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## VOLTAGE REGULATOR

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NO. EA-022-120404

### OUTLINE

The Rx5RL Series are CMOS-based voltage regulator ICs with high accuracy output voltage and ultra-low quiescent current. Each of these ICs consists of a voltage reference unit, an error amplifier, a driver transistor, and resistors for setting output voltage. The output voltage is fixed with high accuracy.

Three types of packages, TO-92 (**Discontinued**), SOT-89 (Mini-power Mold), SOT-23-5 (Mini-mold), are available.

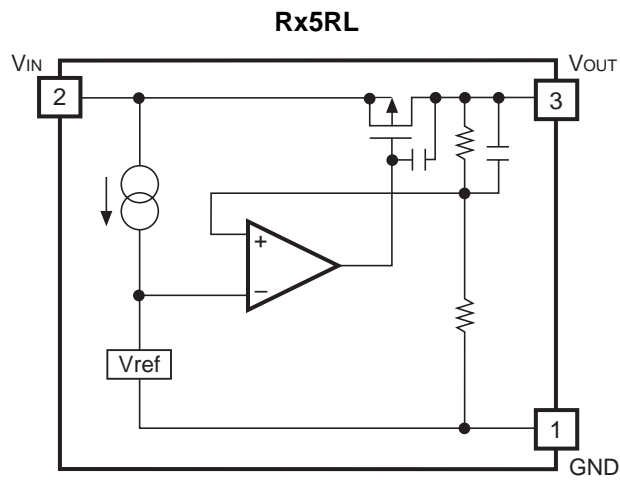
### FEATURES

- Supply Current ..... Typ. 1.1 $\mu$ A ( $V_{OUT}=3.0V$ ,  $V_{IN}=5.0V$ )
- Dropout Voltage ..... Typ. 0.04V ( $I_{OUT}=1mA$ ,  $V_{OUT}=2.8V$ )
- Input Voltage Range ..... Max. 10.0V
- Output Voltage Range..... 2.0V to 6.0V (0.1V steps)  
(For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy.....  $\pm 2.5\%$
- Temperature-Drift Coefficient of Output Voltage ..... Typ.  $\pm 100ppm/^{\circ}C$
- Line Regulation ..... Typ. 0.05%/V
- Packages ..... SOT-23-5 (Mini-mold), SOT-89 (Mini-power Mold),  
TO-92 (**Discontinued**)

### APPLICATIONS

- Power source for battery-powered equipment
- Power source for cameras, video instruments such as camcorders, VCRs, and hand-held communication equipment
- Precision voltage references

## BLOCK DIAGRAMS



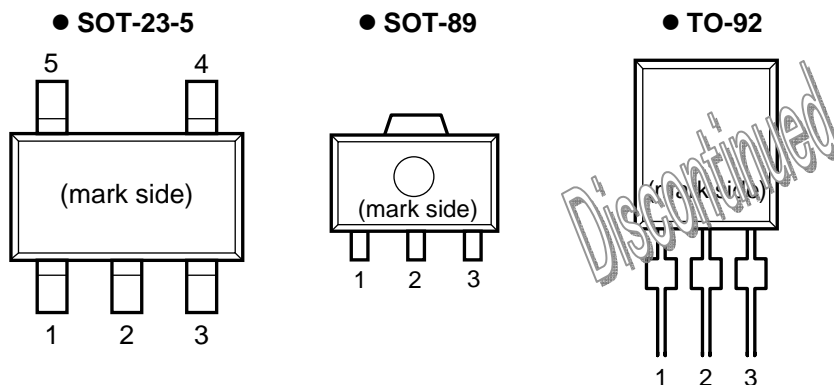
## SELECTION GUIDE

The output voltage and package for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RN5RLxxAA-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes
RH5RLxxAA-T1-FE	SOT-89	1,000 pcs	Yes	Yes
RE5RLxxAA-TR-F	TO-92 (Discontinued)	2,500 pcs	Yes	No

xx: The output voltage can be designated in the range from 2.0V (20) to 6.0V (60) in 0.1V steps.  
(For other voltages, please refer to MARK INFORMATION.)

## PIN CONFIGURATION



## PIN DESCRIPTION

### ● SOT-23-5

Pin No	Symbol	Pin Description
1	GND	Ground Pin
2	$V_{IN}$	Input Pin
3	$V_{OUT}$	Output Pin
4	NC	No Connection
5	NC	No Connection

### ● SOT-89

Pin No	Symbol	Pin Description
1	GND	Ground Pin
2	$V_{IN}$	Input Pin
3	$V_{OUT}$	Output Pin

### ● TO-92 (Discontinued)

Pin No	Symbol	Pin Description
1	GND	Ground Pin
2	$V_{IN}$	Input Pin
3	$V_{OUT}$	Output Pin

## ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
$V_{IN}$	Input Voltage	12	V
$V_{OUT}$	Output Voltage	-0.3 to $V_{IN}+0.3$	V
$I_{OUT}$	Output Current	150	mA
$P_D$	Power Dissipation* (SOT-23-5)	420	mW
	Power Dissipation* (SOT-89)	900	
	Power Dissipation* (TO-92) (Discontinued)	300	
$T_{opt}$	Operating Temperature Range	-40 to 85	°C
$T_{stg}$	Storage Temperature Range	-55 to 125	°C
$T_{solder}$	Lead Temperature (Soldering)	260°C, 10s	

\*) 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

### • Rx5RL20A

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	Output Voltage	V <sub>IN</sub> =4.0V 10μA≤I <sub>OUT</sub> ≤10mA	1.950	2.000	2.050	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =4.0V	25	35		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =4.0V 1mA≤I <sub>OUT</sub> ≤35mA		30	45	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =1mA		60	90	mV
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =4.0V		1.0	3.0	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =1mA V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V		0.05	0.20	%/V
V <sub>IN</sub>	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C≤T <sub>opt</sub> ≤85°C		±100		ppm/°C

### • Rx5RL30A

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	Output Voltage	V <sub>IN</sub> =5.0V 10μA≤I <sub>OUT</sub> ≤10mA	2.925	3.000	3.075	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =5.0V	35	50		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =5.0V 1mA≤I <sub>OUT</sub> ≤50mA		40	60	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =1mA		40	60	mV
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =5.0V		1.1	3.3	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =1mA V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V		0.05	0.20	%/V
V <sub>IN</sub>	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C≤T <sub>opt</sub> ≤85°C		±100		ppm/°C

## Rx5RL

### • Rx5RL40A

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	Output Voltage	V <sub>IN</sub> =6.0V 10μA≤I <sub>OUT</sub> ≤10mA	3.900	4.000	4.100	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =6.0V	45	65		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =6.0V 1mA≤I <sub>OUT</sub> ≤65mA		50	75	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =1mA		25	38	mV
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =6.0V		1.2	3.6	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =1mA V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V		0.05	0.20	%/V
V <sub>IN</sub>	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C≤T <sub>opt</sub> ≤85°C		±100		ppm/°C

### • Rx5RL50A

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	Output Voltage	V <sub>IN</sub> =7.0V 10μA≤I <sub>OUT</sub> ≤10mA	4.875	5.000	5.125	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =7.0V	55	80		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =7.0V 1mA≤I <sub>OUT</sub> ≤80mA		60	90	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =1mA		25	38	mV
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =7.0V		1.3	3.9	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =1mA V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V		0.05	0.20	%/V
V <sub>IN</sub>	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C≤T <sub>opt</sub> ≤85°C		±100		ppm/°C

## • Rx5RL60A

T<sub>opt</sub>=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	Output Voltage	V <sub>IN</sub> =8.0V 10μA≤I <sub>OUT</sub> ≤10mA	5.850	6.000	6.150	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =8.0V	55	80		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =8.0V 1mA≤I <sub>OUT</sub> ≤80mA		60	90	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =1mA		25	38	mV
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =8.0V		1.3	3.9	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =1mA V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V		0.05	0.20	%/V
V <sub>IN</sub>	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C≤T <sub>opt</sub> ≤85°C		±100		ppm/°C

## ELECTRICAL CHARACTERISTICS BY OUTPUT VOLTAGE

Part Number	Output Voltage				Output Current			Load Regulation			Dropout Voltage		
	V <sub>OUT</sub> (V)				I <sub>OUT</sub> (mA)			ΔV <sub>OUT</sub> (mV)			V <sub>DIF</sub> (mV)		
	Conditions	Min.	Typ.	Max.	Conditions	Min.	Typ.	Conditions	Typ.	Max.	Conditions	Typ.	Max.
Rx5RL20A	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V  10μA≤ I <sub>OUT</sub> ≤10mA	1.950	2.000	2.050	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V	25	35	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V  1mA≤ I <sub>OUT</sub> ≤35mA	30	45	60	90	
Rx5RL21A													
Rx5RL22A													
Rx5RL23A													
Rx5RL24A													
Rx5RL25A													
Rx5RL26A													
Rx5RL27A													
Rx5RL28A													
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Rx5RL59A													
Rx5RL60A													
						35	50	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V  1mA≤ I <sub>OUT</sub> ≤50mA	40	60	35	53	
						45	65	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V  1mA≤ I <sub>OUT</sub> ≤65mA	50	70			
						55	80	V <sub>IN</sub> – V <sub>OUT</sub> =2.0V  1mA≤ I <sub>OUT</sub> ≤80mA	60	90	25	38	



T<sub>opt</sub>=25°C

Quiescent Current			Line Regulation			Input Voltage	Output Voltage Tempco.	
I <sub>SS</sub> (μA)			ΔV <sub>OUT</sub> /ΔV <sub>IN</sub> (%/V)			V <sub>IN</sub> (V)	ΔV <sub>OUT</sub> /ΔT(ppm/°C)	
Conditions	Typ.	Max.	Conditions	Typ.	Max.	Max.	Conditions	Typ.
V <sub>IN</sub> V <sub>OUT</sub> =2.0V	1.0	3.0	I <sub>OUT</sub> =1mA  V <sub>OUT</sub> + 0.5V≤ V <sub>IN</sub> ≤ ≤10V	0.05	0.2	10	I <sub>OUT</sub> =10mA  -40°C≤ T <sub>opt</sub> 85°C	±100
	1.1	3.3						
	1.2	3.6						
	1.3	3.9						

