VOLTAGE REGULATOR

NO. EA-016-130402

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, theses 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 (Discontinued) and SOT-89 (Mini-power Mold) are available.

FEATURES

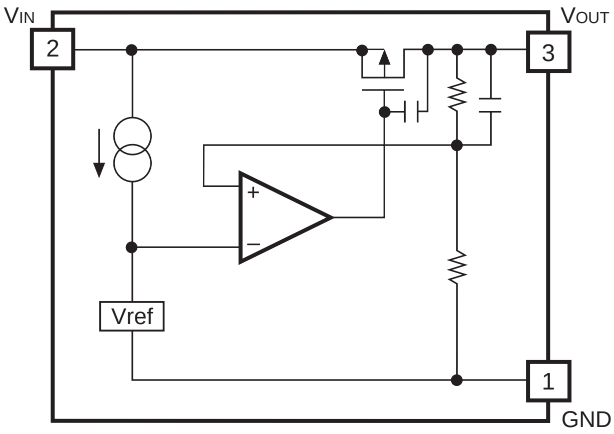
- Supply Current .... Typ. 1.1μA (V_{OUT}=3.0V, V_{IN}=5.0V)
- Dropout Voltage .... Typ. 0.5V (I_{OUT}=60mA, V_{OUT}=2.8V)
- Output Current .... Typ. 120mA (V_{OUT}=5.0V)
- Input Voltage Range .... Max. 10.0V
- Output Voltage Range.. 2.0V to 6.0V (0.1V steps)
  (For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy.. ±2.5%
- Temperature-Drift Coefficient of Output Voltage .... Typ. ± 100ppm/°C
- Line Regulation .... Typ. 0.1%/V
- Packages .... 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

Rx5RE



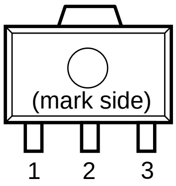
SELECTION GUIDE

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

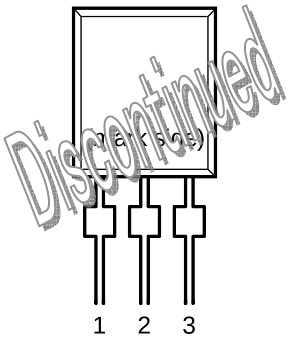
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RH5RExxAA-T1-FE	SOT-89	1,000 pcs	Yes	Yes
RE5RExxAA-TZ-F	TO-92 (Discontinued)	2,500 pcs	Yes	No
xx: The output voltage can be designated in the range from 2.0V (20) to 6.0V (60) in 0.1V steps. (For other voltages, please refer to MARK INFORMATIONS.)				

PIN CONFIGURATION

● SOT-89



● TO-92



PIN DESCRIPTION

● **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	300	mA
P_D	Power Dissipation* (SOT-89)	900	mW
	Power Dissipation* (TO-92) (Discontinued)	300	
Topt	Operating Temperature Range	–40 to 85	°C
Tstg	Storage Temperature Range	–55 to 125	°C
Tsolder	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

• **Rx5RE20A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN}=4.0V,I_{OUT}=10mA	1.950	2.000	2.050	V
I_{OUT}	Output Current	V_{IN}=4.0V	40	60		mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=4.0V 1mA≤I_{OUT}≤50mA		40	80	mV
V_{DIF}	Dropout Voltage	I_{OUT}=30mA		0.5	0.7	V
I_{SS}	Quiescent Current	V_{IN}=4.0V		1.0	3.0	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=10mA V_{OUT}+1.0V≤V_{IN}≤10V		0.1		%/V
V_{IN}	Input Voltage				10	V
Ilim	Current Limit			240		mA
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –40°C≤Topt≤85°C		±100		ppm/°C

• **Rx5RE30A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN}=5.0V,I_{OUT}=10mA	2.925	3.000	3.075	V
I_{OUT}	Output Current	V_{IN}=5.0V	50	80		mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=5.0V 1mA≤I_{OUT}≤60mA		40	80	mV
V_{DIF}	Dropout Voltage	I_{OUT}=40mA		0.5	0.7	V
I_{SS}	Quiescent Current	V_{IN}=5.0V		1.1	3.3	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=10mA V_{OUT}+1.0V≤V_{IN}≤10V		0.1		%/V
V_{IN}	Input Voltage				10	V
Ilim	Current Limit			240		mA
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –40°C≤Topt≤85°C		±100		ppm/°C

• **Rx5RE40A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN}=6.0V,I_{OUT}=10mA	3.900	4.000	4.100	V
I_{OUT}	Output Current	V_{IN}=6.0V	65	100		mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=6.0V 1mA≤I_{OUT}≤70mA		40	80	mV
V_{DIF}	Dropout Voltage	I_{OUT}=50mA		0.5	0.7	V
I_{SS}	Quiescent Current	V_{IN}=6.0V		1.2	3.6	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=10mA V_{OUT}+1.0V≤V_{IN}≤10V		0.1		%/V
V_{IN}	Input Voltage				10	V
Ilim	Current Limit			240		mA
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –40°C≤Topt≤85°C		±100		ppm/°C

• **Rx5RE50A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN}=7.0V,I_{OUT}=10mA	4.875	5.000	5.125	V
I_{OUT}	Output Current	V_{IN}=7.0V	80	120		mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=7.0V 1mA≤I_{OUT}≤80mA		40	80	mV
V_{DIF}	Dropout Voltage	I_{OUT}=60mA		0.5	0.7	V
I_{SS}	Quiescent Current	V_{IN}=7.0V		1.3	3.9	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=10mA V_{OUT}+1.0V≤V_{IN}≤10V		0.1		%/V
V_{IN}	Input Voltage				10	V
Ilim	Current Limit			240		mA
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –40°C≤Topt≤85°C		±100		ppm/°C

• **Rx5RE60A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{IN}=8.0V,I_{OUT}=10mA	5.850	6.000	6.150	V
I_{OUT}	Output Current	V_{IN}=8.0V	80	120		mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=8.0V 1mA≤I_{OUT}≤80mA		40	80	mV
V_{DIF}	Dropout Voltage	I_{OUT}=60mA		0.5	0.7	V
I_{SS}	Quiescent Current	V_{IN}=8.0V		1.4	4.2	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=10mA V_{OUT}+1.0V≤V_{IN}≤10V		0.1		%/V
V_{IN}	Input Voltage				10	V
Ilim	Current Limit			240		mA
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –40°C≤Topt≤85°C		±100		ppm/°C

