60 V Input Low Supply Current Voltage Detector for Industrial Applications

No. EY-402-170822

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. This is a high-reliability semiconductor device for industrial applications (-Y) that has passed both the screening at high temperature and the reliability test with extended hours. This line of products operate in a wide temperature range from low temperature to high temperature to support harsh environment applications.

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 ±1.5% to ±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:
  −50°C to 125°C
- Supply Current: Typ. 1.8 µA
- Voltage Detector Threshold Range:
  10.0 V to 48.0 V
- Hysteresis Threshold: Typ. 4.3%
- Voltage Detector Threshold Accuracy:
  ±1.75% (Detector Threshold 20 V or lower)
  ±1.5% (Detector Threshold 20.5 V or higher)
- Release Delay Time (at Power-on):
  Typ. 18 ms (C_D = 0.01 µF)
- Output Type: Nch. Open-drain

SELECTION GUIDE

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

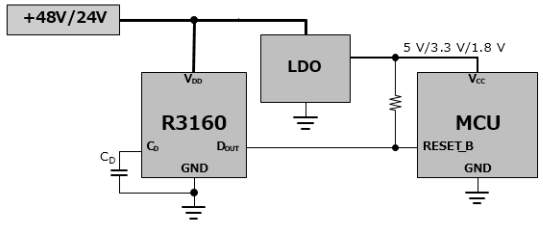
Product Name: R3160Nxxx$

xxx: Detector Threshold (V_{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

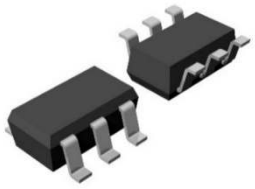
$	DOUT Pin Output	
	Detection	Release
A	Low	High
B	High	Low

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

- Reset of microcomputers and logic circuits.
- Voltage supervisor for high-voltage batteries.

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-YE	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

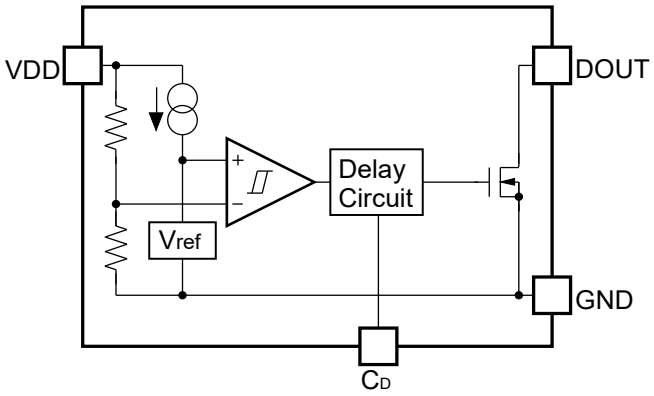
If a device with a voltage other than above is required, contact our sales representatives or our distributors.

$: Version

Version	DOUT Pin Output	
	Detection	Release
A	Low	High
B(1)	High	Low

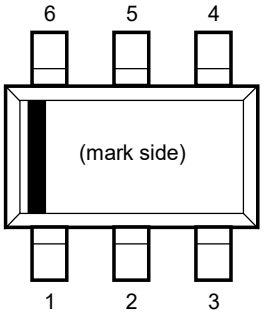
(1) R3160NxxxB is the inverted output of R3160NxxxA.

BLOCK DIAGRAM



R3160NxxxA/B Block Diagram

PIN DESCRIPTIONS



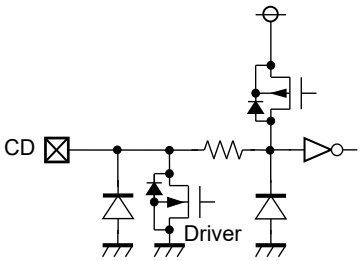
SOT-23-6 Pin Configuration

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

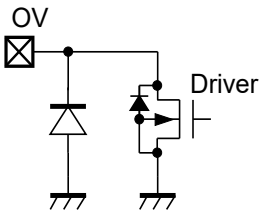
Equivalent Circuits of Individual Pins

<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 (1)	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 (2) (SOT-23-6, Standard Land Pattern)	525	mW
Tj	Junction Temperature Range	−50 to 150	°C
Tstg	Storage Temperature Range	−55 to 150	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages 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
Ta	Operating Temperature Range	−50 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 when 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.

