SOT-23-5 VFM STEP-UP DC/DC CONVERTER

RN5RK××1A/××1B/××2A SERIES

APPLICATION MANUAL

NO. EA-045-0006

RICOH

SOT-23-5 VFM STEP-UP DC/DC CONVERTER

RN5RK××1A/××1B/××2A SERIES

OUTLINE

The RN5RK××1A/××1B/××2A Series are VFM (Chopper) Step-up DC/DC converter ICs with ultra low supply current and high output voltage accuracy by CMOS process.

Each of the RN5RK××1A/××1B consists of an oscillator, a VFM control circuit, a driver transistor to have low ON resistance (Lx switch), a reference voltage unit, a high speed comparator, resistors for voltage detection, an Lx switch protection circuit and an internal chip enable circuit. A low ripple, high efficiency step-up DC/DC converter can be composed of this RN5RK××1A/××1B with only three external components: an inductor, a diode and a capacitor.

The RN5RK××2A uses the same chip as what is employed in the RN5RK××1A/1B IC and has a drive pin (EXT) for an external transistor instead of an Lx pin. As it is possible to load a large output current with a power transistor which has a low saturation voltage, RN5RK××2A IC is recommendable to users who need an output current as large as between several tens mA and several hundreds mA.

Using the chip enable function, it is possible to make the supply current on standby minimized.

Since the package for these ICs are SOT-23-5 (Mini-mold), high density mounting of the ICs on board is possible.

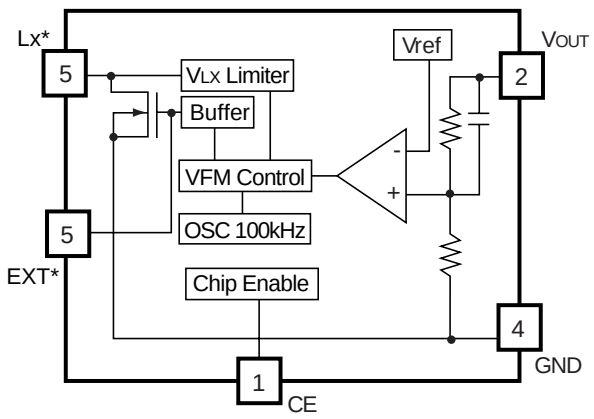
FEATURES

- Small Number of External Components ..... Only an inductor, a diode and a capacitor (RN5RK××1A/××1B)
- Ultra Low Input Current on Standby ..... TYP. 0μA
- High Output Voltage Accuracy ..... ±2.5%
- Low Ripple and Low Noise
- Low Start-up Voltage..... MAX. 0.9V
- High Efficiency ..... TYP. 80%
- Including a Driver Transistor with Low ON Resistance
- Two Kinds of Duty Ratio ..... 77% (××1A, ××2A)/ 55% (××1B)
- Output Voltage ..... Stepwise setting with a step of 0.1V in the range of 2.0V to 5.5V is possible (refer to Selection Guide)
- Low Temperature-Drift Coefficient of Output Voltage..... TYP. ±100ppm/°C
- Small Packages ..... SOT-23-5 (Mini-Mold)

APPLICATIONS

- Power source for battery-powered equipment.
- Power source for cameras, camcorders, VCRs, and hand-held communication equipment.
- Power source for those appliances which require higher cell voltage than that of batteries.

BLOCK DIAGRAM



*) Lx pin: only for RN5RK××1A/××1B

SELECTION GUIDE

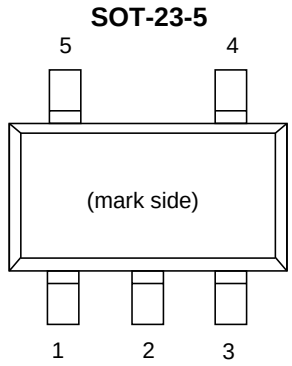
The output voltage, the driver type, the duty cycle and the taping type for the ICs can be selected at the user's request.

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

RN5RK xxxx-xx ←Part Number
↑↑↑ ↑
a bc d

Code	Contents
a	Setting Output Voltage (V_{OUT}) : Stepwise setting with a step of 0.1V in the range of 2.0V to 5.5V is possible.
b	Designation of Driver 1: Internal Lx Tr. Driver 2: External Tr. Driver
c	Designation of Duty Cycle A: 77% B: 55%
d	Designation of Taping type Ex. TR, TL (refer to Taping Specifications, TR type is prescribed as a standard.)

