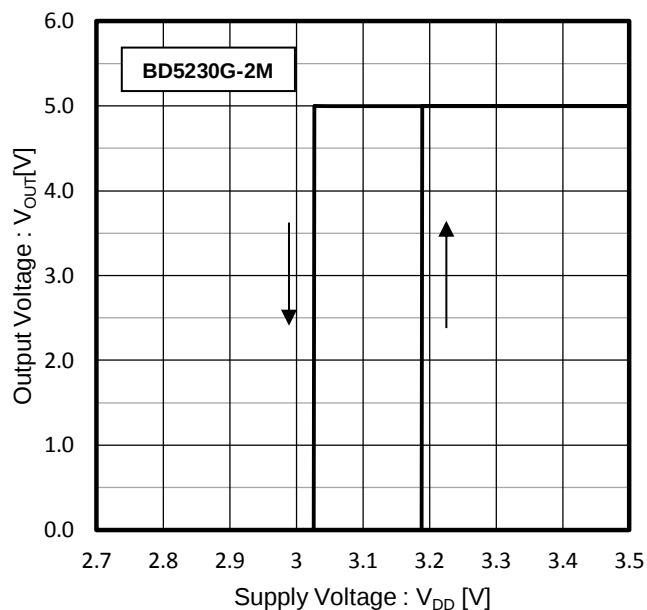


Figure 13. Detection Voltage

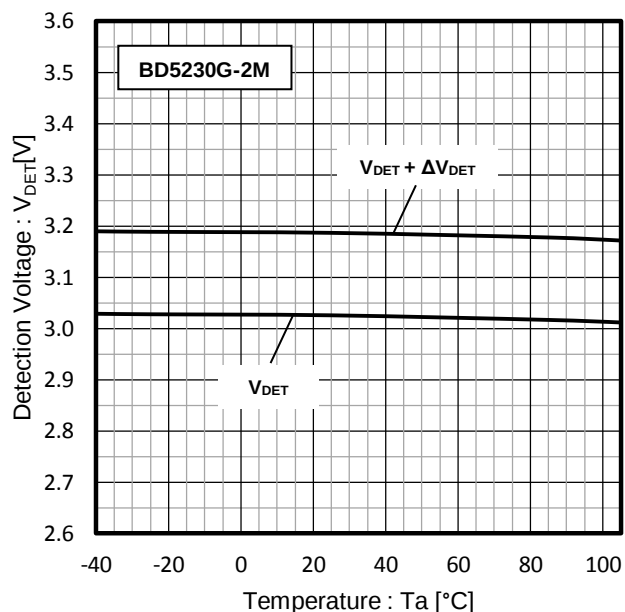


Figure 14. Detection Voltage and Release Voltage

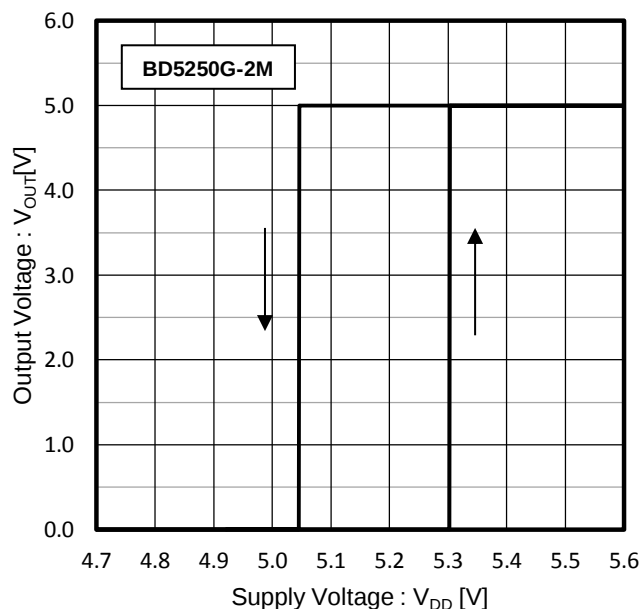


Figure 15. Detection Voltage

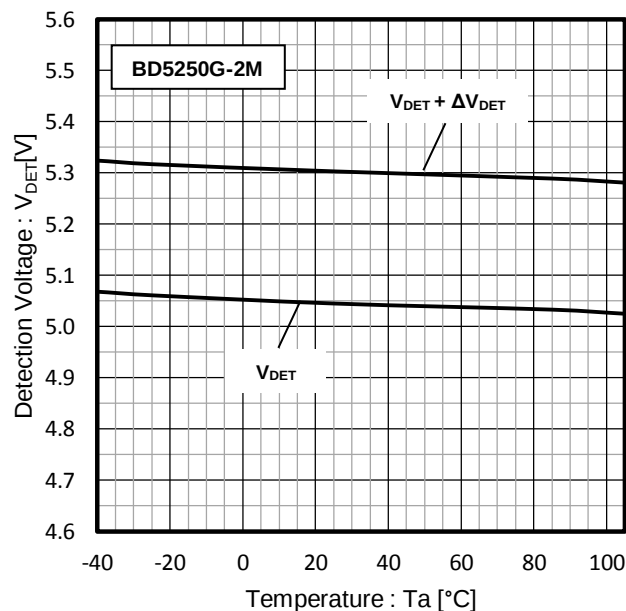


Figure 16. Detection Voltage and Release Voltage

## Typical Performance Curves - continued

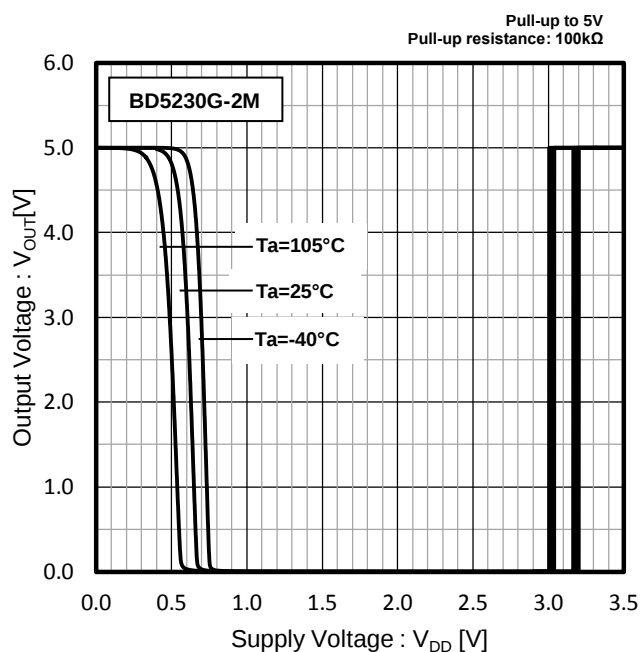