(1) Applied Time: 200 ms or less
(2) Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

The specifications surrounded by [ ] are guaranteed by design engineering at −50°C ≤ Ta ≤ 125°C.

R3160Nxxx$ (-YE) Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$-V_{DET}$	Detector Threshold	Ta = 25°C		×0.99		×1.01	V
		−50°C ≤ Ta ≤ 125°C	$-V_{DET}$ ≤ 20 V	[×0.9825]		[×1.0175]	
			$-V_{DET}$ ≥ 20.5 V	[×0.985]		[×1.015]	
V_{HYS}	Hysteresis Threshold			[3.4]	4.3	[5.2]	%
I_{SS}	Supply Current	V_{DD} = $-V_{DET}$ - 0.1 V			1.8	[5.0]	µA
		V_{DD} = $-V_{DET}$ + 0.1 V			1.8	[5.0]	
V_{DDH}	Maximum Operating Voltage					60	V
V_{DDL}	Minimum Operating Voltage					2.7	V
V_{DDLV}	Driver Output Minimum Operating Voltage (1)					1.5	V
I_{OUT}	Output Current (Driver Output Current)	R3160NxxxA	V_{DD} = 3.0 V, V_{DS} = 0.05 V	[360]			µA
		R3160NxxxA	V_{DD} = $-V_{DET}$ − 0.1 V V_{DS} = 0.5 V	3.3			mA
		R3160NxxxB	V_{DD} = $+V_{DET}$ + 0.1 V V_{DS} = 0.5 V				
I_{LEAK}	Nch. Driver Leakage Current	R3160NxxxA	V_{DD} = 60 V, V_{DS} = 6.0 V			[1.0]	µA
		R3160NxxxB	V_{DD} = $-V_{DET}$ − 0.1 V V_{DS} = 6.0 V				
t_{DELAY}	Release Delay Time	$-V_{DET}$ x 0.9 → V_{DET} x 1.1 C_D = 10 nF		[9]	18	[27]	ms

All test items listed under Electrical Characteristics are done under the pulse load condition (Tj ≈ Ta = 25°C).

(1) 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).

The specifications surrounded by [ ] are guaranteed by design engineering at −50°C ≤ Ta ≤ 125°C.

R3160Nxxx$ (-YE) Product-specific Electrical Characteristics

Product Name	$-V_{DET}$ [V]					
	Ta = 25°C			−50°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

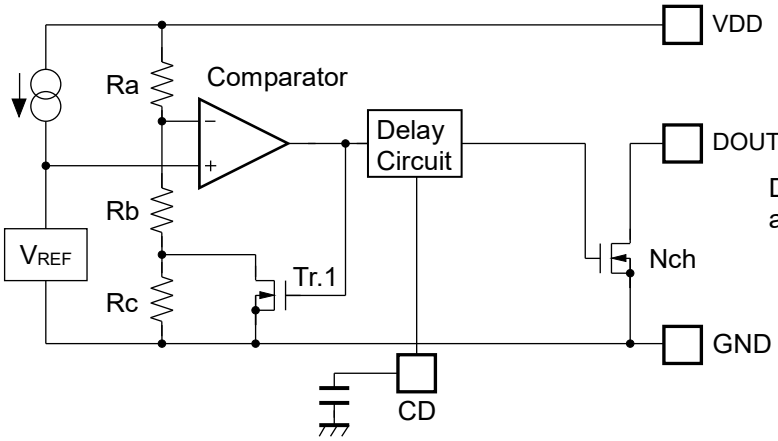
The specifications surrounded by [ ] are guaranteed by design engineering at −50°C ≤ Ta ≤ 125°C.