ELECTRICAL CHARACTERISTICS BY OUTPUT VOLTAGE

<table>
<tr><th rowspan="3">Part Number</th><th colspan="4">Output Voltage</th><th colspan="3">OutputCurrent</th><th colspan="3">Load Regulation</th><th colspan="3">Dropout Voltage</th></tr>
<tr><th colspan="4">V_{OUT}(V)</th><th colspan="3">I_{OUT}(mA)</th><th colspan="3">$\Delta V_{OUT}/\Delta I_{OUT}$(mV)</th><th colspan="3">V_{DIF}(V)</th></tr>
<tr><th>Conditions</th><th>Min.</th><th>Typ.</th><th>Max.</th><th>Conditions</th><th>Min.</th><th>Typ.</th><th>Conditions</th><th>Typ.</th><th>Max.</th><th>Conditions</th><th>Typ.</th><th>Max.</th></tr>
<tr><td>Rx5RE20A</td><td rowspan="41">$V_{IN}-V_{OUT}$=2.0V
I_{OUT}=10mA</td><td>1.950</td><td>2.000</td><td>2.050</td><td rowspan="41">$V_{IN}-V_{OUT}$=2.0V</td><td rowspan="10">40</td><td rowspan="10">60</td><td rowspan="5">$V_{IN}-V_{OUT}$=2.0V
1mA≤I_{OUT}≤50mA</td><td rowspan="41">40</td><td rowspan="41">80</td><td rowspan="10">I_{OUT}=30mA</td><td rowspan="41">0.5</td><td rowspan="41">0.7</td></tr>
<tr><td>Rx5RE21A</td><td>2.048</td><td>2.100</td><td>2.152</td></tr>
<tr><td>Rx5RE22A</td><td>2.145</td><td>2.200</td><td>2.255</td></tr>
<tr><td>Rx5RE23A</td><td>2.243</td><td>2.300</td><td>2.357</td></tr>
<tr><td>Rx5RE24A</td><td>2.340</td><td>2.400</td><td>2.460</td></tr>
<tr><td>Rx5RE25A</td><td>2.438</td><td>2.500</td><td>2.562</td><td rowspan="10">$V_{IN}-V_{OUT}$=2.0V
1mA≤I_{OUT}≤60mA</td></tr>
<tr><td>Rx5RE26A</td><td>2.535</td><td>2.600</td><td>2.665</td></tr>
<tr><td>Rx5RE27A</td><td>2.633</td><td>2.700</td><td>2.767</td></tr>
<tr><td>Rx5RE28A</td><td>2.730</td><td>2.800</td><td>2.870</td></tr>
<tr><td>Rx5RE29A</td><td>2.828</td><td>2.900</td><td>2.972</td></tr>
<tr><td>Rx5RE30A</td><td>2.925</td><td>3.000</td><td>3.075</td><td rowspan="10">50</td><td rowspan="10">80</td><td rowspan="10">I_{OUT}=40mA</td></tr>
<tr><td>Rx5RE31A</td><td>3.023</td><td>3.100</td><td>3.177</td></tr>
<tr><td>Rx5RE32A</td><td>3.120</td><td>3.200</td><td>3.280</td></tr>
<tr><td>Rx5RE33A</td><td>3.218</td><td>3.300</td><td>3.382</td></tr>
<tr><td>Rx5RE34A</td><td>3.315</td><td>3.400</td><td>3.485</td></tr>
<tr><td>Rx5RE35A</td><td>3.413</td><td>3.500</td><td>3.587</td><td rowspan="10">$V_{IN}-V_{OUT}$=2.0V
1mA≤I_{OUT}≤70mA</td></tr>
<tr><td>Rx5RE36A</td><td>3.510</td><td>3.600</td><td>3.690</td></tr>
<tr><td>Rx5RE37A</td><td>3.608</td><td>3.700</td><td>3.792</td></tr>
<tr><td>Rx5RE38A</td><td>3.705</td><td>3.800</td><td>3.895</td></tr>
<tr><td>Rx5RE39A</td><td>3.803</td><td>3.900</td><td>3.997</td></tr>
<tr><td>Rx5RE40A</td><td>3.900</td><td>4.000</td><td>4.100</td><td rowspan="10">65</td><td rowspan="10">100</td><td rowspan="10">I_{OUT}=50mA</td></tr>
<tr><td>Rx5RE41A</td><td>3.998</td><td>4.100</td><td>4.202</td></tr>
<tr><td>Rx5RE42A</td><td>4.095</td><td>4.200</td><td>4.305</td></tr>
<tr><td>Rx5RE43A</td><td>4.193</td><td>4.300</td><td>4.407</td></tr>
<tr><td>Rx5RE44A</td><td>4.290</td><td>4.400</td><td>4.510</td></tr>
<tr><td>Rx5RE45A</td><td>4.388</td><td>4.500</td><td>4.612</td><td rowspan="16">$V_{IN}-V_{OUT}$=2.0V
1mA≤I_{OUT}≤80mA</td></tr>
<tr><td>Rx5RE46A</td><td>4.485</td><td>4.600</td><td>4.715</td></tr>
<tr><td>Rx5RE47A</td><td>4.583</td><td>4.700</td><td>4.817</td></tr>
<tr><td>Rx5RE48A</td><td>4.680</td><td>4.800</td><td>4.920</td></tr>
<tr><td>Rx5RE49A</td><td>4.778</td><td>4.900</td><td>5.022</td></tr>
<tr><td>Rx5RE50A</td><td>4.875</td><td>5.000</td><td>5.125</td><td rowspan="11">80</td><td rowspan="11">120</td><td rowspan="11">I_{OUT}=60mA</td></tr>
<tr><td>Rx5RE51A</td><td>4.973</td><td>5.100</td><td>5.227</td></tr>
<tr><td>Rx5RE52A</td><td>5.070</td><td>5.200</td><td>5.330</td></tr>
<tr><td>Rx5RE53A</td><td>5.168</td><td>5.300</td><td>5.432</td></tr>
<tr><td>Rx5RE54A</td><td>5.265</td><td>5.400</td><td>5.535</td></tr>
<tr><td>Rx5RE55A</td><td>5.363</td><td>5.500</td><td>5.637</td></tr>
<tr><td>Rx5RE56A</td><td>5.460</td><td>5.600</td><td>5.740</td></tr>
<tr><td>Rx5RE57A</td><td>5.558</td><td>5.700</td><td>5.842</td></tr>
<tr><td>Rx5RE58A</td><td>5.655</td><td>5.800</td><td>5.945</td></tr>
<tr><td>Rx5RE59A</td><td>5.753</td><td>5.900</td><td>6.047</td></tr>
<tr><td>Rx5RE60A</td><td>5.850</td><td>6.000</td><td>6.150</td></tr>
</table>