Figure 17. I/O Characteristics

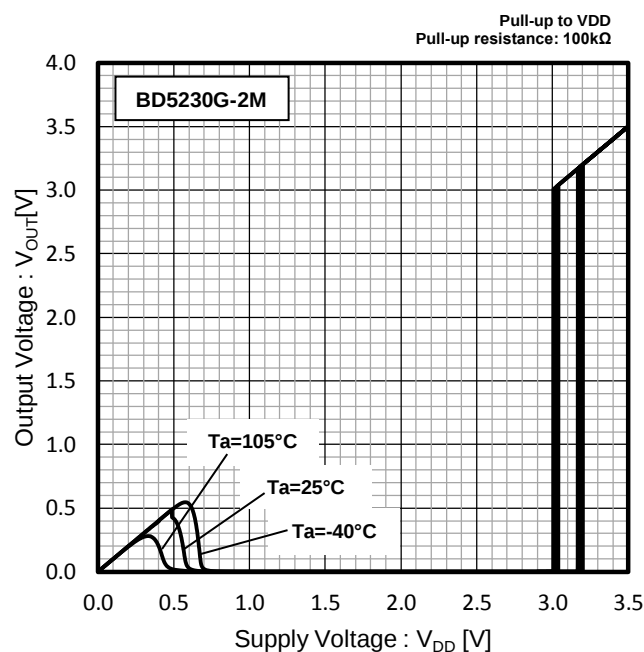


Figure 18. I/O Characteristics

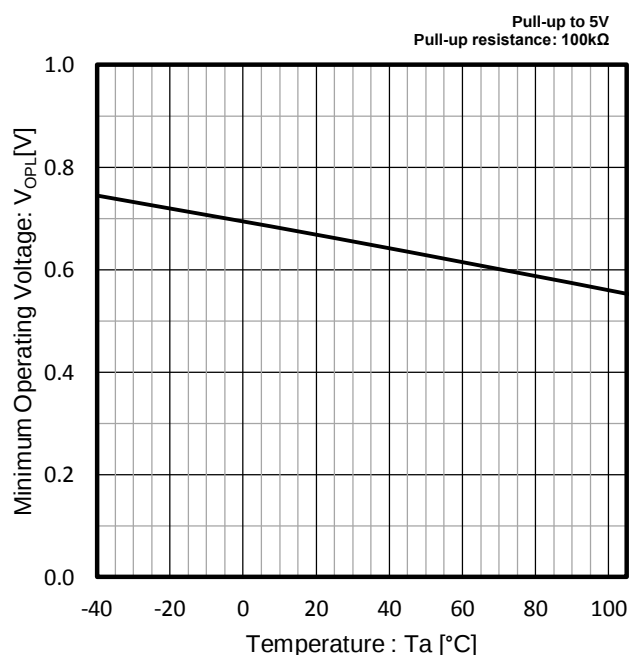


Figure 19. Operating Limit Voltage

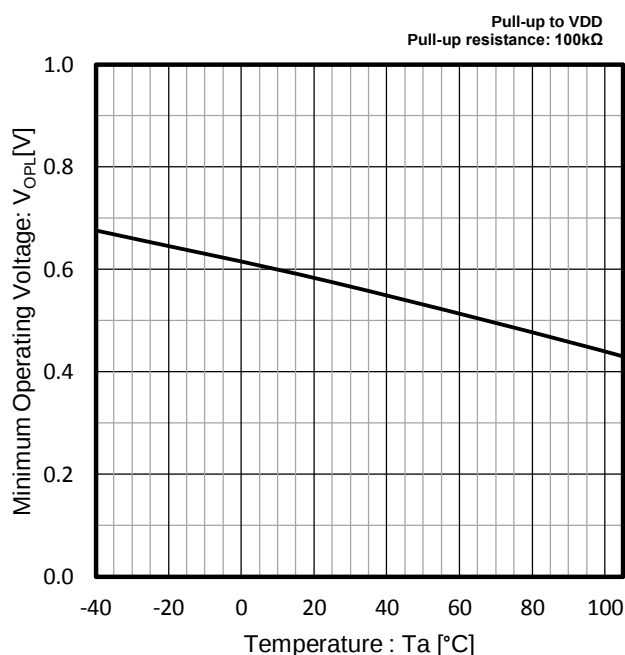


Figure 20. Operating Limit Voltage

## Typical Performance Curves - continued

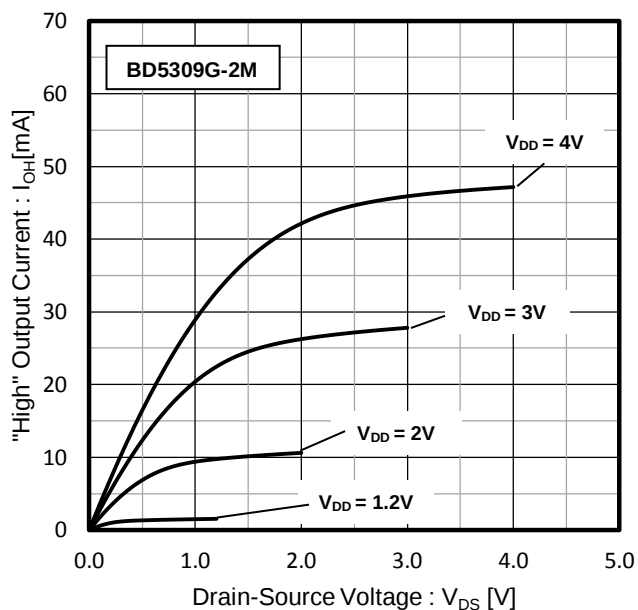


Figure 21. "High" Output Current

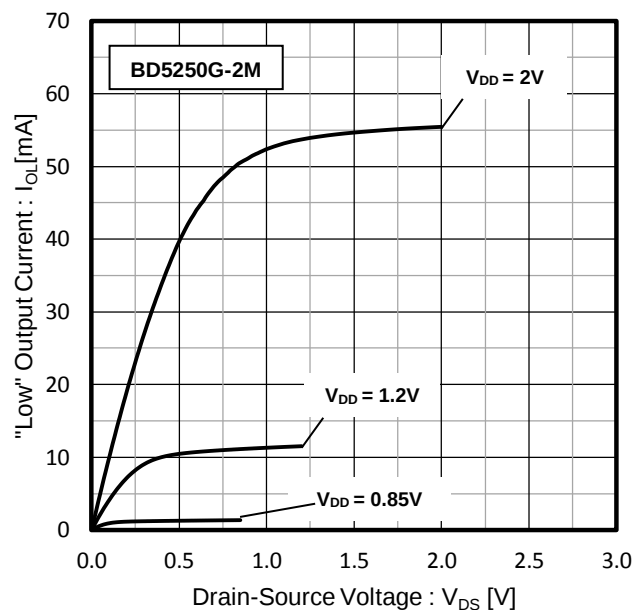