R3160Nxxx$ (-YE) Product-specific Electrical Characteristics

Product Name	$-V_{DET}$ [V]					
	Ta = 25°C			−50°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

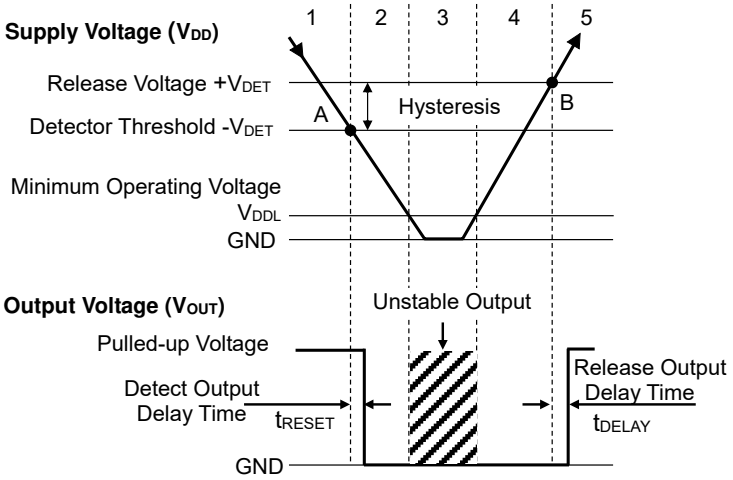
THEORY OF OPERATION

Operating Conditions (R3160NxxxA)



DOUT pin should be pulled-up to an external voltage.

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 $\frac{Rb+Rc}{Ra+Rb+Rc} \times V_{DD}$

Ⅱ $\frac{Rb}{Ra+Rb} \times V_{DD}$

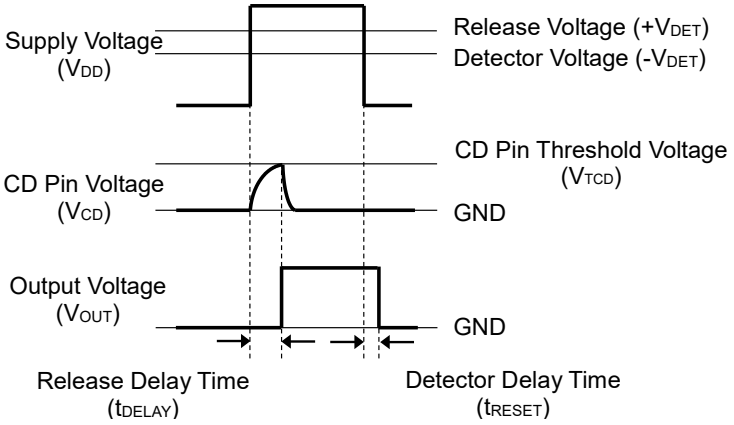
Operation Diagram

Operating Conditions [1]

1. V_{OUT} is equalized to the pulled-up voltage.
2. When V_{DD} drops to $-V_{DET}$ (A point) which means Vref ≥ V_{DD} x (Rb+Rc) / (Ra+Rb+Rc), 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 $V_{REF} \leq V_{DD} \times Rb / (Ra+Rb)$, the comparator output shifts from “High” to “Low” voltage and V_{OUT} becomes equal to the pulled-up voltage.

[1] 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_{DELAY})



Release Delay Timing Diagram

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

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

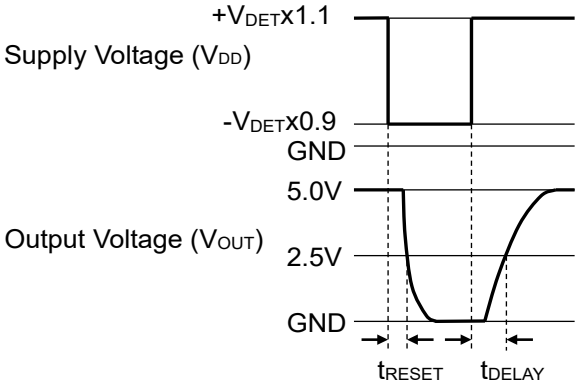
For R3160NxxxB, the above output voltage logic is inverted.

Calculation of Release Delay Time (t_{DELAY})

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

$$t_{DELAY}\,(s) = 1.8 \times 10^6 \times C_D\,(F)$$

t_{DELAY} is the period from supplying a pulse voltage of $-V_{DET}$ x 0.9 to V_{DET} x 1.1 to the VDD pin to VOUT reached 2.5 V after the COUT pin is pulled up to 5 V with a resistor of 100 kΩ.