PIN CONFIGURATION



PIN DESCRIPTION

Pin No.	Symbol	Pin description
1	CE	Chip Enable Pin
2	V_{OUT}	Step-up Output Monitoring Pin, Power Supply (for device itself)
3	NC	No Connection
4	GND	Ground Pin
5	L_X	Switching Pin (Nch Open Drain)

Pin No.	Symbol	Pin description
1	CE	Chip Enable Pin
2	V_{OUT}	Step-up Output Monitoring Pin, Power Supply (for device itself)
3	NC	No Connection
4	GND	Ground Pin
5	EXT	External Tr. Drive Pin (CMOS Output)

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{OUT}	Step-up Output Pin Voltage	9	V
V_{LX}	Lx Pin Voltage	9	V
V_{EXT}	EXT Pin Voltage	–0.3 to V_{OUT} +0.3	V
V_{CE}	CE Pin Voltage	–0.3 to V_{OUT} +0.3	V
I_{LX}	Lx Pin Output Current	500	mA
I_{EXT}	EXT Pin Output Current	±30	mA
P_D	Power Dissipation	250	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

- **RN5RK 1A/ 1B**

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=set V_{OUT}×0.6, I_{OUT}=1mA	×0.975		×1.025	V
V_{IN}	Input Voltage				8	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	-40°C≤Topt≤85°C		±100		ppm/°C
Vstart	Start-Up Voltage	V_{IN}=0V→2V*1		0.75	0.9	V
ΔVstart/ΔTopt	Start-Up Voltage Temperature Coefficient	-40°C≤Topt≤85°C V_{IN}=0V→2V*1		-1.6		mV/°C
Vhold	Hold-on Voltage (××1A)	V_{IN}=2V→0V*1	0.7			V
Vhold	Hold-on Voltage (××1B)	V_{IN}=2V→0V*1	0.9			V
I_{DD2}	Supply Current2	V_{OUT}=V_{CE}=set V_{OUT}+0.5V		2	5	μA
Istanby	Standby Current	V_{OUT}=6V, V_{CE}=0V			0.5	μA
I_{LXleak}	Lx Leakage Current	V_{OUT}=V_{LX}=8V			1	μA
fosc	Maximum Oscillator Frequency	V_{OUT}=V_{CE}=set V_{OUT}×0.96	80	100	120	kHz
Δfosc/ΔTopt	Frequency Temperature Coefficient	-40°C≤Topt≤85°C		0.41		kHz/°C
Duty	Oscillator Duty Cycle (××1A)	V_{OUT}=V_{CE}=set V_{OUT}×0.96, ON (VLx "L" side)	70	77	85	%
Duty	Oscillator Duty Cycle (××1B)	V_{OUT}=V_{CE}=set V_{OUT}×0.96, ON (VLx "L" side)	47	55	63	%
V_{lxlim}	VLx Voltage Limit	V_{OUT}=V_{CE}=1.95V, Lx Switch ON	0.4	0.6	0.8	V
V_{CEH}	CE "H" Input Voltage	V_{OUT}=V_{CE}=set V_{OUT}×0.96, Judgment is made by the Lx waveform	0.9			V
V_{CEL}	CE "L" Input Voltage	V_{OUT}=V_{CE}=set V_{OUT}×0.96, Judgment is made by the Lx waveform			0.3	V
I_{CEH}	CE "H" Input Current	V_{OUT}=6.0V, V_{CE}=6.0V	-0.5	0	0.5	μA
I_{CEL}	CE "L" Input Current	V_{OUT}=6.0V, V_{CE}=0.0V	-0.5	0	0.5	μA
I_{DD1}	Supply Current1 *2	2.0V≤V_{OUT}≤2.4V		25	50	μA
I_{DD1}	Supply Current1 *2	2.5V≤V_{OUT}≤2.9V		30	55	μA

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
I_{DD1}	Supply Current1 *2	3.0V≤V_{OUT}≤3.4V		35	60	μA
I_{DD1}	Supply Current1 *2	3.5V≤V_{OUT}≤3.9V		40	65	μA
I_{DD1}	Supply Current1 *2	4.0V≤V_{OUT}≤4.4V		45	75	μA
I_{DD1}	Supply Current1 *2	4.5V≤V_{OUT}≤4.9V		50	80	μA
I_{DD1}	Supply Current1 *2	5.0V≤V_{OUT}≤5.5V		60	90	μA
I_{LX}	Lx Switching Current	2.0V≤V_{OUT}≤2.4V, V_{LX}=0.4V	80			mA
I_{LX}	Lx Switching Current	2.5V≤V_{OUT}≤2.9V, V_{LX}=0.4V	100			mA
I_{LX}	Lx Switching Current	3.0V≤V_{OUT}≤3.4V, V_{LX}=0.4V	120			mA
I_{LX}	Lx Switching Current	3.5V≤V_{OUT}≤3.9V, V_{LX}=0.4V	140			mA
I_{LX}	Lx Switching Current	4.0V≤V_{OUT}≤4.4V, V_{LX}=0.4V	160			mA
I_{LX}	Lx Switching Current	4.5V≤V_{OUT}≤4.9V, V_{LX}=0.4V	180			mA
I_{LX}	Lx Switching Current	5.0V≤V_{OUT}≤5.5V, V_{LX}=0.4V	200			mA

*1) Condition: An Output load resistor R_L is connected between V_{OUT} and GND.
Note that the resistor R_L has a resistance which makes an output current 1mA after step-up operation.

