

## 60 V Input Low Supply Current Voltage Detector for Automotive Applications

No. EC-402-190607

### OVERVIEW

The R3160N is a 60 V-input voltage detector provided with high detector threshold accuracy and low supply current. This device offers a direct-monitoring of 24-/48-V battery and a detection of low-voltage battery state.

### KEY BENEFITS

- Enables a direct-monitoring of battery voltage and can be used for an early warning of low-voltage battery state.
- Provides a wide-range detector threshold of 10 V to 48 V and a high-accuracy of  $\pm 1.5\%$  to  $\pm 1.75\%$ .
- Available in a small SOT-23-6 package.

### KEY SPECIFICATIONS

- Operating Voltage Range (Maximum Rating): 2.7 V to 60.0 V (80.0 V)
- Operating Temperature Range:  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$
- Supply Current: Typ. 1.8  $\mu\text{A}$
- Voltage Detector Threshold Range: 10.0 V to 48.0 V
- Hysteresis Threshold: Typ. 4.3%
- Voltage Detector Threshold Accuracy:  $\pm 1.75\%$  (Detector Threshold 20 V or lower)  
 $\pm 1.5\%$  (Detector Threshold 20.5 V or higher)
- Release Delay Time (at Power-on): Typ. 18 ms ( $C_D = 0.01 \mu\text{F}$ )
- Output Type: Nch. Open-drain

### SELECTION GUIDE

The detector threshold and the output logic are user selectable options.

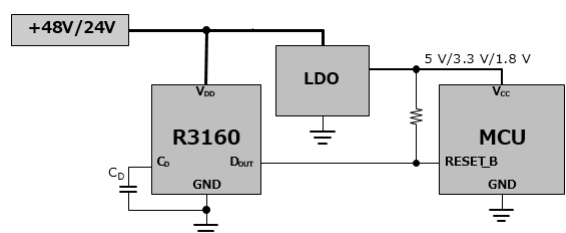
Product Name: R3160Nxxx\$

xxx: Detector Threshold ( $V_{\text{SET}}$ ) Ranges  
10.0 V (100) to 20.0 V (200) in 0.2 V step  
20.5 V (205) to 30.0 V (300) in 0.5 V step  
31.0 V (310) to 48.0 V (480) in 1.0 V step

\$: Output Logic

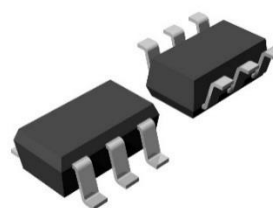
| \$ | DOUT Pin Output |         |
|----|-----------------|---------|
|    | Detection       | Release |
| A  | Low             | High    |
| B  | High            | Low     |

### TYPICAL APPLICATION



$C_D$ : The capacitor according to the release delay time setting

### PACKAGE



SOT-23-6

Size = 2.9 mm x 2.8 mm, t = 1.3 mm (Max.)

### APPLICATIONS

- Voltage supervisor for in-vehicle battery.

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## R3160N

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No. EC-402-190607

### SELECTION GUIDE

The detector threshold and the polarity of DOUT pin are user selectable options.

| Product Name      | Package  | Quantity per Reel | Pb Free | Halogen Free |
|-------------------|----------|-------------------|---------|--------------|
| R3160Nxxx\$-TR-#E | SOT-23-6 | 3,000 pcs         | Yes     | Yes          |

xxx : Detector Threshold ( $V_{SET}$ ) Ranges

10.0 V (100) to 20.0 V (200) in 0.2 V step

20.5 V (205) to 30.0 V (300) in 0.5 V step

31.0 V (310) to 48.0 V (480) in 1.0 V step

If a device with a voltage other than above is required, contact our sales representatives or our distributors.

\$. Version

| Version                | DOUT Pin Output |         |
|------------------------|-----------------|---------|
|                        | Detection       | Release |
| <b>A</b>               | Low             | High    |
| <b>B<sup>(1)</sup></b> | High            | Low     |

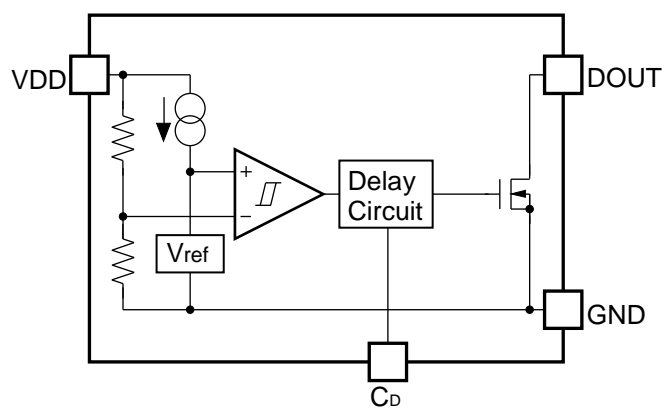
#: Quality Class

|          | Operating Temperature Range | Guaranteed Specs Temperature Range | Screening                |
|----------|-----------------------------|------------------------------------|--------------------------|
| <b>A</b> | -40°C to 125°C              | 25°C                               | High Temperature         |
| <b>K</b> | -40°C to 125°C              | -40°C to 125°C                     | High and Low Temperature |

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<sup>(1)</sup> R3160NxxxB is the inverted output of R3160NxxxA.

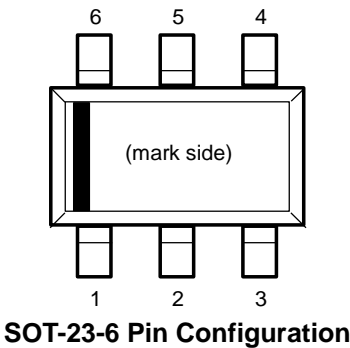
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**BLOCK DIAGRAM****R3160NxxxA/B Block Diagram**

# R3160N

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## PIN DESCRIPTIONS

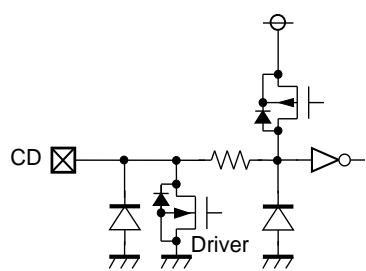


### Pin Description

| Pin No. | Symbol | Description                                      |
|---------|--------|--|
| 1       | VDD    | Supply Voltage Pin                               |
| 2       | NC     | No Connection                                    |
| 3       | DOUT   | Driver Output Pin                                |
| 4       | CD     | Connection Pin with External Capacitor for Delay |
| 5       | TAB    | TAB Pin. GND short before use.                   |
| 6       | GND    | GND Pin  |

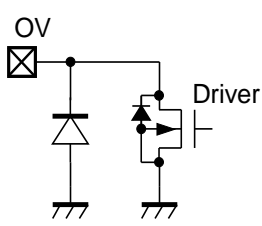
### Equivalent Circuits of Individual Pins

#### <CD Pin>



Equivalent Circuit for CD Pin

#### <DOUT Pin>



Equivalent Circuit for DOUT Pin

## ABSOLUTE MAXIMUM RATINGS

| Symbol    | Item   | Rating       | Unit |
|-----------|--|--------------|------|
| $V_{DD}$  | Supply Voltage   | -0.3 to 80.0 | V    |
|           | Peak Voltage <sup>(1)</sup>  | 90           |      |
| $V_{OUT}$ | DOUT Pin Output Voltage  | -0.3 to 7.0  | V    |
| $V_{CD}$  | CD Pin Output Voltage  | -0.3 to 7.0  | V    |
| $I_{OUT}$ | DOUT Pin Output Voltage  | 20           | mA   |
| $P_D$     | Power Dissipation <sup>(2)</sup> (SOT-23-6, Standard Land Pattern) | 525          | mW   |
| $T_j$     | Junction Temperature Range   | -40 to 150   | °C   |
| $T_{stg}$ | Storage Temperature Range  | -55 to 150   | °C   |

### ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are not assured.

## RECOMMENDED OPERATING CONDITIONS

| Symbol   | Item                        | Rating      | Unit |
|----------|-----------------------------|-------------|------|
| $V_{DD}$ | Operating Voltage           | 2.7 to 60.0 | V    |
| $T_a$    | Operating Temperature Range | -40 to 125  | °C   |

### RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

<sup>(1)</sup> Applied Time: 200 ms or less

<sup>(2)</sup> Refer to *POWER DISSIPATION* for detailed information.

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## ELECTRICAL CHARACTERISTICS

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$ .