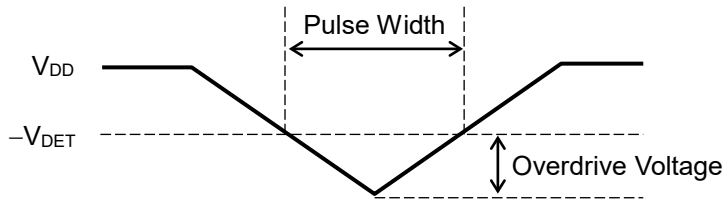


R3160NxxxA

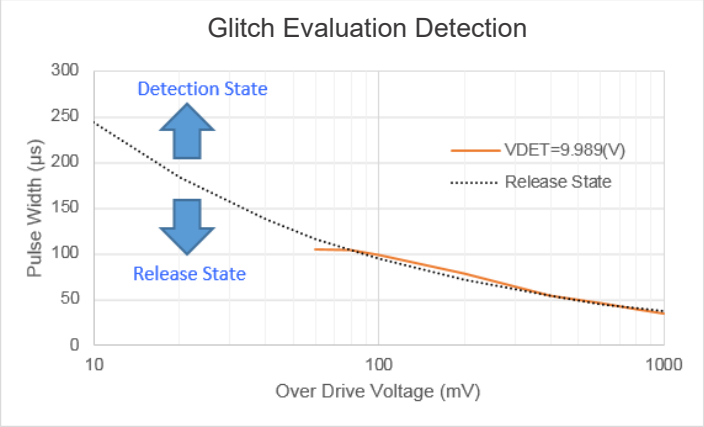
Detection by the glitch of V_{DD}

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}.

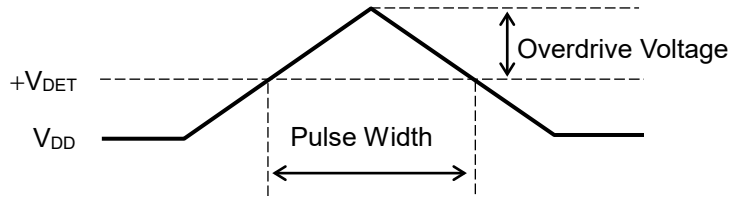


V_{DD} Input Waveform

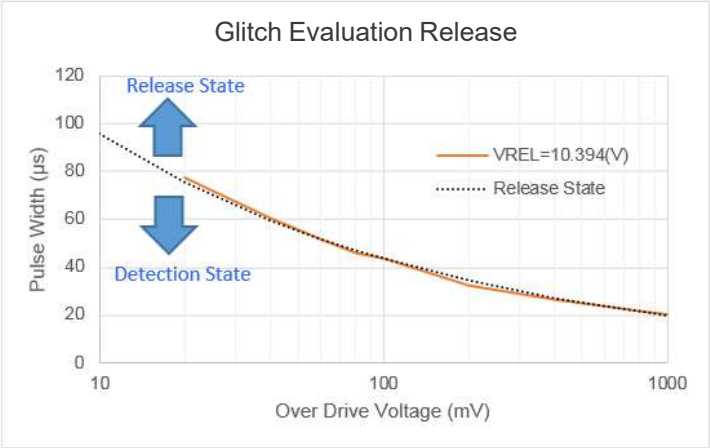


Release by the glitch of V_{DD}

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}.

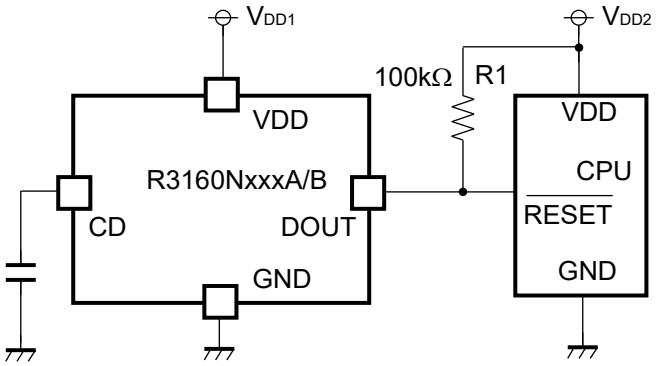


V_{DD} Input Waveform



APPLICATION INFORMATION

Typical Application Circuit



R3160NxxxA/B Typical Application Circuit

Recommended External Components

Symbol	Description
C_D	A capacitor corresponding to the release delay time setting is required. Refer to *Delay in Operation and Release Delay Time (t_{DELAY})* in *THEORY OF OPERATION* 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 *ELECTRICAL CHARACTERISTICS* 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_{IN}(1) 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.