*2) The Supply Current 1 (I_{DD1}) for IC itself is measured when the internal oscillator works continuously.
If the oscillator works intermittently, the supply current becomes smaller than the value which is written on the above table.
Measurement condition: V_{OUT}=V_{CE}=Setting Output Voltage ×0.96

- **RN5RK××2A**

Topt=25°C

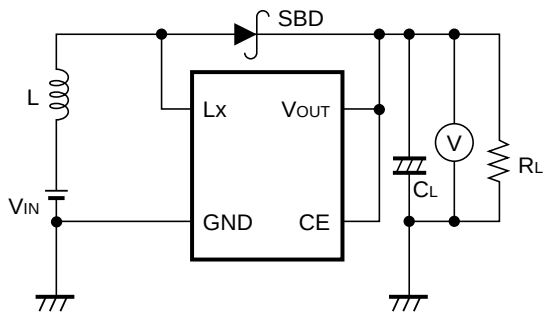
Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=set V_{OUT}×0.6, I_{OUT}=1mA	×0.975		×1.025	V
V_{IN}	Input Voltage				8	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	-40°C≤Topt≤85°C		±100		ppm/°C
Vstart	Start-Up Voltage	V_{IN}=0V→2V*1		0.7	0.8	V
ΔVstart/ΔTopt	Start-Up Voltage Temperature Coefficient	-40°C≤Topt≤85°C V_{IN}=0V→2V*1	-1.6			mV/°C
I_{DD2}	Supply Current2	V_{OUT}=V_{CE}=set V_{OUT}+0.5V		2	5	μA
Istanby	Standby Current	V_{OUT}=6V, V_{CE}=0V			0.5	μA
Fosc	Maximum Oscillator Frequency	V_{OUT}=V_{CE}=set V_{OUT}×0.96	80	100	120	kHz
Δfosc/ΔTopt	Frequency Temperature Coefficient	-40°C≤Topt≤85°C		0.41		kHz/°C
Duty	Oscillator Duty Cycle	V_{OUT}=V_{CE}=set V_{OUT}×0.96, ON (V_{EXT} "H" side)	70	77	85	%
V_{CEH}	CE "H" Input Voltage	V_{OUT}=V_{CE}=set V_{OUT}×0.96, Judgment is made by the EXT waveform	0.9			V
V_{CEL}	CE "L" Input Voltage	V_{OUT}=V_{CE}=set V_{OUT}×0.96 Judgment is made by the EXT waveform			0.3	V
I_{CEH}	CE "H" Input Current	V_{OUT}=6.0V, V_{CE}=6.0V	-0.5	0	0.5	μA
I_{CEL}	CE "L" Input Current	V_{OUT}=6.0V, V_{CE}=0.0V	-0.5	0	0.5	μA
I_{DD1}	Supply Current1	2.0V≤V_{OUT}≤2.9V, EXT no load*2		20	40	μA
I_{DD1}	Supply Current1	3.0V≤V_{OUT}≤3.9V, EXT no load*2		25	50	μA
I_{DD1}	Supply Current1	4.0V≤V_{OUT}≤4.9V, EXT no load*2		30	60	μA
I_{DD1}	Supply Current1	5.0V≤V_{OUT}≤5.5V, EXT no load*2		35	70	μA
I_{EXTH}	EXT "H" Output Voltage	2.0V≤V_{OUT}≤2.9V, V_{EXT}=V_{OUT}-0.4V			-1.0	mA
I_{EXTH}	EXT "H" Output Voltage	3.0V≤V_{OUT}≤3.9V, V_{EXT}=V_{OUT}-0.4V			-1.5	mA

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
I_{EXTH}	EXT "H" Output Voltage	4.0V≤V_{OUT}≤5.5V, V_{EXT}=V_{OUT}-0.4V			-2.0	mA
I_{EXTH}	EXT "L" Output Voltage	2.0V≤V_{OUT}≤2.9V, V_{EXT}=0.4V	1.0			mA
I_{EXTH}	EXT "L" Output Voltage	3.0V≤V_{OUT}≤3.9V, V_{EXT}=0.4V	1.5			mA
I_{EXTH}	EXT "L" Output Voltage	4.0V≤V_{OUT}≤5.5V, V_{EXT}=0.4V	2.0			mA

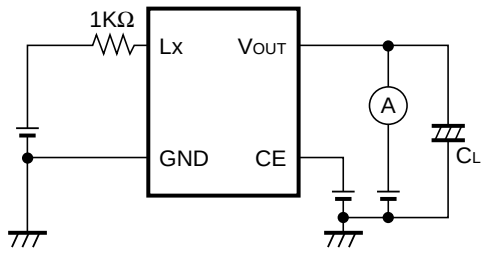
*1) Condition: An Output load resistor R_L is connected between V_{OUT} and GND.
Note that the resistor R_L has a resistance which makes an output current 1mA after step-up operation.