### R3160Nxxx\$ (-AE) Electrical Characteristics

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

| Symbol             | Item   | Conditions   |  | Min.   | Typ. | Max.   | Unit          |
|--------------------|--|--|--|--|------|--|---------------|
| $-V_{\text{DET}}$  | Detector Threshold                                     | $T_a = 25^{\circ}\text{C}$   |  | $\times 0.99$  |      | $\times 1.01$  | V             |
|                    |  | $-40^{\circ}\text{C} \leq T_a$   | $-V_{\text{DET}} \leq 20 \text{ V}$  | <span style="border: 1px solid black;"><math>\times 0.9825</math></span> |      | <span style="border: 1px solid black;"><math>\times 1.0175</math></span> |               |
|                    |  | $\leq 125^{\circ}\text{C}$   | $-V_{\text{DET}} \geq 20.5 \text{ V}$  | <span style="border: 1px solid black;"><math>\times 0.985</math></span>  |      | <span style="border: 1px solid black;"><math>\times 1.015</math></span>  |               |
| $V_{\text{HYS}}$   | Hysteresis Threshold                                   |  |  | <span style="border: 1px solid black;">3.4</span>                        | 4.3  | <span style="border: 1px solid black;">5.2</span>                        | %             |
| $I_{\text{SS}}$    | Supply Current   | $V_{\text{DD}} = -V_{\text{DET}} - 0.1 \text{ V}$  |  |  | 1.8  | <span style="border: 1px solid black;">5.0</span>                        | $\mu\text{A}$ |
|                    |  | $V_{\text{DD}} = -V_{\text{DET}} + 0.1 \text{ V}$  |  |  | 1.8  | <span style="border: 1px solid black;">5.0</span>                        |               |
| $V_{\text{DDH}}$   | Maximum Operating Voltage                              |  |  |  |      | 60   | V             |
| $V_{\text{DDL}}$   | Minimum Operating Voltage                              |  |  |  |      | 2.7  | V             |
| $V_{\text{DDL V}}$ | Driver Output Minimum Operating Voltage <sup>(1)</sup> |  |  |  |      | 1.5  | V             |
| $I_{\text{OUT}}$   | Output Current (Driver Output Current)                 | R3160NxxxA   | $V_{\text{DD}} = 3.0 \text{ V}, V_{\text{DS}} = 0.05 \text{ V}$                      | <span style="border: 1px solid black;">360</span>                        |      |  | $\mu\text{A}$ |
|                    |  | R3160NxxxA   | $V_{\text{DD}} = -V_{\text{DET}} - 0.1 \text{ V}$<br>$V_{\text{DS}} = 0.5 \text{ V}$ | 3.3  |      |  | mA            |
|                    |  | R3160NxxxB   | $V_{\text{DD}} = +V_{\text{DET}} + 0.1 \text{ V}$<br>$V_{\text{DS}} = 0.5 \text{ V}$ |  |      |  |               |
| $I_{\text{LEAK}}$  | Nch. Driver Leakage Current                            | R3160NxxxA   | $V_{\text{DD}} = 60 \text{ V}, V_{\text{DS}} = 6.0 \text{ V}$                        |  |      | <span style="border: 1px solid black;">1.0</span>                        | $\mu\text{A}$ |
|                    |  | R3160NxxxB   | $V_{\text{DD}} = -V_{\text{DET}} - 0.1 \text{ V}$<br>$V_{\text{DS}} = 6.0 \text{ V}$ |  |      |  |               |
| $t_{\text{DELAY}}$ | Release Delay Time                                     | $-V_{\text{DET}} \times 0.9 \rightarrow V_{\text{DET}} \times 1.1$<br>$C_{\text{D}} = 10 \text{ nF}$ |  | <span style="border: 1px solid black;">9</span>                          | 18   | <span style="border: 1px solid black;">27</span>                         | ms            |

All test items listed under Electrical Characteristics are done under the pulse load condition ( $T_j \approx T_a = 25^{\circ}\text{C}$ ).

<sup>(1)</sup> The Minimum value of power supply voltage when an output voltage becomes 50 mV or less at a detection (pulled-up resistance: 100 k $\Omega$ , pulled-up voltage: 5 V).

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$ .

### R3160Nxxx\$ (-AE) Product-specific Electrical Characteristics

| Product Name | $-V_{\text{DET}}$ [V]      |      |        |   |      |         |
|--------------|----------------------------|------|--------|---|------|---------|
|              | $T_a = 25^{\circ}\text{C}$ |      |        | $-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$ |      |         |
|              | Min.                       | Typ. | Max.   | Min.  | Typ. | Max.    |
| R3160N100x   | 9.900                      | 10.0 | 10.100 | 9.8250  | 10.0 | 10.1750 |
| R3160N102x   | 10.098                     | 10.2 | 10.302 | 10.0215   | 10.2 | 10.3785 |
| R3160N104x   | 10.296                     | 10.4 | 10.504 | 10.2180   | 10.4 | 10.5820 |
| R3160N106x   | 10.494                     | 10.6 | 10.706 | 10.4145   | 10.6 | 10.7855 |
| R3160N108x   | 10.692                     | 10.8 | 10.908 | 10.6110   | 10.8 | 10.9890 |
| R3160N110x   | 10.890                     | 11.0 | 11.110 | 10.8075   | 11.0 | 11.1925 |
| R3160N112x   | 11.088                     | 11.2 | 11.312 | 11.0040   | 11.2 | 11.3960 |
| R3160N114x   | 11.286                     | 11.4 | 11.514 | 11.2005   | 11.4 | 11.5995 |
| R3160N116x   | 11.484                     | 11.6 | 11.716 | 11.3970   | 11.6 | 11.8030 |
| R3160N118x   | 11.682                     | 11.8 | 11.918 | 11.5935   | 11.8 | 12.0065 |
| R3160N120x   | 11.880                     | 12.0 | 12.120 | 11.7900   | 12.0 | 12.2100 |
| R3160N122x   | 12.078                     | 12.2 | 12.322 | 11.9865   | 12.2 | 12.4135 |
| R3160N124x   | 12.276                     | 12.4 | 12.524 | 12.1830   | 12.4 | 12.6170 |
| R3160N126x   | 12.474                     | 12.6 | 12.726 | 12.3795   | 12.6 | 12.8205 |
| R3160N128x   | 12.672                     | 12.8 | 12.928 | 12.5760   | 12.8 | 13.0240 |
| R3160N130x   | 12.870                     | 13.0 | 13.130 | 12.7725   | 13.0 | 13.2275 |
| R3160N132x   | 13.068                     | 13.2 | 13.332 | 12.9690   | 13.2 | 13.4310 |
| R3160N134x   | 13.266                     | 13.4 | 13.534 | 13.1655   | 13.4 | 13.6345 |
| R3160N136x   | 13.464                     | 13.6 | 13.736 | 13.3620   | 13.6 | 13.8380 |
| R3160N138x   | 13.662                     | 13.8 | 13.938 | 13.5585   | 13.8 | 14.0415 |
| R3160N140x   | 13.860                     | 14.0 | 14.140 | 13.7550   | 14.0 | 14.2450 |
| R3160N142x   | 14.058                     | 14.2 | 14.342 | 13.9515   | 14.2 | 14.4485 |
| R3160N144x   | 14.256                     | 14.4 | 14.544 | 14.1480   | 14.4 | 14.6520 |
| R3160N146x   | 14.454                     | 14.6 | 14.746 | 14.3445   | 14.6 | 14.8555 |
| R3160N148x   | 14.652                     | 14.8 | 14.948 | 14.5410   | 14.8 | 15.0590 |
| R3160N150x   | 14.850                     | 15.0 | 15.150 | 14.7375   | 15.0 | 15.2625 |
| R3160N152x   | 15.048                     | 15.2 | 15.352 | 14.9340   | 15.2 | 15.4660 |
| R3160N154x   | 15.246                     | 15.4 | 15.554 | 15.1305   | 15.4 | 15.6695 |
| R3160N156x   | 15.444                     | 15.6 | 15.756 | 15.3270   | 15.6 | 15.8730 |
| R3160N158x   | 15.642                     | 15.8 | 15.958 | 15.5235   | 15.8 | 16.0765 |
| R3160N160x   | 15.840                     | 16.0 | 16.160 | 15.7200   | 16.0 | 16.2800 |
| R3160N162x   | 16.038                     | 16.2 | 16.362 | 15.9165   | 16.2 | 16.4835 |
| R3160N164x   | 16.236                     | 16.4 | 16.564 | 16.1130   | 16.4 | 16.6870 |
| R3160N166x   | 16.434                     | 16.6 | 16.766 | 16.3095   | 16.6 | 16.8905 |
| R3160N168x   | 16.632                     | 16.8 | 16.968 | 16.5060   | 16.8 | 17.0940 |
| R3160N170x   | 16.830                     | 17.0 | 17.170 | 16.7025   | 17.0 | 17.2975 |
| R3160N172x   | 17.028                     | 17.2 | 17.372 | 16.8990   | 17.2 | 17.5010 |
| R3160N174x   | 17.226                     | 17.4 | 17.574 | 17.0955   | 17.4 | 17.7045 |
| R3160N176x   | 17.424                     | 17.6 | 17.776 | 17.2920   | 17.6 | 17.9080 |
| R3160N178x   | 17.622                     | 17.8 | 17.978 | 17.4885   | 17.8 | 18.1115 |
| R3160N180x   | 17.820                     | 18.0 | 18.180 | 17.6850   | 18.0 | 18.3150 |
| R3160N182x   | 18.018                     | 18.2 | 18.382 | 17.8815   | 18.2 | 18.5185 |
| R3160N184x   | 18.216                     | 18.4 | 18.584 | 18.0780   | 18.4 | 18.7220 |
| R3160N186x   | 18.414                     | 18.6 | 18.786 | 18.2745   | 18.6 | 18.9255 |
| R3160N188x   | 18.612                     | 18.8 | 18.988 | 18.4710   | 18.8 | 19.1290 |

## R3160N

No. EC-402-190607

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$ .

