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## LOW RIPPLE VOLTAGE REGULATOR WITH EXTERNAL TRANSISTOR

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NO. EA-043-111116

### OUTLINE

The RN5RF Series are CMOS-based voltage regulator ICs which control external driver transistors with high ripple rejection, high accuracy output voltage, low supply current. 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 suitable for portable communicator such as cell phones, PDAs, walky talkies. SOT23-5 (Mini Mold) package is available.

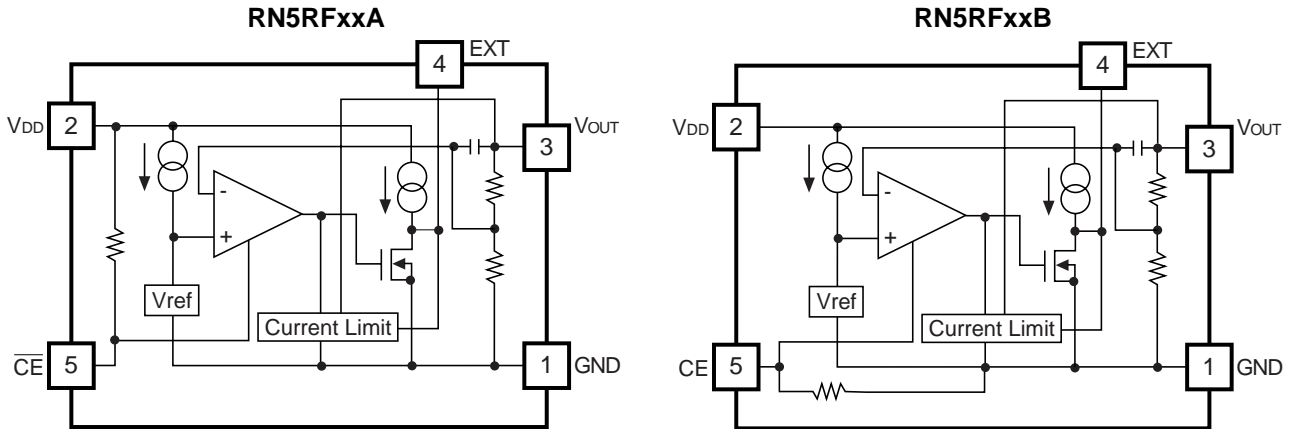
### FEATURES

- Supply Current ..... Typ. 30 $\mu$ A
- Supply Current (Standby) ..... Typ. 0.1 $\mu$ A
- Output Voltage Accuracy..... $\pm$ 2%
- Ripple Rejection..... Typ. 60dB (f=1kHz)
- Dropout Voltage ..... Typ. 0.1V (I<sub>OUT</sub>=100mA, dependent on External Tr.)
- Temperature-Drift Coefficient of Output Voltage ..... Typ.  $\pm$  100ppm/ $^{\circ}$ C
- Line Regulation ..... Typ. 0.05%/V
- Output Voltage Range..... 1.2V to 6.0V (0.1V steps)  
(For other voltages, please refer to MARK INFORMATIONS.)
- Package ..... SOT-23-5
- Current Limit for external Tr. .... Current limit Typ. 8mA

### APPLICATIONS

- Power source for battery-powered equipment
- Power source for hand-held communication equipment, cameras, and VCRs
- Power source for home appliances

**BLOCK DIAGRAMS**

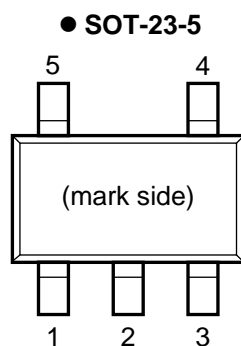


**SELECTION GUIDE**

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

| Product Name   | Package  | Quantity per Reel | Pb Free | Halogen Free |
|--|----------|-------------------|---------|--------------|
| RN5RFxx*A-TR-FE  | SOT-23-5 | 3,000 pcs         | Yes     | Yes          |
| xx: The output voltage can be designated in the range from 1.2V (12) to 6.0V (60) in 0.1V steps.<br>(For other voltages, please refer to MARK INFORMATIONS.) |          |                   |         |              |
| * : CE pin polarity are options as follows<br>(A) "L" active<br>(B) "H" active   |          |                   |         |              |