*2) The Supply Current 1 (I_{DD1}) for IC itself is measured when the internal oscillator works continuously.
If the oscillator works intermittently, the supply current becomes smaller than the value which is written on the above table. Measurement condition: V_{OUT}=V_{CE}=Setting Output Voltage ×0.96

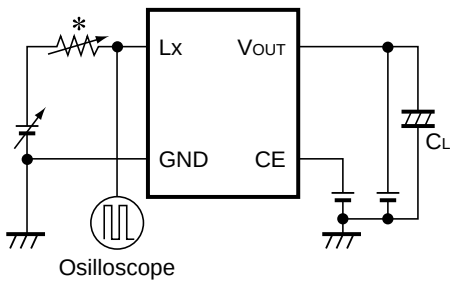
TEST CIRCUITS



Test Circuit 1



Test Circuit 2



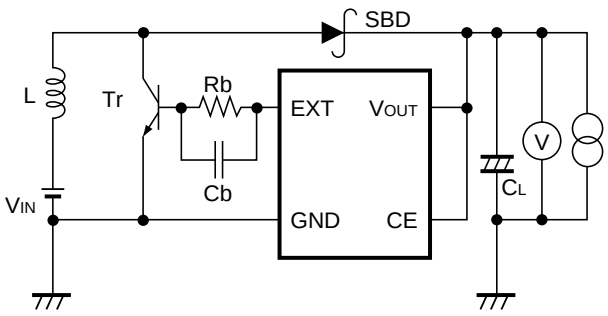
Test Circuit 3

*) When V_{LX}lim and I_{LX} are measured, the 5Ωresistor is used. Otherwise 1kΩis used.

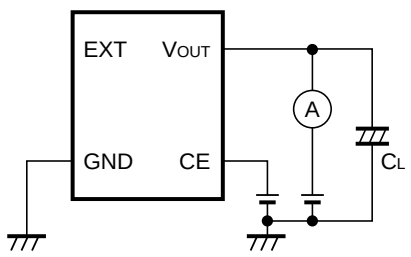
Components Inductor (L) : 100μH, 220μH (Sumida Electric Co., Ltd; CD-54)
Diode (SBD) : MA721 (Matsushita Electronics Corporation; Schottky Type)
Capacitor (C_L) : 47μF (Tantalum Type)

Using these test circuits characteristics data has been obtained as shown on the following pages.

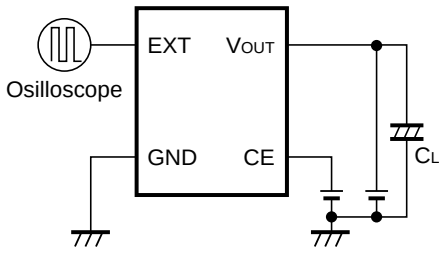
Test Circuit 1 : TYPICAL CHARACTERISTICS (1)-(7)
Test Circuit 2 : TYPICAL CHARACTERISTICS (9)-(11)
Test Circuit 3 : TYPICAL CHARACTERISTICS (8), (12)-(16)



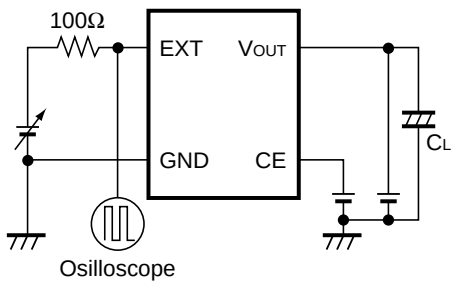
Test Circuit 1



Test Circuit 2



Test Circuit 3



Test Circuit 4

Components Inductor	(L)	: 27μH (Sumida Electric Co., Ltd; CD-104)
Diode	(SBD)	: RB111C (ROHM Co., Ltd; Schottky Type)
Capacitor	(C_L)	: 47μF×2(Tantalume Type)
Transistor	(Tr)	: 2SD1628G
Base Resistor	(Rb)	: 300ΩBase Capacitor (Cb): 0.01μF

Using these test circuits characteristics data has been obtained as shown on the following pages.

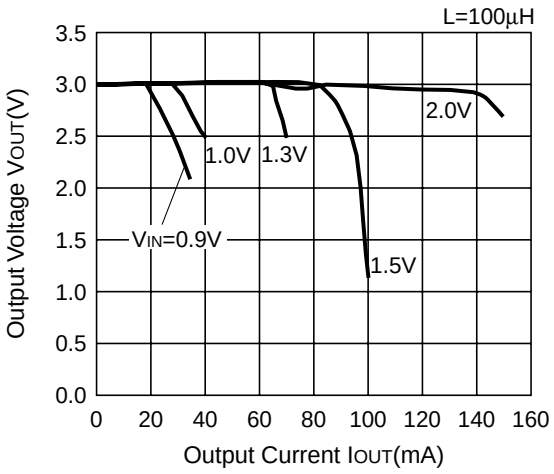
Test Circuit 1 : TYPICAL CHARACTERISTICS (1)-(5)
Test Circuit 2 : TYPICAL CHARACTERISTICS (8)-(10)
Test Circuit 3 : TYPICAL CHARACTERISTICS (11)-(14)
Test Circuit 4 : TYPICAL CHARACTERISTICS (6), (7)

TYPICAL CHARACTERISTICS

- **RN5RK××1A/B**

1) Output Voltage vs. Output Current (Topt=25°C)