### R3160Nxxx\$ (-AE) Product-specific Electrical Characteristics

| Product Name | -V <sub>DET</sub> [V] |      |        |                                |      |         |
|--------------|-----------------------|------|--------|--------------------------------|------|---------|
|              | T <sub>a</sub> = 25°C |      |        | -40°C ≤ T <sub>a</sub> ≤ 125°C |      |         |
|              | Min.                  | Typ. | Max.   | Min.                           | Typ. | Max.    |
| R3160N190x   | 18.810                | 19.0 | 19.190 | 18.6675                        | 19.0 | 19.3325 |
| R3160N192x   | 19.008                | 19.2 | 19.392 | 18.8640                        | 19.2 | 19.5360 |
| R3160N194x   | 19.206                | 19.4 | 19.594 | 19.0605                        | 19.4 | 19.7395 |
| R3160N196x   | 19.404                | 19.6 | 19.796 | 19.2570                        | 19.6 | 19.9430 |
| R3160N198x   | 19.602                | 19.8 | 19.998 | 19.4535                        | 19.8 | 20.1465 |
| R3160N200x   | 19.800                | 20.0 | 20.200 | 19.6500                        | 20.0 | 20.3500 |
| R3160N205x   | 20.295                | 20.5 | 20.705 | 20.1925                        | 20.5 | 20.8075 |
| R3160N210x   | 20.790                | 21.0 | 21.210 | 20.6850                        | 21.0 | 21.3150 |
| R3160N215x   | 21.285                | 21.5 | 21.715 | 21.1775                        | 21.5 | 21.8225 |
| R3160N220x   | 21.780                | 22.0 | 22.220 | 21.6700                        | 22.0 | 22.3300 |
| R3160N225x   | 22.275                | 22.5 | 22.725 | 22.1625                        | 22.5 | 22.8375 |
| R3160N230x   | 22.770                | 23.0 | 23.230 | 22.6550                        | 23.0 | 23.3450 |
| R3160N235x   | 23.265                | 23.5 | 23.735 | 23.1475                        | 23.5 | 23.8525 |
| R3160N240x   | 23.760                | 24.0 | 24.240 | 23.6400                        | 24.0 | 24.3600 |
| R3160N245x   | 24.255                | 24.5 | 24.745 | 24.1325                        | 24.5 | 24.8675 |
| R3160N250x   | 24.750                | 25.0 | 25.250 | 24.6250                        | 25.0 | 25.3750 |
| R3160N255x   | 25.245                | 25.5 | 25.755 | 25.1175                        | 25.5 | 25.8825 |
| R3160N260x   | 25.740                | 26.0 | 26.260 | 25.6100                        | 26.0 | 26.3900 |
| R3160N265x   | 26.235                | 26.5 | 26.765 | 26.1025                        | 26.5 | 26.8975 |
| R3160N270x   | 26.730                | 27.0 | 27.270 | 26.5950                        | 27.0 | 27.4050 |
| R3160N275x   | 27.225                | 27.5 | 27.775 | 27.0875                        | 27.5 | 27.9125 |
| R3160N280x   | 27.720                | 28.0 | 28.280 | 27.5800                        | 28.0 | 28.4200 |
| R3160N285x   | 28.215                | 28.5 | 28.785 | 28.0725                        | 28.5 | 28.9275 |
| R3160N290x   | 28.710                | 29.0 | 29.290 | 28.5650                        | 29.0 | 29.4350 |
| R3160N295x   | 29.205                | 29.5 | 29.795 | 29.0575                        | 29.5 | 29.9425 |
| R3160N300x   | 29.700                | 30.0 | 30.300 | 29.5500                        | 30.0 | 30.4500 |
| R3160N310x   | 30.690                | 31.0 | 31.310 | 30.5350                        | 31.0 | 31.4650 |
| R3160N320x   | 31.680                | 32.0 | 32.320 | 31.5200                        | 32.0 | 32.4800 |
| R3160N330x   | 32.670                | 33.0 | 33.330 | 32.5050                        | 33.0 | 33.4950 |
| R3160N340x   | 33.660                | 34.0 | 34.340 | 33.4900                        | 34.0 | 34.5100 |
| R3160N350x   | 34.650                | 35.0 | 35.350 | 34.4750                        | 35.0 | 35.5250 |
| R3160N360x   | 35.640                | 36.0 | 36.360 | 35.4600                        | 36.0 | 36.5400 |
| R3160N370x   | 36.630                | 37.0 | 37.370 | 36.4450                        | 37.0 | 37.5550 |
| R3160N380x   | 37.620                | 38.0 | 38.380 | 37.4300                        | 38.0 | 38.5700 |
| R3160N390x   | 38.610                | 39.0 | 39.390 | 38.4150                        | 39.0 | 39.5850 |
| R3160N400x   | 39.600                | 40.0 | 40.400 | 39.4000                        | 40.0 | 40.6000 |
| R3160N410x   | 40.590                | 41.0 | 41.410 | 40.3850                        | 41.0 | 41.6150 |
| R3160N420x   | 41.580                | 42.0 | 42.420 | 41.3700                        | 42.0 | 42.6300 |
| R3160N430x   | 42.570                | 43.0 | 43.430 | 42.3550                        | 43.0 | 43.6450 |
| R3160N440x   | 43.560                | 44.0 | 44.440 | 43.3400                        | 44.0 | 44.6600 |
| R3160N450x   | 44.550                | 45.0 | 45.450 | 44.3250                        | 45.0 | 45.6750 |
| R3160N460x   | 45.540                | 46.0 | 46.460 | 45.3100                        | 46.0 | 46.6900 |
| R3160N470x   | 46.530                | 47.0 | 47.470 | 46.2950                        | 47.0 | 47.7050 |
| R3160N480x   | 47.520                | 48.0 | 48.480 | 47.2800                        | 48.0 | 48.7200 |



## R3160Nxxx\$ (-KE) Electrical Characteristics

(-40°C ≤ Ta ≤ 125°C)

| Symbol             | Item   | Conditions   |  | Min.    | Typ. | Max.    | Unit |
|--------------------|--|--|--|---------|------|---------|------|
| -V <sub>DET</sub>  | Detector Threshold                                     | Ta = 25°C  |  | ×0.99   |      | ×1.01   | V    |
|                    |  | -40°C ≤ Ta ≤ 125°C   | -V <sub>DET</sub> ≤ 20 V   | ×0.9825 |      | ×1.0175 |      |
|                    |  |  | -V <sub>DET</sub> ≥ 20.5 V   | ×0.985  |      | ×1.015  |      |
| V <sub>HYS</sub>   | Hysteresis Threshold                                   |  |  | 3.4     | 4.3  | 5.2     | %    |
| I <sub>SS</sub>    | Supply Current   | V <sub>DD</sub> = -V <sub>DET</sub> - 0.1 V                                |  |         | 1.8  | 5.0     | μA   |
|                    |  | V <sub>DD</sub> = -V <sub>DET</sub> + 0.1 V                                |  |         | 1.8  | 5.0     |      |
| V <sub>DDH</sub>   | Maximum Operating Voltage                              |  |  |         |      | 60      | V    |
| V <sub>DDL</sub>   | Minimum Operating Voltage                              |  |  |         |      | 2.7     | V    |
| V <sub>DDL</sub> V | Driver Output Minimum Operating Voltage <sup>(1)</sup> |  |  |         |      | 1.5     | V    |
| I <sub>OUT</sub>   | Output Current (Driver Output Current)                 | R3160NxxxA   | V <sub>DD</sub> = 3.0 V, V <sub>DS</sub> = 0.05 V                      | 360     |      |         | μA   |
|                    |  | R3160NxxxA   | V <sub>DD</sub> = -V <sub>DET</sub> - 0.1 V<br>V <sub>DS</sub> = 0.5 V | 3.3     |      |         | mA   |
|                    |  | R3160NxxxB   | V <sub>DD</sub> = +V <sub>DET</sub> + 0.1 V<br>V <sub>DS</sub> = 0.5 V |         |      |         |      |
| I <sub>LEAK</sub>  | Nch. Driver Leakage Current                            | R3160NxxxA   | V <sub>DD</sub> = 60 V, V <sub>DS</sub> = 6.0 V                        |         |      | 1.0     | μA   |
|                    |  | R3160NxxxB   | V <sub>DD</sub> = -V <sub>DET</sub> - 0.1 V<br>V <sub>DS</sub> = 6.0 V |         |      |         |      |
| t <sub>DELAY</sub> | Release Delay Time                                     | -V <sub>DET</sub> × 0.9 → V <sub>DET</sub> × 1.1<br>C <sub>D</sub> = 10 nF |  | 9       | 18   | 27      | ms   |

<sup>(1)</sup> The Minimum value of power supply voltage when an output voltage becomes 50 mV or less at a detection (pulled-up resistance: 100 kΩ, pulled-up voltage: 5 V).

