
0.8% LOW VOLTAGE DETECTOR WITH OUTPUT DELAY

NO.EA-161-111104

OUTLINE

The R3116x series are CMOS-based voltage detector ICs with high detector threshold accuracy and ultra-low supply current, which can be operated at an extremely low voltage and is used for system reset as an example.

Each of these ICs consists of a voltage reference unit, a comparator, resistors for detector threshold setting, an output driver, a hysteresis circuit and an output delay circuit. The detector threshold is internally fixed with high accuracy and does not require any adjustment.

Two output types, Nch open drain type and CMOS type are available.

The R3116x series are operable at a lower voltage than that of the R3112x series, and can be driven by a single battery.

Three types of packages, SOT-23-5, SC-82AB, and DFN(PLP)1010-4 are available.

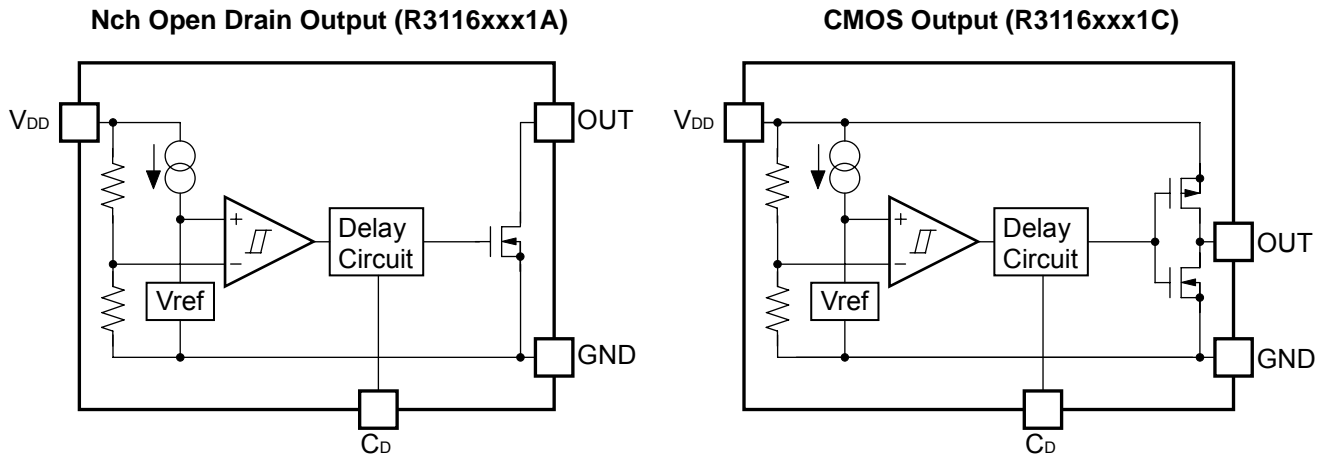
FEATURES

- Supply Current Typ. 0.35 μ A ($-V_{DET}=1.5V$, $V_{DD}=-V_{DET}+1V$)
- Operating Voltage Range..... 0.5V to 6.0V ($T_{opt}=25^{\circ}C$)
- Detector Threshold Range..... 0.7V to 5.0V (0.1V steps)
(For other voltages, please refer to MARK INFORMATION.)
- Detector Threshold Accuracy..... $\pm 0.8\%$ ($-V_{DET} \geq 1.5V$)
- Temperature-Drift Coefficient of Detector Threshold Typ. $\pm 30ppm/^{\circ}C$
- Built-in Output Delay Circuit..... Typ. 100ms with an external capacitor: 0.022 μ F
- Output Delay Time Accuracy..... $\pm 15\%$ ($-V_{DET} \geq 1.5V$)
- Output Types..... Nch Open Drain "L" and CMOS
- Packages DFN(PLP)1010-4, SC-82AB, SOT-23-5

APPLICATIONS

- CPU and Logic Circuit Reset
- Battery Checker
- Window Comparator
- Wave Shaping Circuit
- Battery Back-up Circuit
- Power Failure Detector

BLOCK DIAGRAMS



SELECTION GUIDE

The package type, the detector threshold, the output type and the taping type for the ICs can be selected at the users' request.

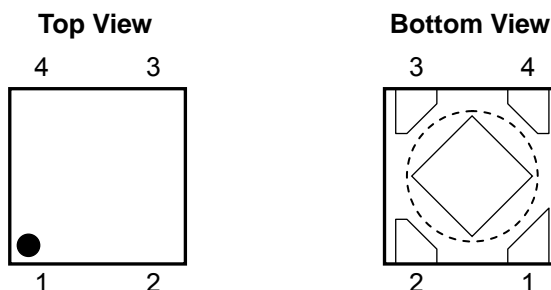
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R3116Kxx1*-TR	DFN(PLP)1010-4	10,000 pcs	Yes	Yes
R3116Qxx1*-TR-FE	SC-82AB	3,000 pcs	Yes	Yes
R3116Nxx1*-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes

xx: The detector threshold can be designated in the range from 0.7V(07) to 5.0V(50) in 0.1V steps.
(For other voltages, please refer to MARK INFORMATIONS.)

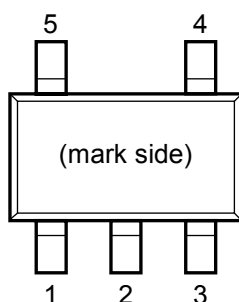
* : Designation of Output Type
(A) Nch Open Drain
(C) CMOS

PIN CONFIGURATIONS

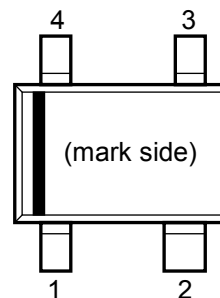
• DFN(PLP)1010-4*



• SOT-23-5



• SC-82AB



PIN DESCRIPTIONS

• DFN(PLP)1010-4*

Pin No.	Symbol	Description
1	OUT	Output Pin ("L" at detection)
2	C _D	Pin for External Capacitor (for setting output delay)
3	GND	Ground Pin
4	V _{DD}	Input Pin

*) Tab is GND level. (They are connected to the reverse side of this IC.)

The tab is better to be connected to the GND, but leaving it open is also acceptable.

• SOT-23-5

Pin No.	Symbol	Description
1	OUT	Output Pin ("L" at detection)
2	V _{DD}	Input Pin
3	GND	Ground Pin
4	NC	No Connection
5	C _D	Pin for External Capacitor (for setting output delay)

• SC-82AB

Pin No.	Symbol	Description
1	V _{DD}	Input Pin
2	GND	Ground Pin
3	C _D	Pin for External Capacitor (for setting output delay)
4	OUT	Output Pin ("L" at detection)

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{DD}	Supply Voltage	7.0	V
V_{OUT}	Output Voltage (Nch Open Drain Output)	$V_{SS}-0.3$ to 7.0	V
	Output Voltage (CMOS Output)	$V_{SS}-0.3$ to $V_{DD}+0.3$	
I_{OUT}	Output Current	20	mA
P_D	Power Dissipation (SOT-23-5)*	420	mW
	Power Dissipation (SC-82AB)*	380	
	Power Dissipation (DFN(PLP)1010-4)*	400	
T_{opt}	Operating Temperature Range	-40 to 85	°C
T_{stg}	Storage Temperature Range	-55 to 125	°C

*) For Power Dissipation, please refer to PACKAGE INFORMATION.

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 is not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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.

ELECTRICAL CHARACTERISTICS

- R3116xxx1A/C values indicate $-40^{\circ}\text{C} \leq T_{\text{opt}} \leq 85^{\circ}\text{C}$, unless otherwise noted. $T_{\text{opt}}=25^{\circ}\text{C}$