RN5RK301A



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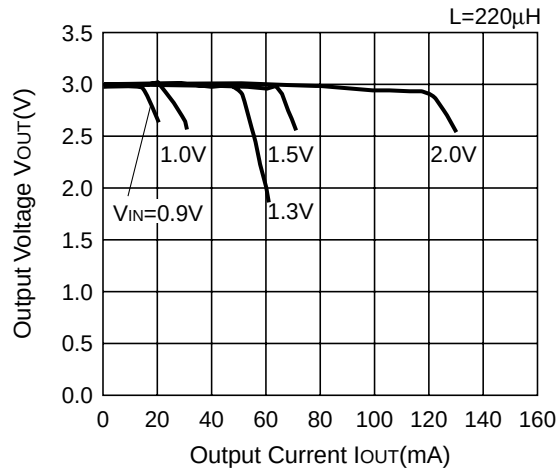

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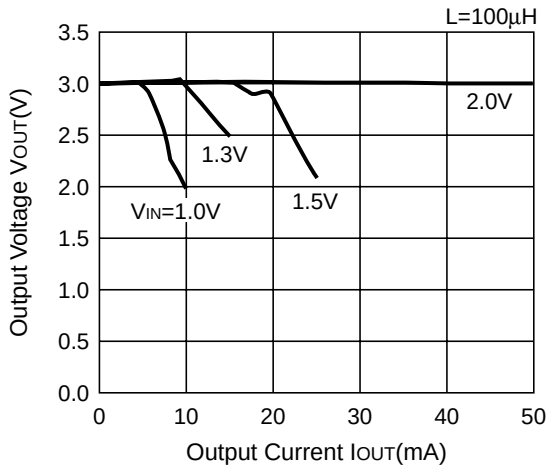

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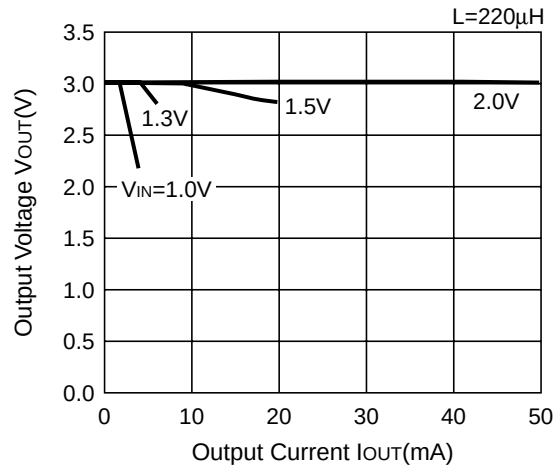

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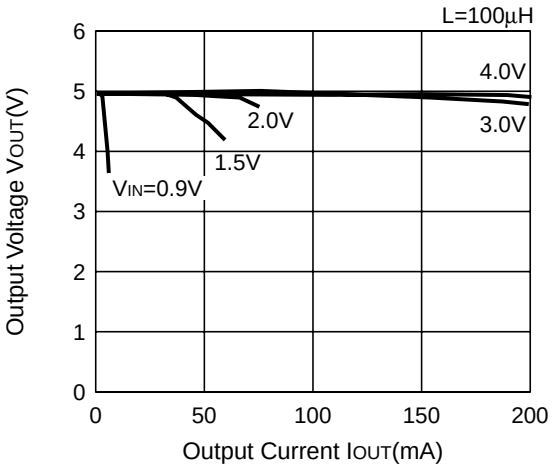

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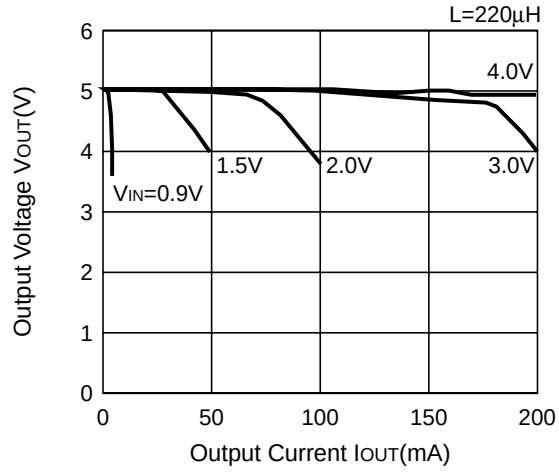

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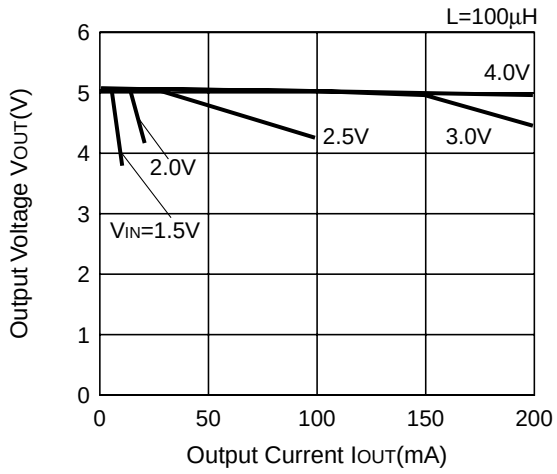