## R3160N

No. EC-402-190607

### R3160Nxxx\$ (-KE) Product-specific Electrical Characteristics

| Product Name | -V <sub>DET</sub> [V] |      |        |                    |      |         |
|--------------|-----------------------|------|--------|--------------------|------|---------|
|              | Ta = 25°C             |      |        | -40°C ≤ Ta ≤ 125°C |      |         |
|              | Min.                  | Typ. | Max.   | Min.               | Typ. | Max.    |
| R3160N100x   | 9.900                 | 10.0 | 10.100 | 9.8250             | 10.0 | 10.1750 |
| R3160N102x   | 10.098                | 10.2 | 10.302 | 10.0215            | 10.2 | 10.3785 |
| R3160N104x   | 10.296                | 10.4 | 10.504 | 10.2180            | 10.4 | 10.5820 |
| R3160N106x   | 10.494                | 10.6 | 10.706 | 10.4145            | 10.6 | 10.7855 |
| R3160N108x   | 10.692                | 10.8 | 10.908 | 10.6110            | 10.8 | 10.9890 |
| R3160N110x   | 10.890                | 11.0 | 11.110 | 10.8075            | 11.0 | 11.1925 |
| R3160N112x   | 11.088                | 11.2 | 11.312 | 11.0040            | 11.2 | 11.3960 |
| R3160N114x   | 11.286                | 11.4 | 11.514 | 11.2005            | 11.4 | 11.5995 |
| R3160N116x   | 11.484                | 11.6 | 11.716 | 11.3970            | 11.6 | 11.8030 |
| R3160N118x   | 11.682                | 11.8 | 11.918 | 11.5935            | 11.8 | 12.0065 |
| R3160N120x   | 11.880                | 12.0 | 12.120 | 11.7900            | 12.0 | 12.2100 |
| R3160N122x   | 12.078                | 12.2 | 12.322 | 11.9865            | 12.2 | 12.4135 |
| R3160N124x   | 12.276                | 12.4 | 12.524 | 12.1830            | 12.4 | 12.6170 |
| R3160N126x   | 12.474                | 12.6 | 12.726 | 12.3795            | 12.6 | 12.8205 |
| R3160N128x   | 12.672                | 12.8 | 12.928 | 12.5760            | 12.8 | 13.0240 |
| R3160N130x   | 12.870                | 13.0 | 13.130 | 12.7725            | 13.0 | 13.2275 |
| R3160N132x   | 13.068                | 13.2 | 13.332 | 12.9690            | 13.2 | 13.4310 |
| R3160N134x   | 13.266                | 13.4 | 13.534 | 13.1655            | 13.4 | 13.6345 |
| R3160N136x   | 13.464                | 13.6 | 13.736 | 13.3620            | 13.6 | 13.8380 |
| R3160N138x   | 13.662                | 13.8 | 13.938 | 13.5585            | 13.8 | 14.0415 |
| R3160N140x   | 13.860                | 14.0 | 14.140 | 13.7550            | 14.0 | 14.2450 |
| R3160N142x   | 14.058                | 14.2 | 14.342 | 13.9515            | 14.2 | 14.4485 |
| R3160N144x   | 14.256                | 14.4 | 14.544 | 14.1480            | 14.4 | 14.6520 |
| R3160N146x   | 14.454                | 14.6 | 14.746 | 14.3445            | 14.6 | 14.8555 |
| R3160N148x   | 14.652                | 14.8 | 14.948 | 14.5410            | 14.8 | 15.0590 |
| R3160N150x   | 14.850                | 15.0 | 15.150 | 14.7375            | 15.0 | 15.2625 |
| R3160N152x   | 15.048                | 15.2 | 15.352 | 14.9340            | 15.2 | 15.4660 |
| R3160N154x   | 15.246                | 15.4 | 15.554 | 15.1305            | 15.4 | 15.6695 |
| R3160N156x   | 15.444                | 15.6 | 15.756 | 15.3270            | 15.6 | 15.8730 |
| R3160N158x   | 15.642                | 15.8 | 15.958 | 15.5235            | 15.8 | 16.0765 |
| R3160N160x   | 15.840                | 16.0 | 16.160 | 15.7200            | 16.0 | 16.2800 |
| R3160N162x   | 16.038                | 16.2 | 16.362 | 15.9165            | 16.2 | 16.4835 |
| R3160N164x   | 16.236                | 16.4 | 16.564 | 16.1130            | 16.4 | 16.6870 |
| R3160N166x   | 16.434                | 16.6 | 16.766 | 16.3095            | 16.6 | 16.8905 |
| R3160N168x   | 16.632                | 16.8 | 16.968 | 16.5060            | 16.8 | 17.0940 |
| R3160N170x   | 16.830                | 17.0 | 17.170 | 16.7025            | 17.0 | 17.2975 |
| R3160N172x   | 17.028                | 17.2 | 17.372 | 16.8990            | 17.2 | 17.5010 |
| R3160N174x   | 17.226                | 17.4 | 17.574 | 17.0955            | 17.4 | 17.7045 |
| R3160N176x   | 17.424                | 17.6 | 17.776 | 17.2920            | 17.6 | 17.9080 |
| R3160N178x   | 17.622                | 17.8 | 17.978 | 17.4885            | 17.8 | 18.1115 |
| R3160N180x   | 17.820                | 18.0 | 18.180 | 17.6850            | 18.0 | 18.3150 |
| R3160N182x   | 18.018                | 18.2 | 18.382 | 17.8815            | 18.2 | 18.5185 |
| R3160N184x   | 18.216                | 18.4 | 18.584 | 18.0780            | 18.4 | 18.7220 |
| R3160N186x   | 18.414                | 18.6 | 18.786 | 18.2745            | 18.6 | 18.9255 |
| R3160N188x   | 18.612                | 18.8 | 18.988 | 18.4710            | 18.8 | 19.1290 |

