

## OUTLINE

The Rx5RE Series are CMOS-based voltage regulator ICs with high output voltage accuracy 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, and a current limit circuit. By use of these ICs, a constant voltage power supply circuit with high efficiency can be constructed because the dropout voltage and quiescent current of these ICs are very small. Furthermore, these ICs have a built-in current limit circuit. The output voltage of these ICs is fixed with high accuracy.

Two types of packages, TO-92 and SOT-89 (Mini-power Mold) are available.

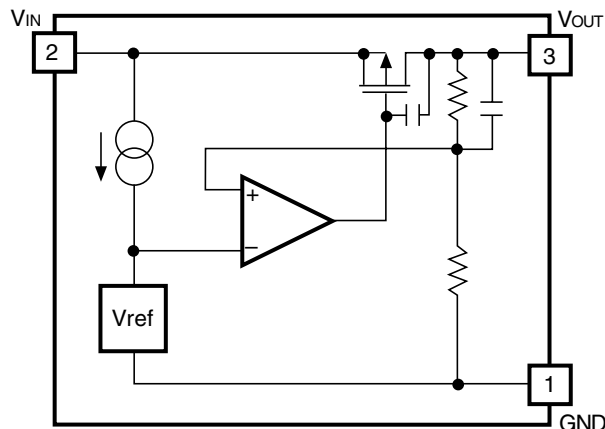
## FEATURES

- Ultra-low Quiescent Current .....Typ. 1.1 $\mu$ A (Rx5RE30A,  $V_{IN}=5.0V$ )
- Ultra-low Dropout Voltage .....Typ. 0.5V (Rx5RE50A,  $I_{OUT}=60mA$ )
- Large Output Current .....Typ. 120mA (Rx5RE50A)
- Low Temperature-Drift Coefficient of Output Voltage .....Typ.  $\pm 100$ ppm/ $^{\circ}C$
- Broad Operating Voltage Range .....Max. 10.0V
- Excellent Line Regulation .....Typ. 0.1%/V
- High Accuracy Output Voltage ..... $\pm 2.5\%$
- Output Voltage .....Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V is possible (refer to Selection Guide)
- Two Types of Packages .....TO-92, SOT-89 (Mini-power Mold)

## 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 DIAGRAM



## SELECTION GUIDE

The package type, the output voltage, the packing type, and the taping type of Rx5RE Series can be designated at the user's request by specifying the part number as follows.

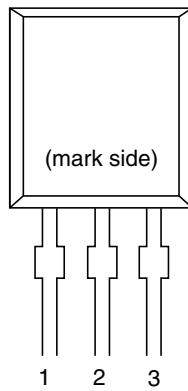
Rx5RE $\overbrace{\text{xxxx}}$ - $\overbrace{\text{xx}}$  ← Part Number  
↑    ↑↑↑ ↑  
a    bcd e

Code	Contents
a	Designation of Package Type: E: TO-92 H: SOT-89 (Mini-power Mold)
b	Setting Output Voltage (V <sub>OUT</sub> ): Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V is possible.
c	A
d	Designation of Packing Type: A: Taping C: Antistatic bag for TO-92 and samples
e	Designation of Taping Type: Ex. TO-92 : RF, RR, TZ SOT-89: T1, T2 (refer to Taping Specifications) "TZ" and "T1" are prescribed as a standard.

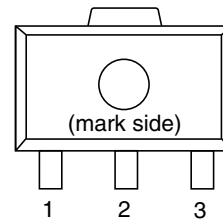
For example, the product with Package Type SOT-89, Output Voltage 5.0V, Version A and Taping Type T1 are designated by Part Number RH5RE50AA-T1.

## PIN CONFIGURATION

### • TO-92



### • SOT-89



## PIN DESCRIPTION

### • TO-92

Pin No.	Symbol
1	GND
2	V <sub>IN</sub>
3	V <sub>OUT</sub>

### • SOT-89

Pin No.	Symbol
1	GND
2	V <sub>IN</sub>
3	V <sub>OUT</sub>

## ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V <sub>IN</sub>	Input Voltage	+12	V
V <sub>OUT</sub>	Output Voltage	-0.3 to V <sub>IN</sub> +0.3	V
I <sub>OUT</sub>	Output Current	300	mA
P <sub>D</sub>	Power Dissipation	300	mW
T <sub>opt</sub>	Operating Temperature	-40 to +85	°C
T <sub>stg</sub>	Storage Temperature	-55 to +25	°C
T <sub>solder</sub>	Lead Temperature (Soldering)	260°C, 10s	

### ABSOLUTE MAXIMUM RATINGS

Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

## ELECTRICAL CHARACTERISTICS

### • Rx5RE20A

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, I <sub>OUT</sub> =10mA	1.950	2.000	2.050	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =4.0V	40	60		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =4.0V 1mA ≤ I <sub>OUT</sub> ≤ 50mA		40	80	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =30mA		0.5	0.7	V
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> =10mA V <sub>OUT</sub> +1.0V ≤ V <sub>IN</sub> ≤ 10V		0.1		%/V
V <sub>IN</sub>	Input Voltage				10	V
I <sub>lim</sub>	Current Limit			240		mA
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C ≤ T <sub>opt</sub> ≤ 85°C		±100		ppm/°C

### • Rx5RE30A

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, I <sub>OUT</sub> =10mA	2.925	3.000	3.075	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =5.0V	50	80		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =5.0V 1mA ≤ I <sub>OUT</sub> ≤ 60mA		40	80	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =40mA		0.5	0.7	V
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> =10mA V <sub>OUT</sub> +1.0V ≤ V <sub>IN</sub> ≤ 10V		0.1		%/V
V <sub>IN</sub>	Input Voltage				10	V
I <sub>lim</sub>	Current Limit			240		mA
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C ≤ T <sub>opt</sub> ≤ 85°C		±100		ppm/°C

## Rx5RE

### • Rx5RE40A

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, I <sub>OUT</sub> =10mA	3.900	4.000	4.100	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =6.0V	65	100		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =6.0V 1mA ≤ I <sub>OUT</sub> ≤ 70mA		40	80	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =50mA		0.5	0.7	V
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> =10mA V <sub>OUT</sub> +1.0V ≤ V <sub>IN</sub> ≤ 10V		0.1		%/V
V <sub>IN</sub>	Input Voltage				10	V
I <sub>lim</sub>	Current Limit			240		mA
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C ≤ T <sub>opt</sub> ≤ 85°C		±100		ppm/°C

### • Rx5RE50A

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, I <sub>OUT</sub> =10mA	4.875	5.000	5.125	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =7.0V	80	120		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =7.0V 1mA ≤ I <sub>OUT</sub> ≤ 80mA		40	80	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =60mA		0.5	0.7	V
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> =10mA V <sub>OUT</sub> +1.0V ≤ V <sub>IN</sub> ≤ 10V		0.1		%/V
V <sub>IN</sub>	Input Voltage				10	V
I <sub>lim</sub>	Current Limit			240		mA
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	Output Voltage Temperature Coefficient	I <sub>OUT</sub> =10mA -40°C ≤ T <sub>opt</sub> ≤ 85°C		±100		ppm/°C