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit	
$-V_{\text{DET}}$	Detector Threshold	$T_{\text{opt}}=25^{\circ}\text{C}$	$1.5\text{V} < -V_{\text{DET}} \leq 5.0\text{V}$	$-V_{\text{DET}}$ $\times 0.992$		$-V_{\text{DET}}$ $\times 1.008$	V	
			$0.7\text{V} \leq -V_{\text{DET}} \leq 1.5\text{V}$	-12		+12	mV	
		$-40^{\circ}\text{C} \leq T_{\text{opt}} \leq 85^{\circ}\text{C}$	$1.5\text{V} < -V_{\text{DET}} \leq 5.0\text{V}$	$-V_{\text{DET}}$ $\times 0.985$		$-V_{\text{DET}}$ $\times 1.015$	V	
			$0.7\text{V} \leq -V_{\text{DET}} \leq 1.5\text{V}$	-22.5		+22.5	mV	
V_{HYS}	Detector Threshold Hysteresis			$-V_{\text{DET}}$ $\times 0.04$		$-V_{\text{DET}}$ $\times 0.07$	V	
I_{SS}	Supply Current	$V_{\text{DD}}=-V_{\text{DET}}-0.1\text{V}$	$0.7\text{V} \leq -V_{\text{DET}} < 1.6\text{V}$			1.40	μA	
			$1.6\text{V} \leq -V_{\text{DET}} < 3.1\text{V}$			1.50		
			$3.1\text{V} \leq -V_{\text{DET}} < 4.1\text{V}$			1.60		
			$4.1\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$			1.70		
		$V_{\text{DD}}=-V_{\text{DET}}+0.1\text{V}$	$0.7\text{V} \leq -V_{\text{DET}} < 1.6\text{V}$			1.20		
			$1.6\text{V} \leq -V_{\text{DET}} < 3.1\text{V}$			1.20		
			$3.1\text{V} \leq -V_{\text{DET}} < 4.1\text{V}$			1.30		
			$4.1\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$			1.40		
V_{DDH}	Maximum Operating Voltage					6	V	
V_{DDL}	Minimum Operating Voltage*1	$T_{\text{opt}}=25^{\circ}\text{C}$				0.50	V	
		$-40^{\circ}\text{C} \leq T_{\text{opt}} \leq 85^{\circ}\text{C}$				0.55		
I_{OUT}	Output Current (Driver Output Pin)	Nch	$V_{\text{DD}}=0.55\text{V}, V_{\text{DS}}=0.05\text{V}$		7		μA	
			$0.7\text{V} \leq -V_{\text{DET}} < 1.1\text{V}$	$V_{\text{DD}}=0.6\text{V}, V_{\text{DS}}=0.5\text{V}$	0.02		mA	
			$1.1\text{V} \leq -V_{\text{DET}} < 1.6\text{V}$	$V_{\text{DD}}=1.0\text{V}, V_{\text{DS}}=0.5\text{V}$	0.40			
			$1.6\text{V} \leq -V_{\text{DET}} < 3.1\text{V}$	$V_{\text{DD}}=1.5\text{V}, V_{\text{DS}}=0.5\text{V}$	1.00			
			$3.1\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$	$V_{\text{DD}}=3.0\text{V}, V_{\text{DS}}=0.5\text{V}$	2.40			
			Pch*2	$0.7\text{V} \leq -V_{\text{DET}} < 4.0\text{V}$	$V_{\text{DD}}=4.5\text{V}, V_{\text{DS}}=-2.1\text{V}$	0.65		mA
		$4.0\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$		$V_{\text{DD}}=6.0\text{V}, V_{\text{DS}}=-2.1\text{V}$	0.90			
		I_{LEAK}	Nch Driver Leakage Current*3	$V_{\text{DD}}=6.0\text{V}, V_{\text{DS}}=7.0\text{V}$				80
$\frac{\Delta-V_{\text{DET}}}{\Delta T_{\text{opt}}}$	Detector Threshold Temperature Coefficient				± 30		ppm/ $^{\circ}\text{C}$	
t_{D}	Output Delay Time	$C_{\text{D}}=0.022\mu\text{F}$ $V_{\text{DD}}=-V_{\text{DET}}-0.1\text{V}$ $t_{\text{O}} -V_{\text{DET}} \times 1.1\text{V}$	$T_{\text{opt}}=25^{\circ}\text{C}$	$0.7\text{V} \leq -V_{\text{DET}} < 1.5\text{V}$	80	100	130	ms
				$1.5\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$	85		115	
			$-40^{\circ}\text{C} \leq T_{\text{opt}} \leq 85^{\circ}\text{C}$	$0.7\text{V} \leq -V_{\text{DET}} < 1.5\text{V}$	70	100	150	
				$1.5\text{V} \leq -V_{\text{DET}} \leq 5.0\text{V}$	75		135	

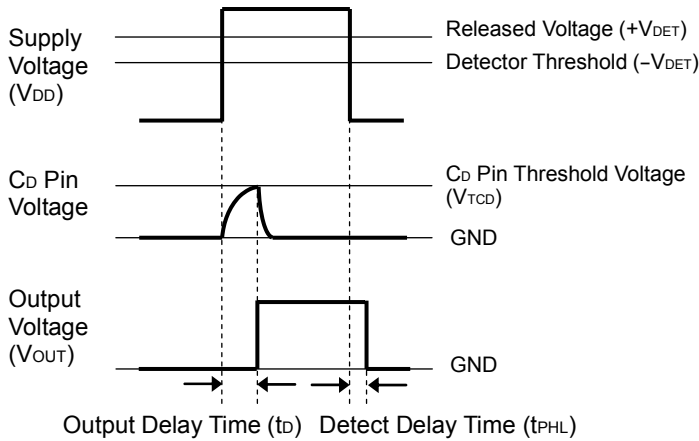
All of unit are tested and specified under load conditions such that $T_{\text{opt}}=25^{\circ}\text{C}$ except for Detector Threshold Temperature Coefficient.

*1: Minimum operating voltage means the value of input voltage when output voltage maintains 0.1V or less.
(In case of Nch Open Drain Output type, the output pin is pulled up with a resistance of 470k Ω to 5.0V)

*2: In case of CMOS type

*3: In case of Nch Open Drain type

TIMING CHART



When the supply voltage, which is higher than released voltage, is forced to V_{DD} pin, charge to an external capacitor starts, then C_D pin voltage increases. Until the C_D pin voltage reaches to C_D pin threshold voltage, output voltage maintains "L". When the C_D pin voltage becomes higher than C_D pin threshold voltage, output voltage is reversed from "L" to "H". Where the time interval between the rising edge of supply voltage and output voltage reverse point means output delay time.

When the output voltage reverses from "L" to "H", the external capacitor starts to discharge. Therefore, when lower voltage than the detector threshold voltage is forced to V_{DD} pin, the output voltage reverses from "H" to "L" thus the detect delay time is constant not being affected by the external capacitor.

• Output Delay Time

Output Delay Time (t_o) can be calculated with the next formula using the external capacitor:

$$t_o(s) = 4.5 \times 10^6 \times C_D(F)$$

DEFINITION OF OUTPUT DELAY TIME

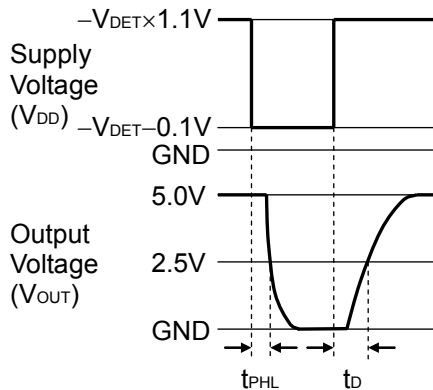
Output Delay Time (t_o) is defined as follows:

1. In the case of Nch Open Drain Output:

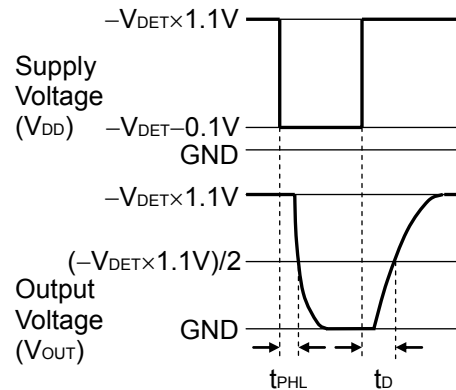
Under the condition of the output pin (OUT) is pulled up through a resistor of 470kΩ to 5V, the time interval between the rising edge of V_{DD} pulse from (-V_{DET})-0.1V to (-V_{DET})×1.1V pulse voltage is supplied, the becoming of the output voltage to 2.5V.

2. In the case of CMOS Output:

The time interval between the rising edge of V_{DD} pulse from (-V_{DET})-0.1V to (-V_{DET})×1.1V pulse voltage is supplied, the becoming of the output voltage to ((-V_{DET})×1.1V)/2.