## R3160Nxxx\$ (-KE) Product-specific Electrical Characteristics

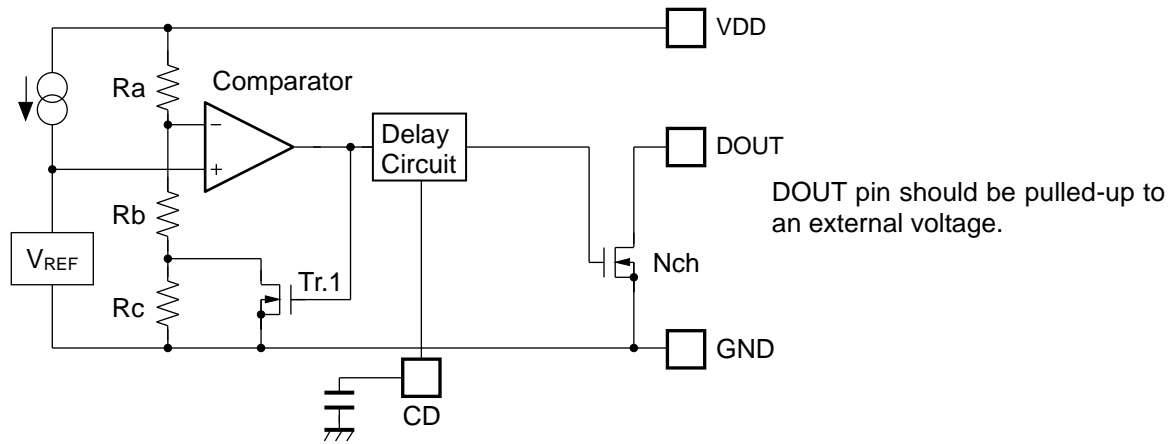
| Product Name | -V <sub>DET</sub> [V] |      |        |                    |      |         |
|--------------|-----------------------|------|--------|--------------------|------|---------|
|              | Ta = 25°C             |      |        | -40°C ≤ Ta ≤ 125°C |      |         |
|              | Min.                  | Typ. | Max.   | Min.               | Typ. | Max.    |
| R3160N190x   | 18.810                | 19.0 | 19.190 | 18.6675            | 19.0 | 19.3325 |
| R3160N192x   | 19.008                | 19.2 | 19.392 | 18.8640            | 19.2 | 19.5360 |
| R3160N194x   | 19.206                | 19.4 | 19.594 | 19.0605            | 19.4 | 19.7395 |
| R3160N196x   | 19.404                | 19.6 | 19.796 | 19.2570            | 19.6 | 19.9430 |
| R3160N198x   | 19.602                | 19.8 | 19.998 | 19.4535            | 19.8 | 20.1465 |
| R3160N200x   | 19.800                | 20.0 | 20.200 | 19.6500            | 20.0 | 20.3500 |
| R3160N205x   | 20.295                | 20.5 | 20.705 | 20.1925            | 20.5 | 20.8075 |
| R3160N210x   | 20.790                | 21.0 | 21.210 | 20.6850            | 21.0 | 21.3150 |
| R3160N215x   | 21.285                | 21.5 | 21.715 | 21.1775            | 21.5 | 21.8225 |
| R3160N220x   | 21.780                | 22.0 | 22.220 | 21.6700            | 22.0 | 22.3300 |
| R3160N225x   | 22.275                | 22.5 | 22.725 | 22.1625            | 22.5 | 22.8375 |
| R3160N230x   | 22.770                | 23.0 | 23.230 | 22.6550            | 23.0 | 23.3450 |
| R3160N235x   | 23.265                | 23.5 | 23.735 | 23.1475            | 23.5 | 23.8525 |
| R3160N240x   | 23.760                | 24.0 | 24.240 | 23.6400            | 24.0 | 24.3600 |
| R3160N245x   | 24.255                | 24.5 | 24.745 | 24.1325            | 24.5 | 24.8675 |
| R3160N250x   | 24.750                | 25.0 | 25.250 | 24.6250            | 25.0 | 25.3750 |
| R3160N255x   | 25.245                | 25.5 | 25.755 | 25.1175            | 25.5 | 25.8825 |
| R3160N260x   | 25.740                | 26.0 | 26.260 | 25.6100            | 26.0 | 26.3900 |
| R3160N265x   | 26.235                | 26.5 | 26.765 | 26.1025            | 26.5 | 26.8975 |
| R3160N270x   | 26.730                | 27.0 | 27.270 | 26.5950            | 27.0 | 27.4050 |
| R3160N275x   | 27.225                | 27.5 | 27.775 | 27.0875            | 27.5 | 27.9125 |
| R3160N280x   | 27.720                | 28.0 | 28.280 | 27.5800            | 28.0 | 28.4200 |
| R3160N285x   | 28.215                | 28.5 | 28.785 | 28.0725            | 28.5 | 28.9275 |
| R3160N290x   | 28.710                | 29.0 | 29.290 | 28.5650            | 29.0 | 29.4350 |
| R3160N295x   | 29.205                | 29.5 | 29.795 | 29.0575            | 29.5 | 29.9425 |
| R3160N300x   | 29.700                | 30.0 | 30.300 | 29.5500            | 30.0 | 30.4500 |
| R3160N310x   | 30.690                | 31.0 | 31.310 | 30.5350            | 31.0 | 31.4650 |
| R3160N320x   | 31.680                | 32.0 | 32.320 | 31.5200            | 32.0 | 32.4800 |
| R3160N330x   | 32.670                | 33.0 | 33.330 | 32.5050            | 33.0 | 33.4950 |
| R3160N340x   | 33.660                | 34.0 | 34.340 | 33.4900            | 34.0 | 34.5100 |
| R3160N350x   | 34.650                | 35.0 | 35.350 | 34.4750            | 35.0 | 35.5250 |
| R3160N360x   | 35.640                | 36.0 | 36.360 | 35.4600            | 36.0 | 36.5400 |
| R3160N370x   | 36.630                | 37.0 | 37.370 | 36.4450            | 37.0 | 37.5550 |
| R3160N380x   | 37.620                | 38.0 | 38.380 | 37.4300            | 38.0 | 38.5700 |
| R3160N390x   | 38.610                | 39.0 | 39.390 | 38.4150            | 39.0 | 39.5850 |
| R3160N400x   | 39.600                | 40.0 | 40.400 | 39.4000            | 40.0 | 40.6000 |
| R3160N410x   | 40.590                | 41.0 | 41.410 | 40.3850            | 41.0 | 41.6150 |
| R3160N420x   | 41.580                | 42.0 | 42.420 | 41.3700            | 42.0 | 42.6300 |
| R3160N430x   | 42.570                | 43.0 | 43.430 | 42.3550            | 43.0 | 43.6450 |
| R3160N440x   | 43.560                | 44.0 | 44.440 | 43.3400            | 44.0 | 44.6600 |
| R3160N450x   | 44.550                | 45.0 | 45.450 | 44.3250            | 45.0 | 45.6750 |
| R3160N460x   | 45.540                | 46.0 | 46.460 | 45.3100            | 46.0 | 46.6900 |
| R3160N470x   | 46.530                | 47.0 | 47.470 | 46.2950            | 47.0 | 47.7050 |
| R3160N480x   | 47.520                | 48.0 | 48.480 | 47.2800            | 48.0 | 48.7200 |

# R3160N

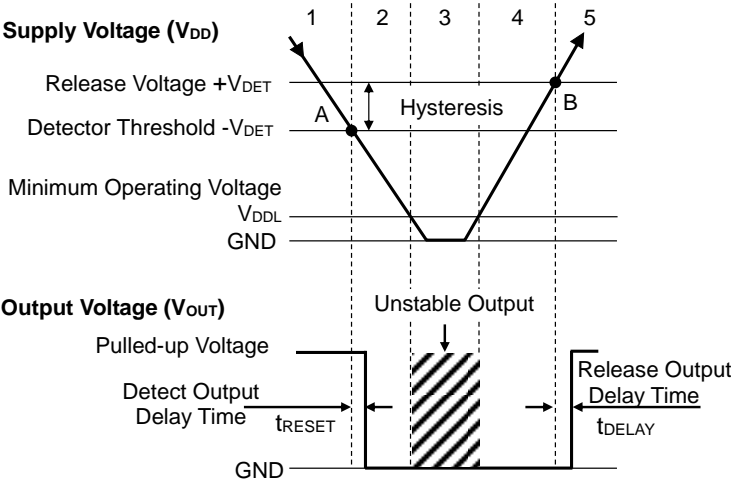
No. EC-402-190607

## THEORY OF OPERATION

### Operating Conditions (R3160NxxxA)



Block Diagram with External Capacitor



| Step                             | 1   | 2  | 3        | 4  | 5   |
|----------------------------------|-----|----|----------|----|-----|
| Comparator (-) Pin Input Voltage | I   | II | II       | II | I   |
| Comparator Output                | L   | H  | Unstable | H  | L   |
| Tr.1                             | OFF | ON | Unstable | ON | OFF |
| Output Tr. (Nch)                 | OFF | ON | Unstable | ON | OFF |

I  $\frac{R_b+R_c}{R_a+R_b+R_c} \times V_{DD}$

II  $\frac{R_b}{R_a+R_b} \times V_{DD}$

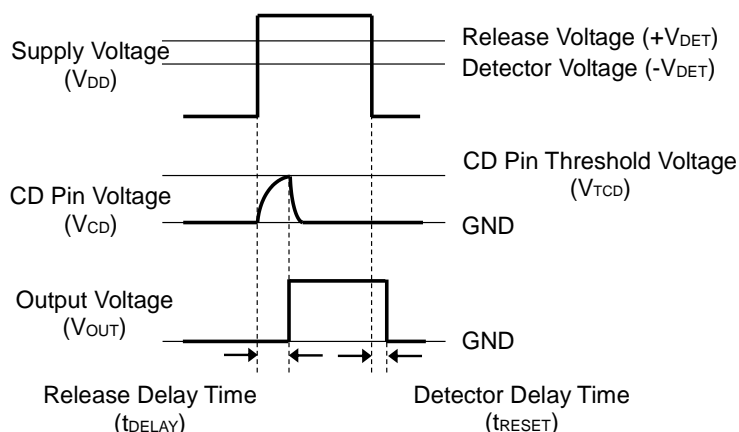
Operation Diagram

### Operating Conditions <sup>(1)</sup>

1.  $V_{OUT}$  is equalized to the pulled-up voltage.
2. When  $V_{DD}$  drops to  $-V_{DET}$  (A point) which means  $V_{ref} \geq V_{DD} \times (R_b+R_c) / (R_a+R_b+R_c)$ , the comparator output shifts from "Low" to "High" voltage and  $V_{OUT}$  becomes equal to GND.
3. If  $V_{DD}$  is lower than  $V_{DDL}$ ,  $V_{OUT}$  becomes unstable.
4.  $V_{OUT}$  becomes equal to GND.
5. When  $V_{DD}$  becomes higher than  $+V_{DET}$  (B point) which means  $V_{REF} \leq V_{DD} \times R_b / (R_a+R_b)$ , the comparator output shifts from "High" to "Low" voltage and  $V_{OUT}$  becomes equal to the pulled-up voltage.

<sup>(1)</sup> For R3160NxxxB, the output voltage logic is inverted except 3. The R3160NxxxB becomes pulled-up voltage in 3.

### Delay in Operation and Release Delay Time ( $t_{\text{DELAY}}$ )



**Release Delay Timing Diagram**

When supplying  $V_{\text{DD}}$  higher than  $+V_{\text{DET}}$  to the VDD pin, charging to an external capacitor starts and  $V_{\text{CD}}$  increases.  $V_{\text{OUT}}$  maintains “Low” until  $V_{\text{CD}}$  reaches  $V_{\text{TCD}}$ .  $V_{\text{OUT}}$  inverts from “Low” to “High” when  $V_{\text{CD}}$  exceeds  $V_{\text{TCD}}$ . The release delay time ( $t_{\text{DELAY}}$ ) is the period from supplying  $V_{\text{DD}}$  to  $V_{\text{OUT}}$  inverted.