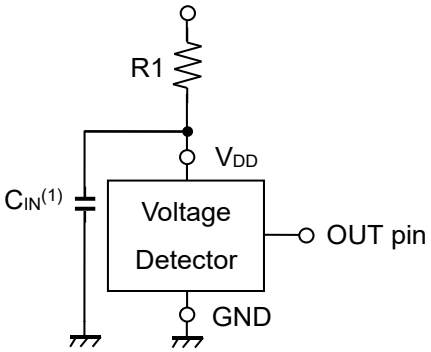


Figure A

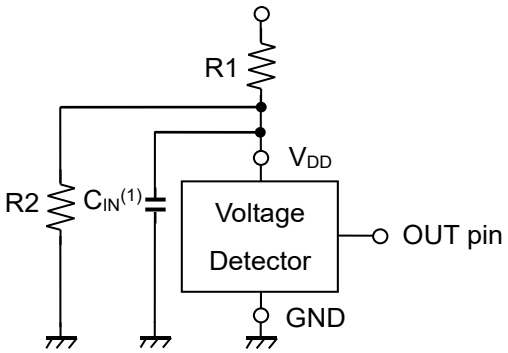


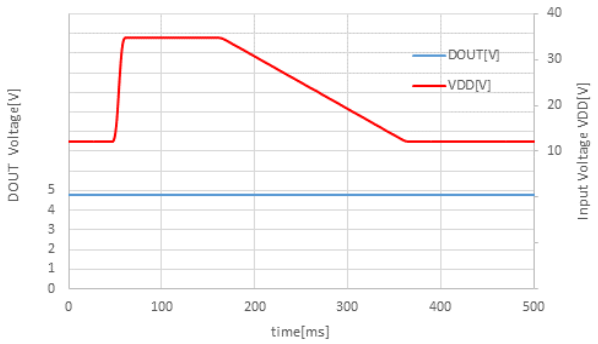
Figure B

(1) Note the bias dependence of capacitors.

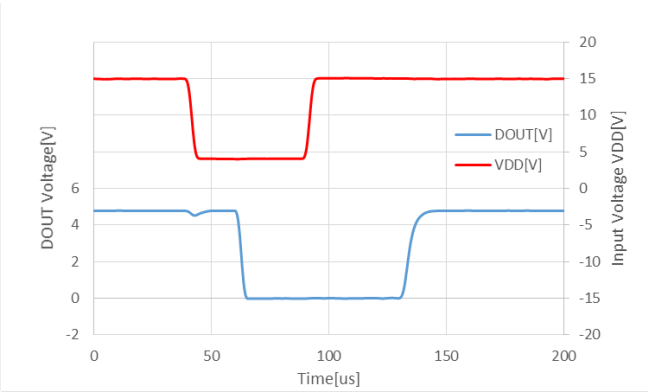
TYPICAL CHARACTERISTICS

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

1) Load Dump (Ta = 25°C)
VDD = 12 V → 35 V (Tr = 1 ms) → 12 V (Tf = 170 ms)
R3160N100A



2) Cranking (Ta = 25°C)
VDD = 15 V → 4 V → 15 V (Tr = Tf = 1 µs)
R3160N100A, CD = none