## OPERATION

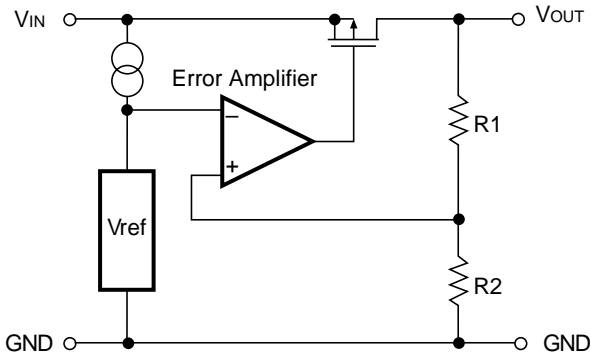


FIG. 1 Block Diagram

Output voltage,  $V_{OUT}$  divided at the node between Registers R1 and R2 is compared with the reference voltage by the error amplifier, so that a constant voltage is output.

## TEST CIRCUITS

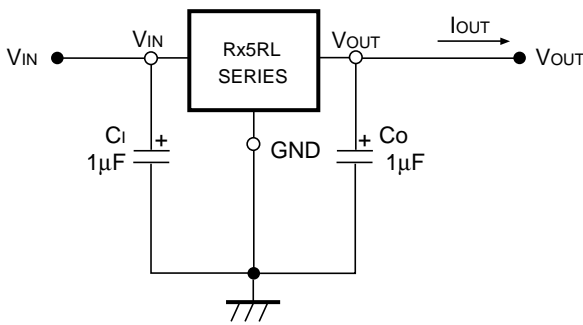


FIG. 2 Test Circuit

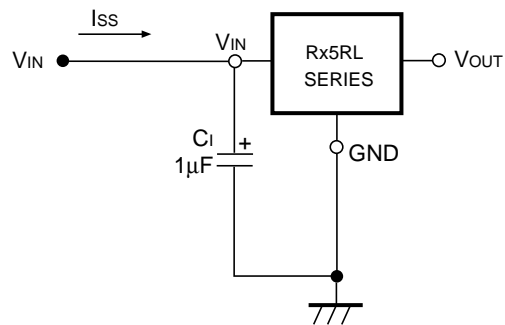


FIG. 3 Quiescent Current Test Circuit

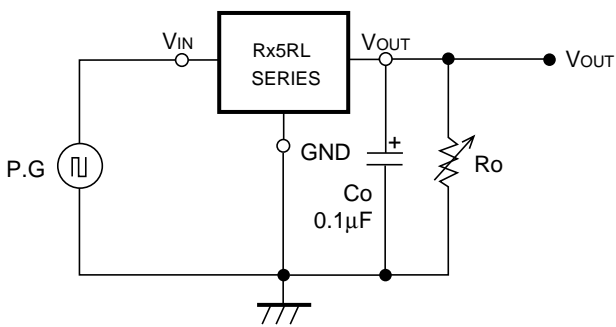
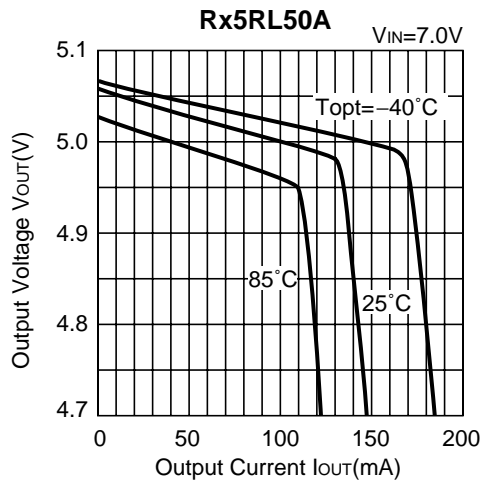
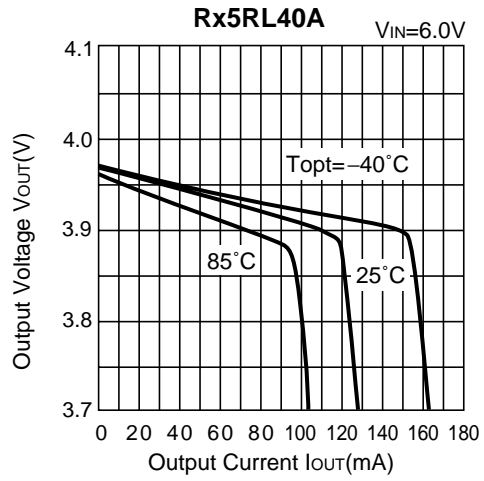
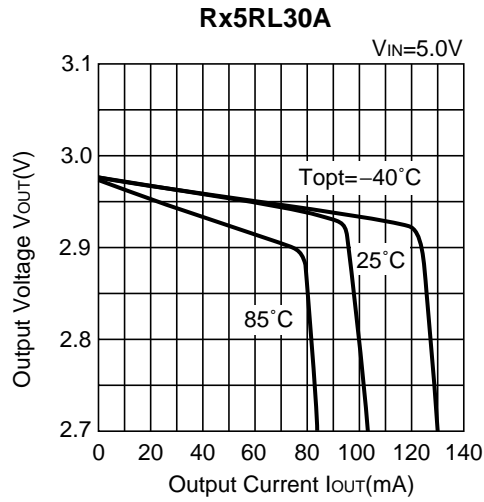