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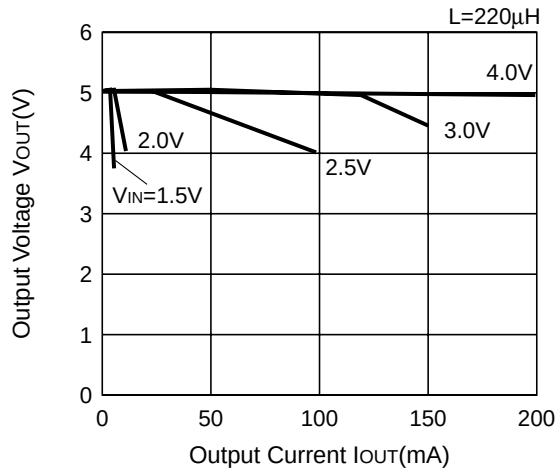
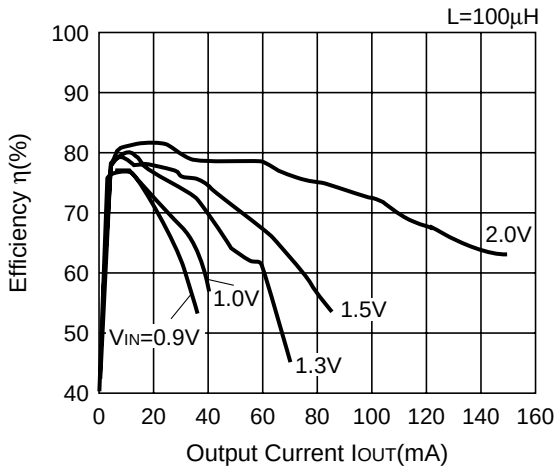


2) Efficiency vs. Output Current (Topt=25°C)

RN5RK301A



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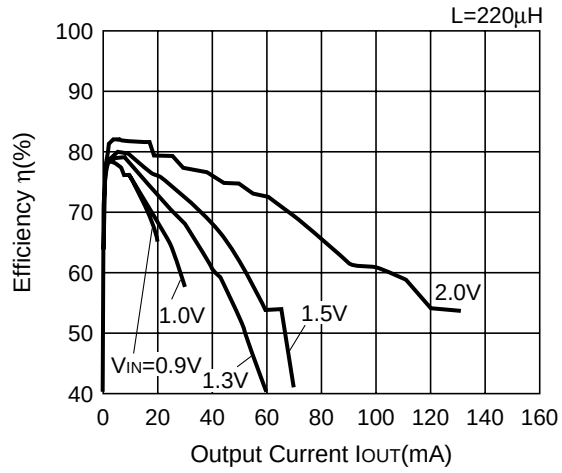

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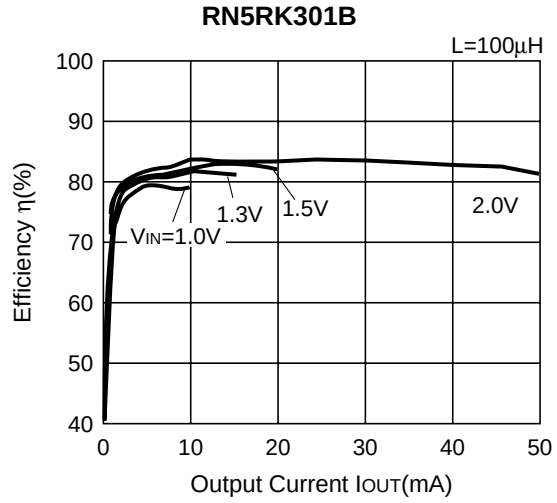

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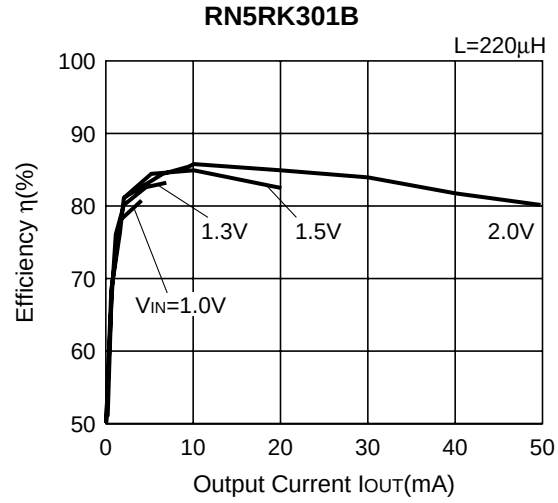
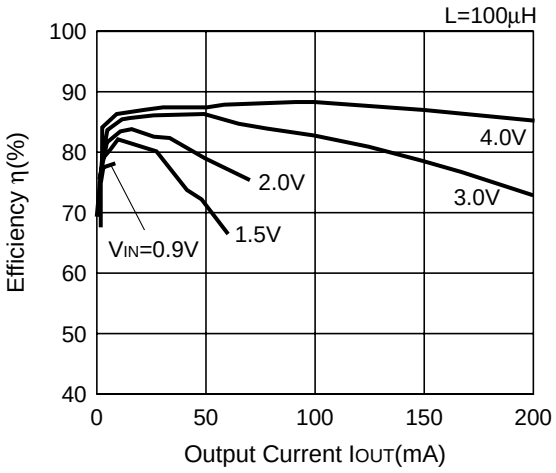
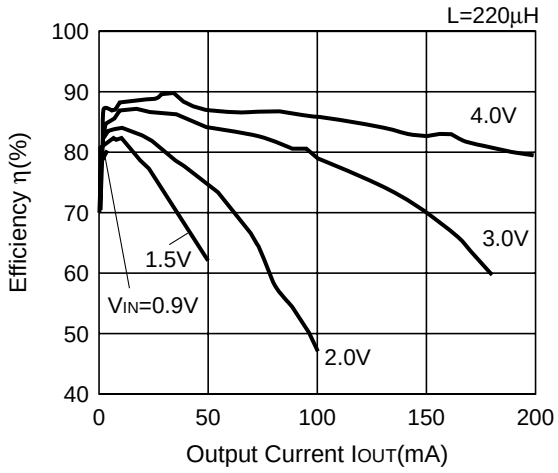