## PIN CONFIGURATION



## PIN DESCRIPTION

● SOT-23-5

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

## ABSOLUTE MAXIMUM RATINGS

| Symbol    | Item                                   | Rating               | Unit |
|-----------|--|----------------------|------|
| $V_{IN}$  | Input Voltage                          | 12.0                 | V    |
| $V_{CE}$  | Input Voltage ( $\overline{CE}$ or CE) | -0.3 to $V_{IN}+0.3$ | V    |
| $V_{EXT}$ | EXT Output Voltage                     | -0.3 to $V_{IN}+0.3$ | V    |
| $I_{EXT}$ | EXT Output Current                     | 50                   | mA   |
| $P_D$     | Power Dissipation* (SOT-23-5)          | 420                  | mW   |
| $T_{opt}$ | 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

## • RN5RFxxA

T<sub>opt</sub>=25°C

| Symbol                               | Item                                     | Conditions   | Min.                      | Typ.              | Max.                      | Unit   |
|--------------------------------------|--|--|---------------------------|-------------------|---------------------------|--------|
| V <sub>OUT</sub>                     | Output Voltage                           | V <sub>IN</sub> -V <sub>OUT</sub> =1.0V<br>I <sub>OUT</sub> =50mA      | V <sub>OUT</sub><br>×0.98 |                   | V <sub>OUT</sub><br>×1.02 | V      |
| I <sub>OUT</sub>                     | Output Current                           | V <sub>IN</sub> -V <sub>OUT</sub> =1.0V                                |                           | 1.0 <sup>*1</sup> |                           | A      |
| I <sub>EXT</sub>                     | EXT Current                              | V <sub>IN</sub> =4.0V, V <sub>EXT</sub> =2.0V                          | 5                         | 8                 | 15                        | mA     |
| ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Load Regulation                          | V <sub>IN</sub> -V <sub>OUT</sub> =1.0V<br>1mA≤I <sub>OUT</sub> ≤100mA | -60                       |                   | 60                        | mV     |
| V <sub>DIF</sub>                     | Dropout Voltage                          | I <sub>OUT</sub> =100mA, I <sub>OUT</sub> =0mA                         |                           | 0.1               | 0.2                       | V      |
| I <sub>SS</sub>                      | Supply Current                           | V <sub>IN</sub> -V <sub>OUT</sub> =1.0V                                |                           | 30                | 50                        | μA     |
| I <sub>standby</sub>                 | Standby Current                          | V <sub>IN</sub> =10.0V   | 0.01                      | 0.10              | 1.00                      | μA     |
| I <sub>EXTleak</sub>                 | EXT Leakage Current                      |  |                           |                   | 0.5                       | μA     |
| ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | Line Regulation                          | I <sub>OUT</sub> =50mA<br>V <sub>OUT</sub> +0.5V≤V <sub>IN</sub> ≤10V  | 0.00                      | 0.05              | 0.30                      | %/V    |
| R <sub>R</sub>                       | Ripple Rejection                         | f=1kHz, sinusoidal 0.5Vp-p<br>V <sub>IN</sub> -V <sub>OUT</sub> =1.0V  |                           | 60                |                           | dB     |
| V <sub>IN</sub>                      | Input Voltage                            |  |                           |                   | 10                        | V      |
| V <sub>EXT</sub>                     | EXT Output Voltage                       |  |                           |                   | 10                        | V      |
| ΔV <sub>OUT</sub> /ΔT <sub>opt</sub> | Output Voltage Temperature Coefficient   | I <sub>OUT</sub> =10mA<br>-40°C≤T <sub>opt</sub> ≤85°C                 |                           | ±100              |                           | ppm/°C |
| R <sub>PU</sub>                      | Pull up resistance for CE pin            |  |                           | 4                 |                           | MΩ     |
| V <sub>CEH</sub>                     | $\overline{\text{CE}}$ Input Voltage “H” |  | 1.5                       |                   | V <sub>IN</sub>           | V      |
| V <sub>CEL</sub>                     | $\overline{\text{CE}}$ Input Voltage “L” |  | 0.00                      |                   | 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<sub>FE</sub> between 100 and 300.