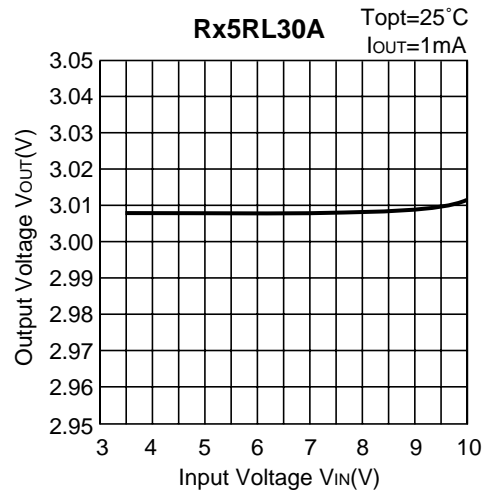
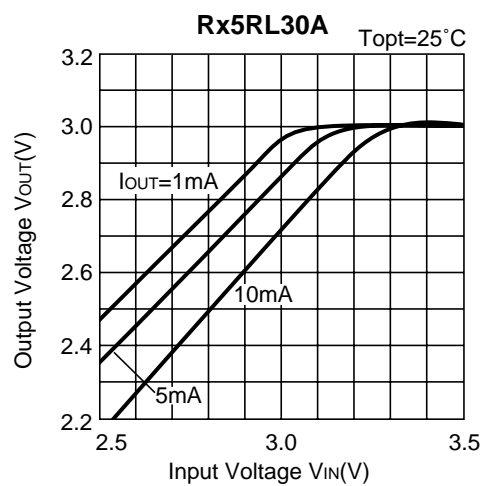
FIG. 4 Line Transient Response Test Circuit

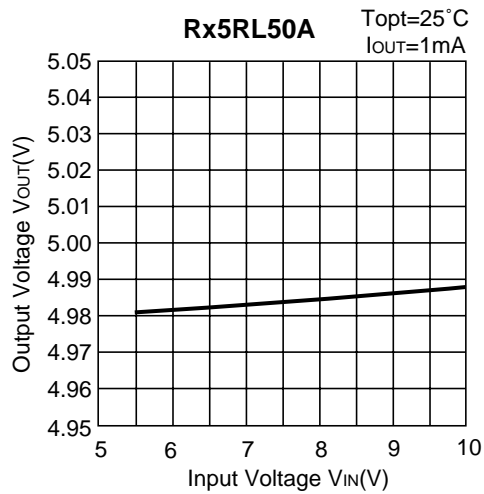
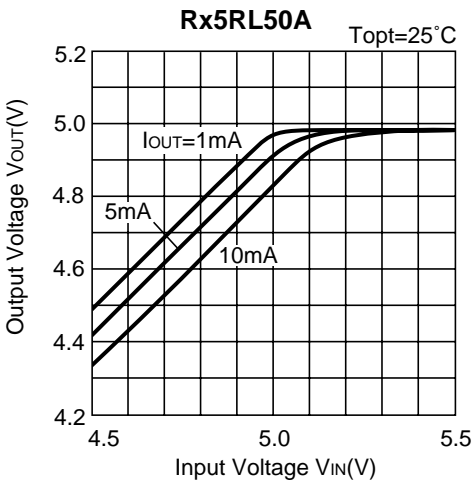
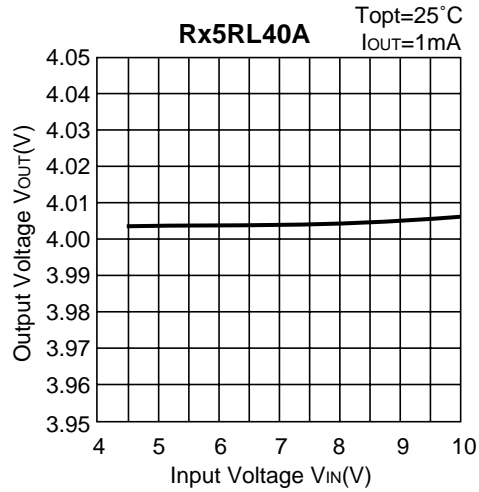
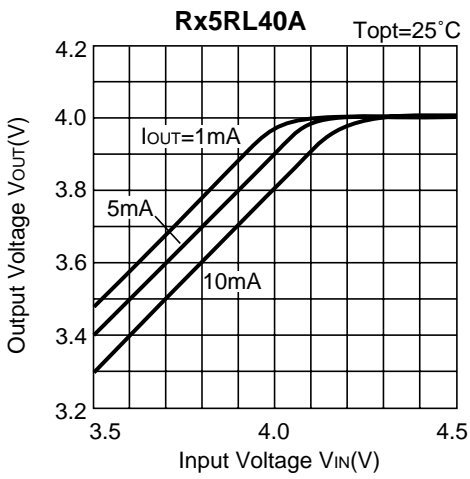
# TYPICAL CHARACTERISTICS