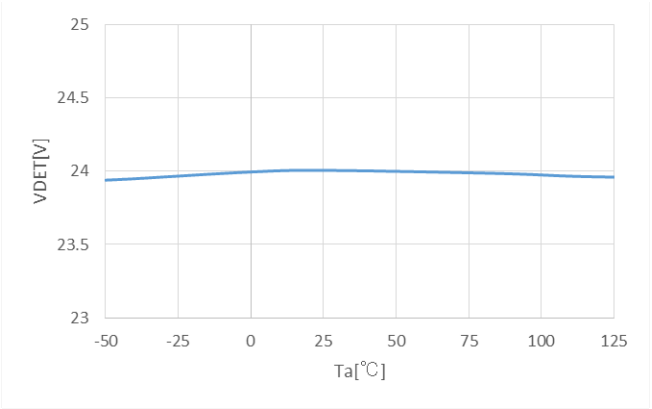
3) Supply Current vs. V_{DD}

R3160N240A

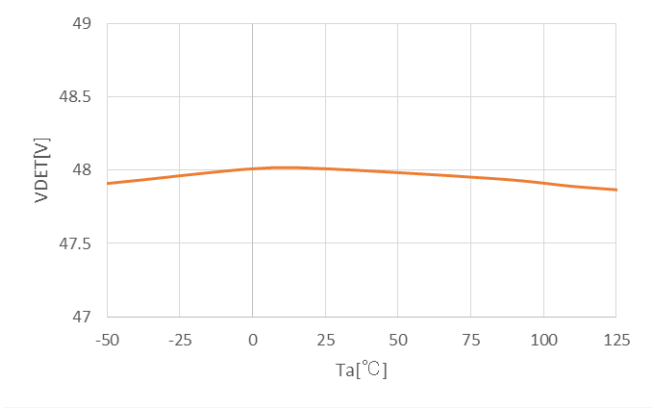
R3160N480A

4) Detector Voltage vs. Ambient Temperature

R3160N240A

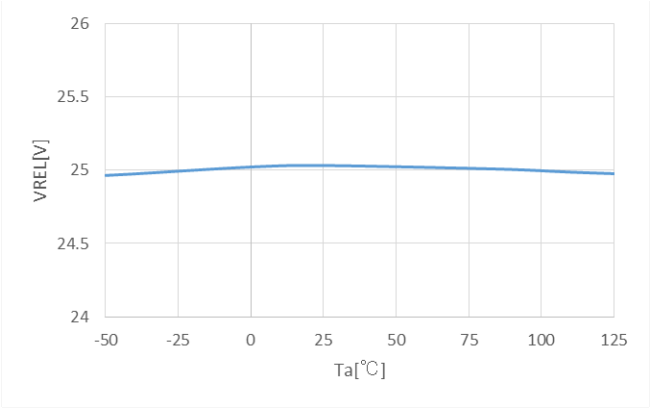


R3160N480A

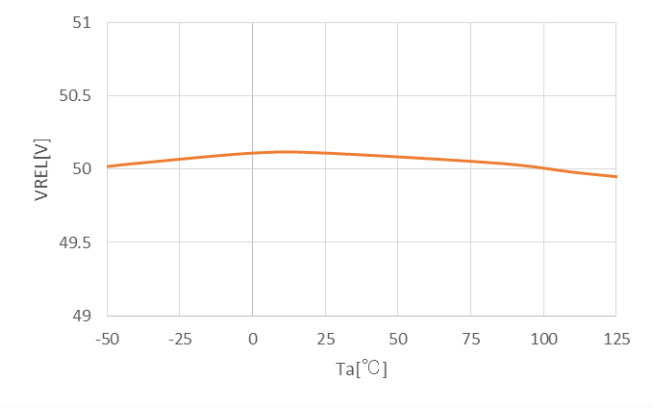


5) Release Voltage vs. Ambient Temperature

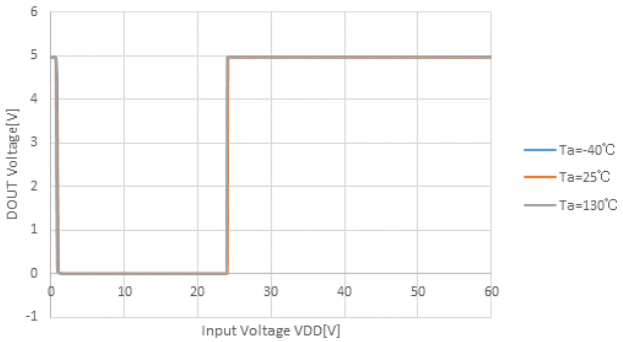
R3160N240A



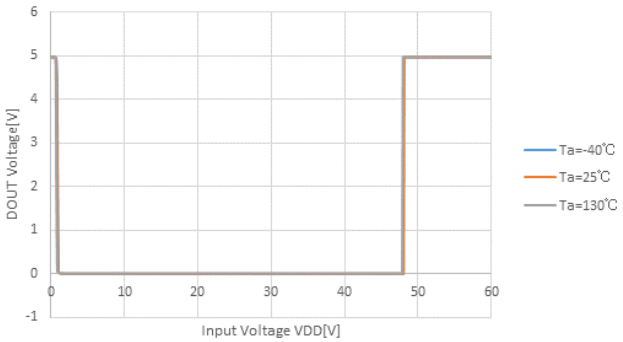
R3160N480A