## • Rx5RE60A

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, I <sub>OUT</sub> =10mA	5.850	6.000	6.150	V
I <sub>OUT</sub>	Output Current	V <sub>IN</sub> =8.0V	80	120		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V <sub>IN</sub> =8.0V 1mA ≤ I <sub>OUT</sub> ≤ 80mA		40	80	mV
V <sub>DIF</sub>	Dropout Voltage	I <sub>OUT</sub> =60mA		0.5	0.7	V
I <sub>SS</sub>	Quiescent Current	V <sub>IN</sub> =8.0V		1.4	4.2	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I <sub>OUT</sub> =10mA V <sub>OUT</sub> +1.0V ≤ V <sub>IN</sub> ≤ 10V		0.1		%/V
V <sub>IN</sub>	Input Voltage				10	V
I <sub>lim</sub>	Current Limit			240		mA
$\frac{\Delta V_{OUT}}{\Delta T_{opt}}$	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> /ΔI <sub>OUT</sub> (mV)			V <sub>DIF</sub> (V)		
	Conditions	Min.	Typ.	Max.	Conditions	Min.	Typ.	Conditions	Typ.	Max.	Conditions	Typ.	Max.
Rx5RE20A	V <sub>IN</sub> - V <sub>OUT</sub> =2.0V	1.950	2.000	2.050	V <sub>IN</sub> - V <sub>OUT</sub> =2.0V	40	60	V <sub>IN</sub> - V <sub>OUT</sub> =2.0V	40	80	I <sub>OUT</sub> =30mA	0.5	0.7
Rx5RE21A		2.048	2.100	2.152									
Rx5RE22A		2.145	2.200	2.255									
Rx5RE23A		2.243	2.300	2.357									
Rx5RE24A		2.340	2.400	2.460									
Rx5RE25A		2.438	2.500	2.562									
Rx5RE26A		2.535	2.600	2.665									
Rx5RE27A		2.633	2.700	2.767									
Rx5RE28A		2.730	2.800	2.870									
Rx5RE29A		2.828	2.900	2.972									
Rx5RE30A		2.925	3.000	3.075									
Rx5RE31A		3.023	3.100	3.177									
Rx5RE32A		3.120	3.200	3.280									
Rx5RE33A		3.218	3.300	3.382									
Rx5RE34A		3.315	3.400	3.485									
Rx5RE35A		3.413	3.500	3.587									
Rx5RE36A		3.510	3.600	3.690									
Rx5RE37A		3.608	3.700	3.792									
Rx5RE38A		3.705	3.800	3.895									
Rx5RE39A		3.803	3.900	3.997									
Rx5RE40A		3.900	4.000	4.100									
Rx5RE41A		3.998	4.100	4.202									
Rx5RE42A		4.095	4.200	4.305									
Rx5RE43A		4.193	4.300	4.407									
Rx5RE44A		4.290	4.400	4.510									
Rx5RE45A		4.388	4.500	4.612									
Rx5RE46A		4.485	4.600	4.715									
Rx5RE47A		4.583	4.700	4.817									
Rx5RE48A		4.680	4.800	4.920									
Rx5RE49A		4.778	4.900	5.022									
Rx5RE50A	4.875	5.000	5.125										
Rx5RE51A	4.973	5.100	5.227										
Rx5RE52A	5.070	5.200	5.330										
Rx5RE53A	5.168	5.300	5.432										
Rx5RE54A	5.265	5.400	5.535										
Rx5RE55A	5.363	5.500	5.637										
Rx5RE56A	5.460	5.600	5.740										
Rx5RE57A	5.558	5.700	5.842										
Rx5RE58A	5.655	5.800	5.945										
Rx5RE59A	5.753	5.900	6.047										
Rx5RE60A	5.850	6.000	6.150										



T<sub>opt</sub>=25°C

Quiescent Current			Line Regulation		Input Voltage	Current Limit	Output Voltage Tempco.	
I <sub>ss</sub> (μA)			ΔV <sub>OUT</sub> /ΔV <sub>IN</sub> (%/V)		V <sub>IN</sub> (V)	I <sub>lim</sub> (mA)	ΔV <sub>OUT</sub> /ΔT(ppm/°C)	
Conditions	Typ.	Max.	Conditions	Typ.	Max.	Typ.	Conditions	Typ.
V <sub>IN</sub> - V <sub>OUT</sub> =2.0V	1.0	3.0	I <sub>OUT</sub> =10mA  V <sub>OUT</sub> + 1.0V≤ V <sub>IN</sub> ≤10V	0.1	10	240	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						
	1.4	4.2						