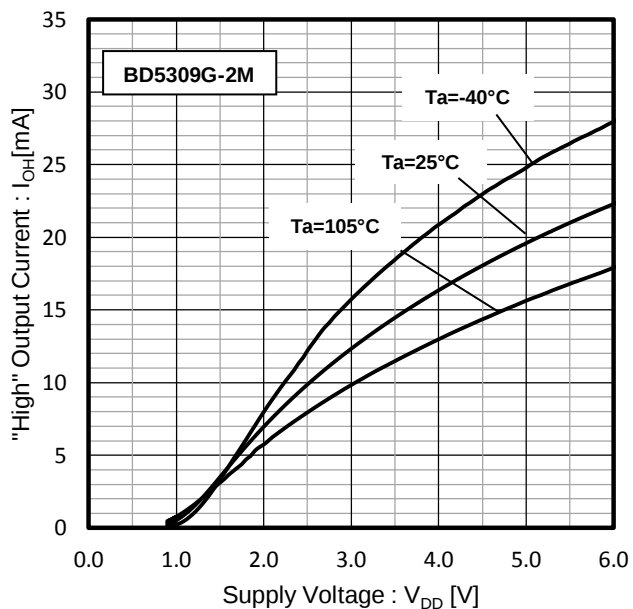
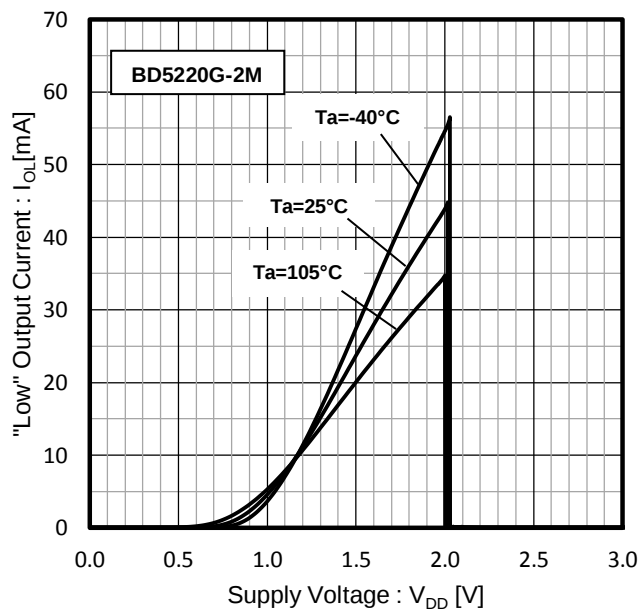


Figure 22. "Low" Output Current

Figure 23. "High" Output Current ( $V_{DS}=0.5V$ )Figure 24. "Low" Output Current ( $V_{DS}=0.5V$ )

## Typical Performance Curves - continued

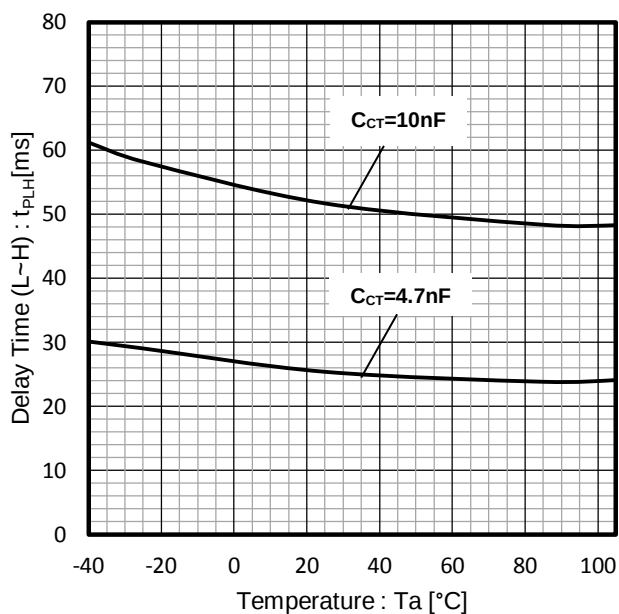


Figure 25. Output Delay Time (L to H)

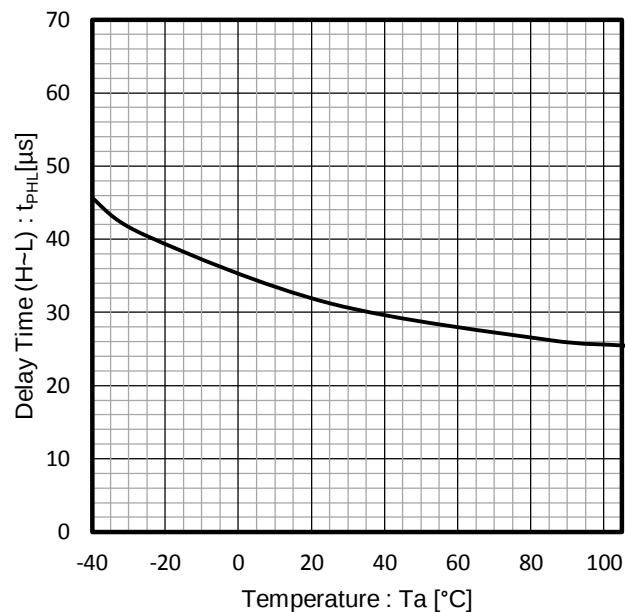


Figure 26. Output Delay Time (H to L)