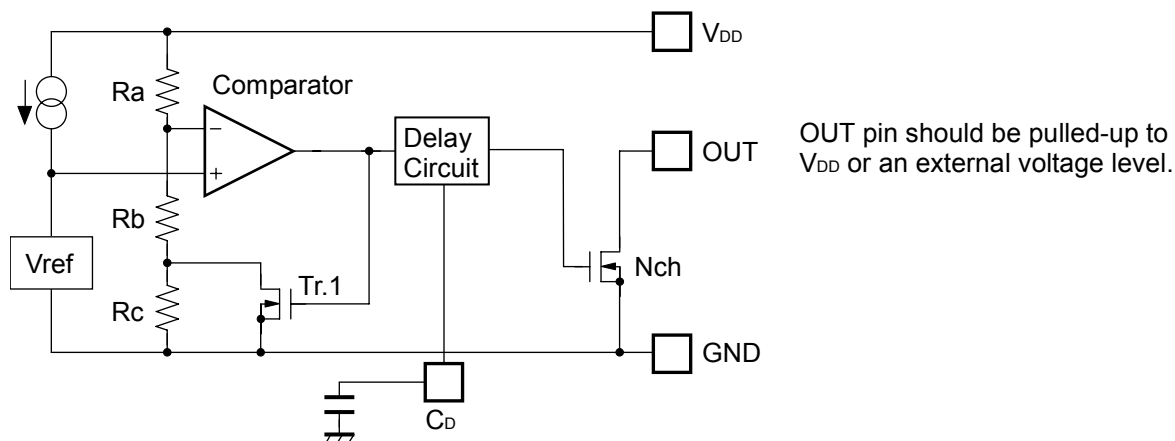
**Nch Open Drain Output
(R3116xxx1A)**



**CMOS Output
(R3116xxx1C)**

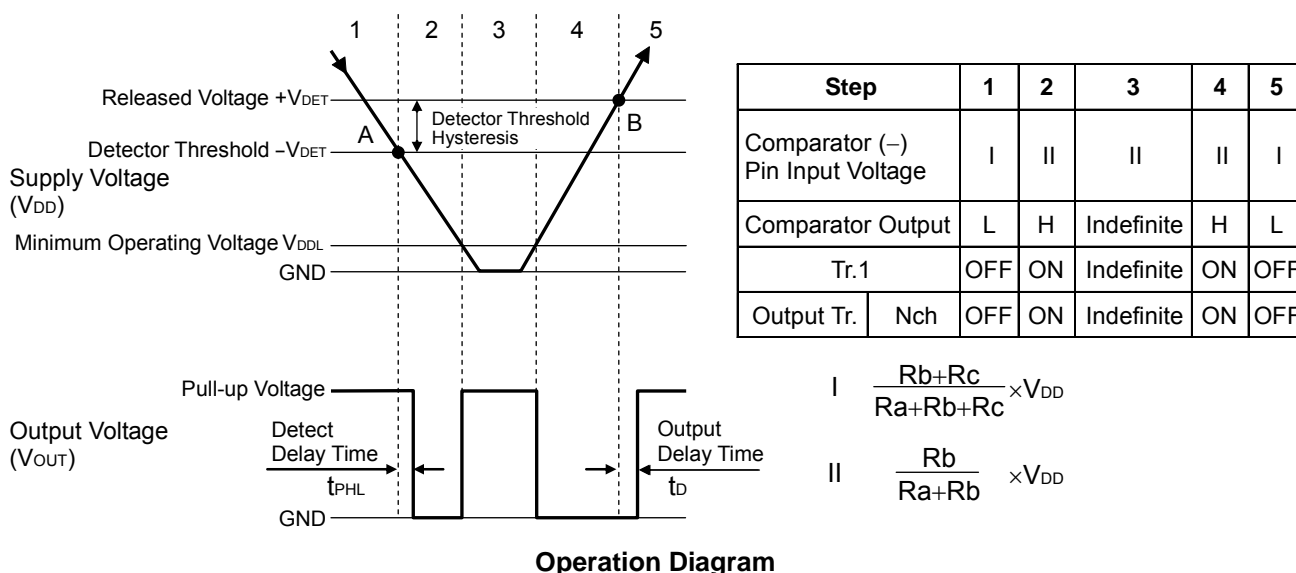
OPERATION

• Operation of R3116xxx1A



OUT pin should be pulled-up to V_{DD} or an external voltage level.

Block Diagram (R3116xxx1A)



Operation Diagram

• Explanation of operation

Step 1. The output voltage is equal to the pull-up voltage.

Step 2. At Point "A", $V_{ref} \geq V_{DD} \times (R_b + R_c) / (R_a + R_b + R_c)$ is true, as a result, the output of comparator is reversed from "L" to "H", therefore the output voltage becomes the GND level. The voltage level of Point A means a detector threshold voltage ($-V_{DET}$).

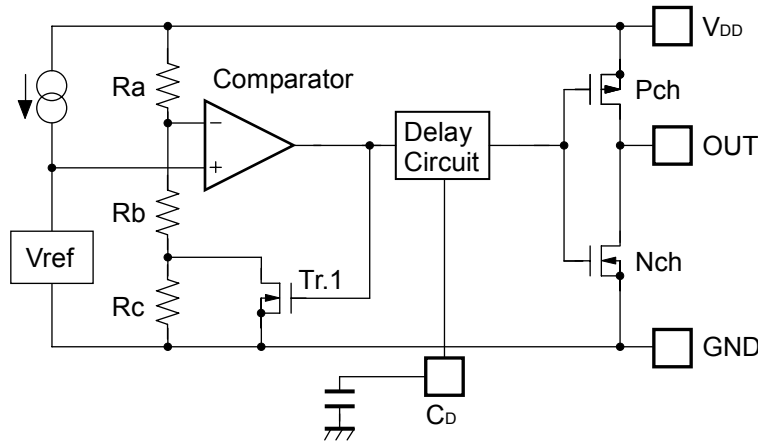
Step 3. When the supply voltage is lower than the minimum operating voltage, the operation of the output transistor becomes indefinite. The output voltage is equal to the pull-up voltage.

Step 4. The output voltage is equal to the GND level.

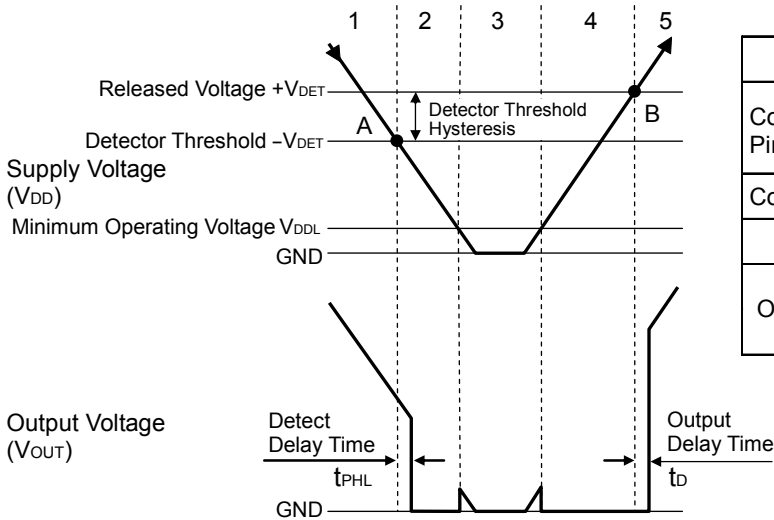
Step 5. At Point "B", $V_{ref} \leq V_{DD} \times R_b / (R_a + R_b)$ is true, as a result, the output of comparator is reversed from "H" to "L", then the output voltage is equal to the pull-up voltage. The voltage level of Point B means a released voltage ($+V_{DET}$).

*) The difference between a released voltage and a detector threshold voltage is a detector threshold hysteresis.

• Operation of R3116xxx1C



Block Diagram (R3116xxx1C)



Operation Diagram

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

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

$$II \quad \frac{Rb}{Ra+Rb} \times V_{DD}$$

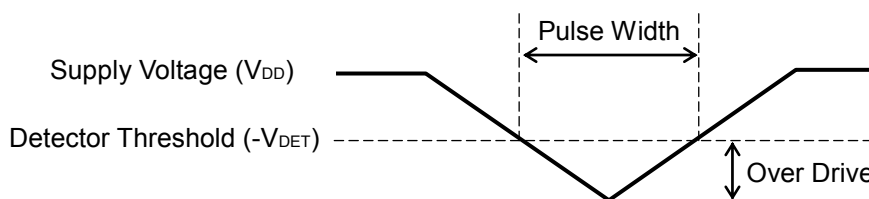
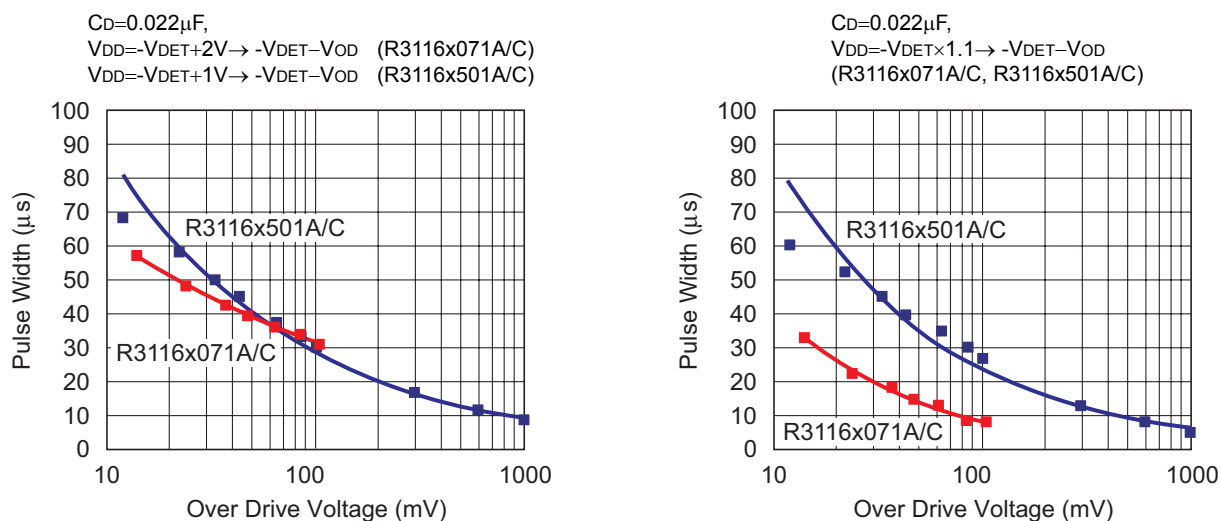
• Explanation of operation

- Step 1. The output voltage is equal to the supply voltage (V_{DD}).
- Step 2. At Point "A", $V_{ref} \geq V_{DD} \times (Rb+Rc) / (Ra+Rb+Rc)$ is true, as a result, the output of comparator is reversed from "L" to "H", therefore the output voltage becomes the GND level. The voltage level of Point A means a detector threshold voltage ($-V_{DET}$).
- Step 3. When the supply voltage is lower than the minimum operating voltage, the operation of the output transistor becomes indefinite.
- Step 4. The output voltage is equal to the GND level.
- Step 5. At Point "B", $V_{ref} \leq V_{DD} \times Rb / (Ra+Rb)$ is true, as a result, the output of comparator is reversed from "H" to "L", then the output voltage is equal to the supply voltage (V_{DD}). The voltage level of Point B means a released voltage ($+V_{DET}$).