## OPERATION

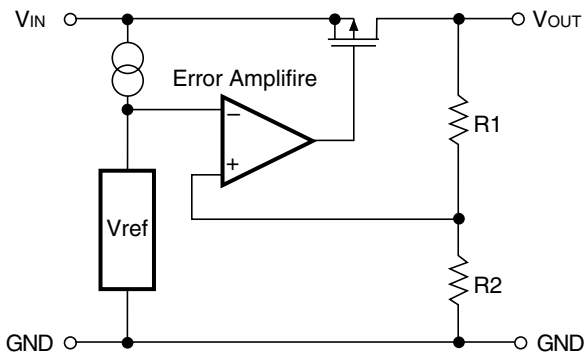


FIG. 1 Block Diagram

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

## TEST CIRCUITS

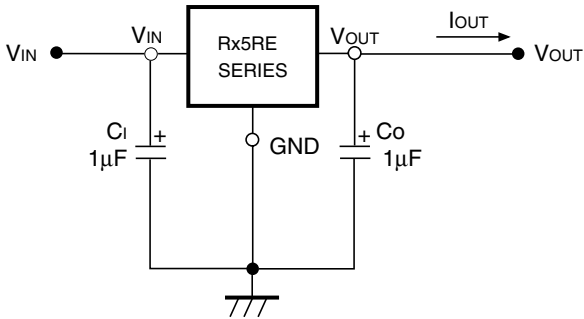


FIG. 2 Test Circuit

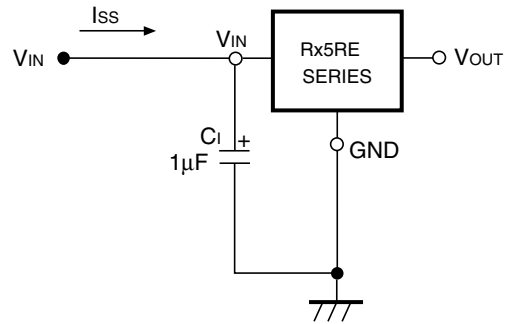


FIG. 3 Quiescent Current Test Circuit

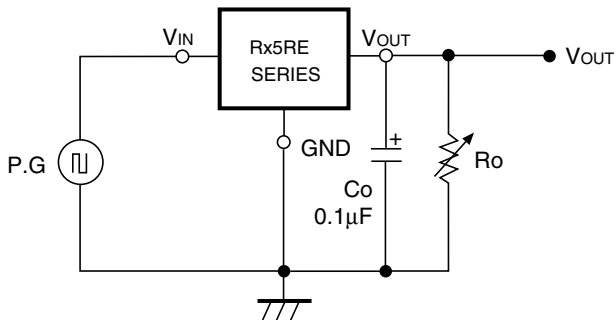
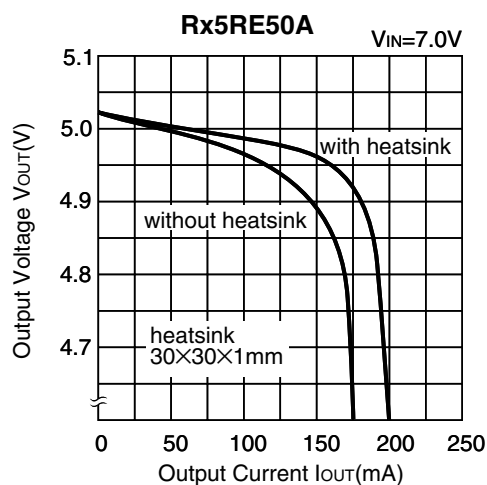
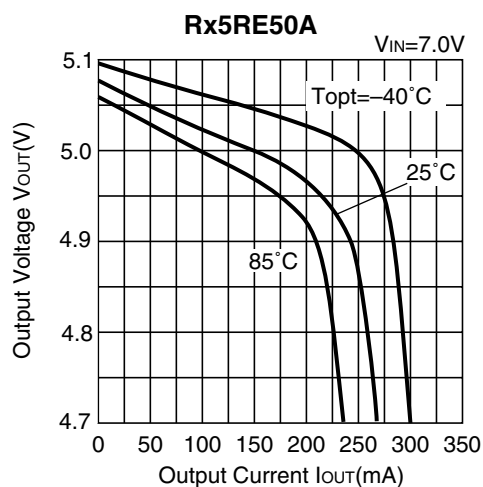
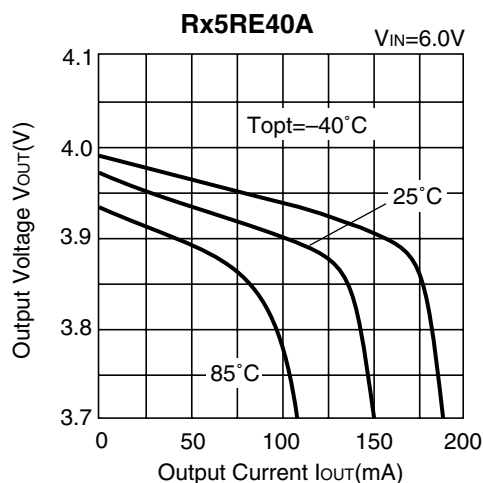
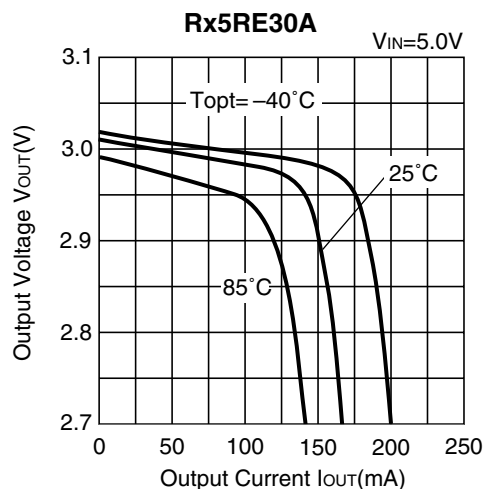


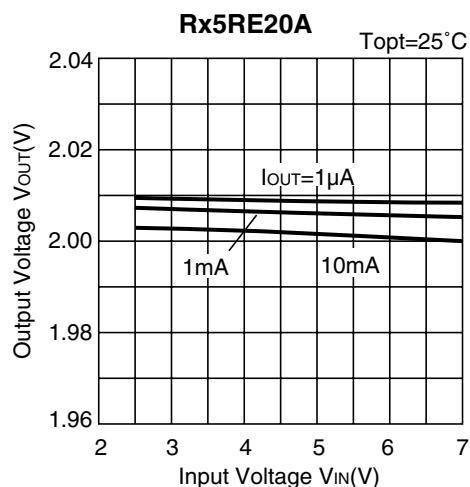
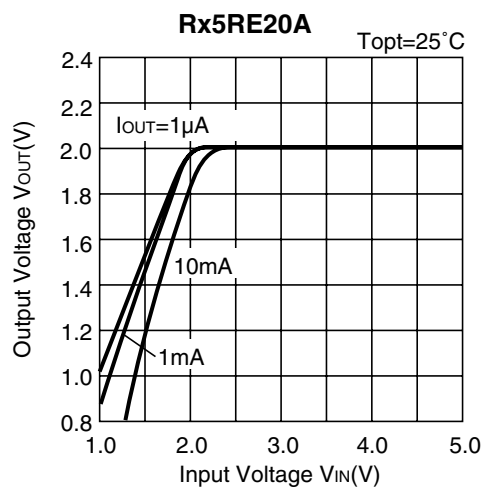
FIG. 4 Line Transient Response Test Circuit

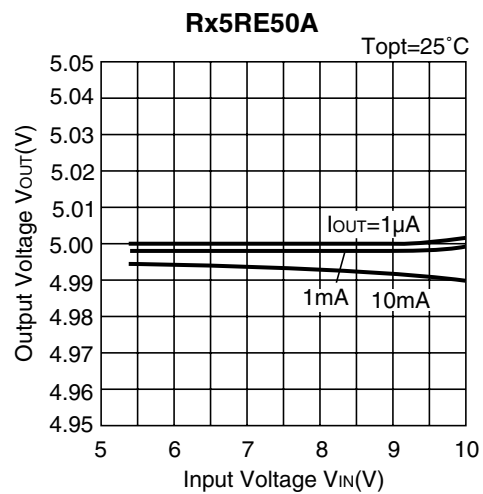
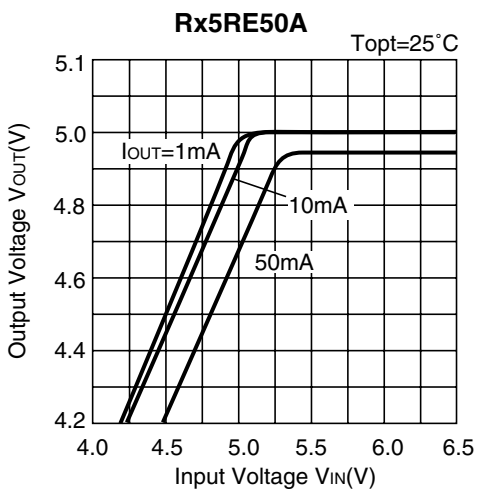
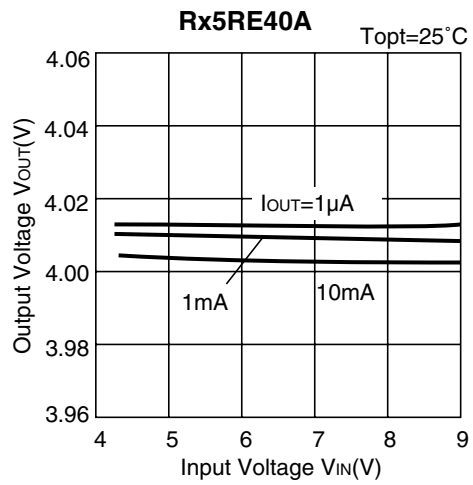
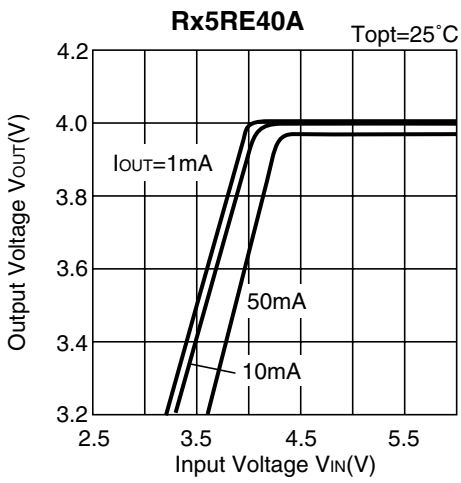
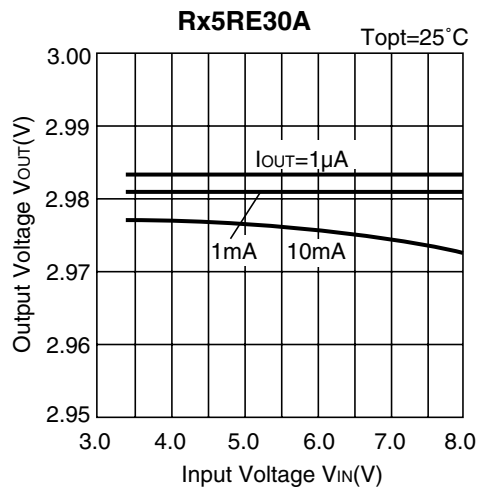
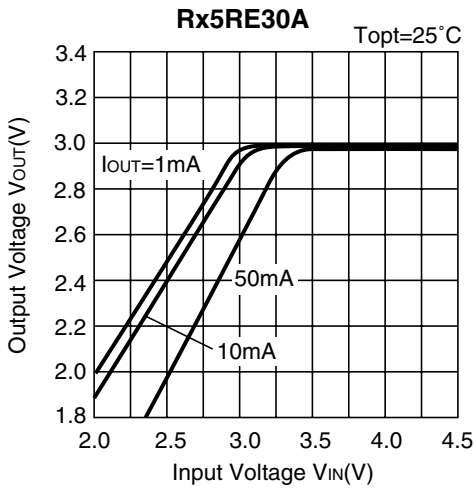
# TYPICAL CHARACTERISTICS