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

## • RN5RFxxB

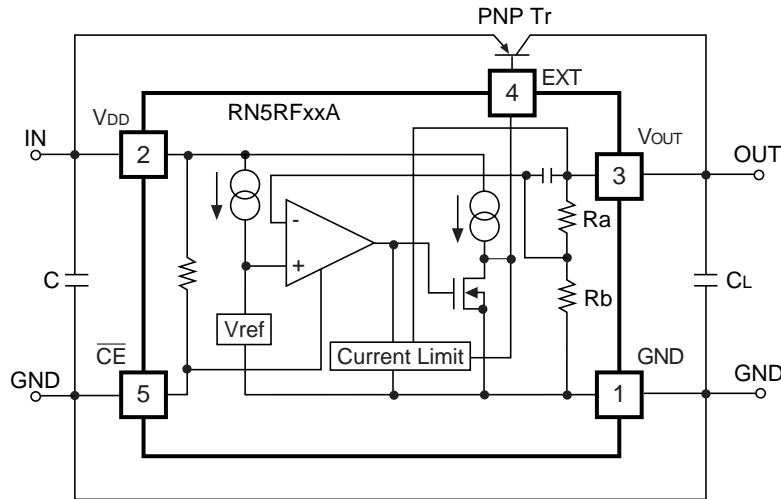
Topt=25°C

| Symbol                          | Item                                   | Conditions   | Min.                       | Typ.       | Max.                       | Unit            |
|---------------------------------|--|--|----------------------------|------------|----------------------------|-----------------|
| $V_{OUT}$                       | Output Voltage                         | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=50mA$                      | $V_{OUT}$<br>$\times 0.98$ |            | $V_{OUT}$<br>$\times 1.02$ | V               |
| $I_{OUT}$                       | Output Current                         | $V_{IN}-V_{OUT}=1.0V$  |                            | $1.0^{*1}$ |                            | 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               |
| $I_{SS}$                        | Supply Current                         | $V_{IN}-V_{OUT}=1.0V$<br>$I_{OUT}=0mA$                       |                            | 30         | 50                         | $\mu A$         |
| Istandby                        | Standby Current                        | $V_{IN}=10.0V$   | 0.01                       | 0.10       | 1.00                       | $\mu A$         |
| $I_{EXTleak}$                   | EXT Leakage Current                    |  |                            |            | 0.5                        | $\mu A$         |
| $\Delta V_{OUT}/\Delta V_{IN}$  | Line Regulation                        | $I_{OUT}=50mA$<br>$V_{OUT}+0.5V \leq V_{IN} \leq 10V$        | 0.00                       | 0.05       | 0.30                       | %/V             |
| $R_R$                           | 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               |
| $\Delta V_{OUT}/\Delta T_{opt}$ | Output Voltage Temperature Coefficient | $I_{OUT}=10mA$<br>$-40^\circ C \leq T_{opt} \leq 85^\circ C$ |                            | $\pm 100$  |                            | ppm/ $^\circ C$ |
| $R_{PD}$                        | Pull down resistance for CE pin        |  |                            | 4          |                            | M $\Omega$      |
| $V_{CEH}$                       | CE Input Voltage "H"                   |  | 1.5                        |            | $V_{IN}$                   | V               |
| $V_{CEL}$                       | CE Input Voltage "L"                   |  | 0.00                       |            | 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**