*) The difference between a released voltage and a detector threshold voltage is a detector threshold hysteresis.

Detector Operation vs. glitch input voltage to the V_{DD} pin

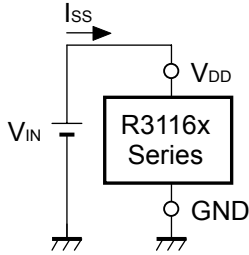
When the R3116x is at released, if the pulse voltage which the detector threshold or lower voltage, the graph below means that the relation between pulse width and the amplitude of the swing to keep the released state for the R3116x.



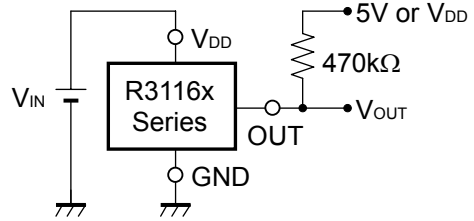
V_{DD} Input Waveform

This graph shows the maximum pulse conditions to keep the released voltage. If the pulse with larger amplitude or wider width than the graph above, is input to V_{DD} pin, the reset signal may be output.

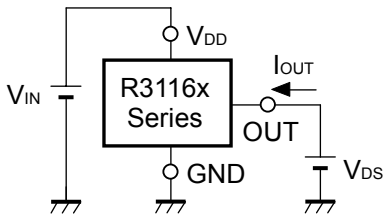
TEST CIRCUITS



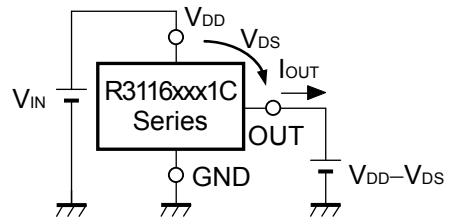
Supply Current Test Circuit



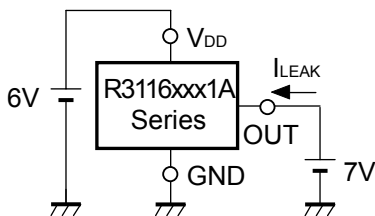
Detector Threshold Test Circuit
(Pull-up circuit is not necessary for CMOS Output type.)



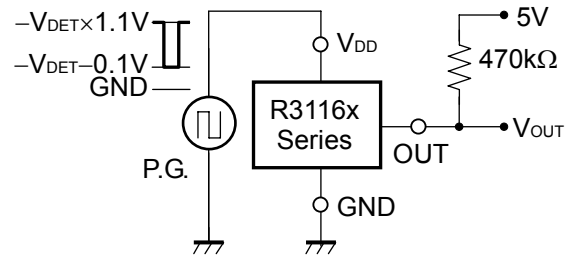
Nch Driver Output Current Test Circuit



Pch Driver Output Current Test Circuit
*Apply to CMOS Output type only



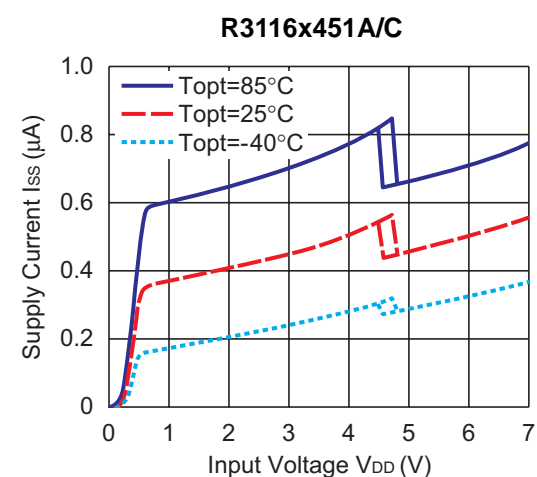
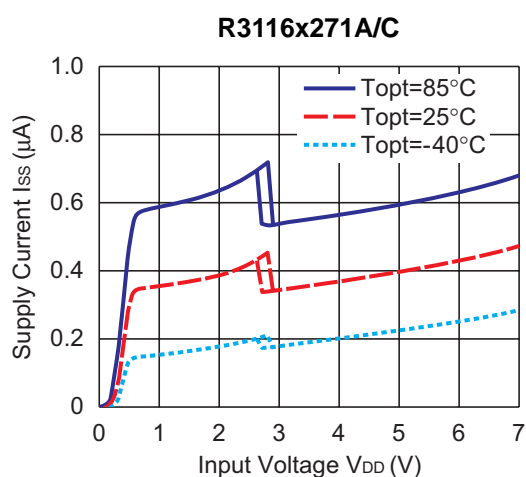
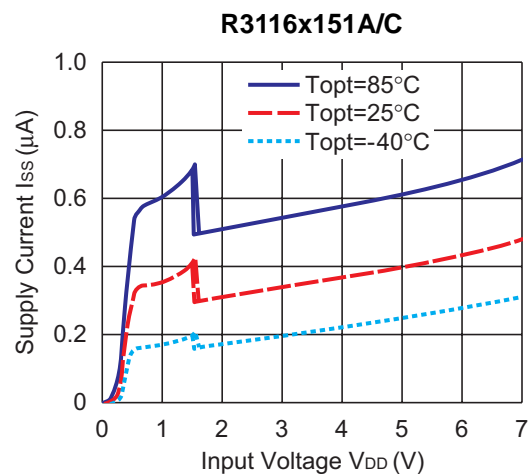
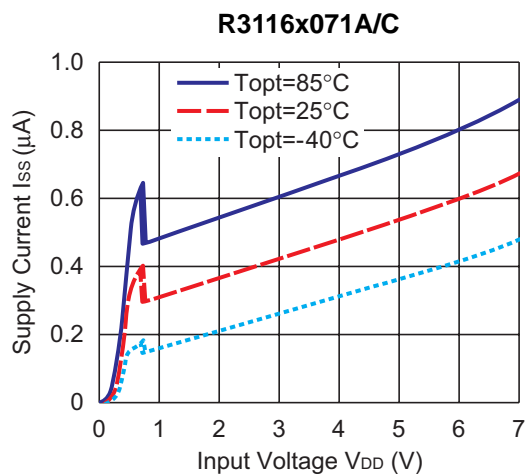
Nch Driver Leakage Current Test Circuit
*Apply to Nch Driver Output type only



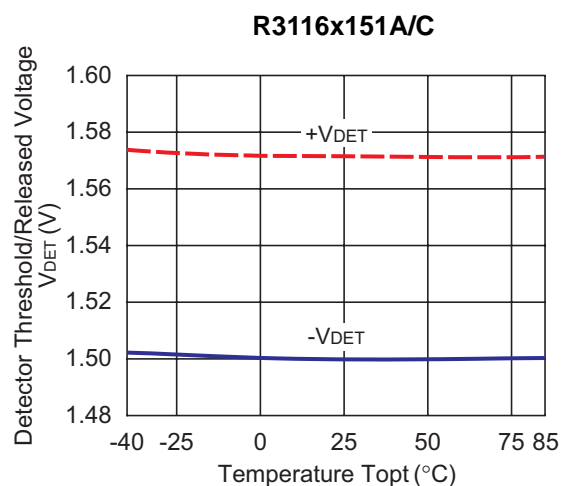
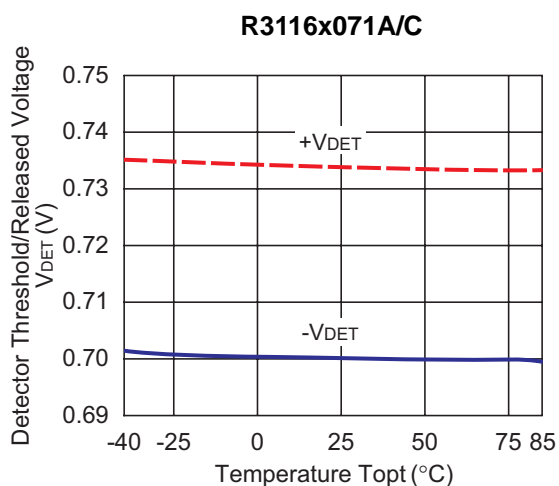
Output Delay Time Test Circuit
(Pull-up circuit is not necessary for CMOS Output type.)