## 1) Output Voltage vs. Output Current

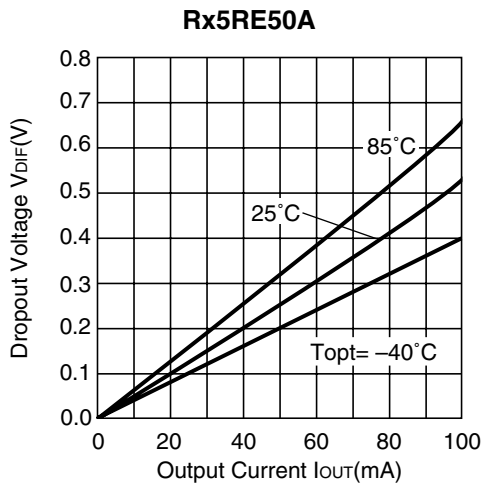
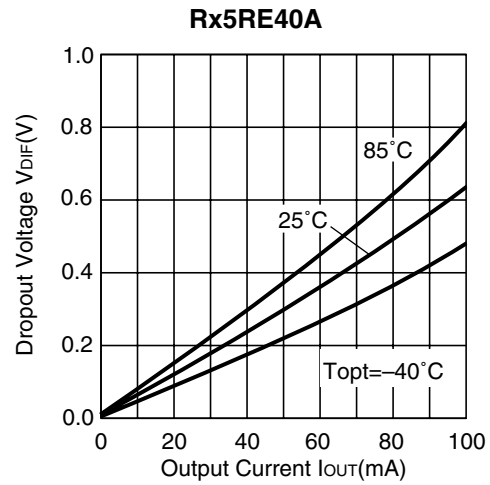
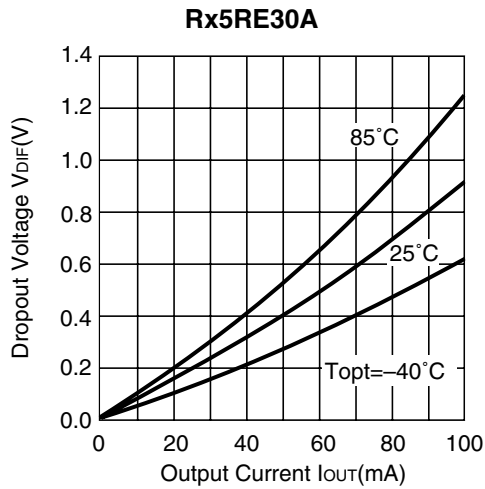


## 2) Output Voltage vs. Input Voltage

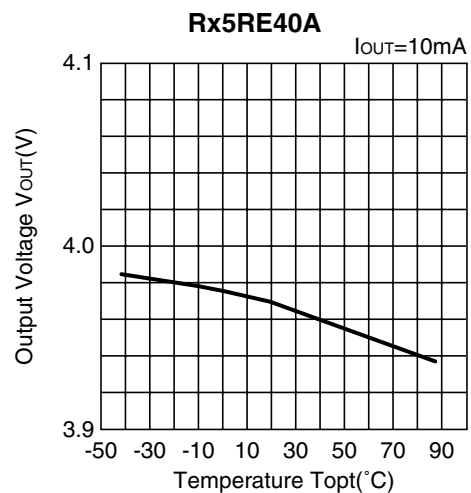
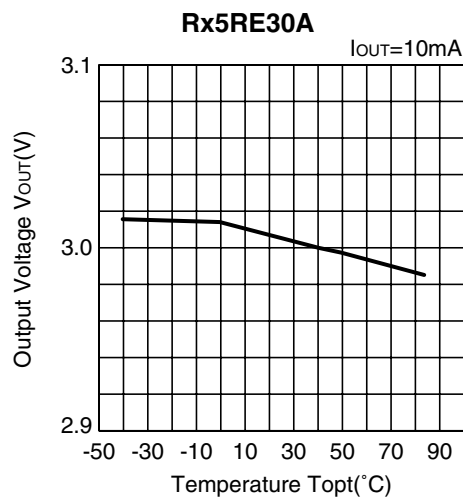


