# LOW RIPPLE VOLTAGE REGULATOR WITH EXTERNAL TRANSISTOR

## RN5RF SERIES

## APPLICATION MANUAL

RICOH

ELECTRONIC DEVICES DIVISION

NO. EA-043-9803

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June 1995

# RN5RF SERIES

## APPLICATION MANUAL

## CONTENTS

# LOW RIPPLE VOLTAGE REGULATOR WITH EXTERNAL TRANSISTOR

# RN5RF SERIES

## OUTLINE

The RN5RF Series are voltage regulator ICs which control external driver transistors with high ripple rejection, high accuracy output voltage, low supply current by CMOS process. Each of these voltage regulator ICs consists of a voltage reference unit, an error amplifier, output voltage setting resistor, short circuit current limiting circuit and chip enable circuit.
These ICs are suitable for constructing regulators with ultra low dropout voltage and an output current in the range of several tens of mA and several hundreds mA. In addition to low supply current by CMOS process, chip enable function can be used to conserve battery life during standby.
Furthermore, a supreme ripple rejection and a transient response are suited for portable communicatior such as cell phones, PDAs, walky talkies. SOT23-5 (Mini Mold) package is available.

## FEATURES

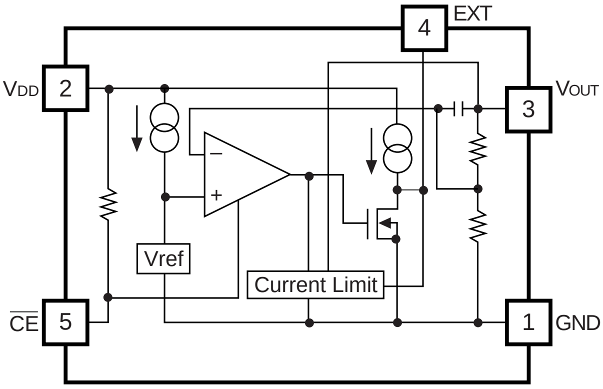
- Ultra Low Supply Current ·····················TYP. 30µA
- Standby Mode ·······································TYP. 0.1µA
- High Accuracy Output Voltage ············±2.0%
- High Ripple Rejection ···························TYP. 60dB/f=1kHz
- Low Dropout Voltage····························TYP. 0.1V/$I_{OUT}$=100mA, dependent on External Tr.
- Low Temperature Drift ·························TYP. ±100ppm/˚C
- High Line Regulation····························TYP. 0.05%/V
- Output Voltage ·····································Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V
- Current Limit for external Tr.···············TYP. 8mA, Limit a base current

## APPLICATIONS

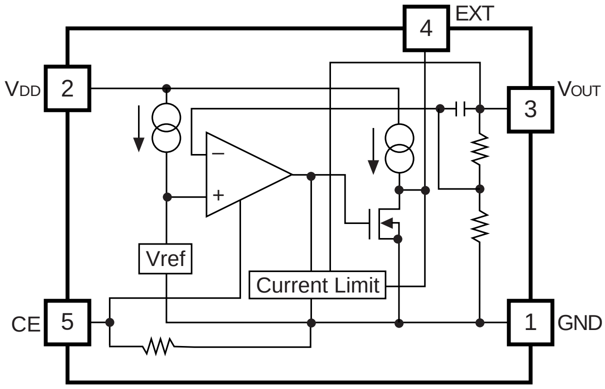
- Power source for battery-powered equipment
- Telecommunications, Cameras, VCRs
- Power source for domestic appliances

# BLOCK DIAGRAM

RN5RF××A




RN5RF××B




# SELECTION GUIDE

The output voltage, the chip enable active type, the packing type and the taping type for the ICs can be selected at the user's request.

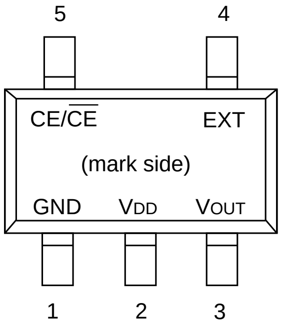
The selection can be made by designating the part number as shown below:

RN5RF ××××-××←Part Number
↑ ↑↑ ↑
a bc d

| Code | Contents |
|---|---|
| a | Setting Output Voltage (VOUT) :<br>Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V is possible. |
| b | Designation of Chip enable Active Type<br>A : "L" active type<br>B : "H" active type |
| c | Designation of Packing type<br>A : Taping<br>C : Antistatic bag only for samples |
| d | Designation of Taping type<br>Ex. TR, TL (refer to Taping Specifications, TR type is prescribed as a standard.) |

## PIN CONFIGURATION

• **SOT-23-5**




## PIN DESCRIPTION

| Pin No. | Symbol | Pin Description |
|---|---|---|
| 1 | GND | Ground Pin |
| 2 | $V_{DD}$ | Input Pin |
| 3 | $V_{OUT}$ | Output Pin |
| 4 | EXT | External Transistor Drive Pin (CMOS Output) |
| 5 | CE or $\overline{CE}$ | Chip Enable Pin |