TYPICAL CHARACTERISTICS

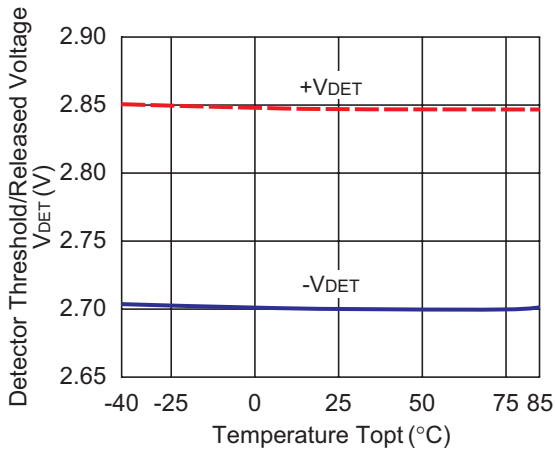
1) Supply Current vs. Input Voltage



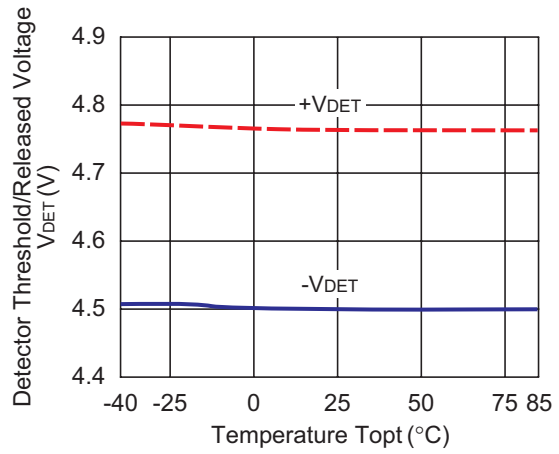
2) Detector Threshold vs. Temperature



R3116x271A/C

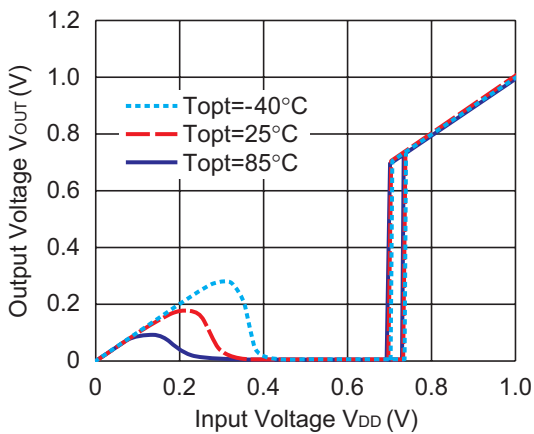


R3116x451A/C

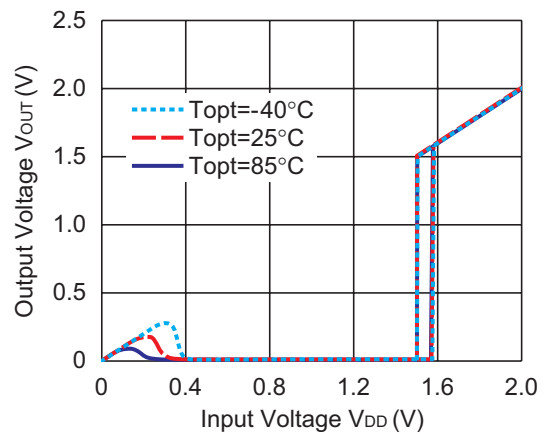


3) Output Voltage vs. Input Voltage

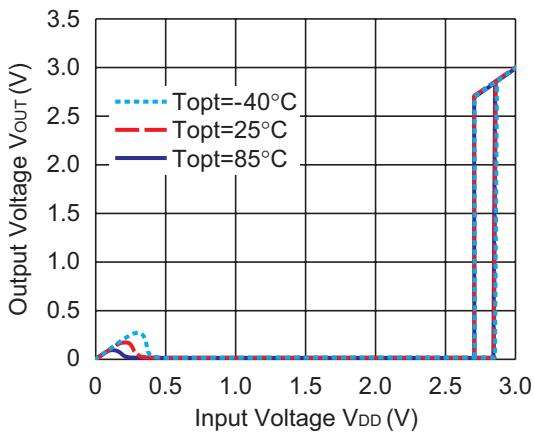
R3116x071C



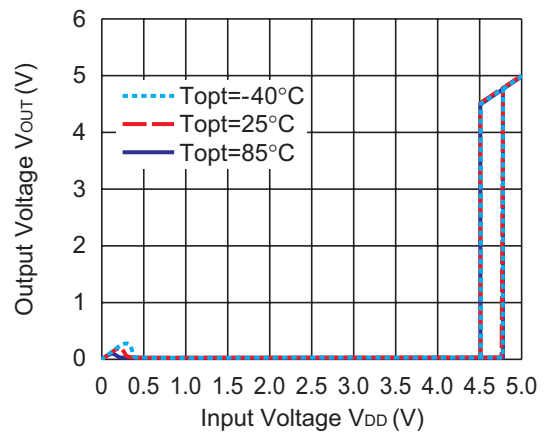
R3116x151C

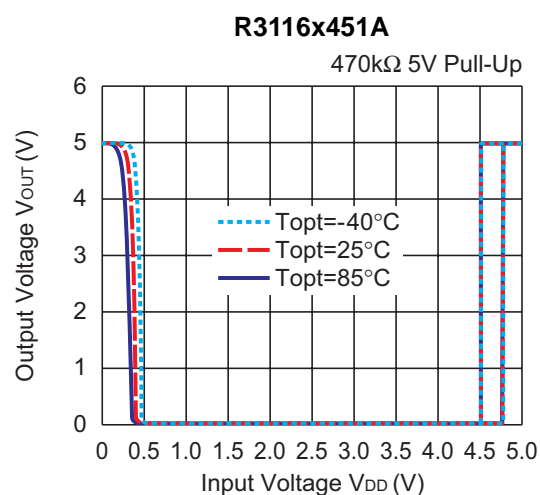
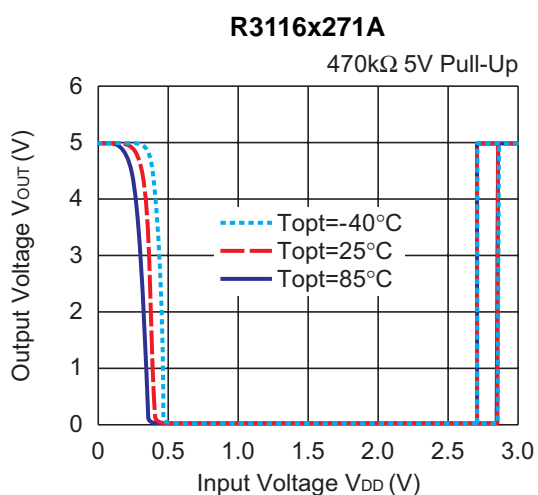
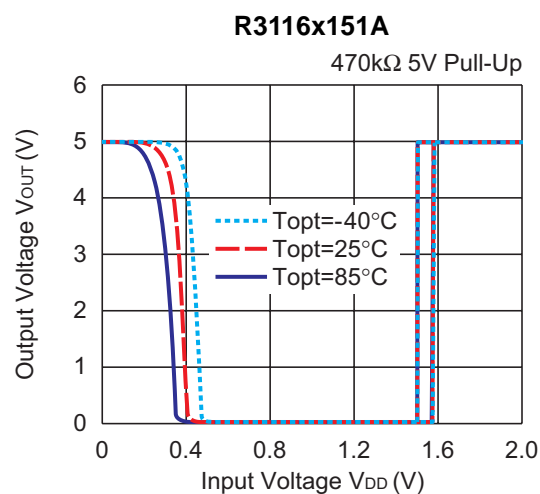
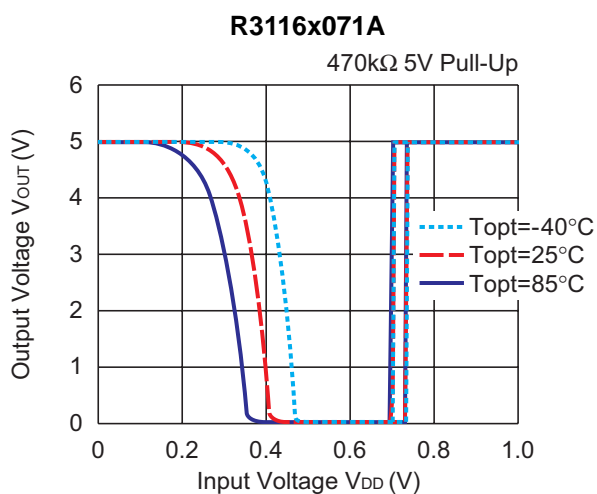


R3116x271C

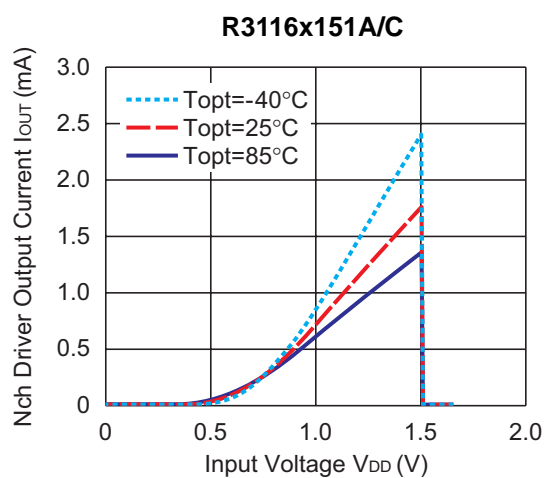
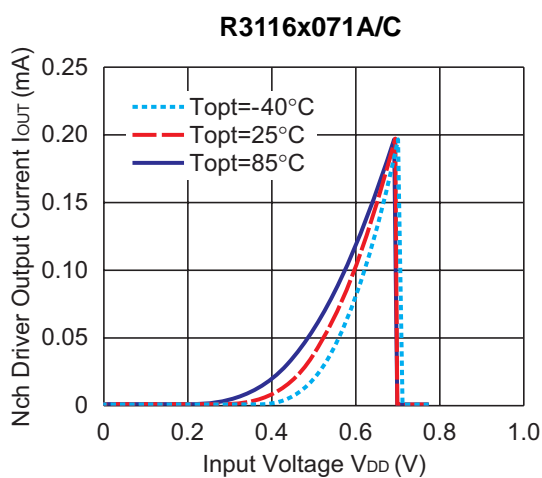