## 1) Output Voltage vs. Output Current

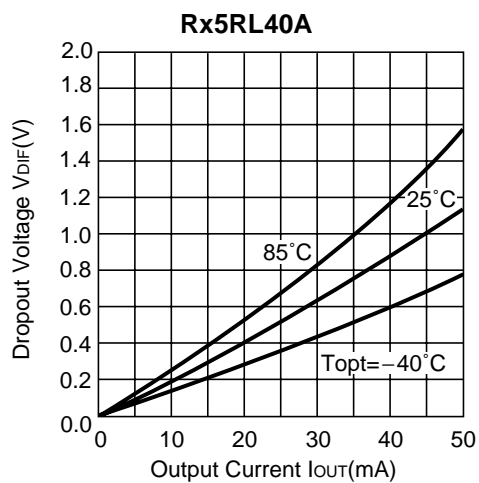
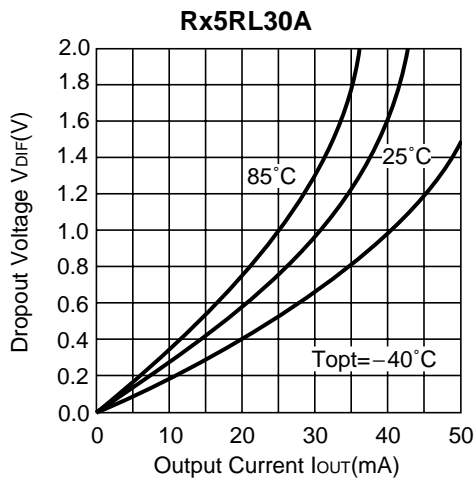


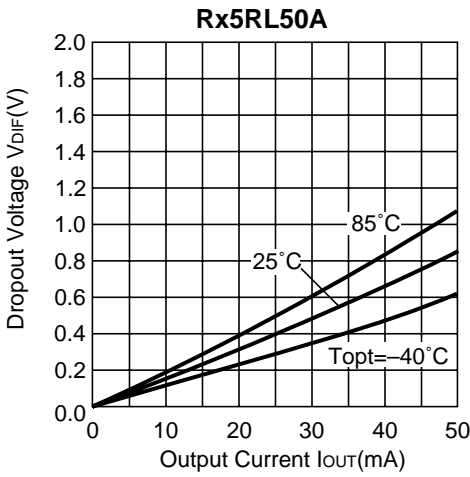
## 2) Output Voltage vs. Input Voltage



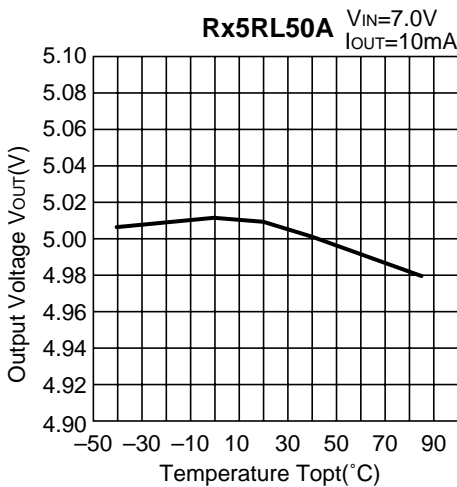
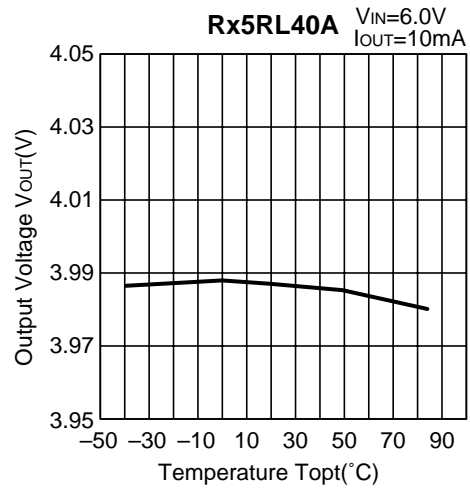
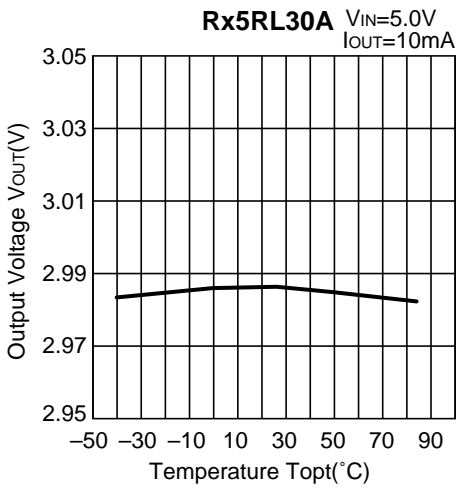