Topt=25˚C

Quiescent Current			Line Regulation		Input Voltage	Current Limit	Output Voltage Tempco.	
Iss(μA)			ΔVOUT/ΔVIN(%/V)		VIN(V)	Ilim(mA)	ΔVOUT/ΔT(ppm/˚C)	
Conditions	Typ.	Max.	Conditions	Typ.	Max.	Typ.	Conditions	Typ.
VIN–VOUT =2.0V	1.0	3.0	IOUT =10mA VOUT+1.0V≤VIN ≤10V	0.1	10	240	IOUT =10mA –40˚C≤Topt ≤85˚C	±100
	1.1	3.3						
	1.2	3.6						
	1.3	3.9						
	1.4	4.2						

OPERATION

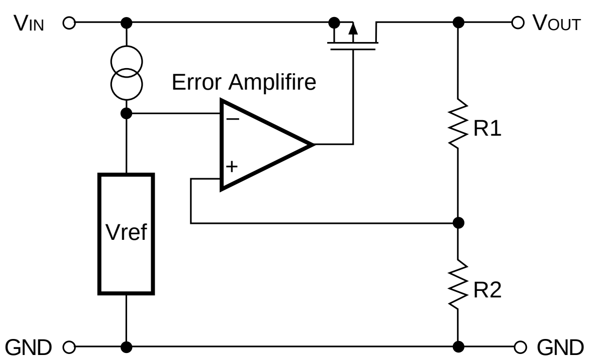


FIG. 1 Brock Diagram

Output voltage VOUT divided at the node between registers R1 and R2 is compared with reference voltage by error amplifier, so that a constant voltage is output.

TEST CIRCUITS

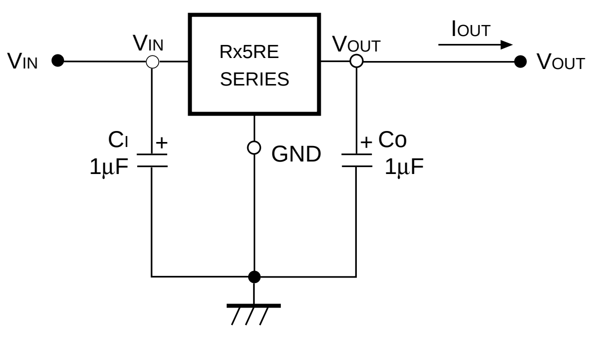


FIG. 2 Test Circuit

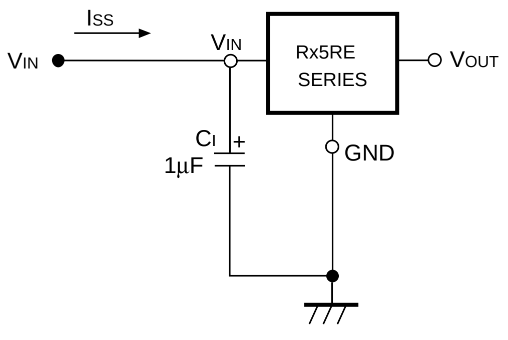


FIG. 3 Quiescent Current Test Circuit

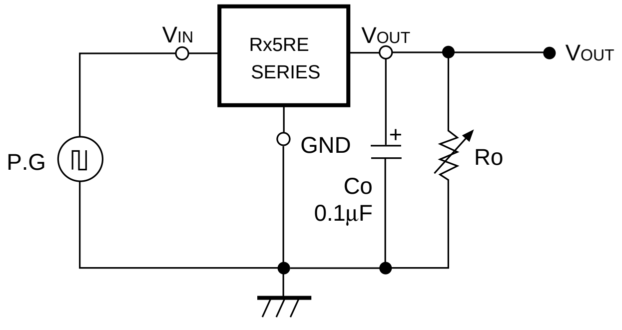
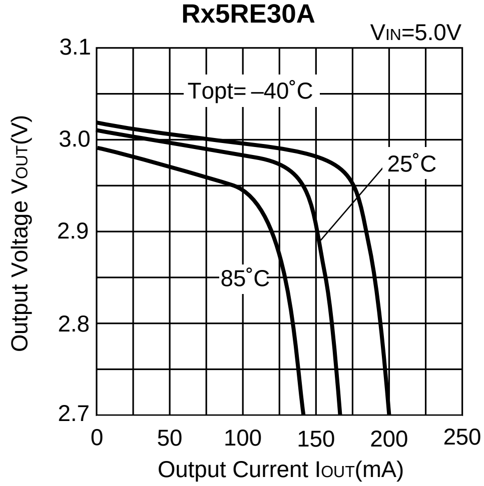


FIG. 4 Line Transient Response Test Circuit

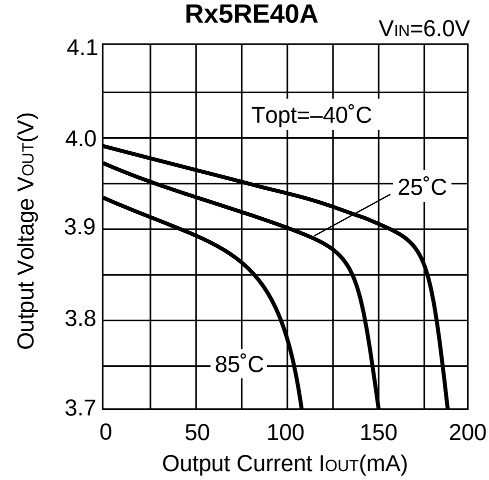
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current