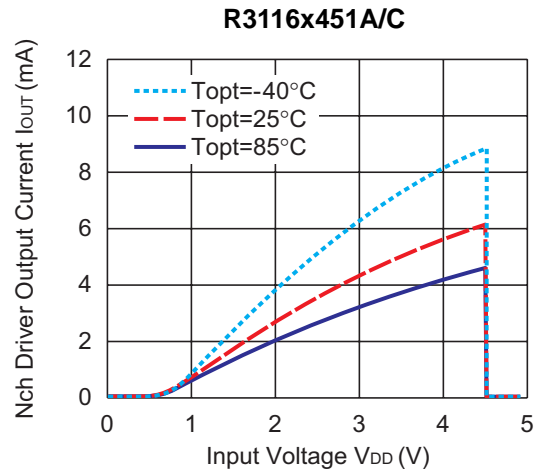
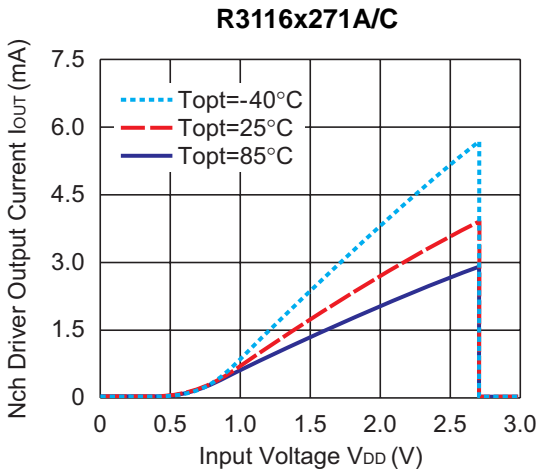
R3116x451C



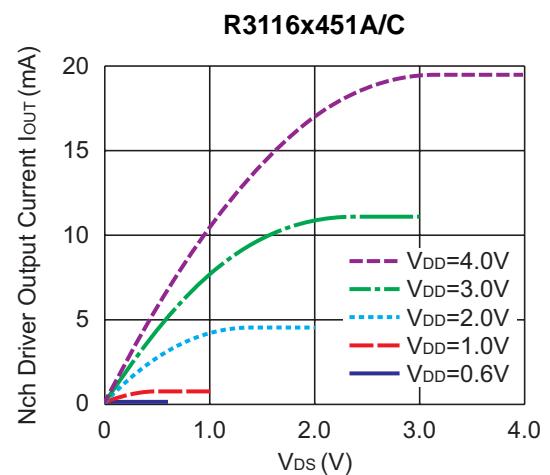
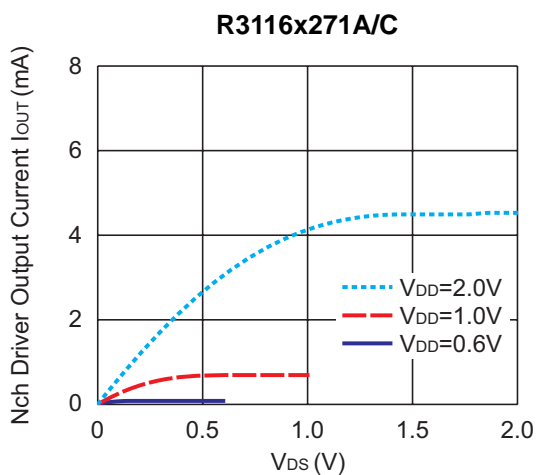
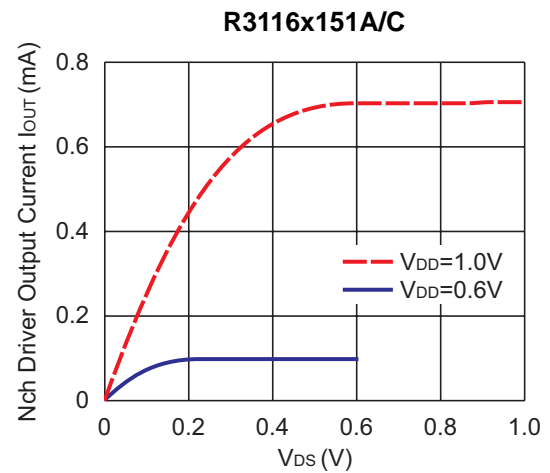
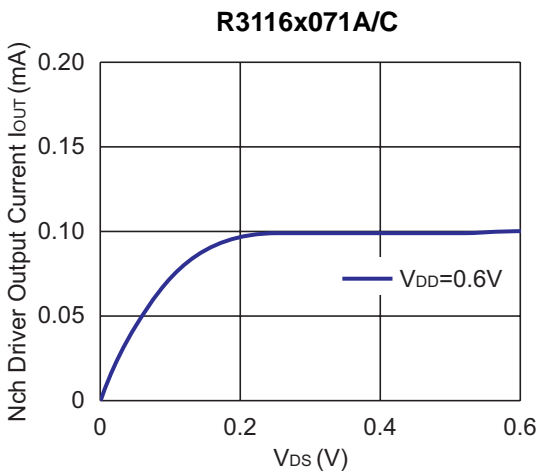


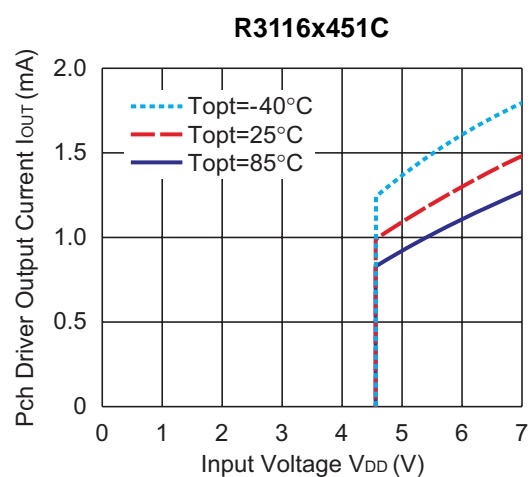
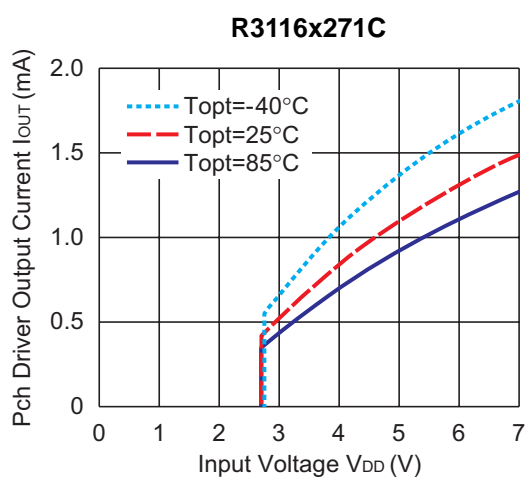
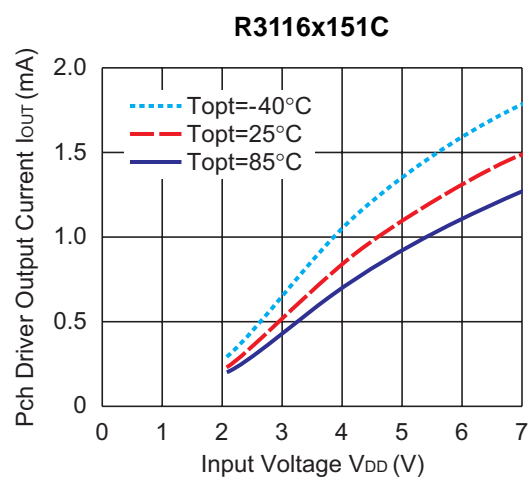
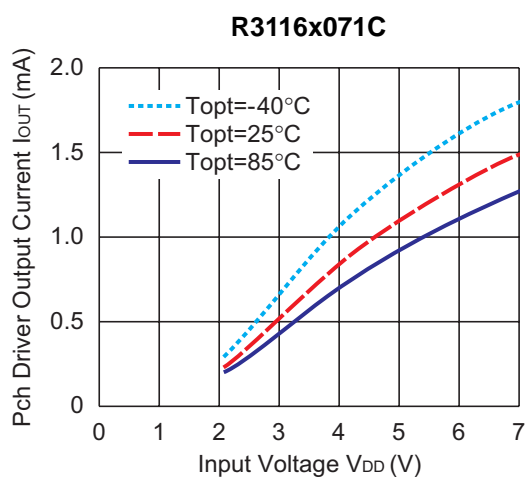
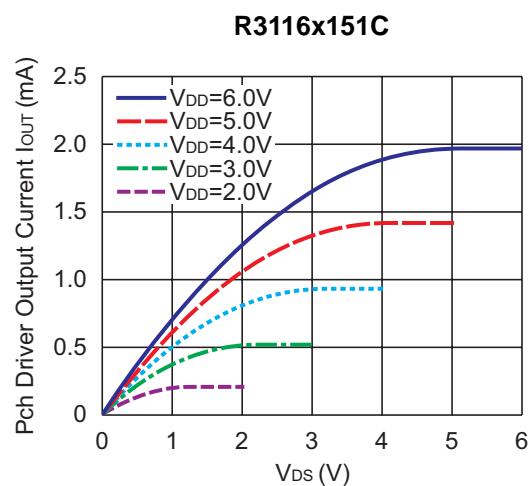
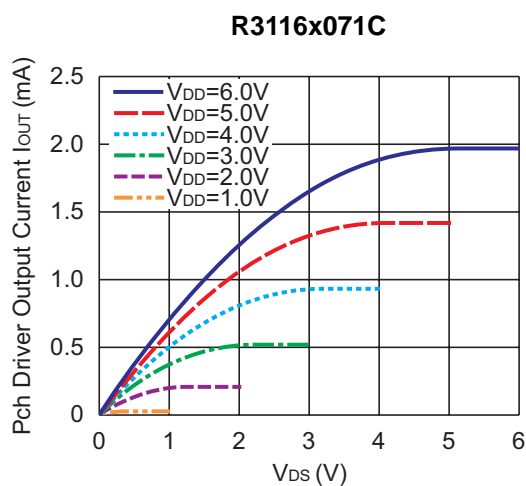
4) Nch Driver Output Current vs. Input Voltage ($V_{DS}=0.5V$)