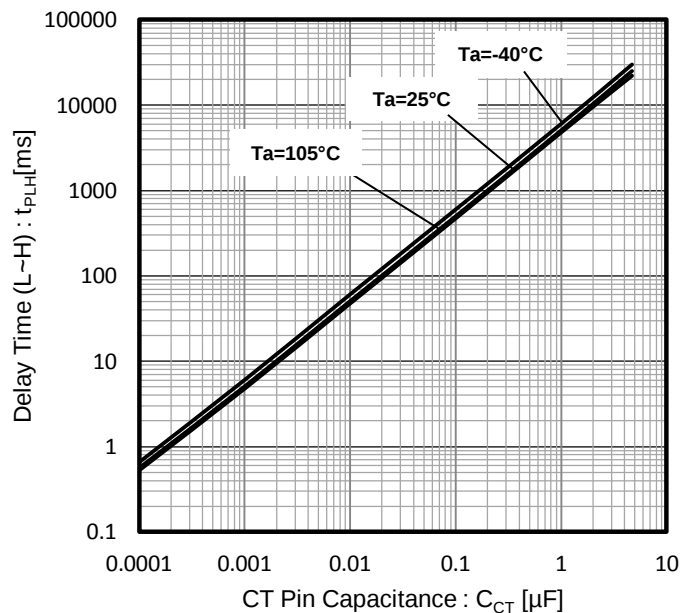


Figure 27. Output Delay Time (L to H)

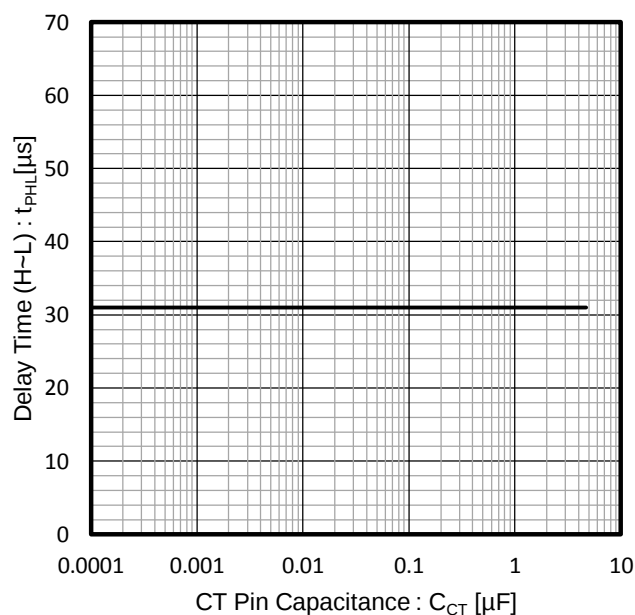


Figure 28. Output Delay Time (H to L)

## Application Information

## 1. Explanation of Operation

For both the open drain type (Figure 29) and the CMOS output type (Figure 30), the detection and release voltages are used as threshold voltages. When the voltage applied to the VDD pin reaches the applicable threshold voltage, the VOUT pin voltage switches from either "High" to "Low" or from "Low" to "High". BD52xx-2M series and BD53xx-2M series have delay time function which set  $t_{PLH}$  (output "Low" to "High") using an external capacitor connected in CT pin ( $C_{CT}$ ). Because the BD52xx-2M 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].

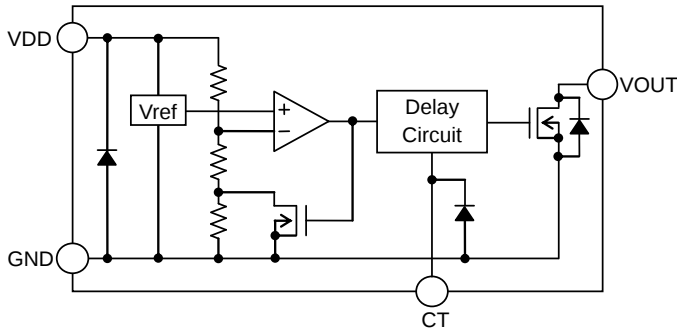


Figure 29. (BD52xx-2M type internal block diagram)

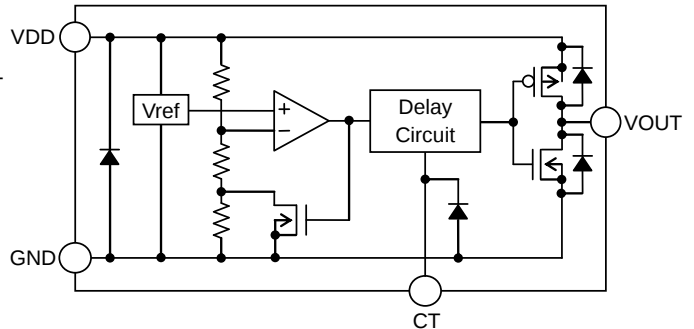


Figure 30. (BD53xx-2M type internal block diagram)

## 2. Setting of Detector Delay Time

Delay time L to H ( $t_{PLH}$ ) is the time when  $V_{OUT}$  rises to 1/2 of  $V_{DD}$  after  $V_{DD}$  rises up and beyond the release voltage ( $V_{DET} + \Delta V_{DET}$ ). The delay time ( $t_{PLH}$ ) at the rise of  $V_{DD}$  is determined by delay coefficient, CT capacitor and delay time when CT pin is open ( $t_{CTO}$ ) and calculated from the following formula. When CT capacitor  $\geq 1\text{nF}$ ,  $t_{CTO}$  has less effect and  $t_{PLH}$  computation is shown on Example No.2. The result has  $\pm 30\%$  tolerance within the operating temperature range of  $-40^\circ\text{C}$  to  $+105^\circ\text{C}$ .

Formula: ( $T_a = 25^\circ\text{C}$ )

$$t_{PLH} = C_{CT} \times \text{Delay Coefficient} + t_{CTO} \quad [\text{s}]$$

where:

$C_{CT}$  is the CT pin external capacitor

Delay Coefficient is equal to  $5.55 \times 10^6$

$t_{CTO}$  is the delay time when CT=open <sup>Note1</sup>

| Temperature                                       | Delay Time ( $t_{CTO}$ ) |                  |                   |
|---------------------------------------------------|--------------------------|------------------|-------------------|
|                                                   | Min                      | Typ              | Max               |
| $T_a = -40^\circ\text{C}$ to $+105^\circ\text{C}$ | 15 $\mu\text{s}$         | 50 $\mu\text{s}$ | 150 $\mu\text{s}$ |

Note1:  $t_{CTO}$  is design guarantee only; outgoing inspection is not done on all products.