$V_{\text{OUT}}$  inverted from “Low” to “High” starts discharging the load charged to the external capacitor. Therefore, the detector delay time ( $t_{\text{RESET}}$ ) until  $V_{\text{OUT}}$  is inverted from “High” to “Low” remains constant independent of the external capacitor, when  $V_{\text{DD}}$  lower than the  $-V_{\text{DET}}$  is supplied to the VDD pin.

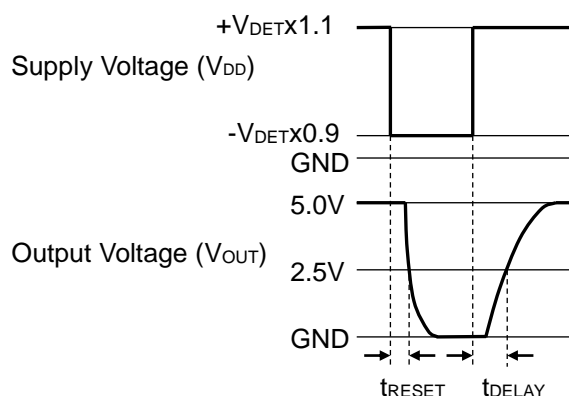
For R3160NxxxB, the above output voltage logic is inverted.

### Calculation of Release Delay Time ( $t_{\text{DELAY}}$ )

The following equation can calculate a typical value of the release delay time ( $t_{\text{DELAY}}$ ) with using the external capacitor ( $C_{\text{D}}$ ).

$$t_{\text{DELAY}} (\text{s}) = 1.8 \times 10^6 \times C_{\text{D}} (\text{F})$$

$t_{\text{DELAY}}$  is the period from supplying a pulse voltage of  $-V_{\text{DET}} \times 0.9$  to  $V_{\text{DET}} \times 1.1$  to the VDD pin to  $V_{\text{OUT}}$  reached 2.5 V after the COUT pin is pulled up to 5 V with a resistor of 100 k $\Omega$ .

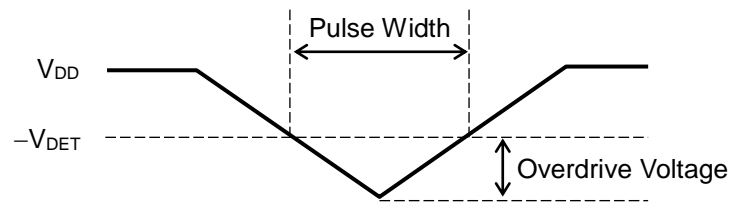
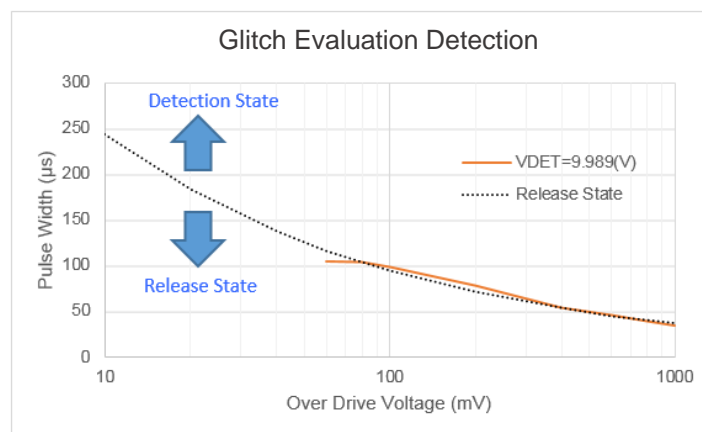


**R3160NxxxA**

**Detection by the glitch of  $V_{DD}$** 

The following graph shows a pulse amplitude and a pulse width, which maintain the release state when the detector voltage ( $-V_{DET}$ ) or lower pulse is input to  $V_{DD}$  at the release state.

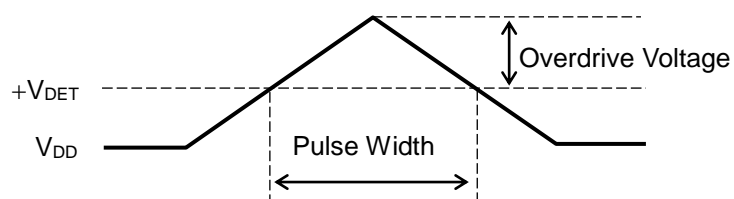
The graph shows the maximum pulse condition that enables to maintain the release state. Note that a reset signal may be output when a pulse with larger amplitude/width than the pulse on the graph is input to  $V_{DD}$ .

 **$V_{DD}$  Input Waveform**

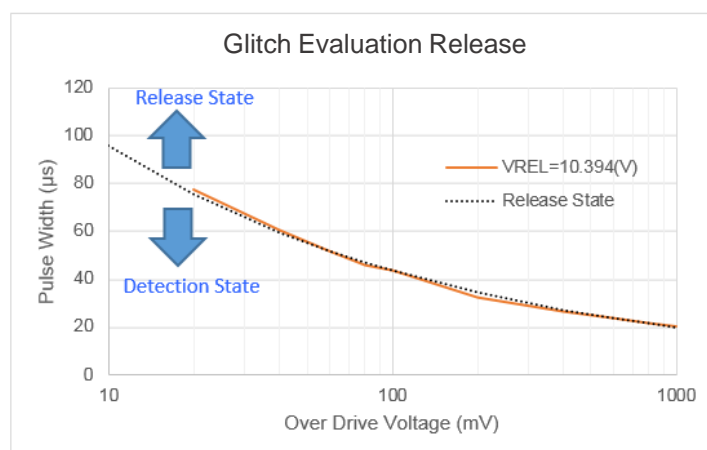
### Release by the glitch of $V_{DD}$

The following graph shows a pulse amplitude and a pulse width, which maintain the detection state when the release voltage ( $+V_{DET}$ ) or higher pulse is input to  $V_{DD}$  at the detection state.

The graph shows the maximum pulse condition that enables to maintain the detection state. Note that a release signal may be output when a pulse with larger amplitude/width than the pulse on the graph is input to  $V_{DD}$ .



**$V_{DD}$  Input Waveform**



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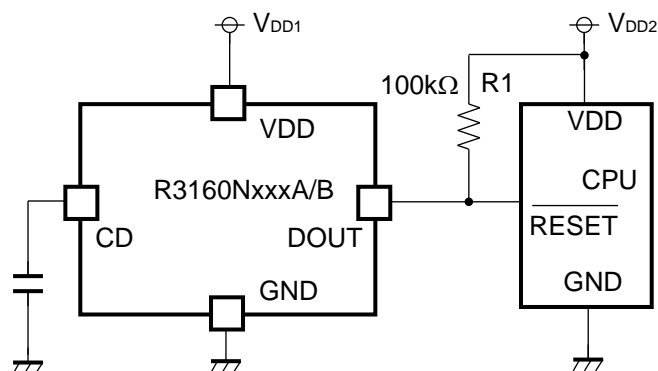
## R3160N

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## APPLICATION INFORMATION

### Typical Application Circuit



R3160Nxxx A/B Typical Application Circuit

### Recommended External Components

| Symbol         | Description  |
|----------------|--|
| C <sub>D</sub> | A capacitor corresponding to the release delay time setting is required. Refer to <i>Delay in Operation and Release Delay Time (t<sub>DELAY</sub>)</i> in <i>THEORY OF OPERATION</i> for details.  |
| R1             | A resistor is required to set with consideration of the output current at Nch. driver's ON and the leakage current at Nch. driver's OFF. Refer to <i>ELECTRICAL CHARACTERISTICS</i> for details – the evaluation result provided with a resistor of 100 kΩ used. |



## TECHNICAL NOTES

### When connecting resistors to the device's input pin

When connecting a resistor (R1) to an input of this device, the input voltage decreases by [Device's Consumption Current] x [Resistance Value] only. And, the cross conduction current, which occurs when changing from the detecting state to the release state, is decreased the input voltage by [Cross Conduction Current] x [Resistance Value] only. And then, this device will enter the re-detecting state if the input voltage reduction is larger than the difference between the detector voltage and the released voltage.

When the input resistance value is large and the VDD is gone up at mildly in the vicinity of the released voltage, repeating the above operation may result in the occurrence of output.

As shown in Figure A/B, set R1 to become 100 kΩ or less as a guide, and connect C<sub>IN</sub><sup>(1)</sup> of 0.1 μF and more to between the input pin and GND. Besides, make evaluations including temperature properties under the actual usage condition, with using the evaluation board like this way. As result, make sure that the cross conduction current has no problem.