## ABSOLUTE MAXIMUM RATINGS

| Symbol | Item | Rating | Unit |
|---|---|---|---|
| $V_{IN}$ | Input Voltage | 12 | V |
| $V_{CE}$ | Input Voltage for CE/$\overline{CE}$ Pin | −0.3 to $V_{IN}$ +0.3 | V |
| $V_{EXT}$ | EXT Output Voltage | 12 | V |
| $I_{EXT}$ | EXT Output Current | 50 | mA |
| $P_D$ | Power Dissipation | 150 | mW |
| Topt | Operating Temperature Range | −40 to +85 | °C |
| Tstg | Storage Temperature Range | −55 to +125 | °C |

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

Topt=25°C

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT}$ | Output Voltage | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=50mA$ | $V_{OUT}$ ×0.98 | | $V_{OUT}$ ×1.02 | V |
| $I_{OUT}$ | Output Current | $V_{IN}-V_{OUT}=1.0V$ | | 1*1 | | A |
| $I_{EXT}$ | EXT Current | $V_{IN}=4.0V$, $V_{EXT}=2.0V$ | 5 | 8 | 15 | mA |
| $\Delta V_{OUT}/\Delta I_{OUT}$ | Load Regulation | $V_{IN}-V_{OUT}=1.0V$<br>$1mA \leq I_{OUT} \leq 100mA$ | −60 | | 60 | mV |
| $V_{DIF}$ | Dropout Voltage | $I_{OUT}=100mA$ | | 0.1 | 0.2 | V |
| Iss | Supply Current | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=0mA$ | | 30 | 50 | μA |
| Istandby | Standby Current | $V_{IN}=10.0V$ | 0.01 | 0.1 | 1.0 | μA |
| $I_{EXTleak}$ | EXT Leakage Current | | | | 0.5 | μA |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | $I_{OUT}=50mA$<br>$V_{OUT}+0.5V \leq V_{IN} \leq 10V$ | 0 | 0.05 | 0.30 | %/V |
| RR | Ripple Rejection | f=1kHz, sinusoidal 0.5Vp-p<br>$V_{IN}-V_{OUT}=1.0V$ | | 60 | | dB |
| $V_{IN}$ | Input Voltage | | | | 10 | V |
| $V_{EXT}$ | EXT Output Voltage | | | | 10 | V |
| $\Delta V_{OUT}/\Delta Topt$ | Output Voltage Temperature Coefficient | $I_{OUT}=10mA$<br>$-40°C \leq Topt \leq 85°C$ | | ±100 | | ppm/°C |
| $R_{PU}$ | Pull up resistance for $\overline{CE}$ pin | | | 4 | | MΩ |
| $V_{CEH}$ | $\overline{CE}$ Input Voltage "H" | | 1.5 | | $V_{IN}$ | V |
| $V_{CEL}$ | $\overline{CE}$ Input Voltage "L" | | 0 | | 0.25 | V |

*1) The output current depends on the performance of external PNP transistor. Use External PNP transistor of a low saturation type, with an $h_{FE}$ between 100 and 300.

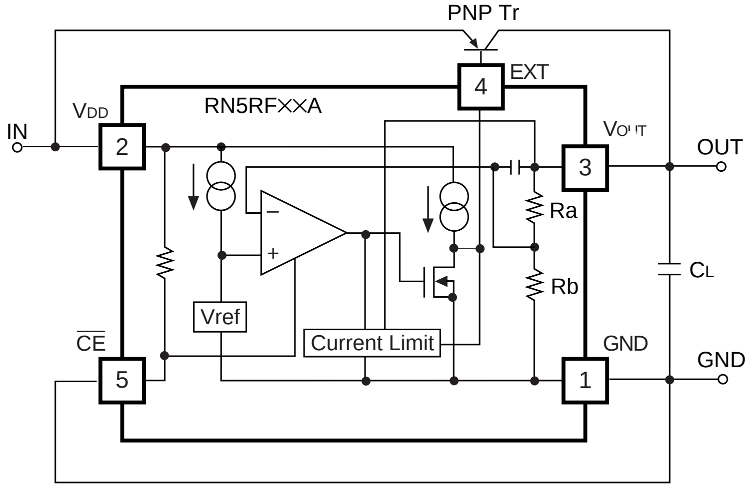
* ) With respect to Test Circuit, refer to Typical Application.