Example No.1:

CT capacitor = 100pF

$$t_{PLH\_min} = (100 \times 10^{-12} \times 5.55 \times 10^6) \times 0.7 + 15 \times 10^{-6} = 403\mu\text{s}$$

$$t_{PLH\_typ} = (100 \times 10^{-12} \times 5.55 \times 10^6) \times 1.0 + 50 \times 10^{-6} = 605\mu\text{s}$$

$$t_{PLH\_max} = (100 \times 10^{-12} \times 5.55 \times 10^6) \times 1.3 + 150 \times 10^{-6} = 872\mu\text{s}$$

Example No.2:

CT capacitor = 1nF

$$t_{PLH\_typ} = 1 \times 10^{-9} \times 5.55 \times 10^6 = 5.55\text{ms}$$

### 3. Timing Waveform

The following shows the relationship between the input voltage  $V_{DD}$  and the output voltage  $V_{OUT}$  when the power supply voltage  $V_{DD}$  is sweep up and sweep down.

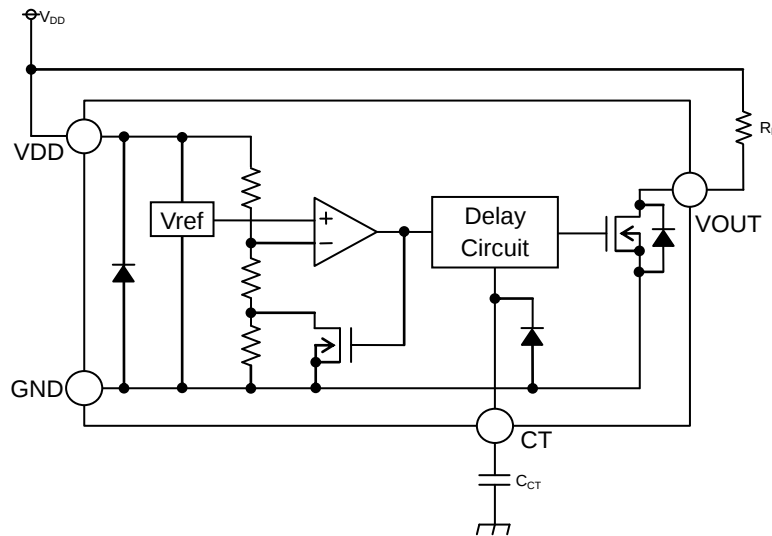


Figure 31. BD52xx-2M Set-up

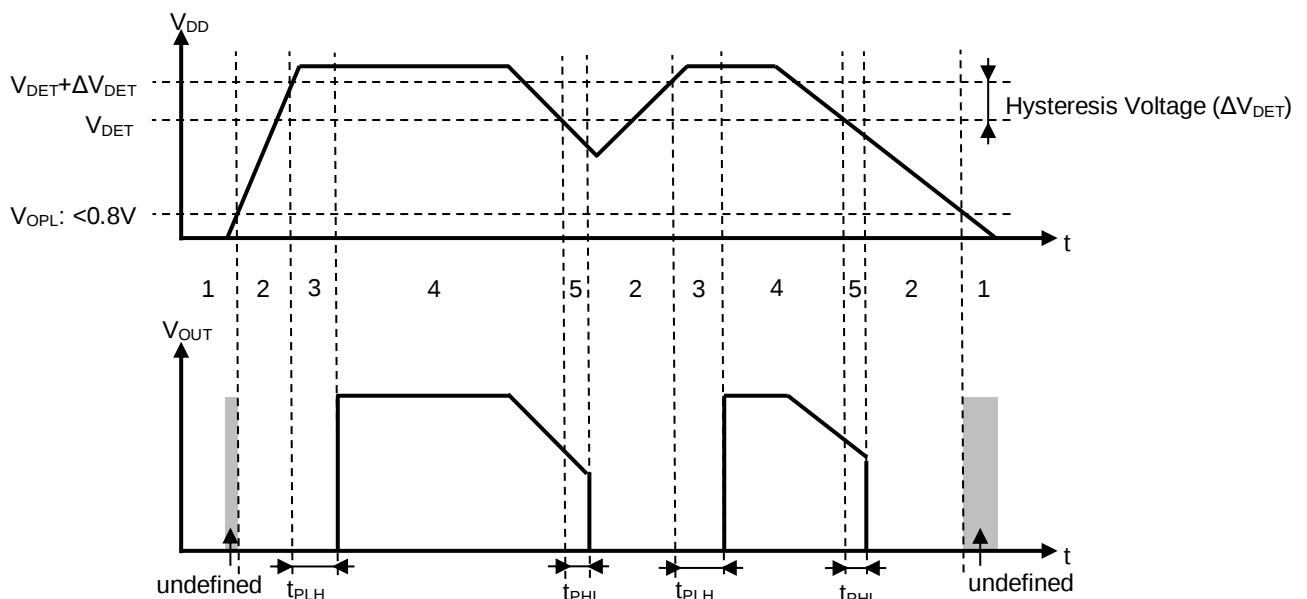


Figure 32. Timing Diagram

1. When the power supply turns on, the Output Voltage ( $V_{OUT}$ ) is undefined until  $V_{DD}$  overcomes the Operating Voltage Limit ( $V_{OPL}$ ).
2.  $V_{OUT}$  will turn to "Low" as  $V_{DD}$  increases above  $V_{OPL}$  but less than the Release Voltage ( $V_{DET} + \Delta V_{DET}$ ).
3. When  $V_{DD}$  exceeds the Release Voltage ( $V_{DET} + \Delta V_{DET}$ ), delay time ( $t_{PLH}$ ) set by capacitor at CT pin ( $C_{CT}$ ) will happen then  $V_{OUT}$  will switch from "Low" to "High".
4.  $V_{OUT}$  will remain "High" until  $V_{DD}$  do not fall below the Detection Voltage ( $V_{DET}$ ).
5. When  $V_{DD}$  drops below  $V_{DET}$ ,  $V_{OUT}$  will switch from "High" to "Low" with a delay of  $t_{PHL}$ .