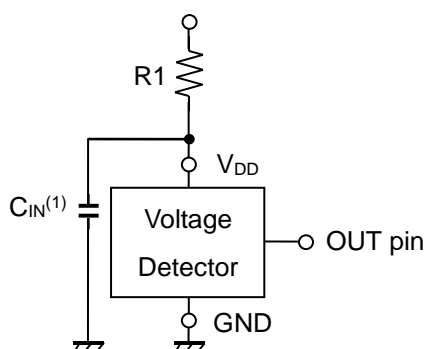


Figure A

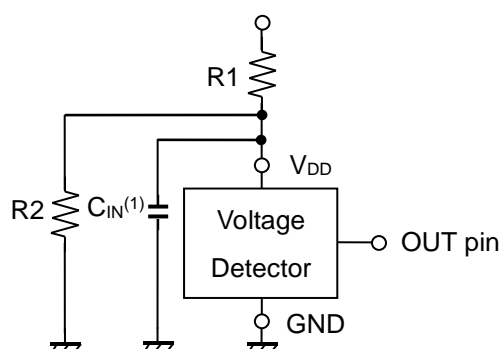


Figure B

<sup>(1)</sup> Note the bias dependence of capacitors.

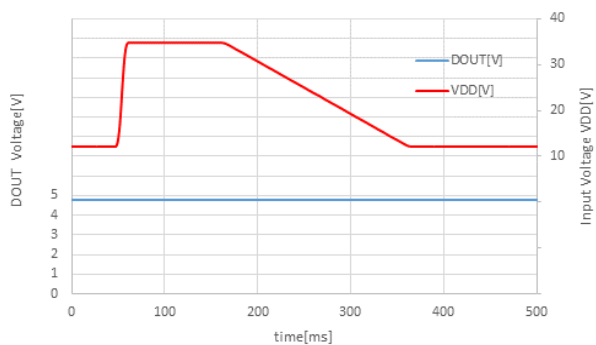
## TYPICAL CHARACTERISTICS

Typical Characteristics are intended to be used as reference data, they are not guaranteed.

1) Load Dump ( $T_a = 25^\circ\text{C}$ )

$V_{DD} = 12\text{ V} \rightarrow 35\text{ V}$  ( $T_r = 1\text{ ms}$ )  $\rightarrow 12\text{ V}$  ( $T_f = 170\text{ ms}$ )

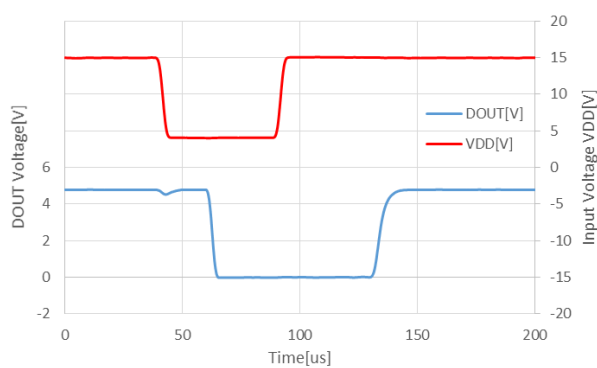
R3160N100A



2) Cranking ( $T_a = 25^\circ\text{C}$ )

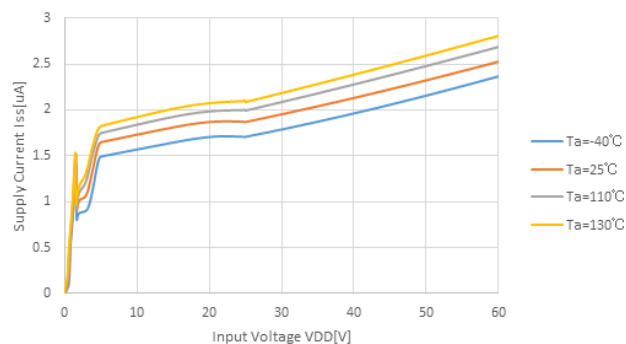
$V_{DD} = 15\text{ V} \rightarrow 4\text{ V} \rightarrow 15\text{ V}$  ( $T_r = T_f = 1\text{ }\mu\text{s}$ )

R3160N100A, CD = none

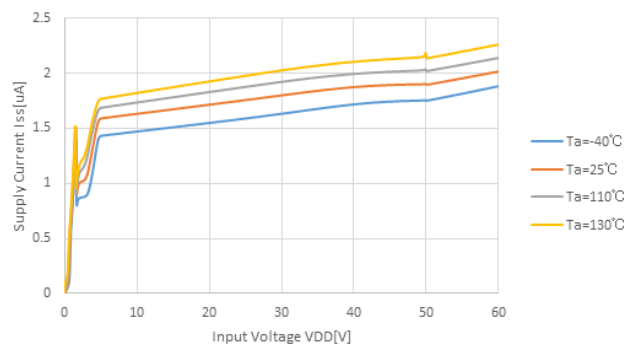


### 3) Supply Current vs. $V_{DD}$

#### R3160N240A

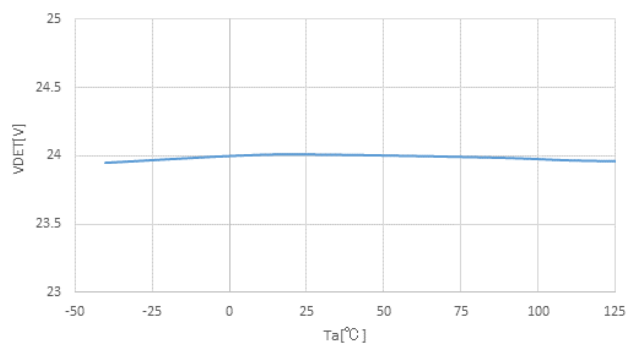


#### R3160N480A

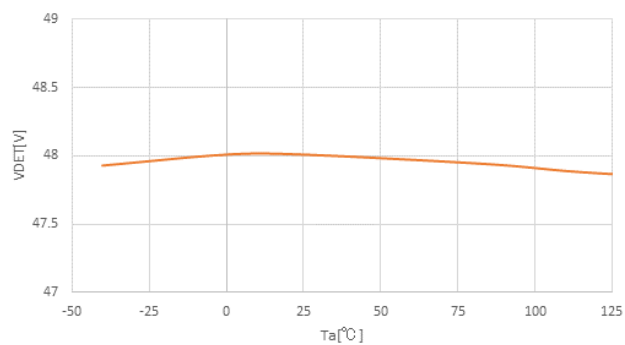


### 4) Detector Voltage vs. Ambient Temperature

#### R3160N240A

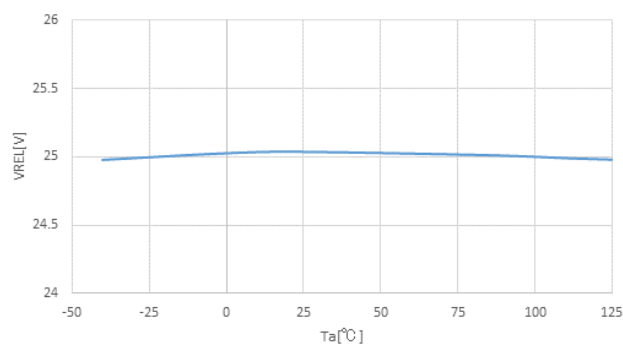


#### R3160N480A

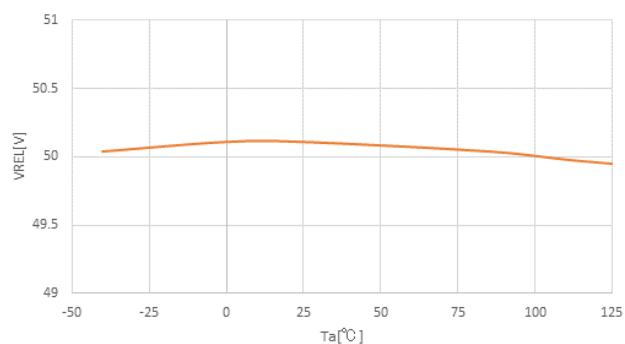


### 5) Release Voltage vs. Ambient Temperature

#### R3160N240A



#### R3160N480A



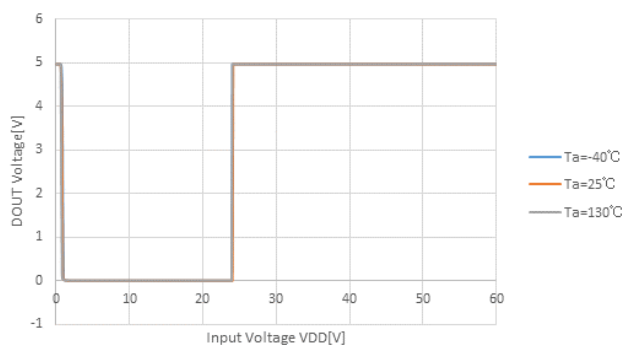
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## R3160N

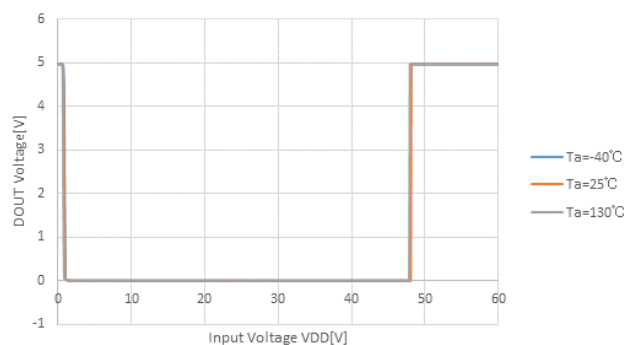
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No. EC-402-190607