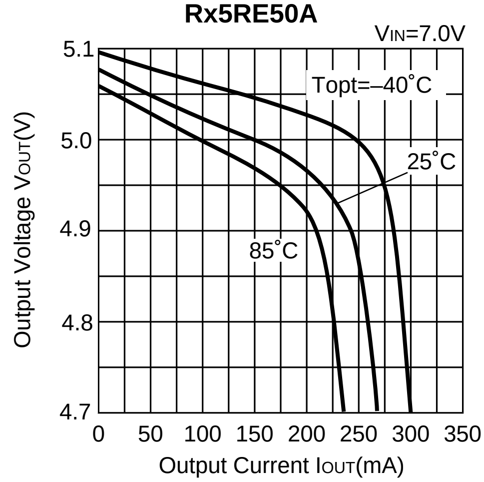
Rx5RE30A



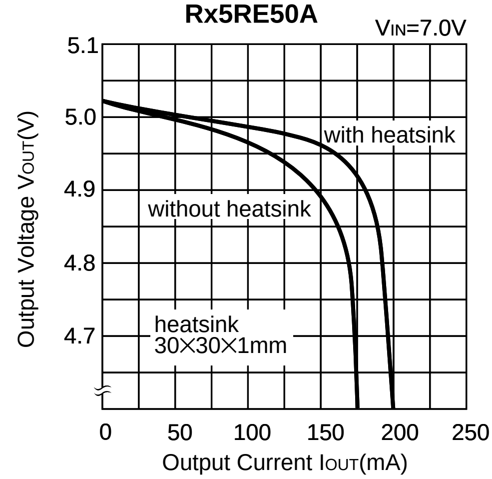
Rx5RE40A



Rx5RE50A

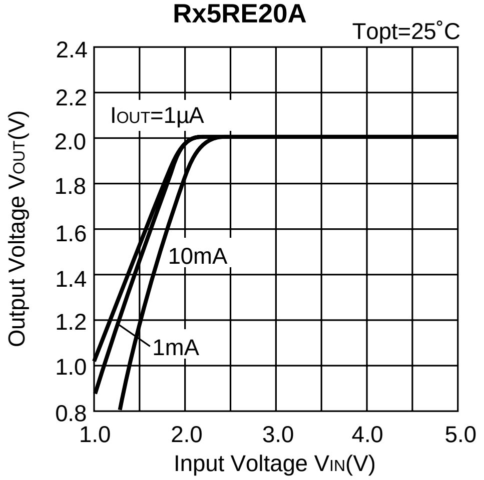


Rx5RE50A

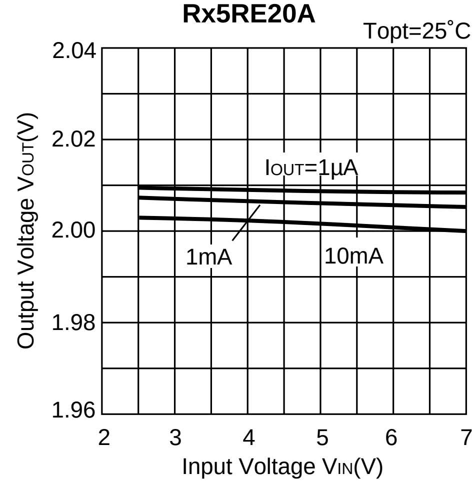


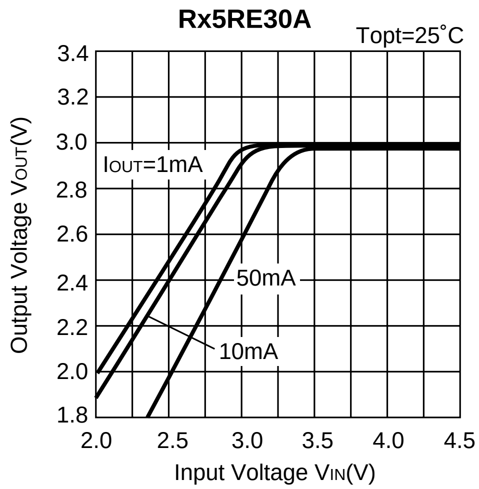
2) Output Voltage vs. Input Voltage

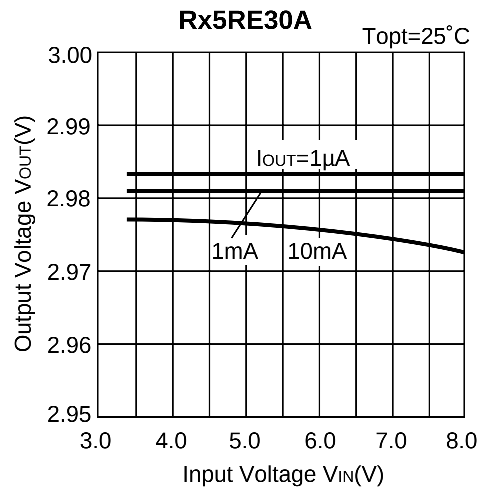
Rx5RE20A

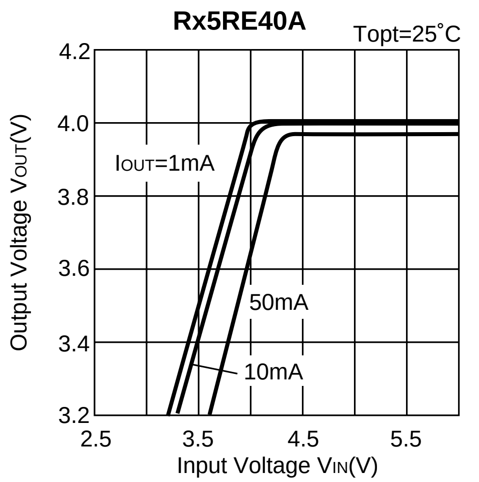


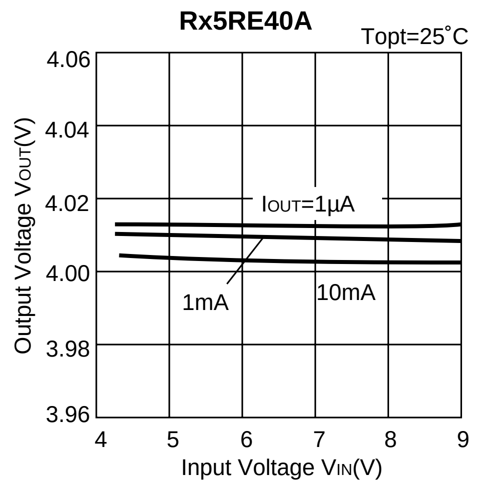
Rx5RE20A

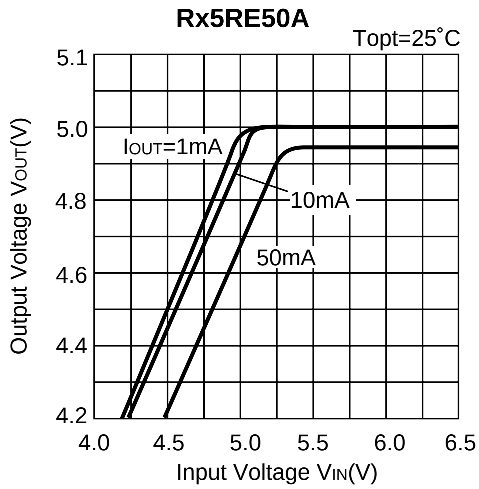


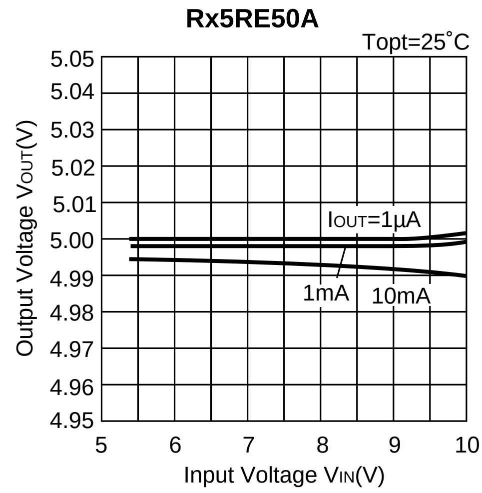

Rx5RE30A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1mA
50mA
10mA
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
2.0
2.5
3.0
3.5
4.0
4.5