\*The potential difference between the detection voltage and the release voltage is known as the Hysteresis Voltage width ( $\Delta V_{DET}$ ). The system is designed such that the output will not toggle with power supply fluctuations within this hysteresis width, preventing malfunctions due to noise.

#### 4. Circuit Applications

##### (1) Examples of common application circuits

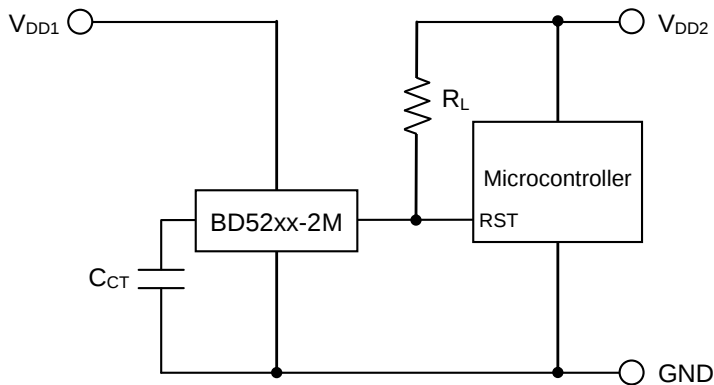


Figure 33. Open Drain Output Type

Application examples of BD52xx-2M series (Open-drain output type) and BD53xx-2M 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 (BD52xx-2M) device with a load resistance  $R_L$  attached as shown in Figure33.

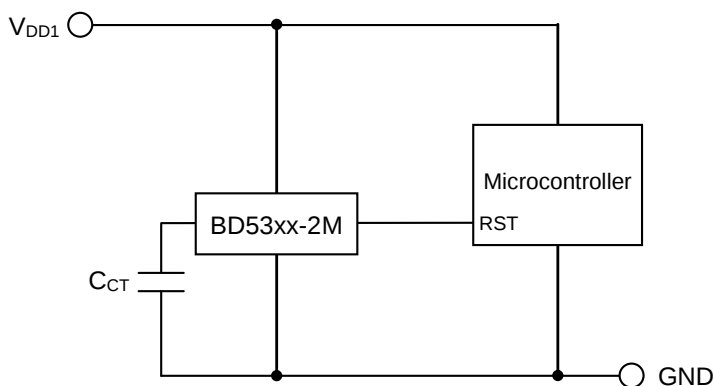


Figure 34. CMOS Output type

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

Use a CMOS output type (BD53xx-2M) device or an open-drain output type (BD52xx-2M) device with a pull-up resistor between the output and  $V_{DD1}$ .

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

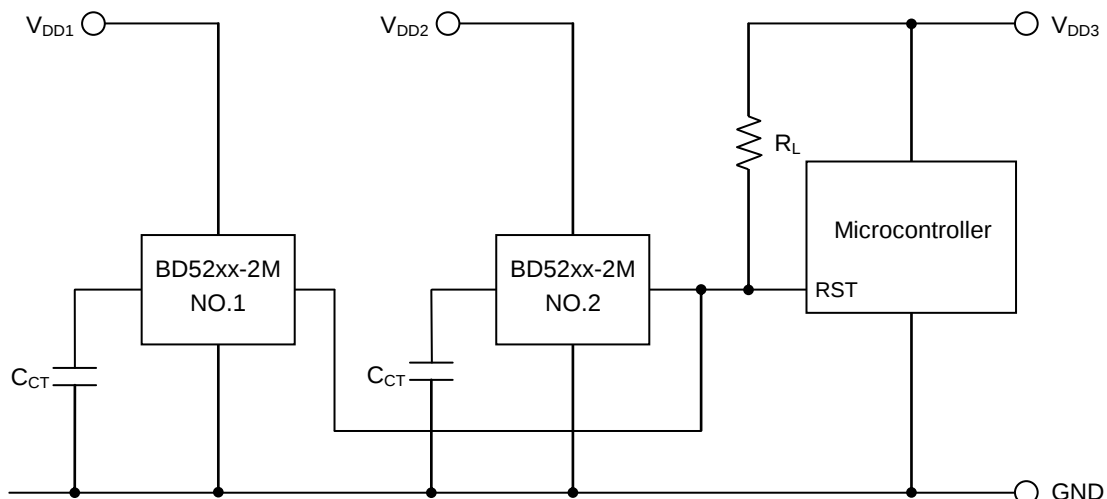


Figure 35. OR Circuit Connection Application

To reset the microcontroller when many independent power supplies are used in the system, OR connect an open drain output type (BD52xx-2M series) to the microcontroller's input with pull-up resistor to the supply voltage of the microcontroller ( $V_{DD3}$ ) as shown in Figure 35. By pulling-up to  $V_{DD3}$ , output "High" voltage of micro-controller power supply is possible.

## Circuit Applications (continued)

## (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 inrush current will flow into the circuit when the output level switches from “Low” to “High” or vice versa. Inrush current is a sudden surge of current that flows from the power supply ( $V_{DD}$ ) 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.