RICOH

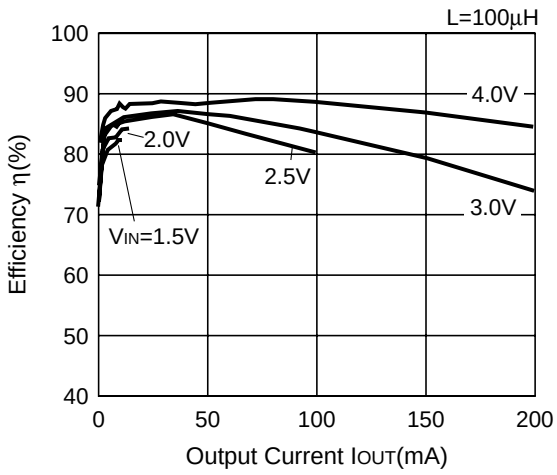
RN5RK501A



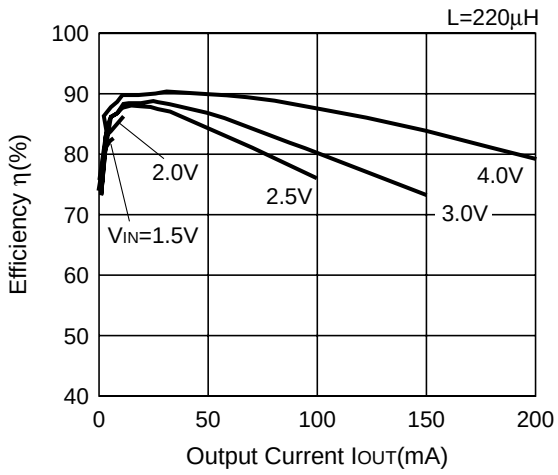
RN5RK501A



RN5RK501B

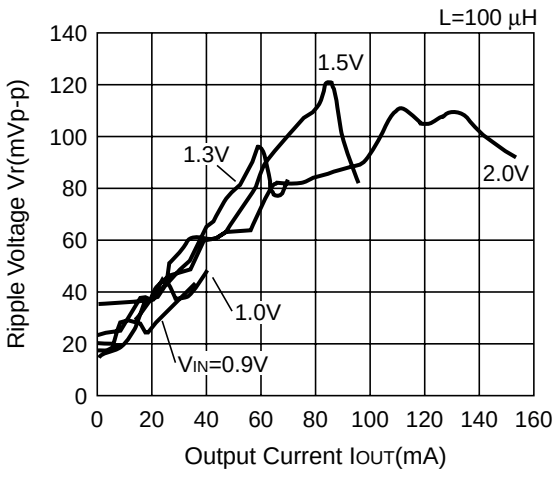


RN5RK501B

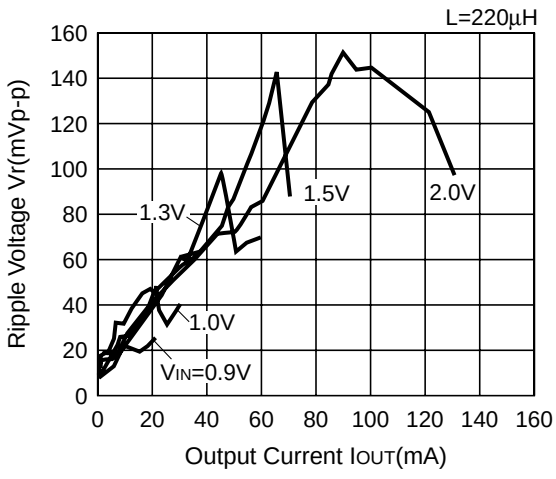


3) Ripple Voltage vs. Output Current (Topt=25°C)