Rx5RE30A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1μA
1mA
10mA
3.00
2.99
2.98
2.97
2.96
2.95
3.0
4.0
5.0
6.0
7.0
8.0


Rx5RE40A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1mA
50mA
10mA
4.2
4.0
3.8
3.6
3.4
3.2
2.5
3.5
4.5
5.5

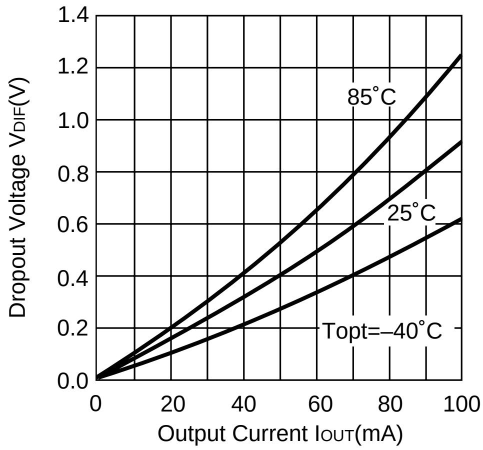

Rx5RE40A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1μA
1mA
10mA
4.06
4.04
4.02
4.00
3.98
3.96
4
5
6
7
8
9


Rx5RE50A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1mA
10mA
50mA
5.1
5.0
4.8
4.6
4.4
4.2
4.0
4.5
5.0
5.5
6.0
6.5

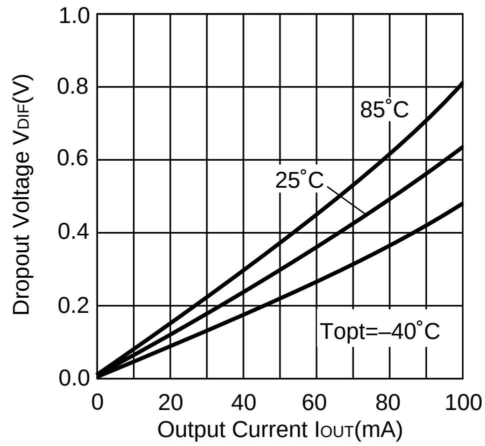

Rx5RE50A
Topt=25˚C
Output Voltage VOUT(V)
Input Voltage VIN(V)
IOUT=1μA
1mA
10mA
5.05
5.04
5.03
5.02
5.01
5.00
4.99
4.98
4.97
4.96
4.95
5
6
7
8
9
10