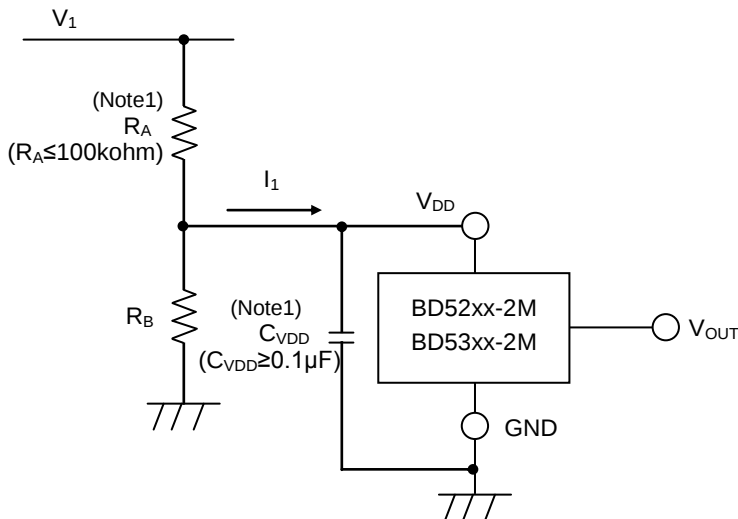
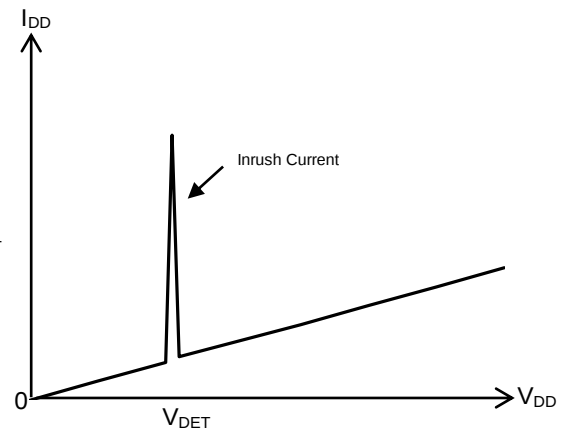
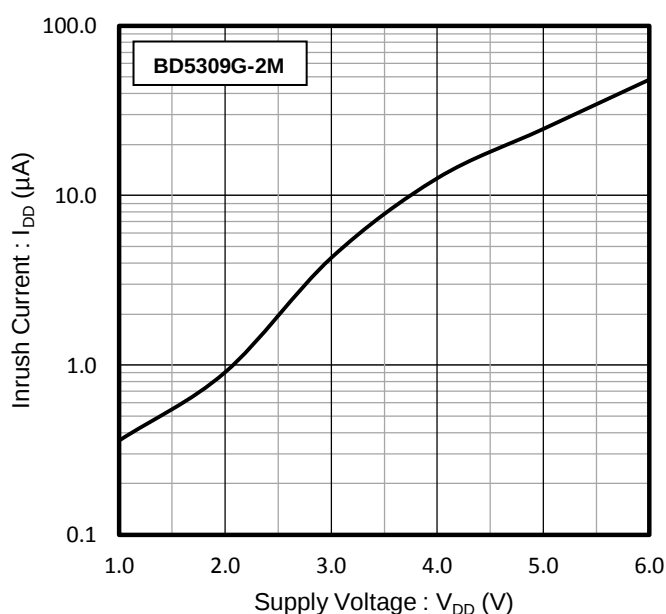
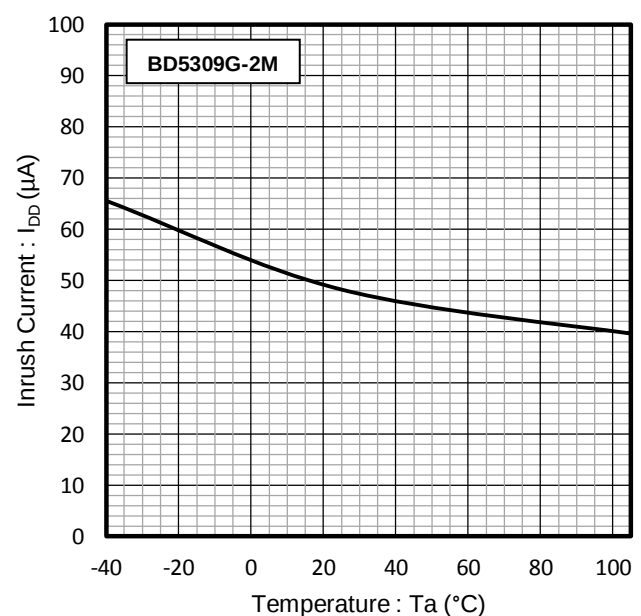


Figure 36. Resistor Divider Connection Application

Figure 37.  $V_{DD}$  Voltage vs. Current Consumption

A voltage drop [Inrush current ( $I_1$ )] × [input resistor ( $R_A$ )] is caused by the inrush current, and causes the input voltage to drop when the output switches from “Low” to “High”. When the input voltage decreases and falls below the detection voltage, the output voltage switches from “High” to “Low”. At this time, the inrush current stops flowing through output “Low”, and the voltage drop is reduced. As a result, the output switches from “Low” to “High”, which again causes the inrush current to flow and the voltage to drop. This operation repeats and will result to oscillation. In case resistor divider will not use and only  $R_A$  will use, same response will happen.

Note1: The circuit connection mentioned above does not guarantee successful operation.  
Please perform thorough evaluation using the actual application and set countermeasures

Figure 38.  $I_{DD}$  Inrush Current  $T_a=25^{\circ}\text{C}$ Figure 39.  $I_{DD}$  Inrush Current  $V_{DD}=6\text{V}$

## Circuit Applications (continued)

Depending on the application set-up, there are times that  $V_{DD}$  voltage is always below the Release Voltage ( $V_{DET} + \Delta V_{DET}$ ) because of the effect of inrush current as shown in Figure 40.

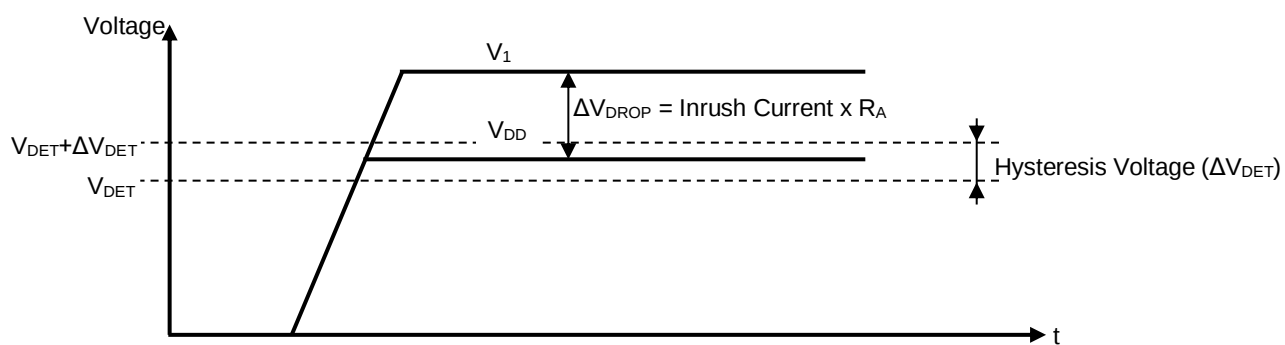


Figure 40.  $V_{DD}$  Drop Caused by Inrush Current

**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 Line**

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 power supply and ground lines must be as short and thick as possible to reduce line impedance.