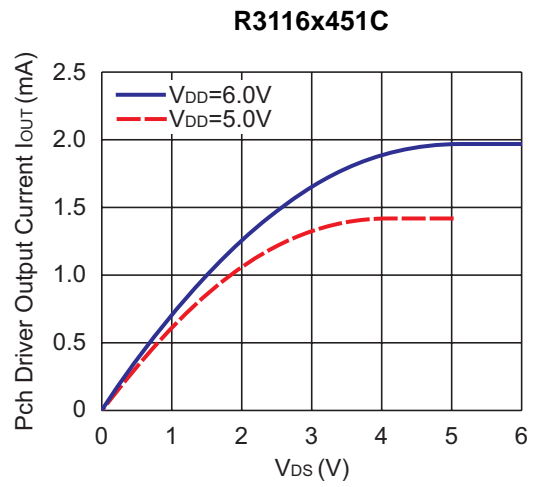
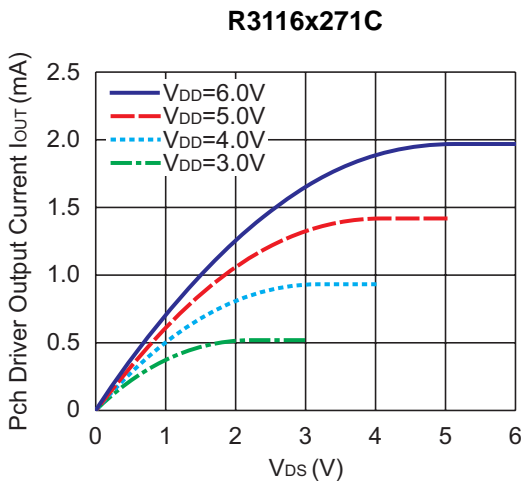




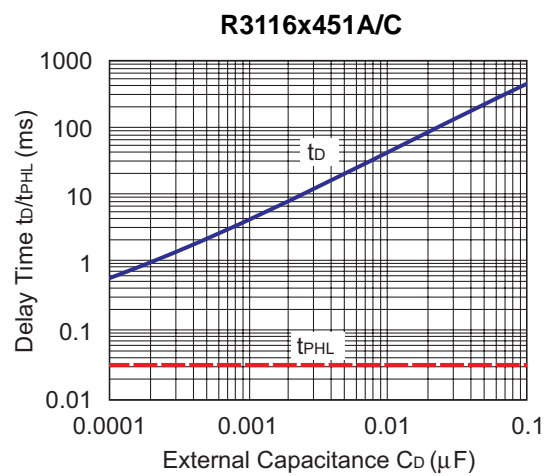
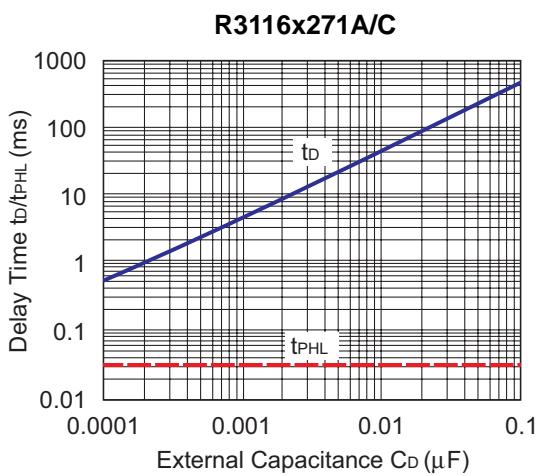
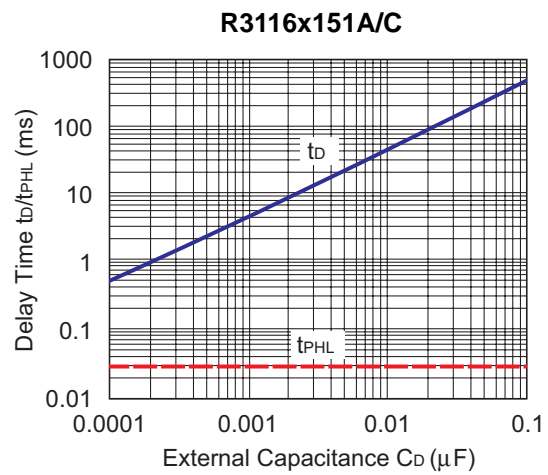
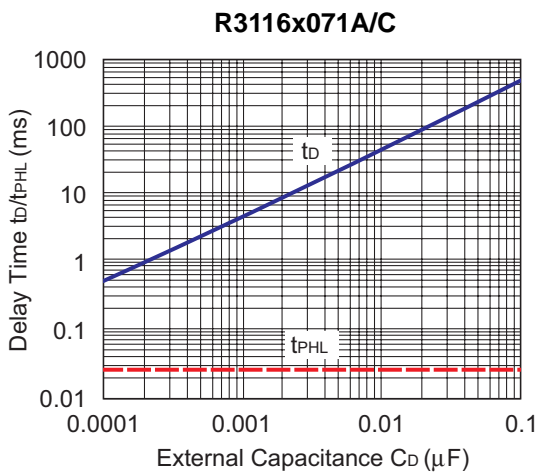
5) Nch Driver Output Current vs. V_{DS}

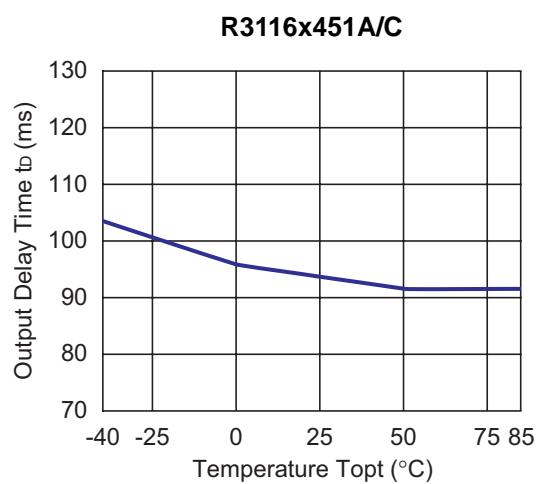
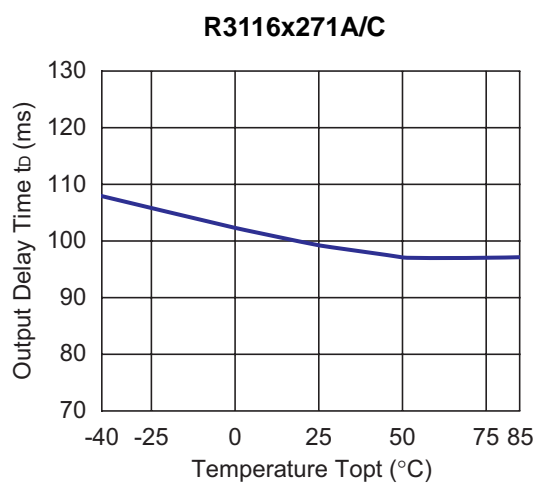
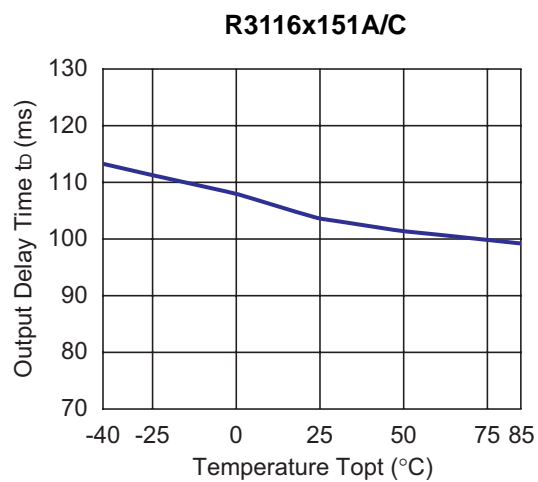
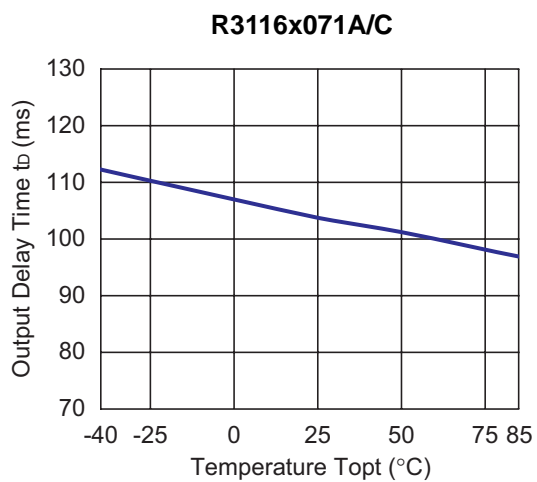