Topt=25°C

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT}$ | Output Voltage | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=50mA$ | $V_{OUT}$ ×0.98 | | $V_{OUT}$ ×1.02 | V |
| $I_{OUT}$ | Output Current | $V_{IN}-V_{OUT}=1.0V$ | | 1*1 | | A |
| $I_{EXT}$ | EXT Current | $V_{IN}=4.0V$, $V_{EXT}=2.0V$ | 5 | 8 | 15 | mA |
| $\Delta V_{OUT}/\Delta I_{OUT}$ | Load Regulation | $V_{IN}-V_{OUT}=1.0V$<br>$1mA \leq I_{OUT} \leq 100mA$ | –60 | | 60 | mV |
| $V_{DIF}$ | Dropout Voltage | $I_{OUT}=100mA$ | | 0.1 | 0.2 | V |
| Iss | Supply Current | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=0mA$ | | 30 | 50 | μA |
| Istandby | Standby Current | $V_{IN}=10.0V$ | 0.01 | 0.1 | 1.0 | μA |
| $I_{EXTleak}$ | EXT Leakage Current | | | | 0.5 | μA |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | $I_{OUT}=50mA$<br>$V_{OUT}+0.5V \leq V_{IN} \leq 10V$ | 0 | 0.05 | 0.30 | %/V |
| RR | Ripple Rejection | f=1kHz, sinusoidal 0.5Vp-p<br>$V_{IN}-V_{OUT}=1.0V$ | | 60 | | dB |
| $V_{IN}$ | Input Voltage | | | | 10 | V |
| $V_{EXT}$ | EXT Output Voltage | | | | 10 | V |
| $\Delta V_{OUT}/\Delta Topt$ | Output Voltage Temperature Coefficient | $I_{OUT}=10mA$<br>$-40°C \leq Topt \leq 85°C$ | | ±100 | | ppm/°C |
| $R_{PD}$ | Pull down resistance for CE pin | | | 4 | | MΩ |
| $V_{CEH}$ | CE Input Voltage "H" | | 1.5 | | $V_{IN}$ | V |
| $V_{CEL}$ | CE Input Voltage "L" | | 0 | | 0.25 | V |

*1) The output current depends on the performance of external PNP transistor. Use External PNP transistor of a low saturation type, with an $h_{FE}$ between 100 and 300.
* ) With respect to Test Circuit, refer to Typical Application.

# OPERATION




In these ICs, Output Voltage $V_{OUT}$ is detected by Feed-back Resistors, $R_A$ and $R_B$ and the detected Output Voltage is compared with a reference voltage by Error Amplifier so that the base current of External PNP Transistor can be adjusted and Output Voltage $V_{OUT}$ is able to be regulated.

The base current of an external Tr. is monitored and controlled by an internal Base Current Limit circuit to keep current within a proper range. Furthermore, the other current limit circuit prevents a problem which is that a base current increases sharply when input Voltage $V_{IN}$ becomes lower than Set Output Voltage.

**Notes on selecting external components**

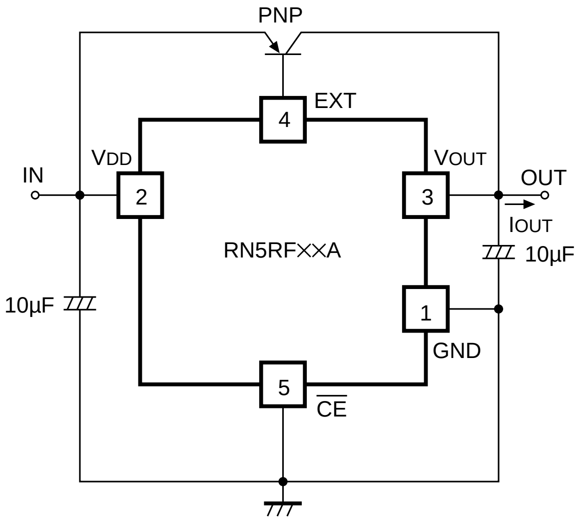
(1) On external PNP transistor

Be careful of output current, input voltage and power dissipation of External PNP Transistor.
It is said that External PNP Transistor with a low $V_{CE}$ (sat) and an $h_{FE}$ between 100 and 300 is suitable.

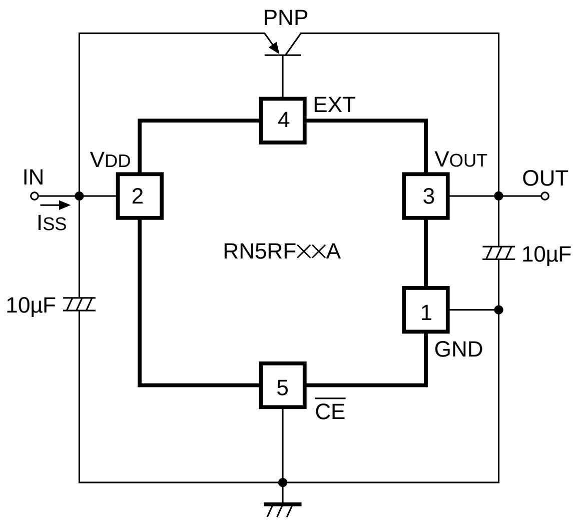
(2) On phase compensation

In these ICs, phase compensation is made for securing stable operation on the output stage even if the load current is varied. For this purpose, be sure to use a capacitor $C_L$ (tantalum type) with a capacitance of 10µF of more. There may be the case the loop oscillation takes place when a tantalum capacitor $C_L$ with a large ESR is used, so select the $C_L$ carefully including the frequency characteristics.