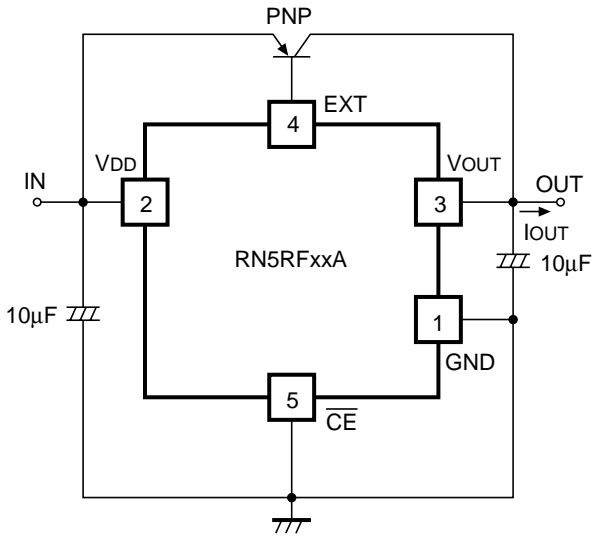
In these ICs, Output Voltage  $V_{OUT}$  is detected by feed-back resistors,  $R_A$  and  $R_B$  and the detected output voltage is compared with a reference voltage by the error amplifier so that the base current of an external PNP Transistor can be adjusted and the output voltage  $V_{OUT}$  is able 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 an input voltage,  $V_{IN}$  becomes lower than set output voltage.

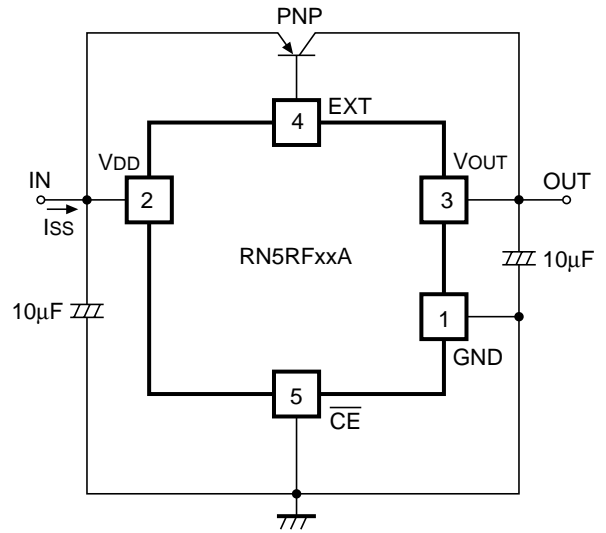
**Notes on selecting external components**

- (1) On external PNP transistor  
 Be careful of output current, input voltage and power dissipation of an external PNP Transistor.  
 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 even if the load current is varied. For this purpose, be sure to use a capacitor  $C_L$  (tantalum type) with a capacitance of  $10\mu F$  or 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 with considering the frequency characteristics also.