6) Pch Driver Output Current vs. Input Voltage ($V_{DS} = -2.1V$)7) Pch Driver Output Current vs. V_{DS} 

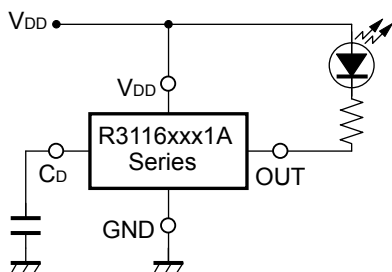


8) Output Delay Time vs. External Capacitance

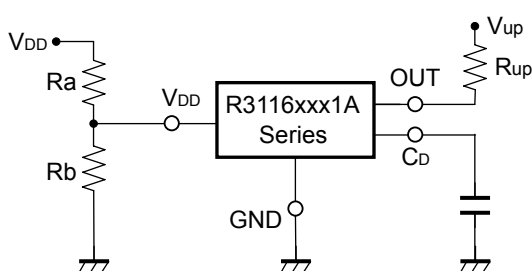


9) Output Delay Time vs. Temperature ($C_D=22nF$)

• **Voltage level Indicator Circuit (lighted when the power runs out)**
(Nch Open Drain Output)



• **Detector Threshold Adjustable Circuit 1**
(Nch Open Drain Output)

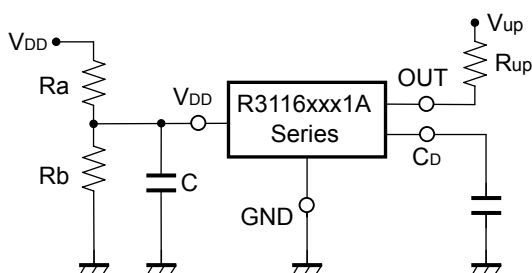


$$\text{Adjustable Detector Threshold} = (-V_{\text{DET}}) \times (R_a + R_b) / R_b$$

$$\text{Hysteresis Voltage} = (V_{\text{HYS}}) \times (R_a + R_b) / R_b$$

- *1) To prevent oscillation, set $R_a \leq 1\text{k}\Omega$, $R_b \leq 100\Omega$.
- *2) If the value of R_a is set excessively large, voltage drop may occur caused by the supply current of IC itself, and detector threshold and hysteresis voltage may vary.
- *3) If V_{up} and V_{DD} are connected, the voltage dropdown caused by R_{up} , may cause difference in the hysteresis voltage.

• **Detector Threshold Adjustable Circuit 2**
(Nch Open Drain Output)

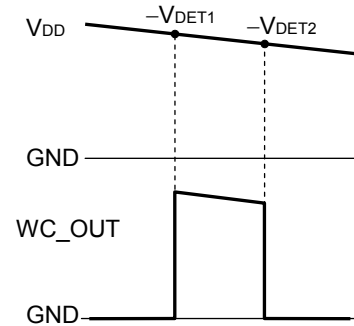
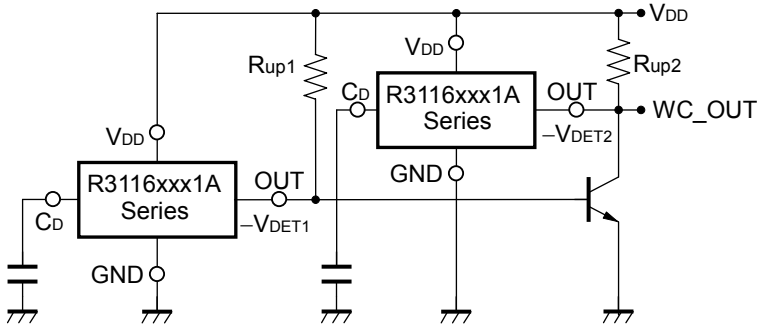


$$\text{Adjustable Detector Threshold} = (-V_{\text{DET}}) \times (R_a + R_b) / R_b$$

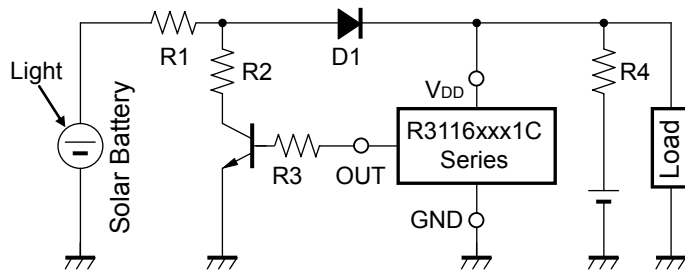
$$\text{Hysteresis Voltage} = (V_{\text{HYS}}) \times (R_a + R_b) / R_b$$

- *1) To prevent oscillation, set $R_a \leq 10\text{k}\Omega$, $R_b \leq 1\text{k}\Omega$, $C \geq 1\mu\text{F}$.
- *2) If the value of R_a is set excessively large, voltage drop may occur caused by the supply current of IC itself, and detector threshold and hysteresis voltage may vary.
- *3) If V_{up} and V_{DD} are connected, the voltage dropdown caused by R_{up} , may cause difference in the hysteresis voltage.
- *4) If the value of R_a , R_b and C are set excessively large, the delay of the start-up may become too long.

• **Window Comparator Circuit
(Nch Open Drain Output)**



• **Over-charge Preventing Circuit**



TECHNICAL NOTES

When R3116xxx1A/C is used in Figure X, if the value of R1 is set excessively large, the dropdown voltage caused by the consumption current of IC itself, may vary the detector threshold and the release voltage. Also, if the value of R1 is set excessively large, there may be delay in start-up and may cause oscillation generated by cross conduction current.

When R3116xxx1A/C is used in Figure Y, if the value of R1 is set excessively large, the dropdown voltage caused by the consumption current of IC itself, may vary the detector threshold and the released voltage. Also, if the value of R1 and R2 is set excessively large, there may be delay in start-up and may cause oscillation generated by cross conduction current.

When R3116xxx1A/C is used in Figure Z, if the value of R1 is set excessively large, the dropdown voltage caused by the consumption current of IC itself may vary the detector threshold and the release voltage. Also, if the value of R1 is set excessively large, there may be delay in start-up and may cause oscillation generated by cross conduction current. Furthermore, if the value of R1 is set large and the value of R2 is set small, released voltage level may shift and the minimum operating voltage may differ. If the value of R2 is set excessively small from R1, release may not occur and may cause oscillation.

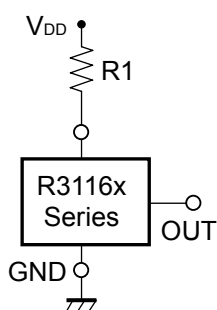


Figure X

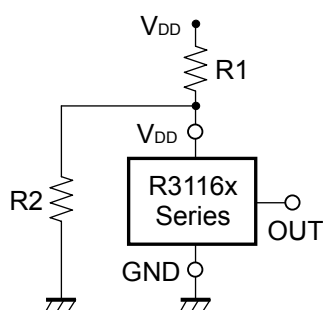


Figure Y

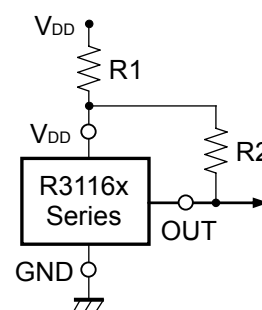


Figure Z



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RICOH COMPANY, LTD. Electronic Devices Company

● Higashi-Shinagawa Office (International Sales)
3-32-3, Higashi-Shinagawa, Shinagawa-ku, Tokyo 140-8655, Japan
Phone: +81-3-5479-2857 Fax: +81-3-5479-0502

RICOH EUROPE (NETHERLANDS) B.V.

● Semiconductor Support Centre
Prof. W.H.Keesomlaan 1, 1183 DL Amstelveen, The Netherlands
P.O.Box 114, 1180 AC Amstelveen
Phone: +31-20-5474-309 Fax: +31-20-5474-791

RICOH ELECTRONIC DEVICES KOREA Co., Ltd.

11 floor, Haesung 1 building, 942, Daechidong, Gangnamgu, Seoul, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2135-5705

RICOH ELECTRONIC DEVICES SHANGHAI Co., Ltd.

Room403, No.2 Building, 690#Bi Bo Road, Pu Dong New district, Shanghai 201203,
People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

RICOH COMPANY, LTD. Electronic Devices Company

● Taipei office
Room109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan (R.O.C.)
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623



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