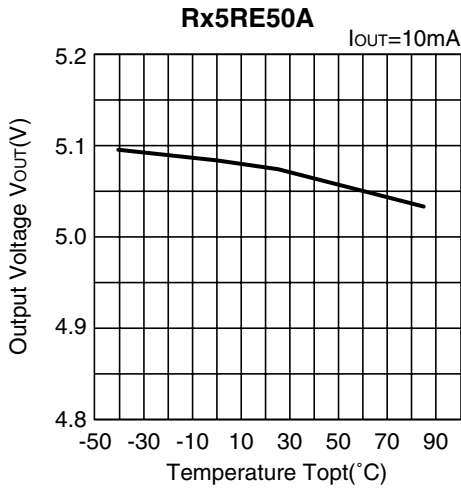


3) Dropout Voltage vs. Output Current

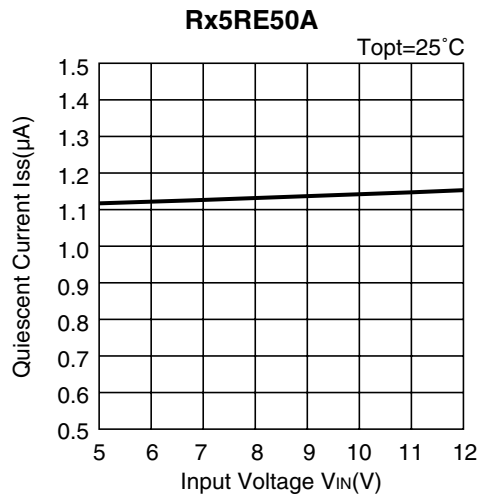
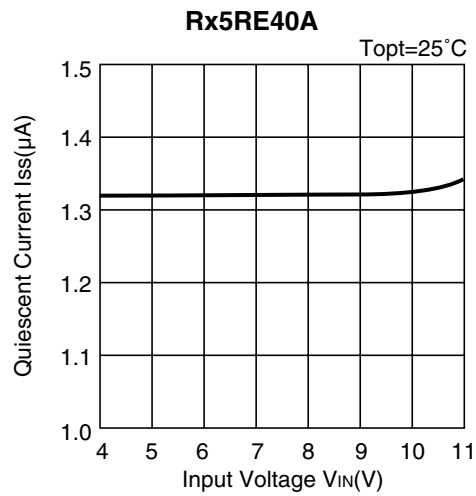
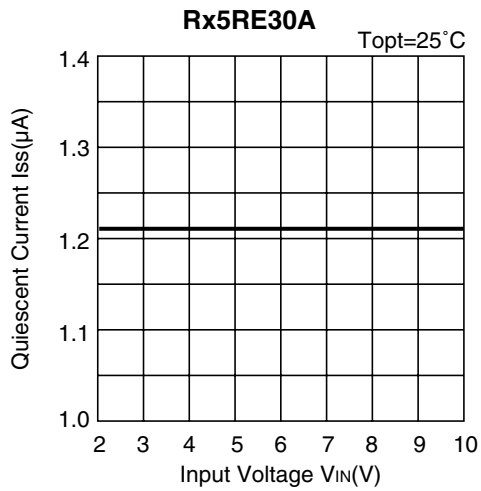
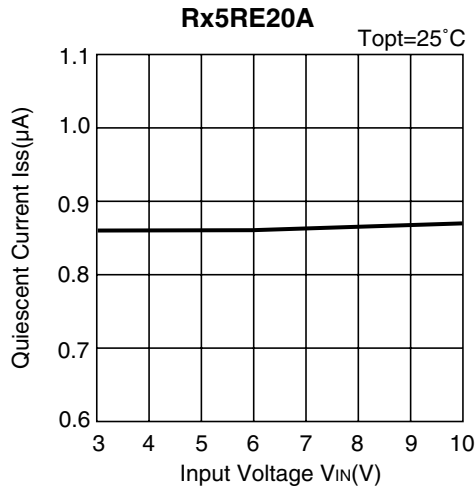