**3) Dropout Voltage vs. Output Current**

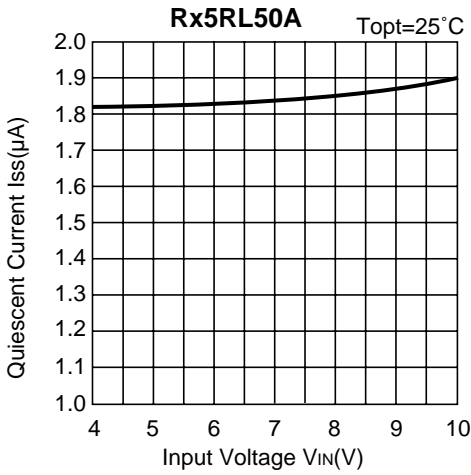
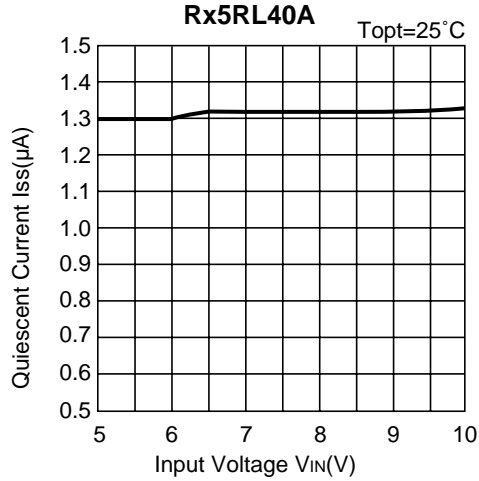
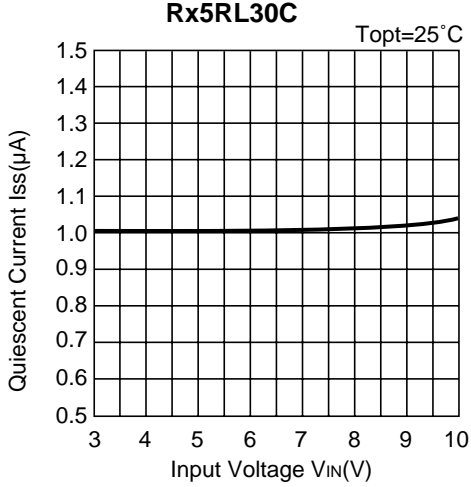




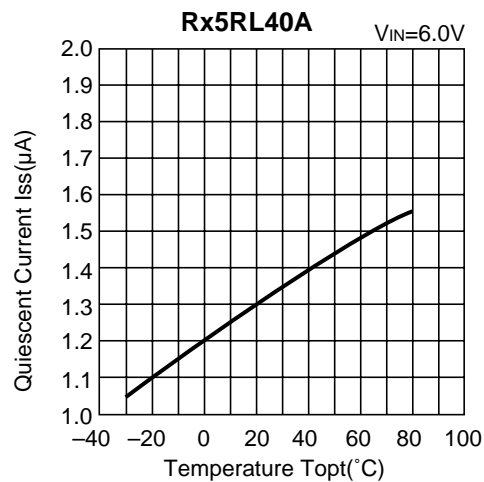
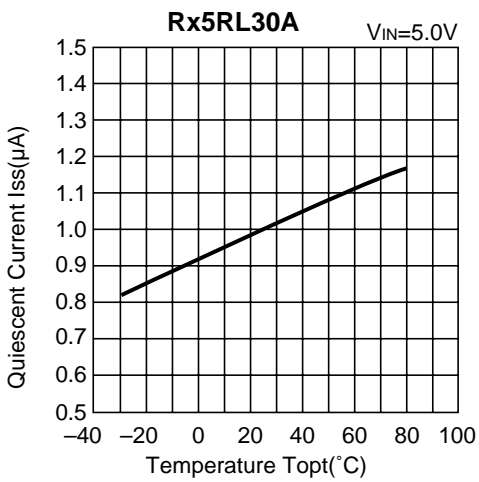
**4) Output Voltage vs. Temperature**