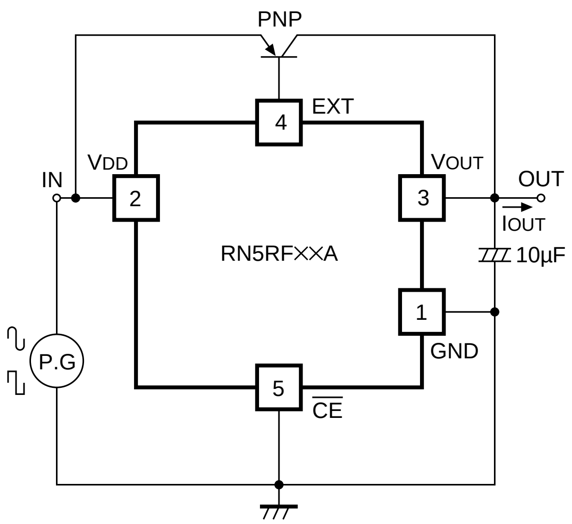
# TEST CIRCUITS



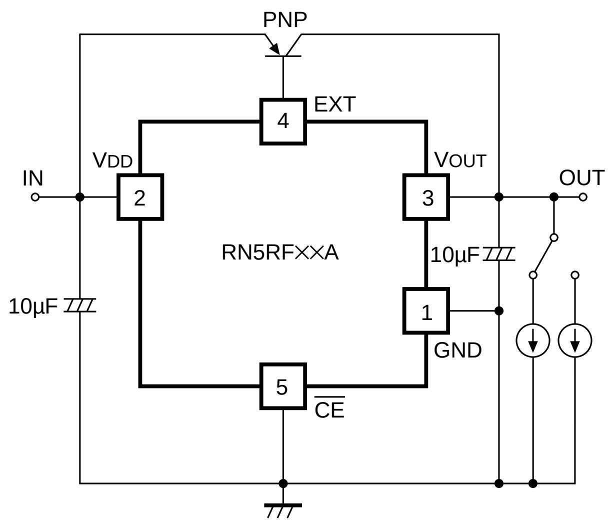

Basic Test Circuit




Test Circuit for Supply Current




Test Circuit for Ripple Rejection and Line Transient Response

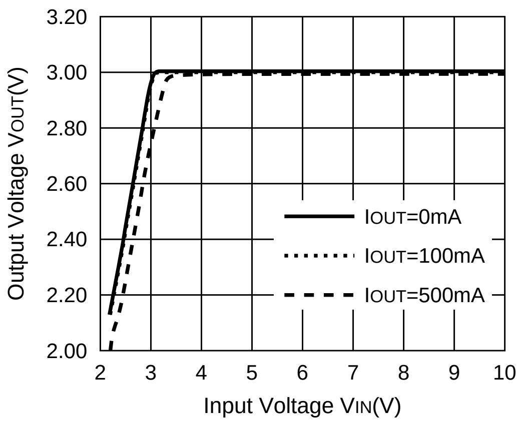



Test Circuit for Load Transient Response

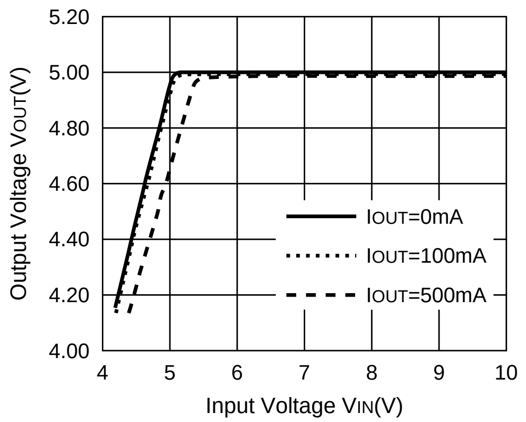
# TYPICAL CHARACTERISTICS

## 1) Output Voltage vs. Input Voltage (Topt=25˚C)

RN5RF30A

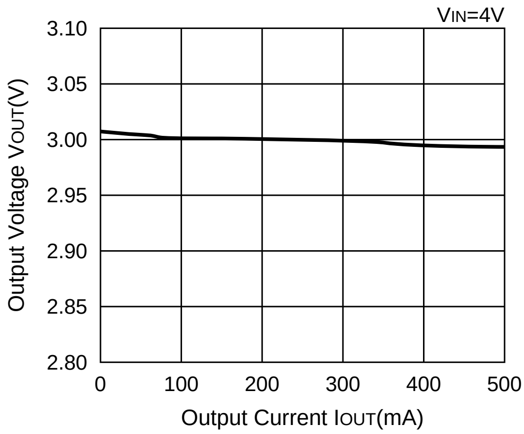



RN5RF50A

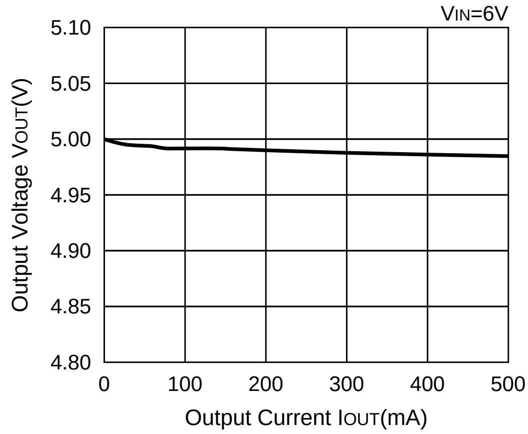



## 2) Output Voltage vs. Output Current (Topt=25˚C)

RN5RF30A

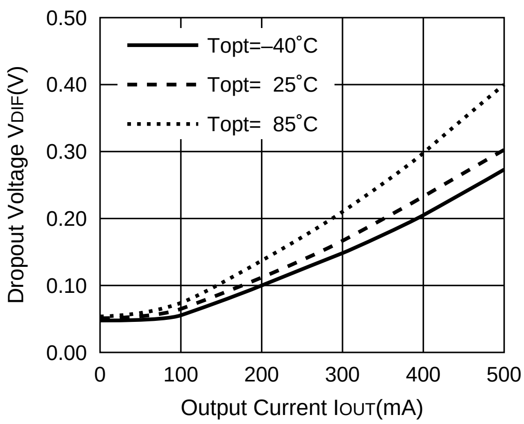



RN5RF50A

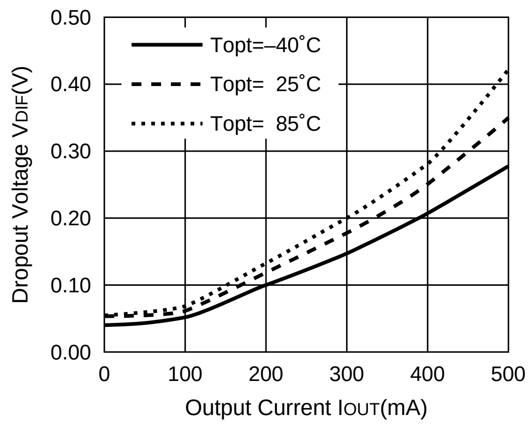



## 3) Dropout Voltage vs. Output Current

RN5RF30A

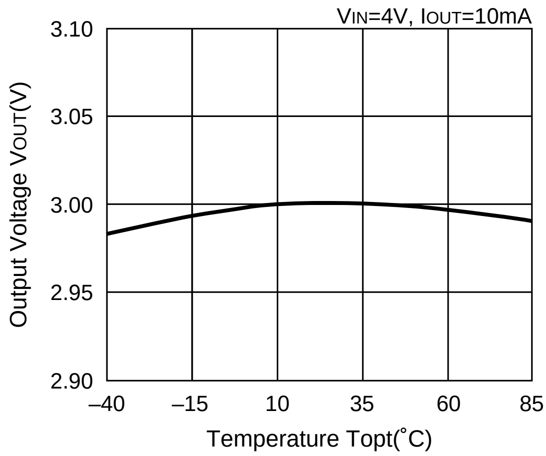