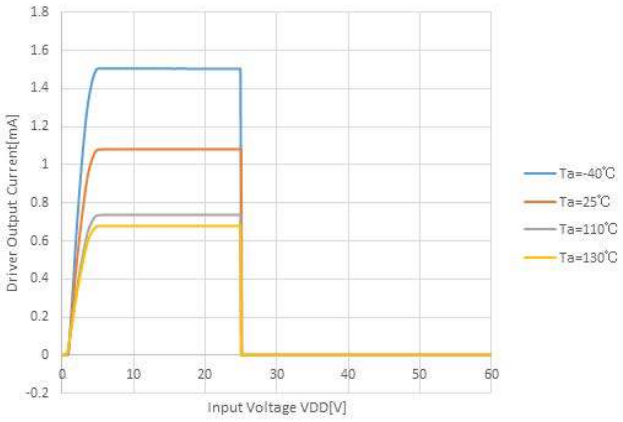
6) DOUT Voltage vs. Input Voltage
DOUT: 5 V pulled up with 100 kohm
R3160N240A



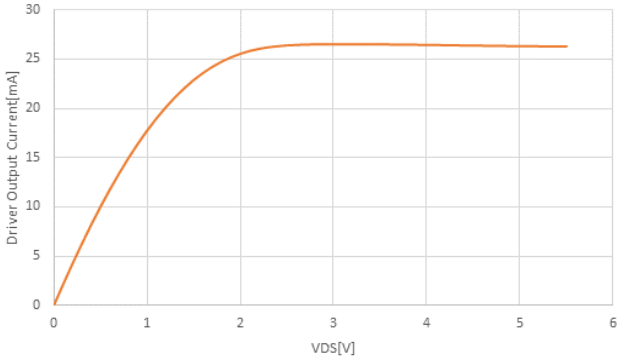
R3160N480A



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

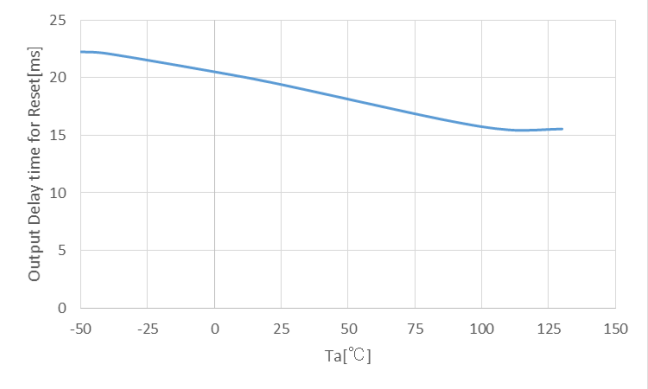


8) Driver Output Current vs. VDS (Ta = 25°C)
VDD = VDET - 0.1 V, DOUT = 0 V → 5.5 V
R3160N240A



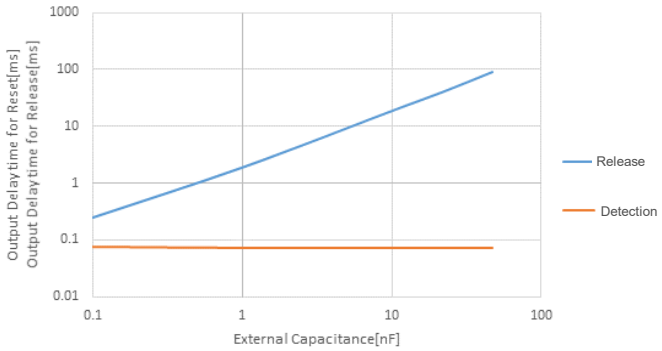
9) Release Delay Time vs. Ambient Temperature