3) Dropout Voltage vs. Output Curret

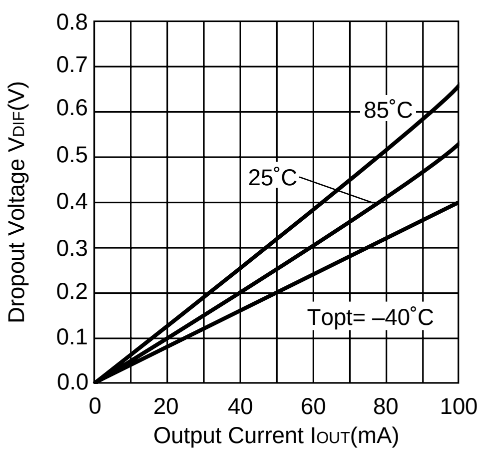
Rx5RE30A



Rx5RE40A

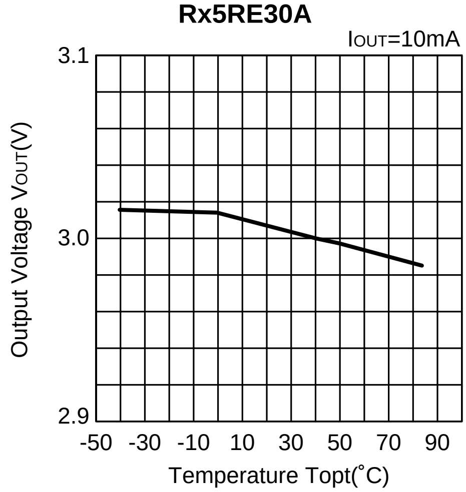


Rx5RE50A

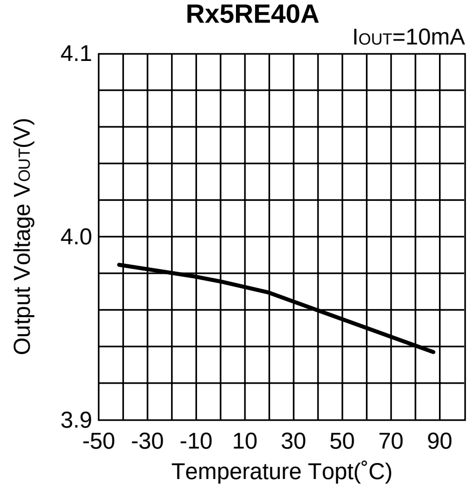


4) Output Voltage vs.Temperature

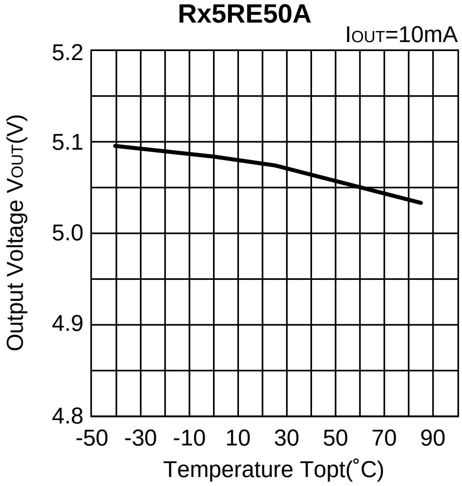
Rx5RE30A



Rx5RE40A

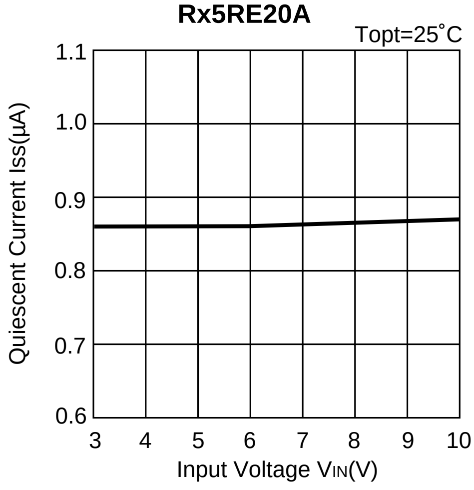


Rx5RE50A

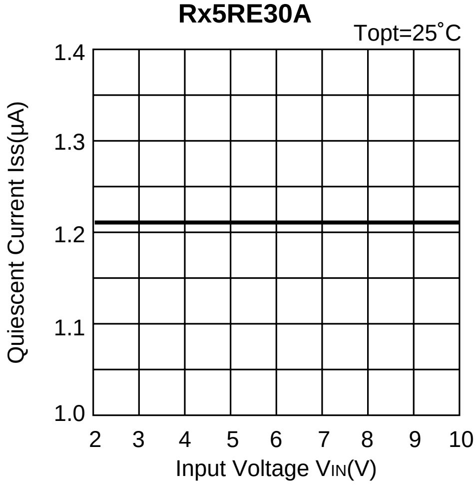


5) Quiescent Current vs. Input Voltage

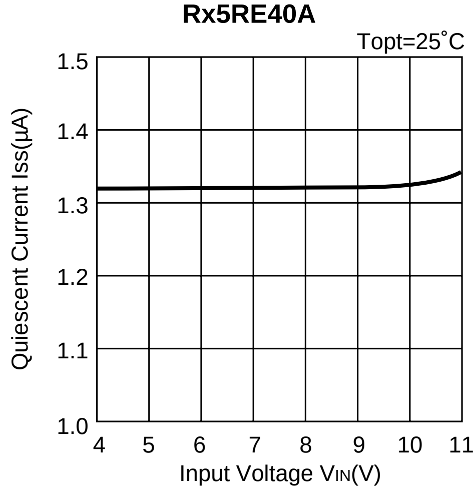
Rx5RE20A



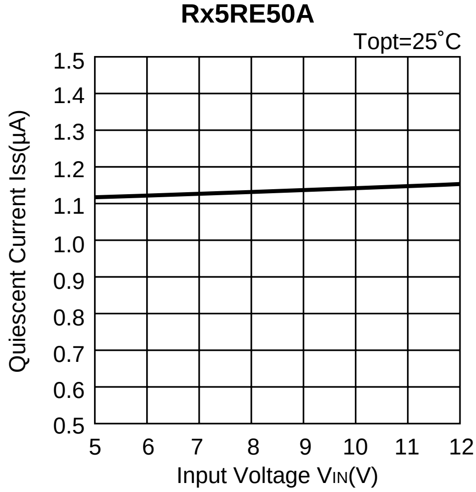
Rx5RE30A



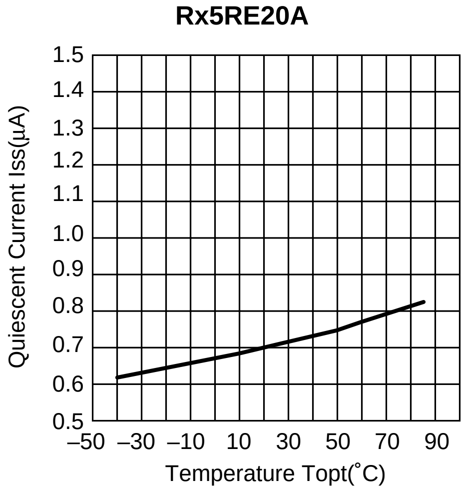
Rx5RE40A