RN5RF50A

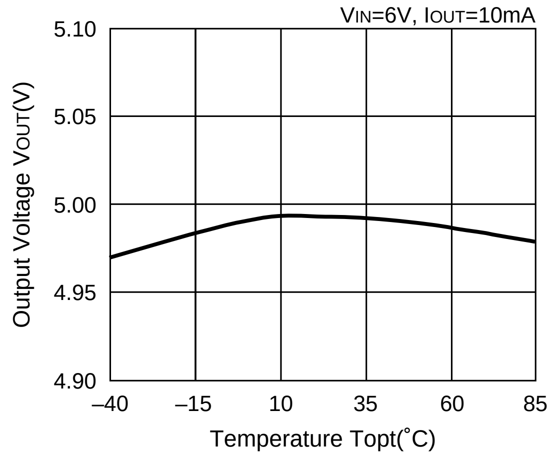


## 4) Output Voltage vs. Temperature

**RN5RF30A**

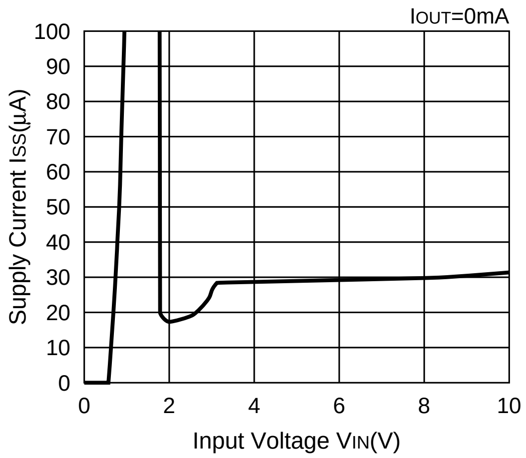



**RN5RF50A**

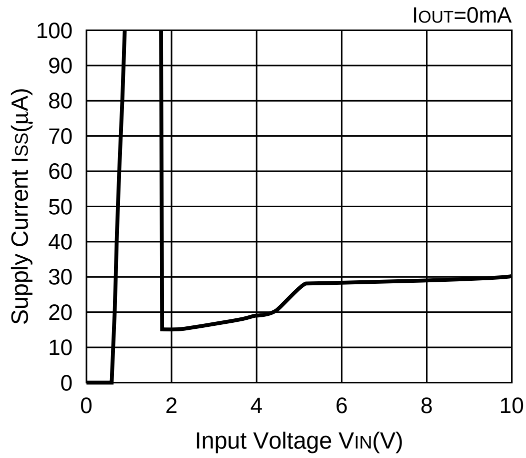



## 5) Supply Current vs. Input Voltage (Topt=25˚C)

**RN5RF30A**

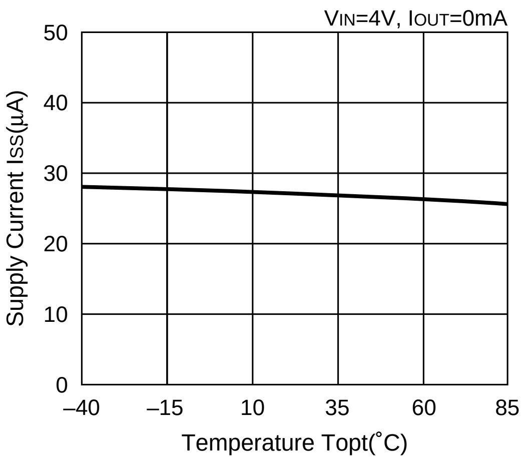



**RN5RF50A**

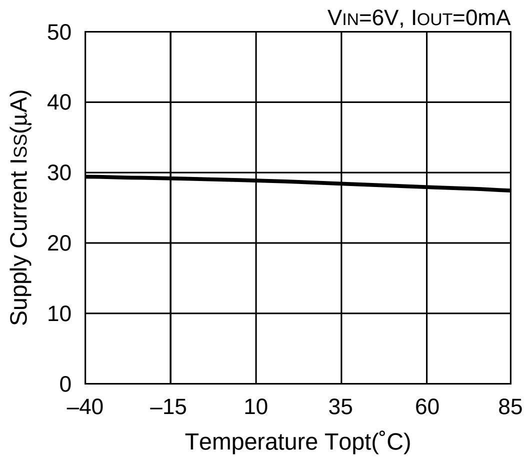



## 6) Supply Current vs. Temperature

**RN5RF30A**

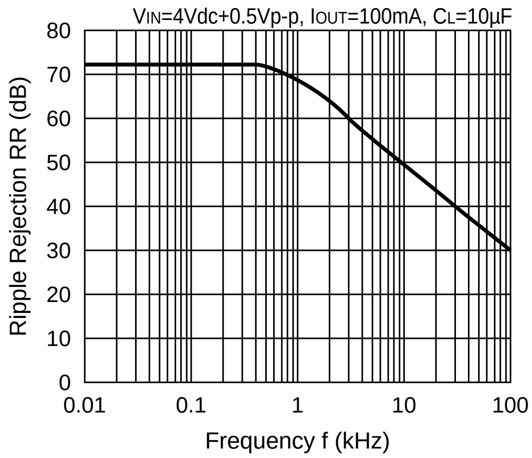



**RN5RF50A**

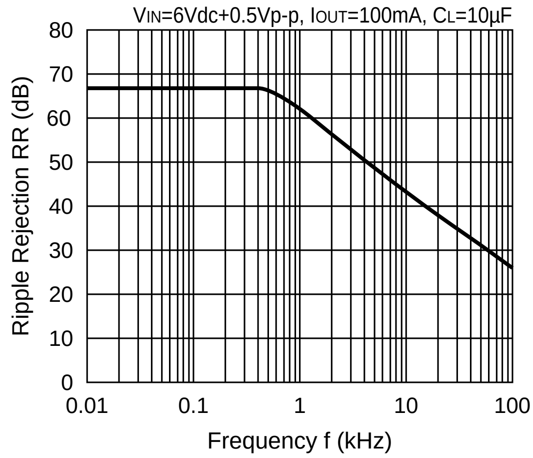


### 7) Ripple Rejection vs. Frequency (Topt=25°C)

**RN5RF30A**

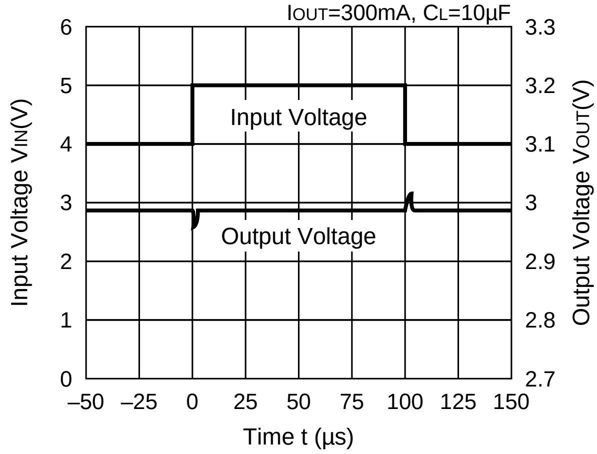



**RN5RF50A**

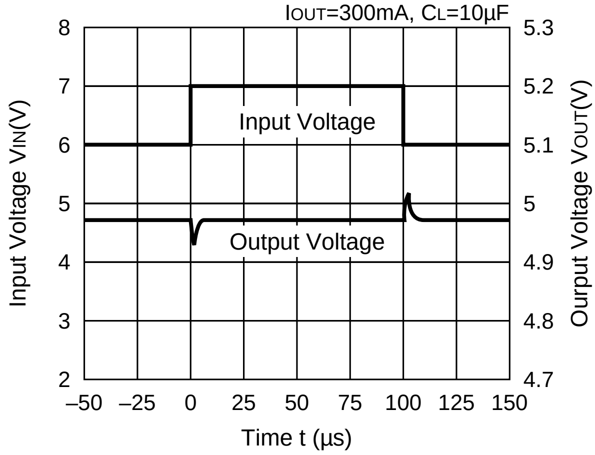



### 8) Line Transient Response (Topt=25°C)

**RN5RF30A**

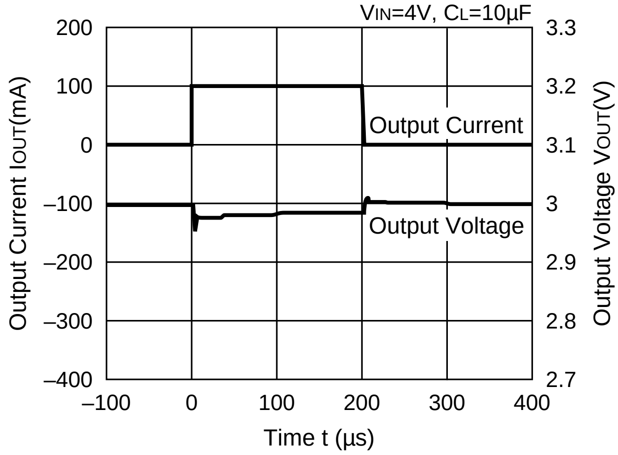