4) Output Voltage vs. Temperature



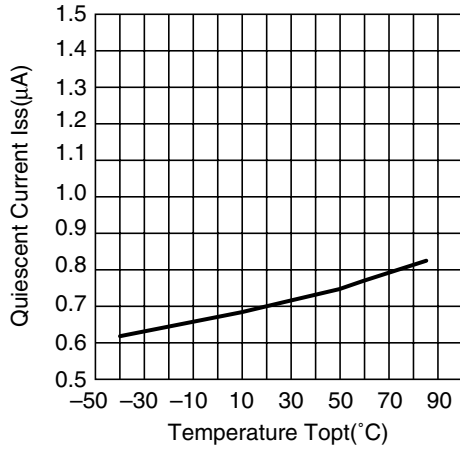


5) Quiescent Current vs. Input Voltage

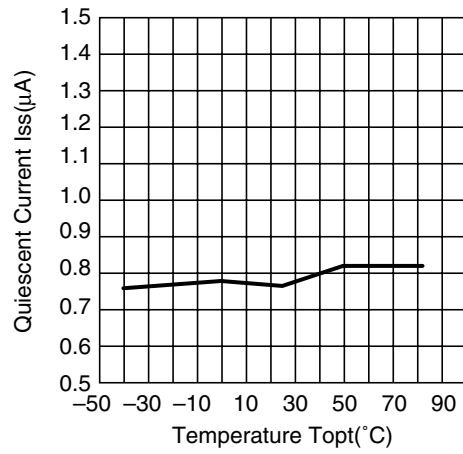


6) Quiescent Current vs. Temperature

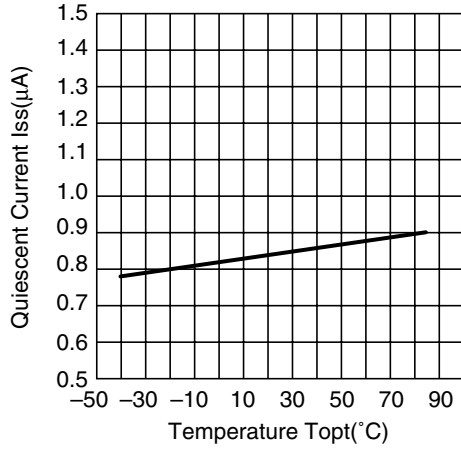
Rx5RE20A



Rx5RE30A

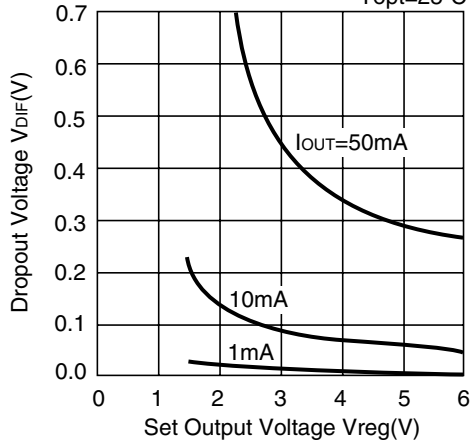


Rx5RE40A

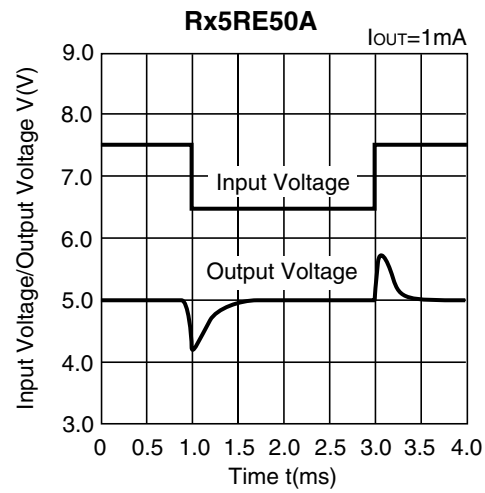
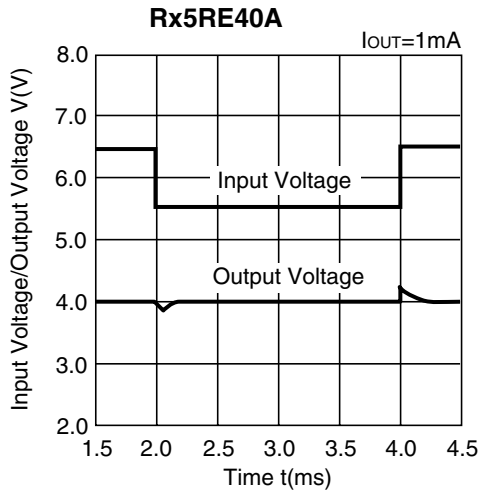
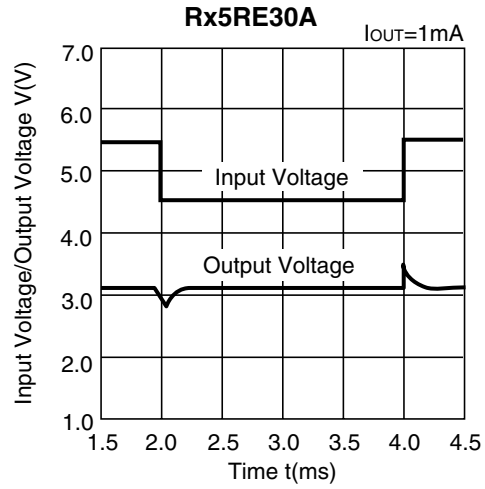
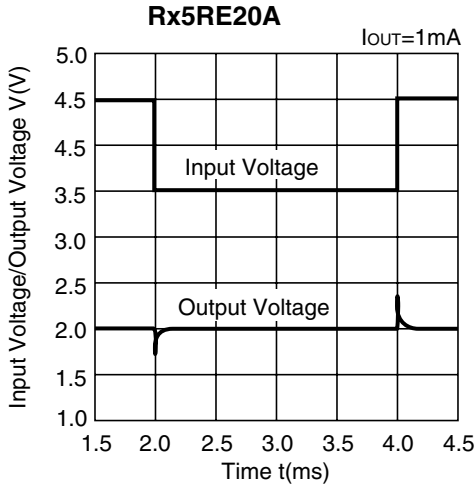


7) Dropout Voltage vs. Set Output Voltage

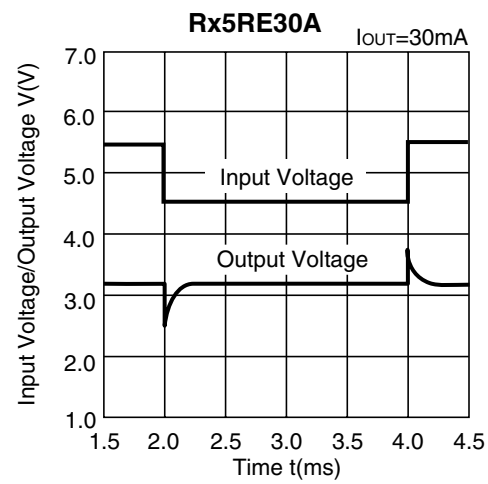
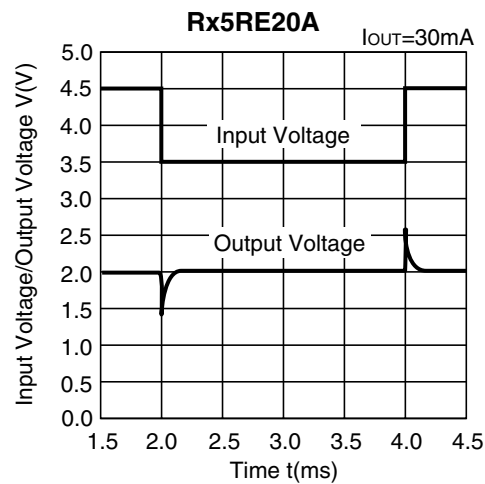
Rx5RE SERIES T<sub>opt</sub>=25°C



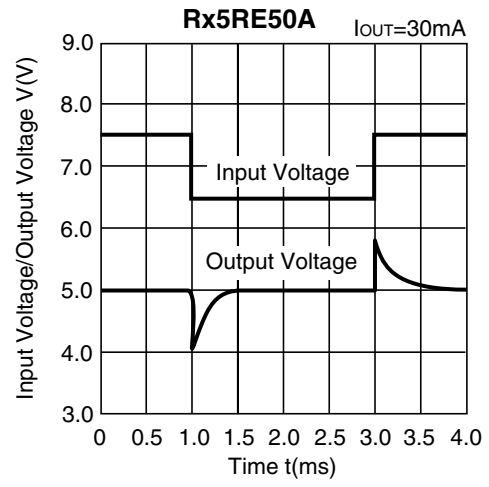
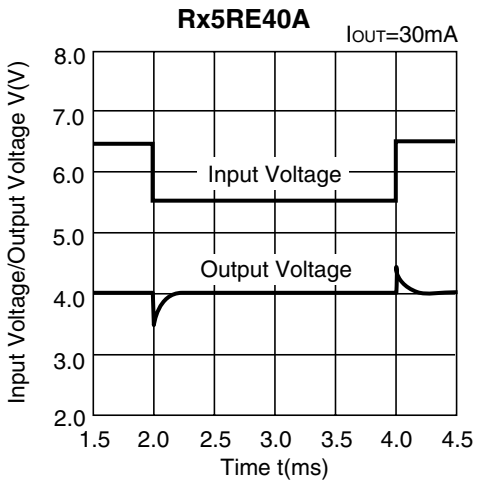
8) Line Transient Response (1)



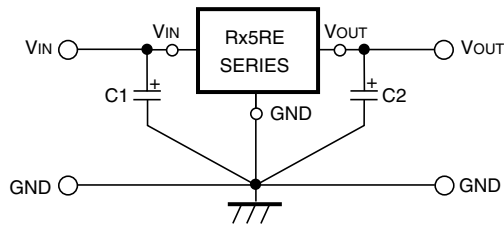
9) Line Transient Response (2)







## TYPICAL APPLICATION

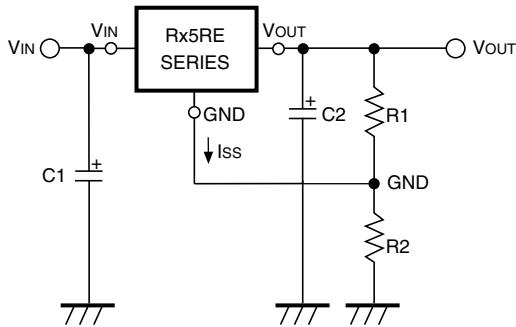


In Rx5RE Series, a constant voltage can be obtained without using capacitors C1 and C2. However, when the wire connected to VIN is long, use capacitor C1. Output noise can be reduced by using capacitor C2.

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 :

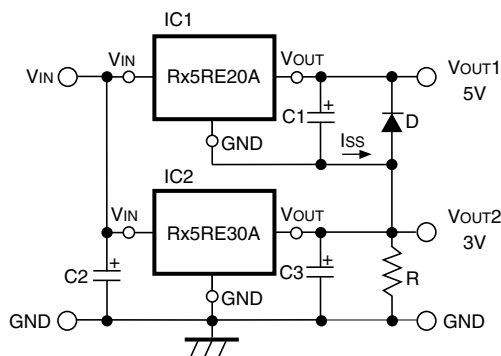
$$V_{OUT} = V_{reg}^{*1} \cdot (1 + R2/R1) + I_{SS} \cdot R2$$

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 Rx5RE 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 Rx5RE Series.