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



Ver. A

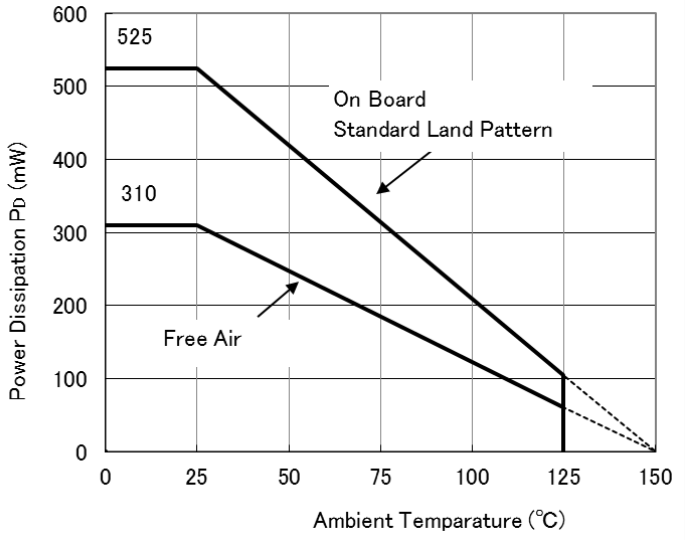
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

Measurement Conditions

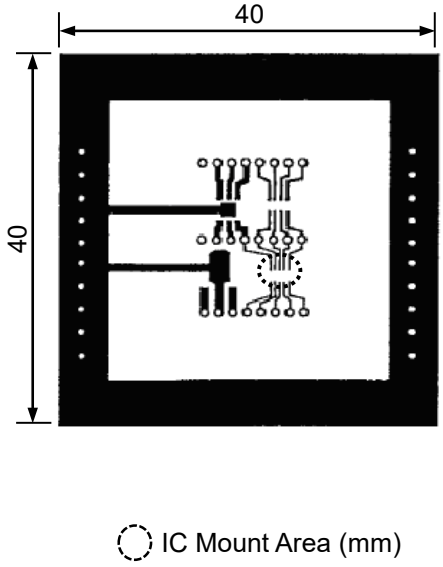
	Standard Test Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm × 40 mm × 1.6 mm
Copper Ratio	Top Side: Approx. 50% Bottom Side: Approx. 50%
Through-holes	ϕ 0.5 mm × 44 pcs

Measurement Result (Ta = 25°C, Tjmax = 150°C)

	Standard Test Land Pattern	Free Air
Power Dissipation	525 mW	310 mW
Thermal Resistance	θja = (150 − 25°C) / 0.525 W = 238°C/W	400°C / W

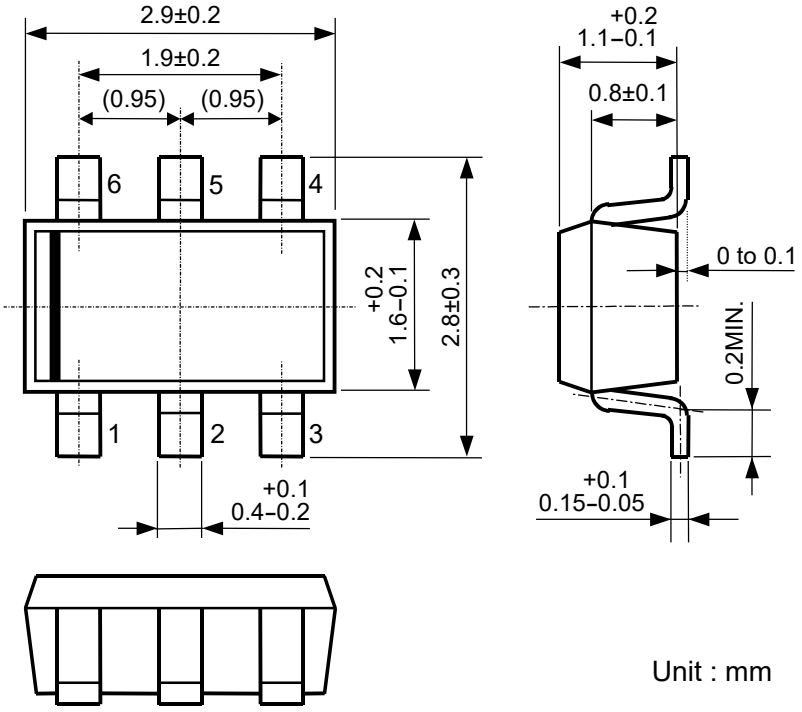


Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

Ver. A



Unit : mm

SOT-23-6 Package Dimensions

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