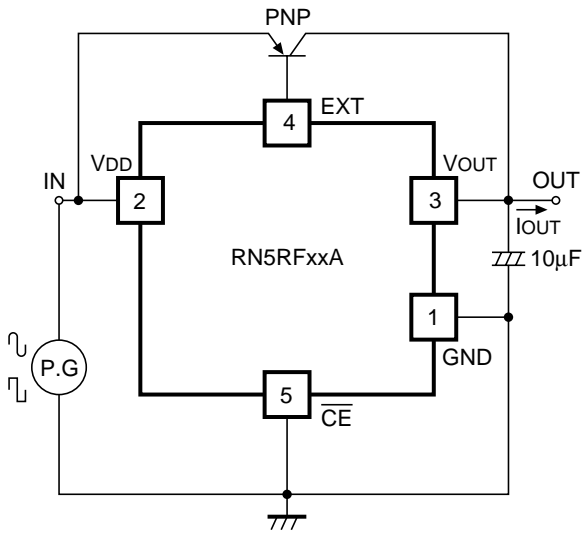
**TEST CIRCUITS**



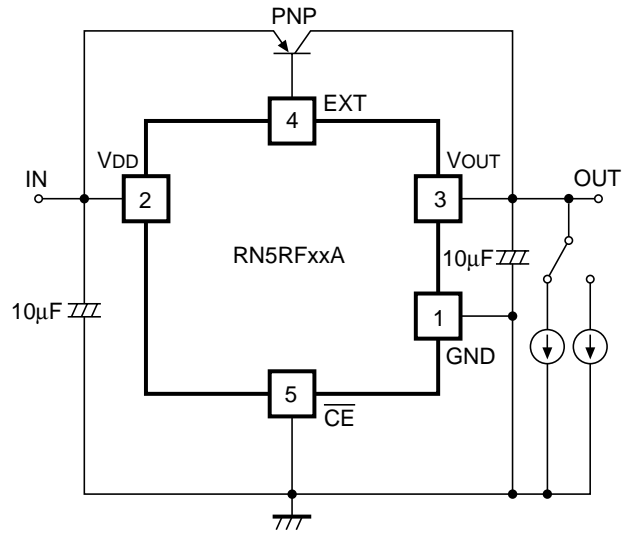
**Basic Test Circuit**



**Test Circuit for Supply Current**



**Test Circuit for Ripple Rejection and Line Transient Response**

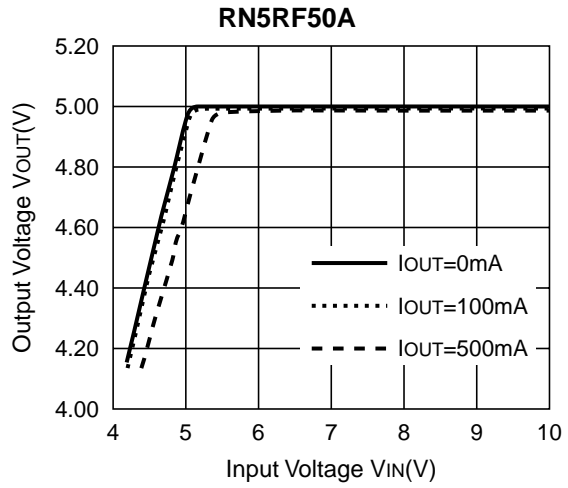
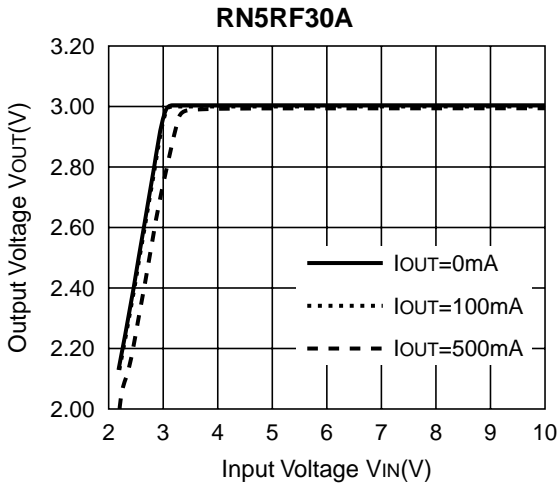