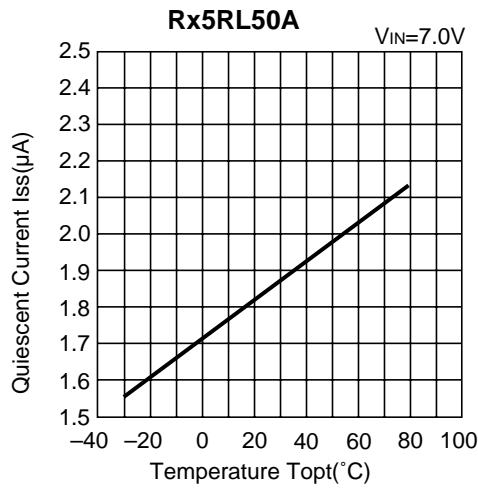


5) Quiescent Current vs. Input Voltage

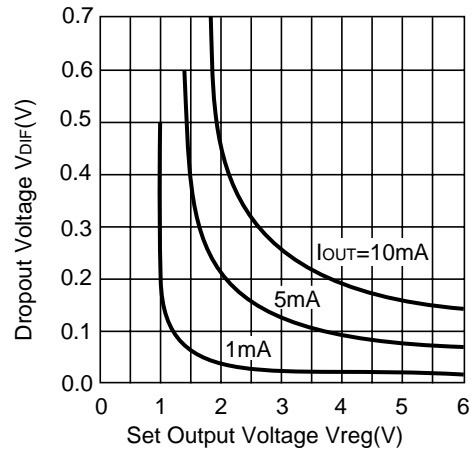


6) Quiescent Current vs. Temperature

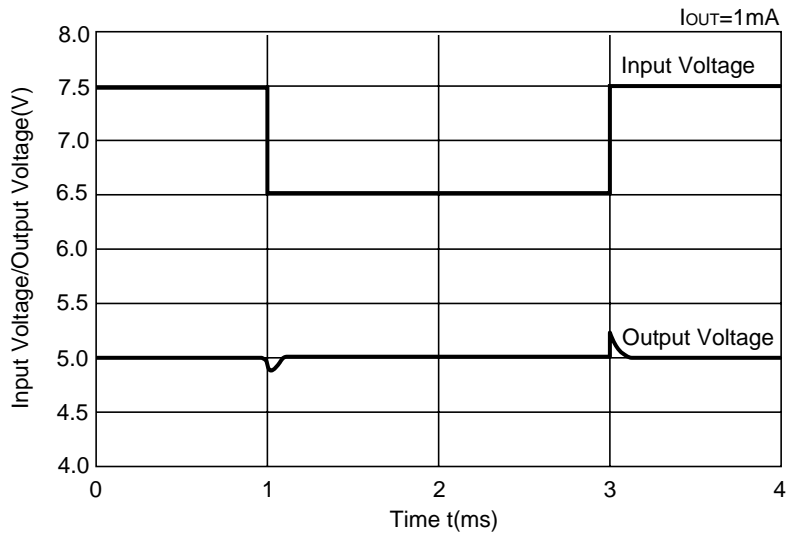




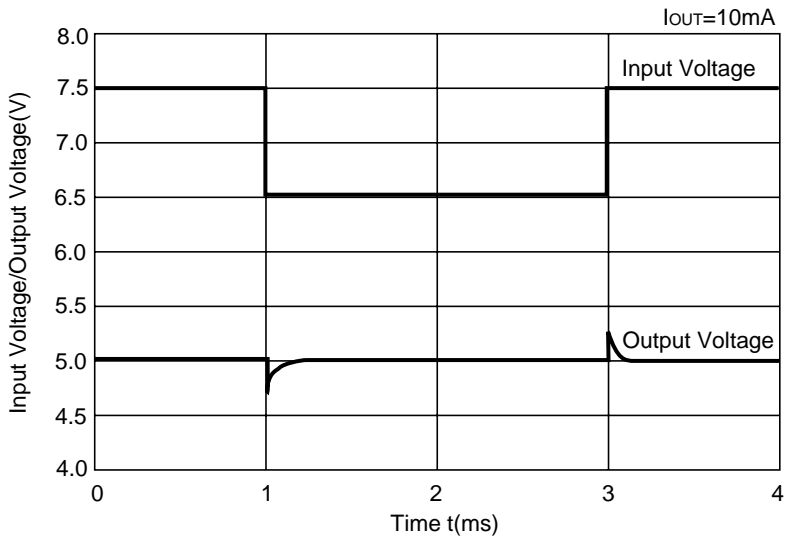
**7) Dropout Voltage vs. Set Output Voltage**



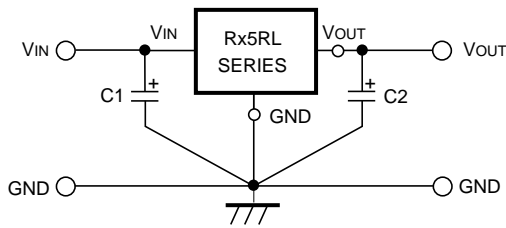
**8) Line Transient Response (1)**



**9) Line Transient Response (2)**



## TYPICAL APPLICATION

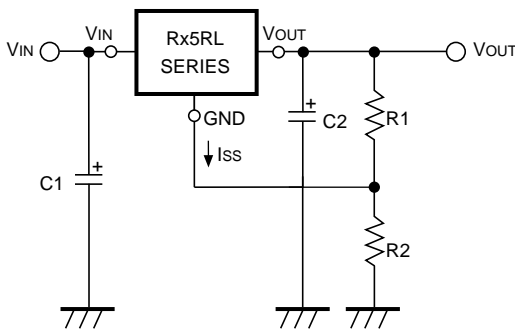


In Rx5RL Series, a constant voltage can be obtained without using Capacitors C1 and C2. However, when the wire connected to Vin is long, use Capacitor C1. Output noise can be reduced by using Capacitor C2.