**5. Thermal Consideration**

Should by any chance the maximum junction temperature 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 maximum junction temperature 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 GND 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 Input Pins 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

**14. Area of Safe Operation (ASO)**

Operate the IC such that the output voltage, output current, and the maximum junction temperature rating are all within the Area of Safe Operation (ASO).

**15. Bypass Capacitor for Noise Rejection**

To help reject noise, put more than 0.1 $\mu$ F capacitor between VDD pin and GND. Be careful when using extremely big capacitor as transient response will be affected.

**16.** The V<sub>DD</sub> line impedance might cause oscillation because of the detection current.

**17.** 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.

**18. External Parameters**

The recommended value of C<sub>T</sub> Capacitor is from open to 4.7 $\mu$ F and pull-up resistance value is 50k $\Omega$  to 1M $\Omega$ . There are many factors (board layout, etc) that can affect characteristics. Operating beyond the recommended values does not guarantee correct operation. Please verify and confirm using practical applications.

**19.** When V<sub>DD</sub> falls below the minimum operating voltage, output will be open. When output is connected to pull-up voltage, output will be equivalent to pull-up voltage.

**20. Power-on Reset Operation**

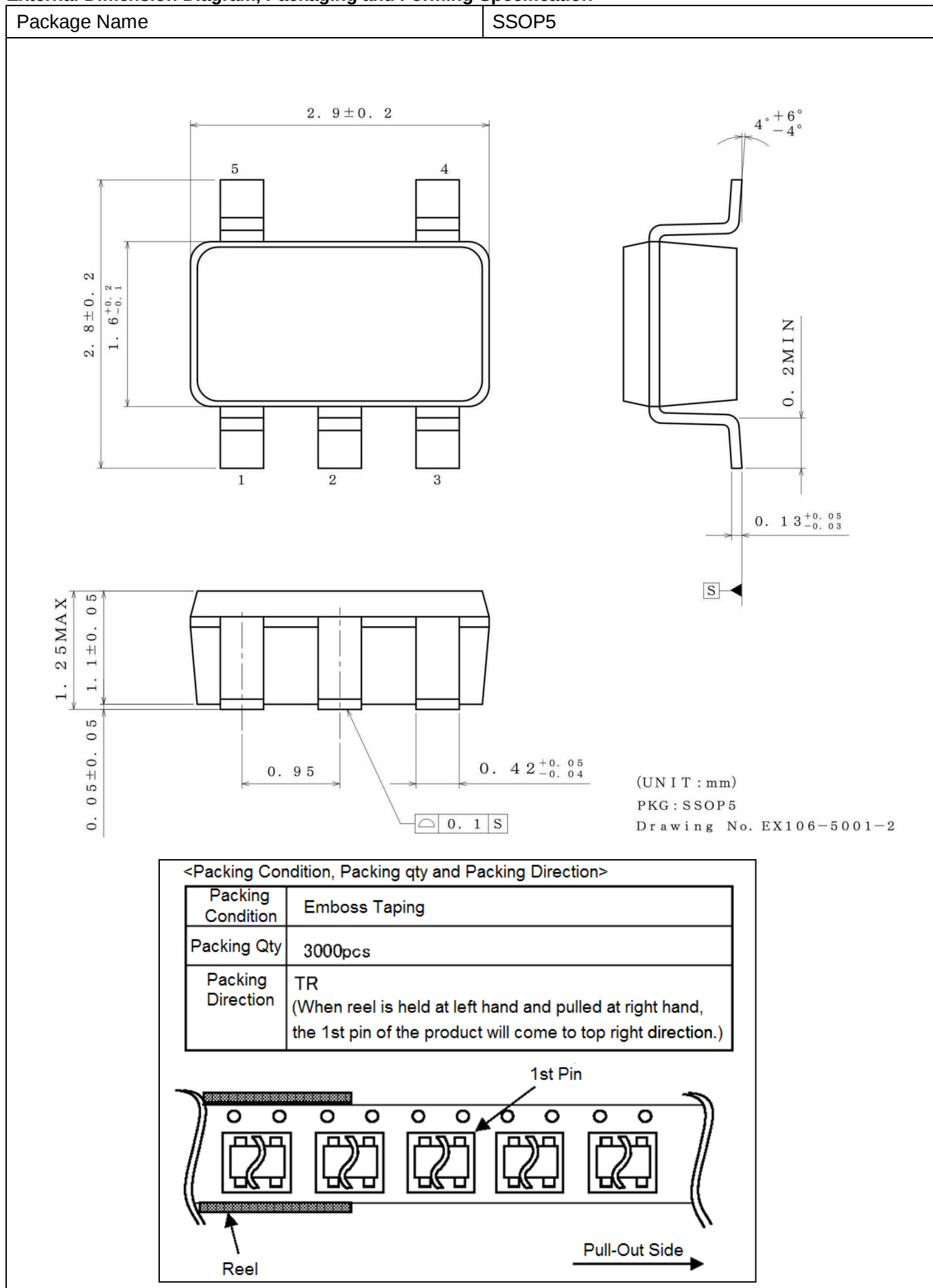
Please note that the power on reset output varies with the V<sub>DD</sub> rise time. Please verify the behavior in the actual operation.

**21. CT Pin Discharge**

Due to the capabilities of the CT pin discharge transistor, the CT pin may not completely discharge when a short input pulse is applied, and in this case the delay time may not be controlled. Please verify the actual operation.

**22.** This IC has extremely high impedance pins. 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 CT and GND pin, it is recommended to insert 1M $\Omega$  resistor between CT and VDD pin. However, delay time will change when resistor is connected externally to CT pin so verify the delay time requirements when using this set-up. Also, when similar leakage is assumed between VOUT and GND pin, consider to set the value of pull up resistor lower than 1/10 of the impedance of assumed leakage route.

## External Dimension Diagram, Packaging and Forming Specification



## Revision History

| Date       | Revision | Changes                       |
|------------|----------|-------------------------------|
| 2017/05/12 | 001      | New                           |
| 2018/07/05 | 002      | Add notation of "Nano Energy" |

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|-----------|-----------|------------|-----------|
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| CLASS IV  |           | CLASS III  |           |

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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.
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