**RN5RF50A**

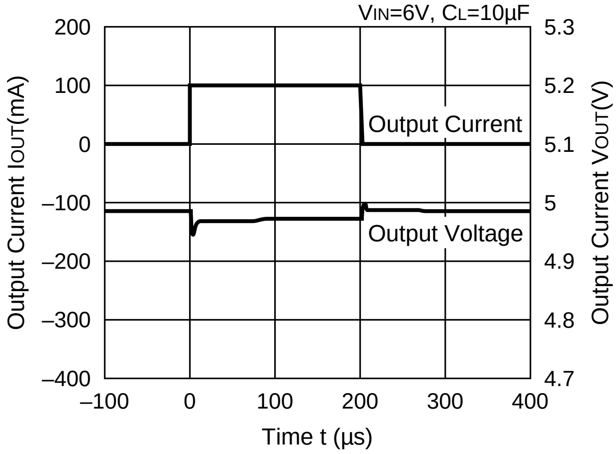



### 9) Load Transient Response (Topt=25°C)

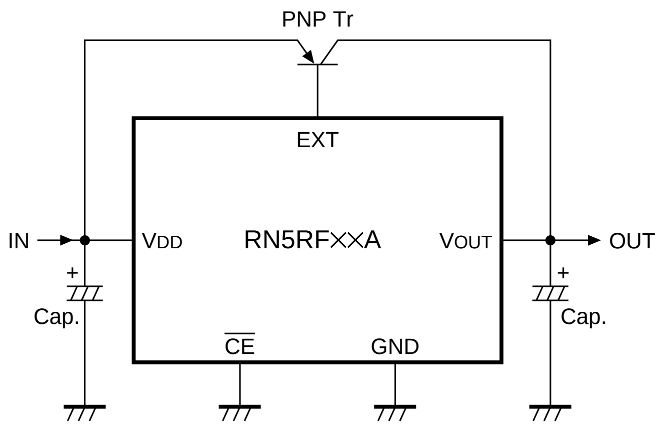
**RN5RF30A**




**RN5RF50A**



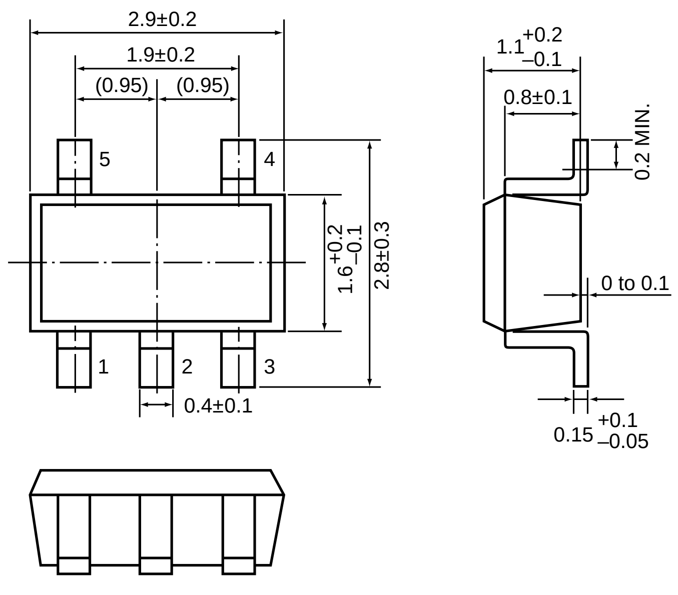
# TYPICAL APPLICATION




Parts Transistor : 2SB766A
Capacitor : 10μF (tantalum type)

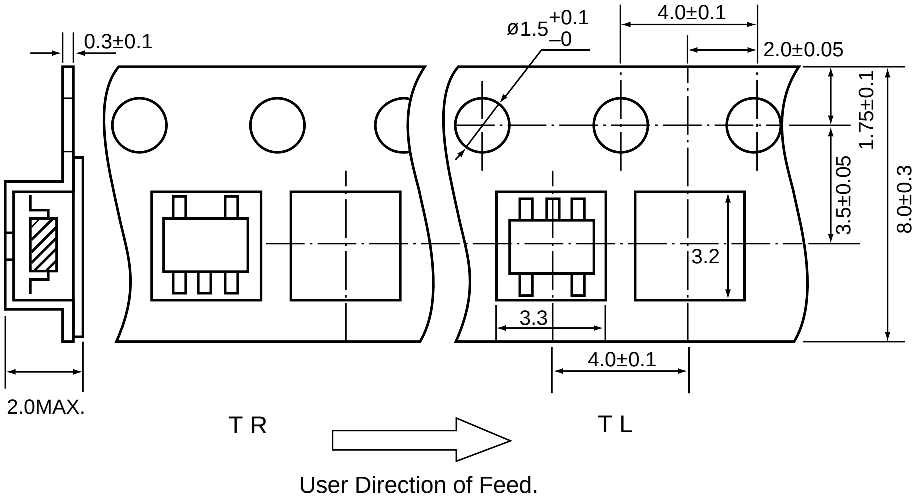
# PACKAGE DIMENSION (Unit : mm)

· **SOT-23-5**



# TAPING SPECIFICATION (Unit : mm)

· **SOT-23-5**




## APPLICATION HINTS

Using these ICs, be sure to take care of the following points:

1) Minimize the impedance of $V_{DD}$ and GND wiring. A large current flows through these wiring. When the wiring impedance is high, the operation of the ICs tends to be unstable and is vulnerable to noise.