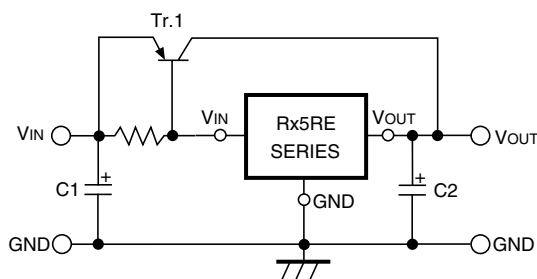
### • DUAL POWER SUPPLY CIRCUIT



As shown in the circuit diagram, a dual power supply circuit can be constructed by using two Rx5RE Series.

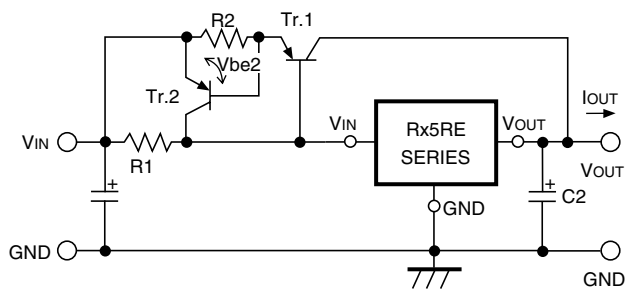
This circuit diagram shows a dual power supply circuit with an output of 3V and an output of 5V. When the minimum output current of IC2 is larger than Iss of IC1, resistor R is unnecessary. Diode D is a protection diode for the case where VOUT2 becomes larger than VOUT1.

### • CURRENT BOOST CIRCUIT



Output current of 120mA or more can be obtained by the current boost circuit constructed as shown in this circuit diagram.

### • CURRENT BOOST CIRCUIT WITH OVERCURRENT LIMIT CIRCUIT



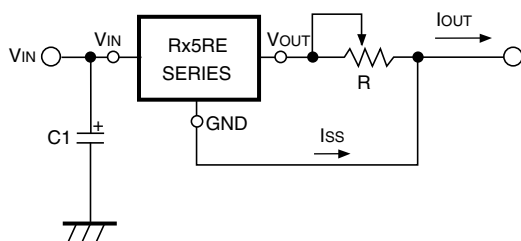
A circuit for protecting Tr.1 from the destruction caused by output short-circuit or overcurrent is shown in this circuit diagram.

When the voltage reduction caused by the current ( $I_{OUT}$ ) 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 :

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

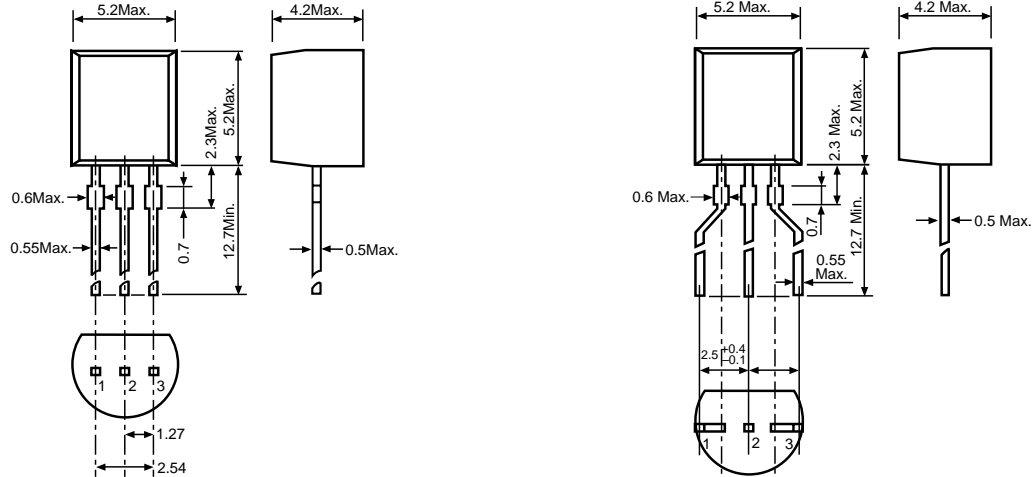
Take care that Output Current  $I_{OUT}$  does not exceed its allowable current.

\*1)  $V_{reg}$  : Set Output Voltage of Rx5RE Series.

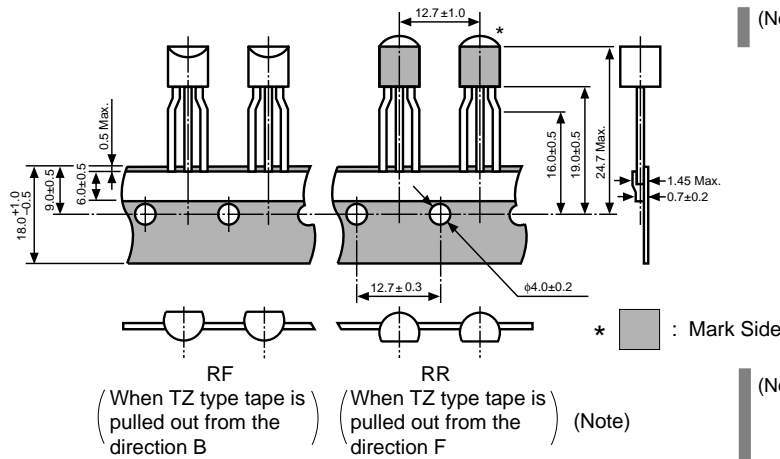
• TO-92 (SC-43A)

Unit: mm

PACKAGE DIMENSIONS



TAPING SPECIFICATION

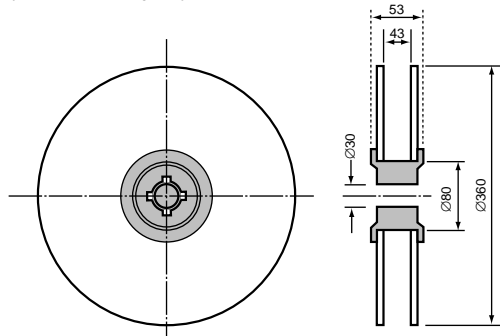


(Note) When taping is performed, the pins of TO-92 are subjected to a particular forming.

(Note) TZ type tape is not in the form of a reel, but is packed in a zigzag state in box. Therefore, the tape can be used as either an RF type tape or an RR type tape, depending upon the pulling out direction (B or F).

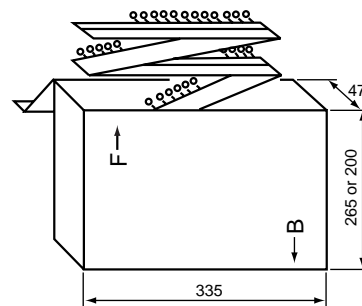
TAPING REEL DIMENSIONS (RF, RR)

(1 reel = 2000 pcs)



PACKING BOX DIMENSIONS (TZ)

(1 box = 2500 pcs)

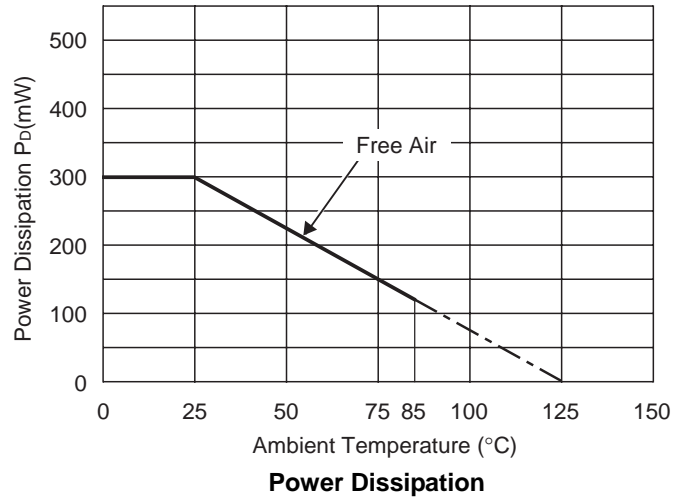


## POWER DISSIPATION (TO-92)

This specification is at mounted on board.