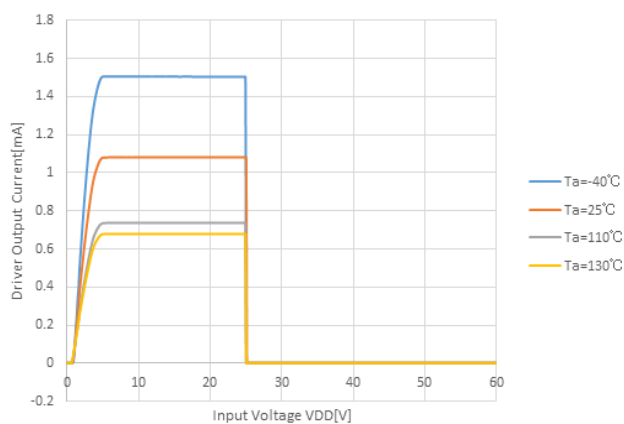
6) DOUT Voltage vs. Input Voltage  
DOUT: 5 V pulled up with 100 kohm  
R3160N240A



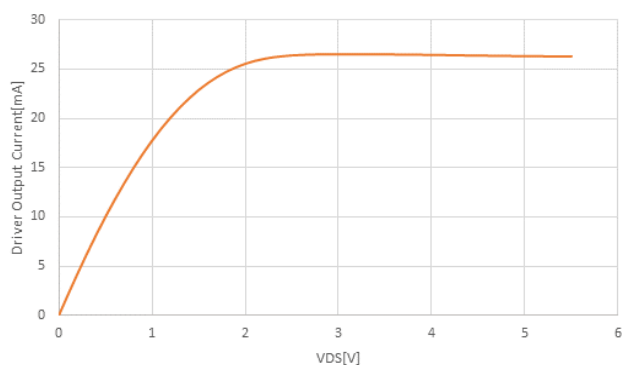
R3160N480A



7) Driver Output Current vs. Input Voltage  
DOUT = 0.05 V  
R3160N240A



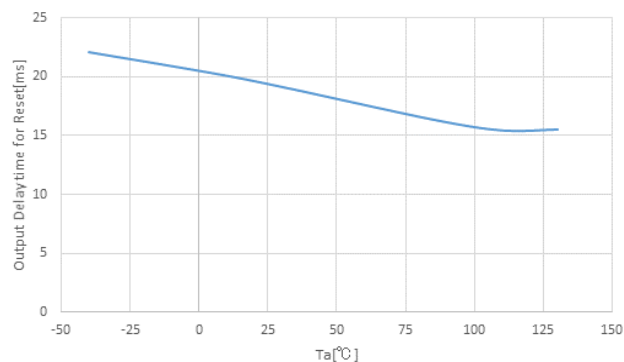
8) Driver Output Current vs. VDS (Ta = 25°C)  
VDD = VDET - 0.1 V, DOUT = 0 V → 5.5 V  
R3160N240A



## 9) Release Delay Time vs. Ambient Temperature

R3160N240A

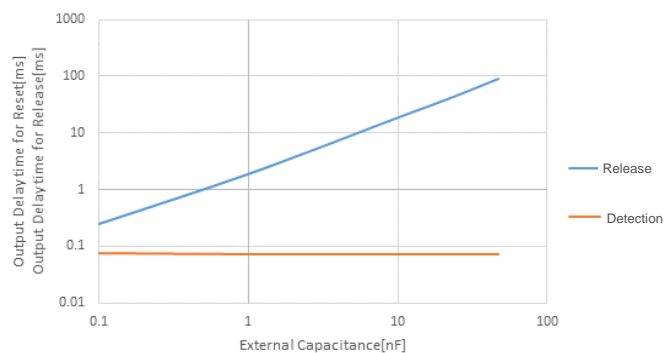
CD = 10 nF



## 10) Detector/Release Delay Time vs. External Capacitor for CD Pin (Ta = 25°C)

R3160N240A

CD = 100 pF to 47 nF



The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

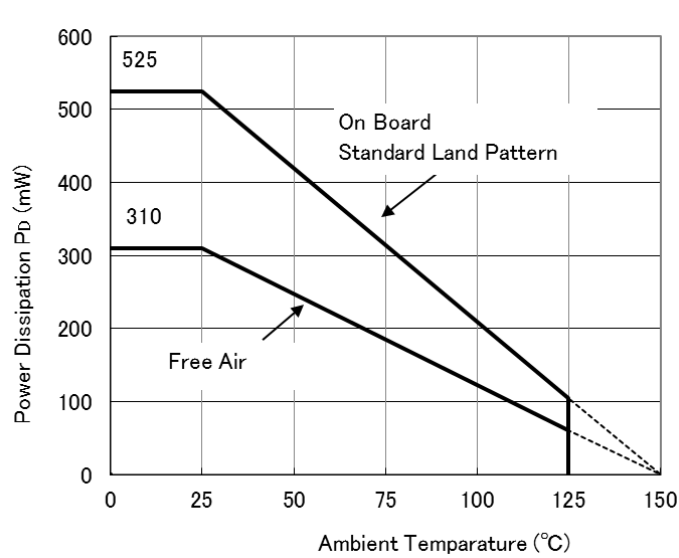
Measurement Conditions

|                  | Standard Test Land Pattern                        |
|------------------|---|
| Environment      | Mounting on Board (Wind Velocity = 0 m/s)         |
| Board Material   | Glass Cloth Epoxy Plastic (Double-Sided Board)    |
| Board Dimensions | 40 mm × 40 mm × 1.6 mm                            |
| Copper Ratio     | Top Side: Approx. 50%<br>Bottom Side: Approx. 50% |
| Through-holes    | φ 0.5 mm × 44 pcs                                 |

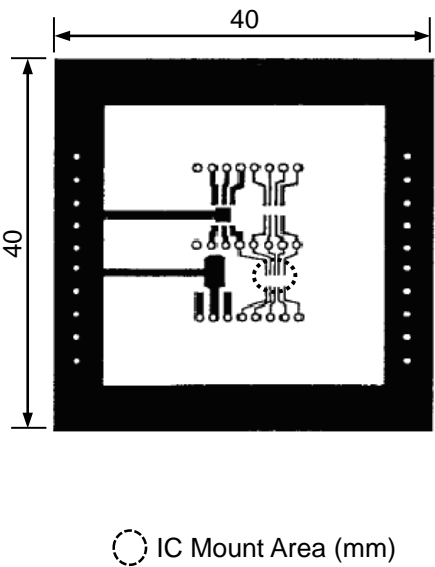
Measurement Result

(Ta = 25°C, Tjmax = 150°C)

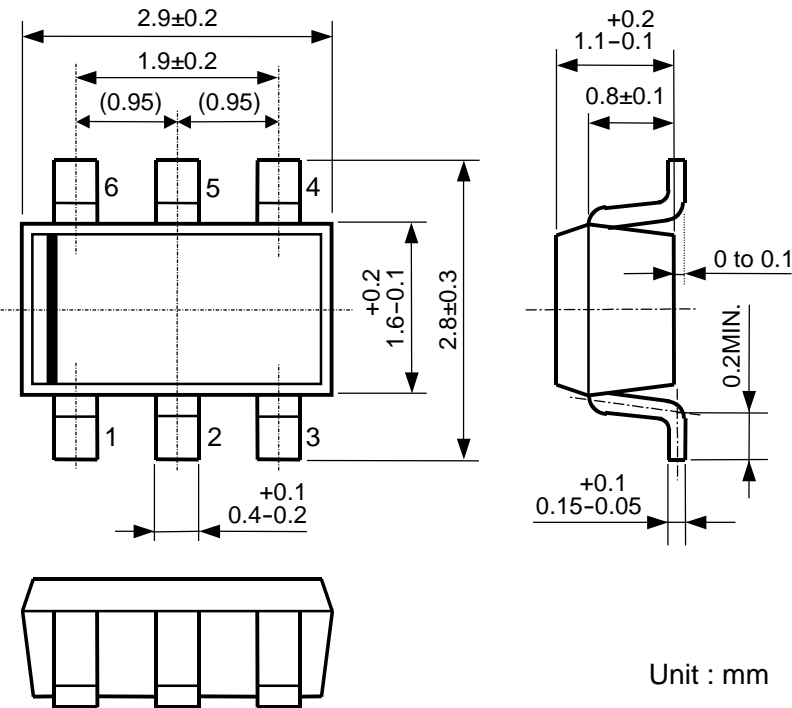
|                    | Standard Test Land Pattern   | Free Air  |
|--------------------|--|-----------|
| Power Dissipation  | 525 mW   | 310 mW    |
| Thermal Resistance | $\theta_{ja} = (150 - 25^{\circ}\text{C}) / 0.525 \text{ W} = 238^{\circ}\text{C/W}$ | 400°C / W |



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-23-6 Package Dimensions



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