2) Provide a capacitor with a capacitance of about 10μF (tantalum type) between $V_{DD}$ pin and GND pin with a minimum wiring length.
3) Rush current flows into the capacitor connected to the output of Regulators at the start of the operation of the Regulators. As these ICs are used with external PNP Transistor, the current drive performance of this Regulator is excellent. Therefore, when Regulator stars to operate, for example, under the conditions that $h_{FE}$ of External PNP Transistor is 100 and the base current of the limiter is 8mA, a rush current becomes 800mA.
4) In these ICs, phase compensation is made for securing stable operation on the output stage even if the load current is varied. For this purpose, be sure to use a capacitor $C_L$ (tantalum type) with a capacitance of 10μF of more. There may be the case the loop oscillation takes place when a tantalum capacitor $C_L$ with a large ESR is used, so select the $C_L$ carefully including the frequency characteristics.
5) Set external parts as close as possible to the IC and minimize the connection between the parts and the IC.

RICOH


**RICOH COMPANY, LTD.**
**ELECTRONIC DEVICES DIVISION**

**HEADQUARTERS**
13-1, Himemuro-cho, Ikeda City, Osaka 563-8501, JAPAN
Phone 81-727-53-1111 Fax 81-727-53-6011

**YOKOHAMA OFFICE** (International Sales)
3-2-3, Shin-Yokohama, Kohoku-ku, Yokohama City, Kanagawa 222-8530,
JAPAN
Phone 81-45-477-1697 Fax 81-45-477-1694 • 1695
http://www.ricoh.co.jp/LSI/english/

**RICOH CORPORATION**
**ELECTRONIC DEVICES DIVISION**

**SAN JOSE OFFICE**
3001 Orchard Parkway, San Jose, CA 95134-2088, U.S.A.
Phone 1-408-432-8800 Fax 1-408-432-8375