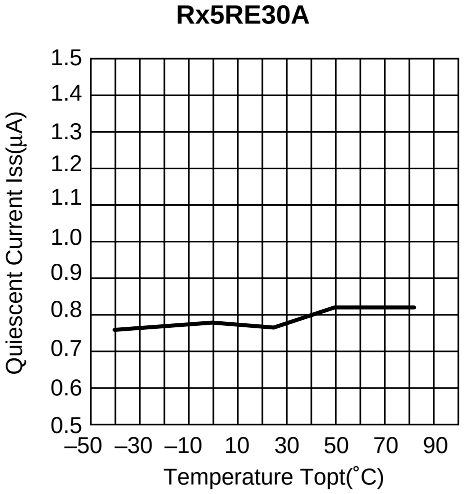


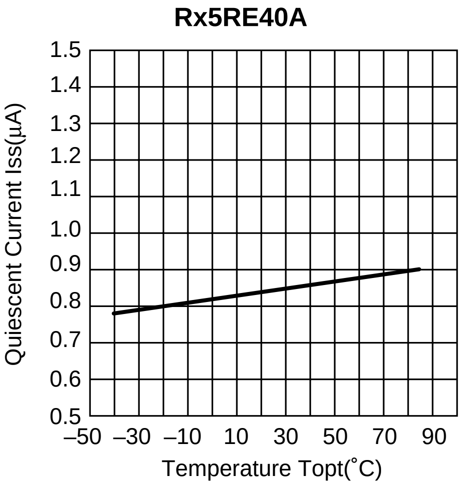
Rx5RE50A



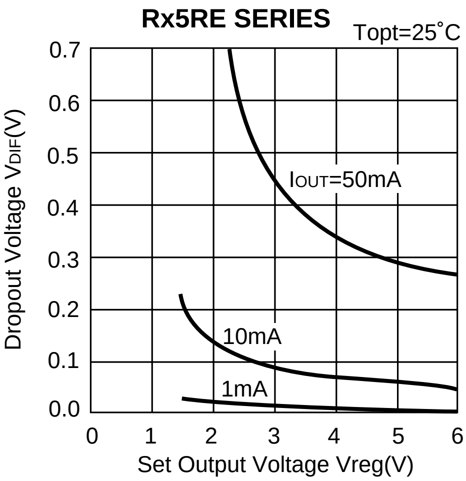
6) Quiescent Current vs. Temperature





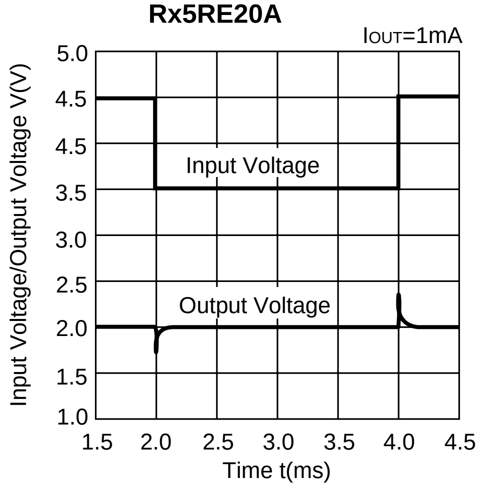


7) Dropout Voltage vs. Set Output Voltage

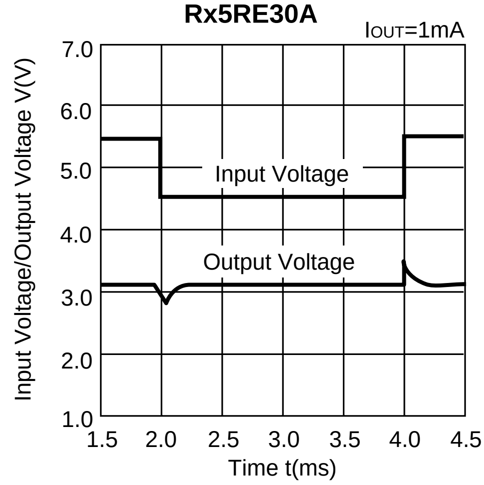


8) Line Transient Response (1)

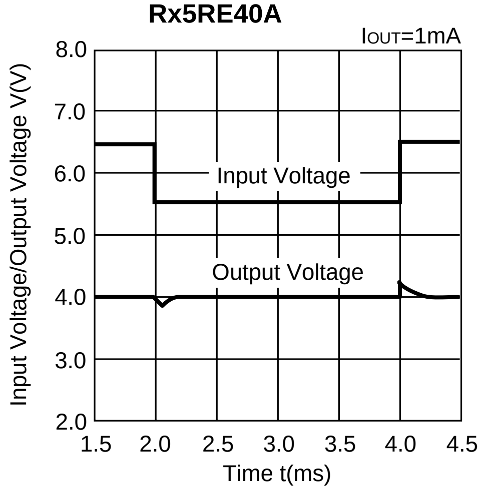
Rx5RE20A



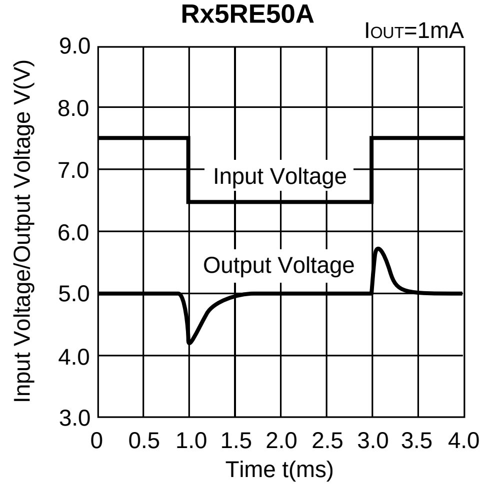
Rx5RE30A



Rx5RE40A

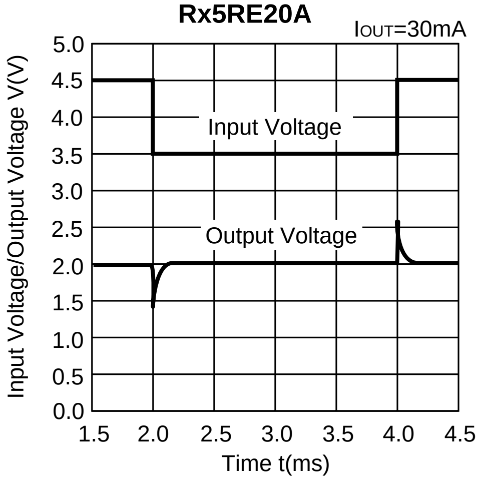


Rx5RE50A

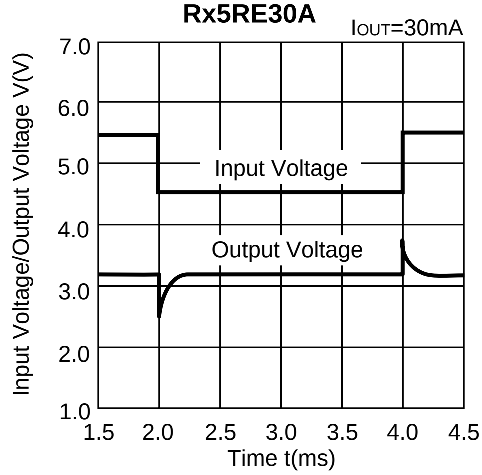


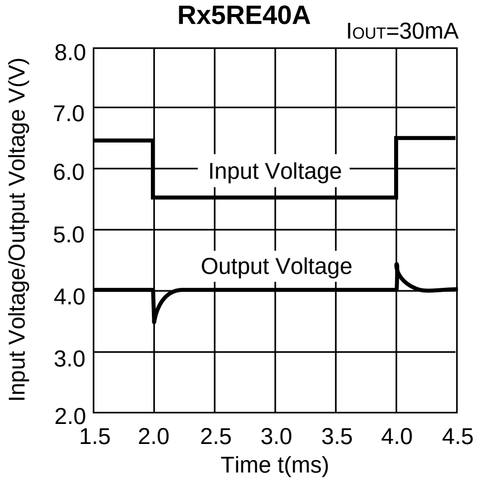
9) Line Transient Response (2)