**Test Circuit for Load Transient Response**

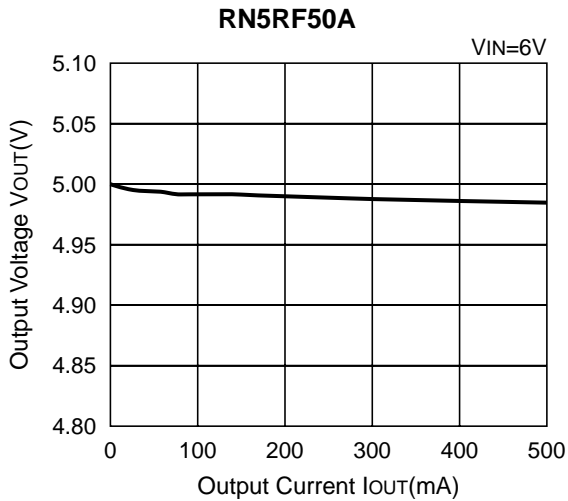
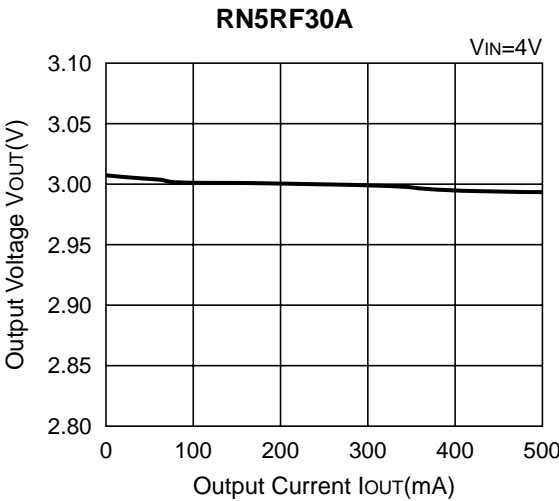


# TYPICAL CHARACTERISTICS

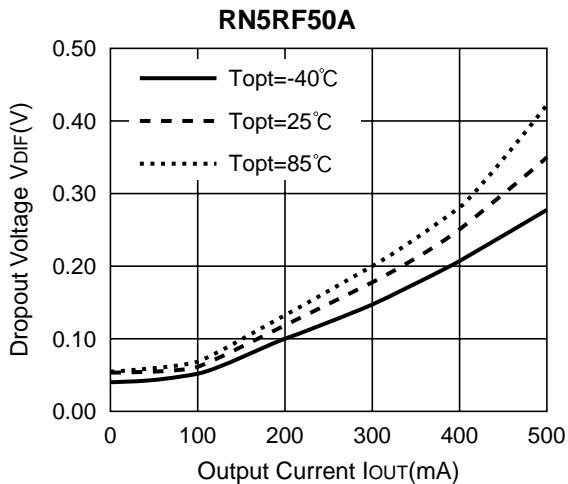
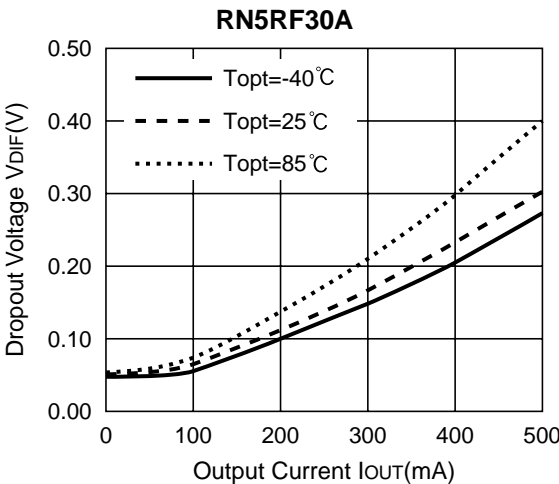
1) Output Voltage vs. Input Voltage (T<sub>opt</sub>=25°C)