Measurement Result (T<sub>opt</sub>=25°C, T<sub>jmax</sub>=125°C)

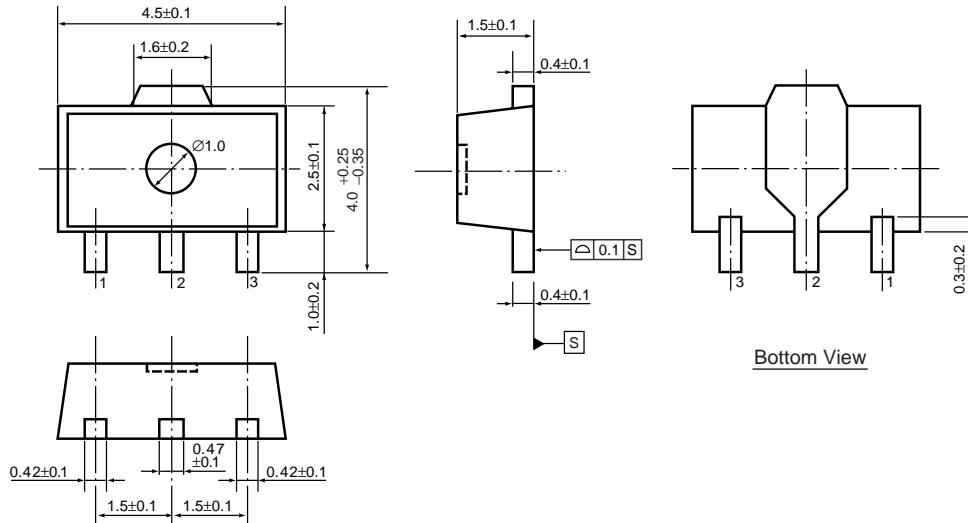
	Free Air
Power Dissipation	300mW
Thermal Resistance	$\theta_{ja}=(125-25^{\circ}\text{C})/0.3\text{W}=333^{\circ}\text{C/W}$



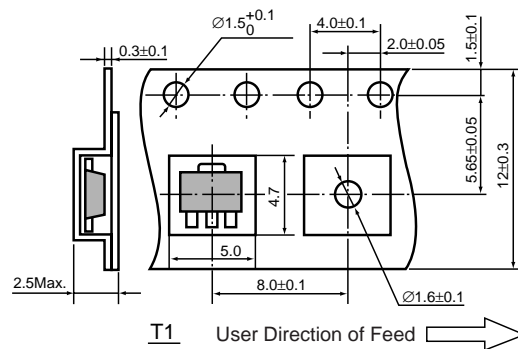
• SOT-89 (SC-62)

Unit: mm

PACKAGE DIMENSIONS

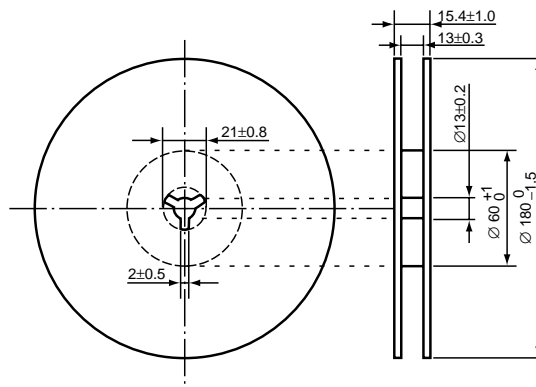


TAPING SPECIFICATION (T1: Standard Type)



TAPING REEL DIMENSIONS

(1reel=1000pcs)



### POWER DISSIPATION (SOT-89)

This specification is at mounted on board. Power Dissipation ( $P_D$ ) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:

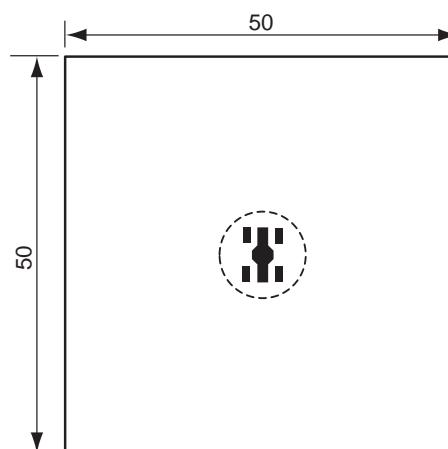
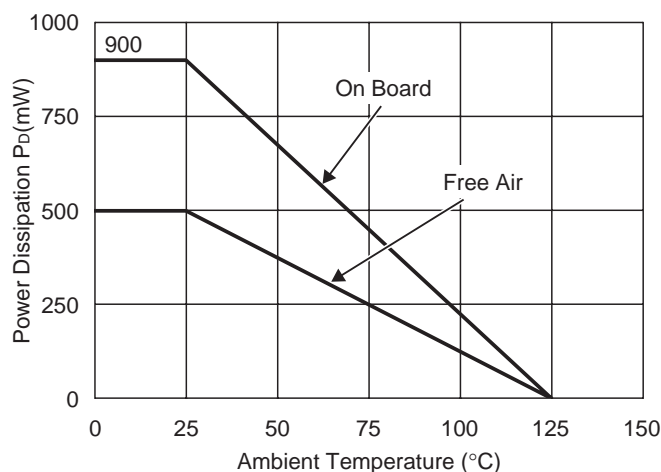
**Measurement Conditions**

	Standard Land Pattern
Environment	Mounting on Board (Wind velocity=0m/s)
Board Material	Glass cloth epoxy plastic (Double sided)
Board Dimensions	50mm × 50mm × 1.6mm
Copper Ratio	Top side : Approx. 10% , Back side : Approx. 100%
Through-hole	-

**Measurement Result**

( $T_{opt}=25^{\circ}C, T_{jmax}=125^{\circ}C$ )

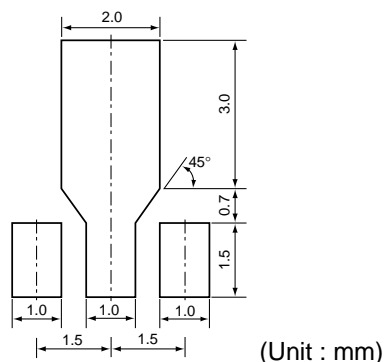
	Standard Land Pattern	Free Air
Power Dissipation	900mW	500mW
Thermal Resistance	$\theta_{ja}=(125-25^{\circ}C)/0.9W=111^{\circ}C/W$	200 $^{\circ}C/W$



**Measurement Board Pattern**

○ IC Mount Area (Unit : mm)

### RECOMMENDED LAND PATTERN (SOT-89)



(Unit : mm)