Insert Capacitors C1 and C2 with the capacitance of 0.1μF to 2.0μF between Input/Output Pins and GND Pin with minimum wiring.

## APPLICATION CIRCUITS

### • VOLTAGE BOOST CIRCUIT



The output voltage can be obtained by the following formula :

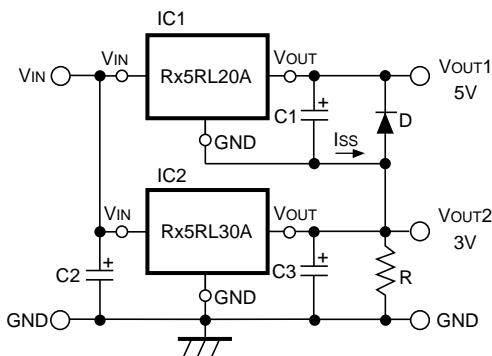
$$V_{OUT} = V_{reg}^{*1} \cdot (1 + R2/R1) + I_{SS} R \cdot 2$$

Since the quiescent current of Rx5RE Series is so small that the resistances of R1 and R2 can be set as large as several hundreds kΩ and therefore the supply current of “Voltage Boost Circuit” itself can be reduced.

Furthermore, since Rx5RL Series are operated by a constant voltage, the supply current of “Voltage Boost Circuit” is not substantially affected by the input voltage.

■ \*1) Vreg : Set Output Voltage of Rx5RL Series.

### • DUAL POWER SUPPLY CIRCUIT

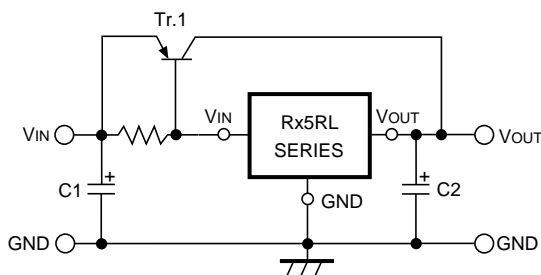


As shown in the circuit diagram, a dual power supply circuit can be constructed by using two Rx5RL Series.

This circuit diagram shows a dual power supply circuit with an output of 3V and an output of 5V. When the minimum output current of IC2 is larger than Iss of IC1, Resistor R is unnecessary. Diode D is a protection diode for the case where VOUT2 becomes larger than VOUT1.

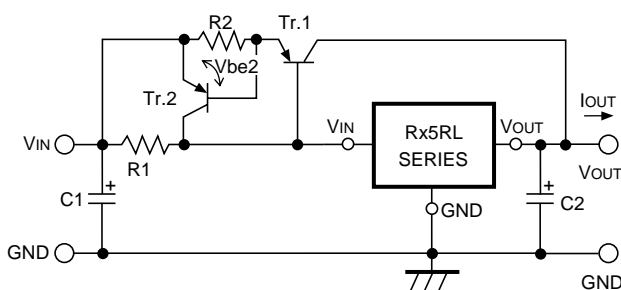


### • CURRENT BOOST CIRCUIT



Output current of 60mA or more can be obtained by the current boost circuit constructed as shown in this circuit diagram.

### • CURRENT BOOST CIRCUIT WITH OVERCURRENT LIMIT CIRCUIT



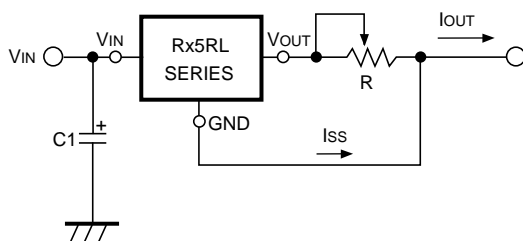
A circuit for protecting Tr.1 from the destruction caused by output short-circuit or overcurrent is shown in this circuit diagram.

When the voltage reduction caused by the current ( $\approx I_{OUT}$ ) which flows through R2 reaches  $V_{be2}$  of Tr.2 by additionally providing the current boost circuit with Tr.2 and R2, Tr.2 is turned on and the base current of Tr.1 is increased, so that the output current is limited.

Current limit of overcurrent limit circuit is obtained as follows :

$$I_{OUT} \approx V_{be2}/R2$$

### • CURRENT SOURCE



A current source with the structure as shown in this circuit diagram can be used. Output Current  $I_{OUT}$  is obtained as follows :

$$I_{OUT} = V_{reg}^{*1}/R + I_{SS}$$

Output current,  $I_{OUT}$  should not exceed its allowable current.

\*1)  $V_{reg}$  : Set output voltage of Rx5RL Series.



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