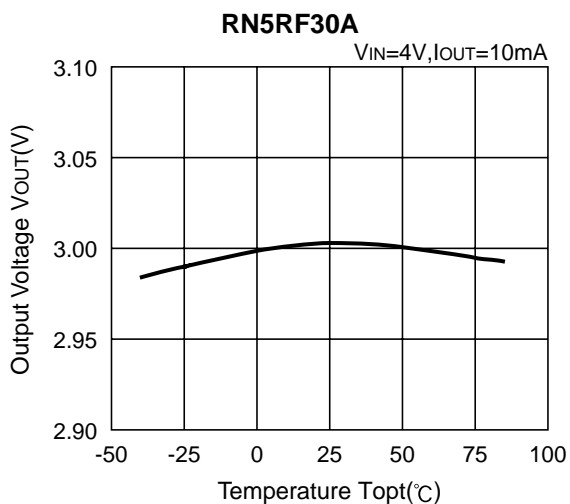
2) Output Voltage vs. Output Current (T<sub>opt</sub>=25°C)



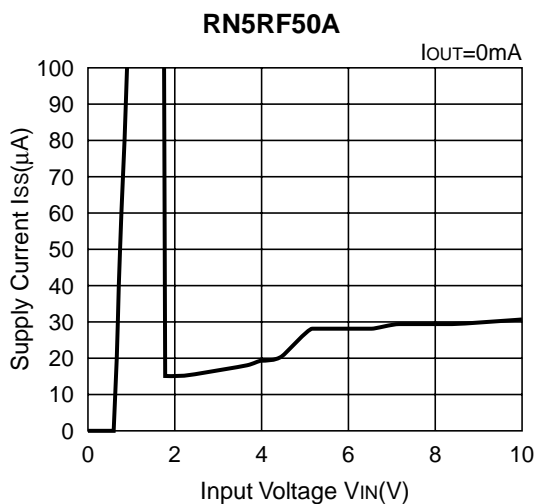
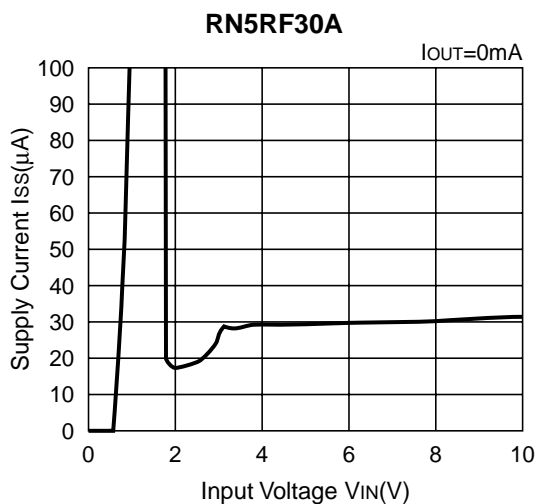
3) Dropout Voltage vs. Output Current



4) Output Voltage vs. Temperature



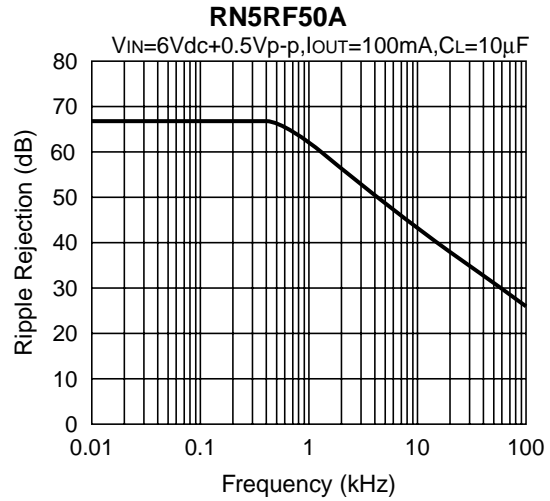
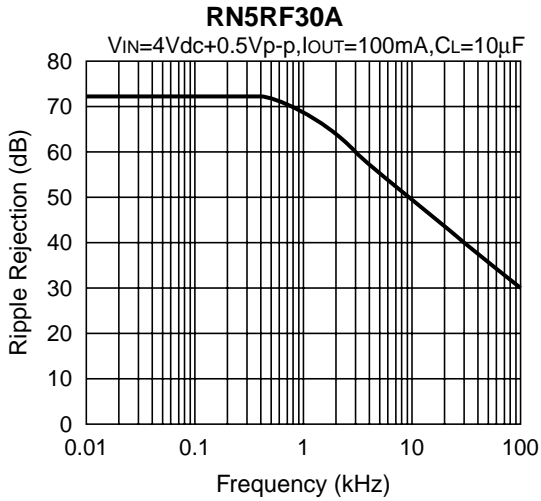
5) Supply Current vs. Input Voltage (Topt=25°C)