Rx5RE20A

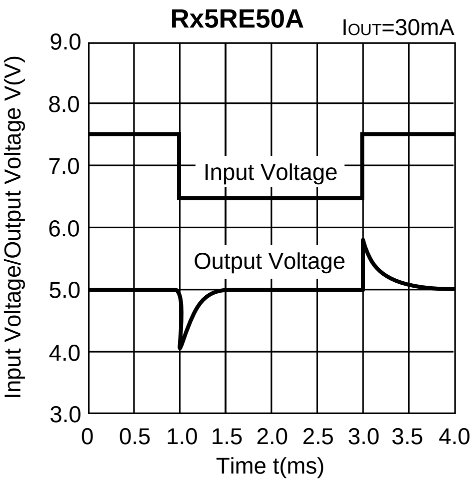


Rx5RE30A



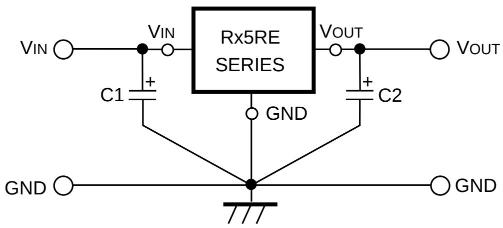


Rx5RE40A
IOUT=30mA
Input Voltage/Output Voltage V(V)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
Input Voltage
Output Voltage
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Time t(ms)



Rx5RE50A
IOUT=30mA
Input Voltage/Output Voltage V(V)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
Input Voltage
Output Voltage
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Time t(ms)

TYPICAL APPLICATION

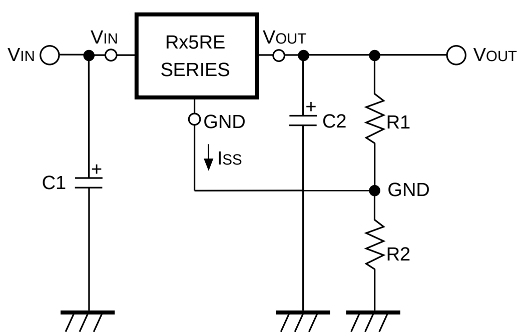


In Rx5RE Series, a constant voltage can be obtained without using capacitors C1 and C2. However, when the wire connected to VIN is long, use capacitor C1. Output noise can be reduced by using capacitor C2.

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 :

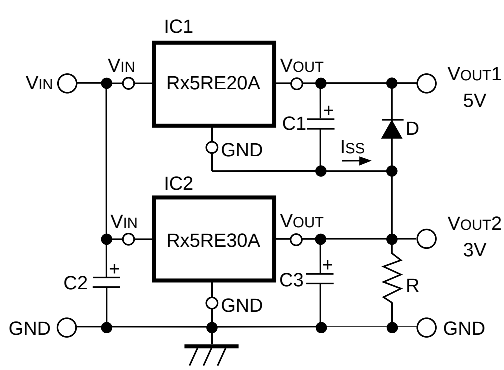
$$V_{OUT}=V_{reg}^{*1}\cdot(1+R2/R1)+I_{SS}\cdot R2$$

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.

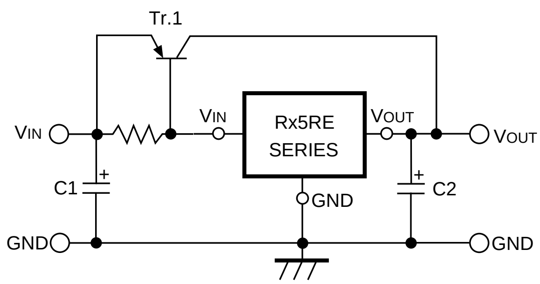
• DUAL POWER SUPPLY CIRCUIT



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

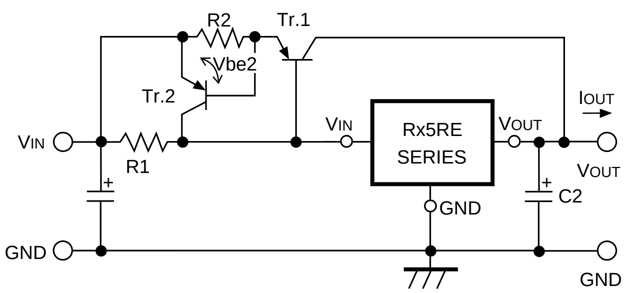
This circuit diagram shows a dual power supply circuit with an output of 3V and an output of 5V. When the minimum output current of IC2 is larger than ISS of IC1, resistor R is unnecessary. Diode D is a protection diode for the case where VOUT2 becomes larger than VOUT1.

• 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



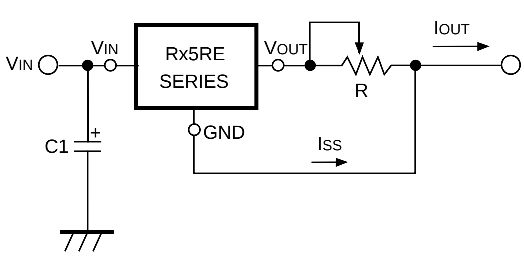
A circuit for protecting Tr.1 from the destruction caused by output short-circuit or overcurrent is shown in this circuit diagram.

When the voltage reduction caused by the current (≒ IOUT) which flows through R2 reaches Vbe2 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 :

$I_{OUT} \fallingdotseq Vbe2/R2$

• CURRENT SOURCE



A current source with the structure as shown in this circuit diagram can be used. Output Current IOUT is obtained as follows :

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

Take care that Output Current IOUT does not exceed its allowable current.

*1) Vreg : Set Output Voltage of Rx5RE Series.

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