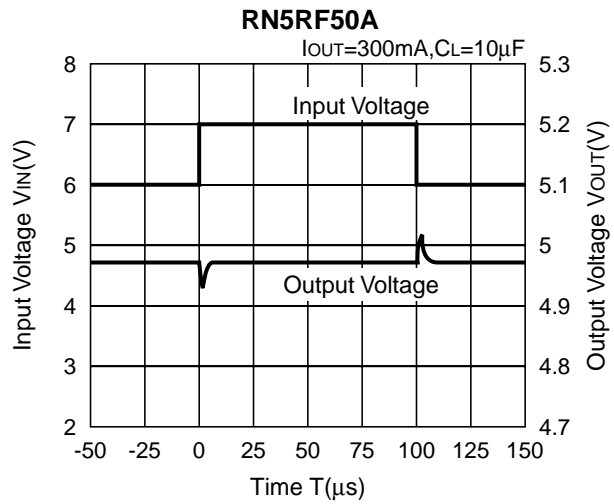
6) Supply Current vs. Temperature



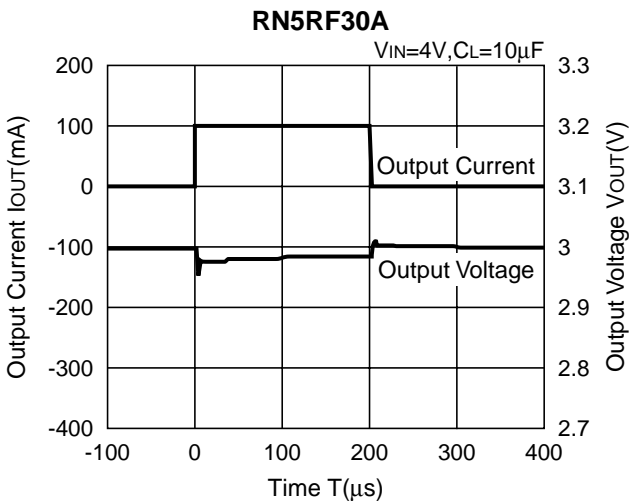
7) Ripple Rejection vs. Frequency (T<sub>opt</sub>=25°C)



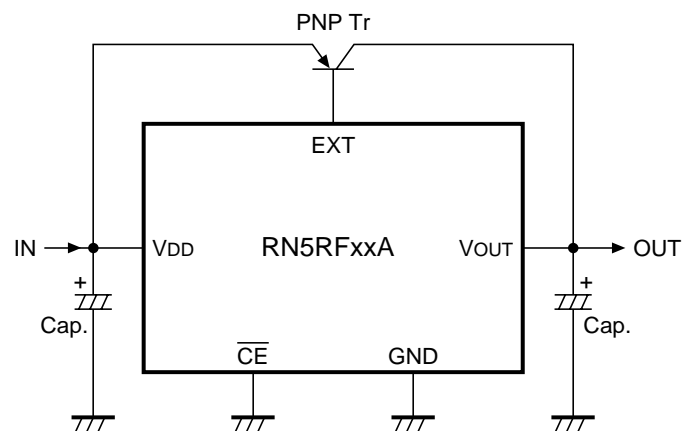
8) Line Transient Response (T<sub>opt</sub>=25°C)



9) Load Transient Response (T<sub>opt</sub>=25°C)



## TYPICAL APPLICATION



### Components

Transistor: 2SB766A

Capacitor: 10 $\mu$ F (Tantalum type)



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