RN5RK301A



RN5RK301A



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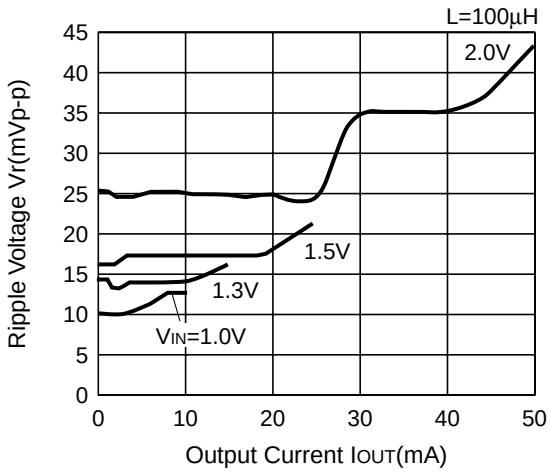
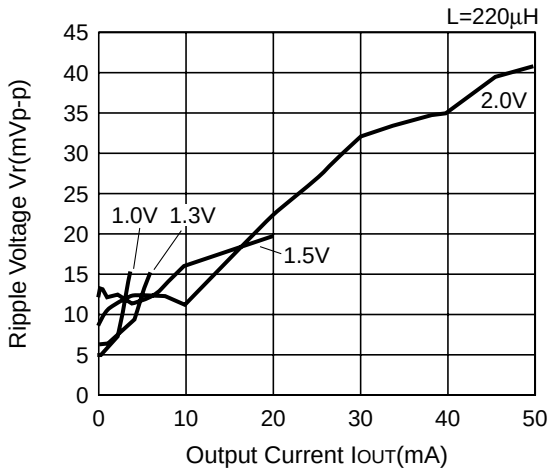
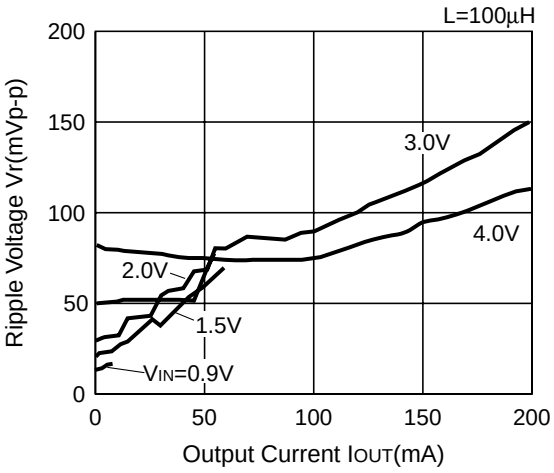


RN5RK301B



RN5RK501A



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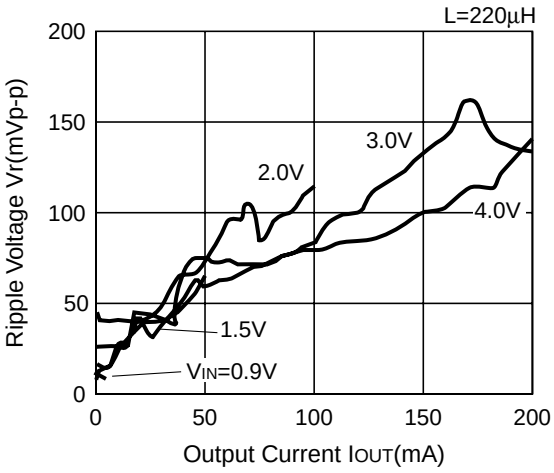

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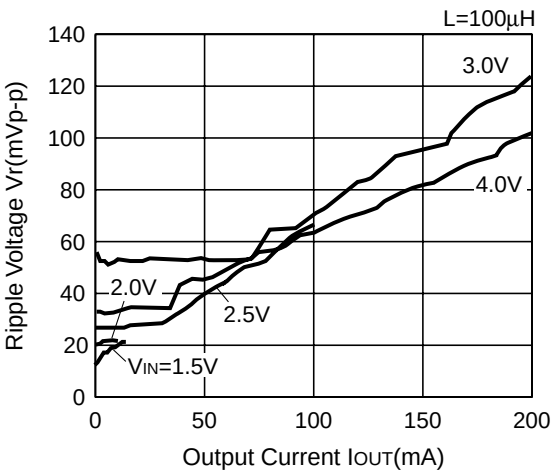

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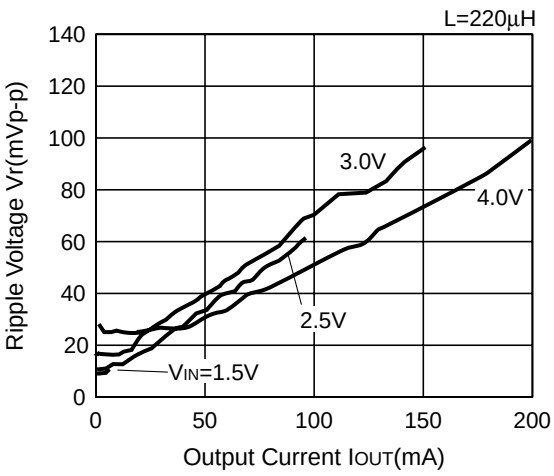
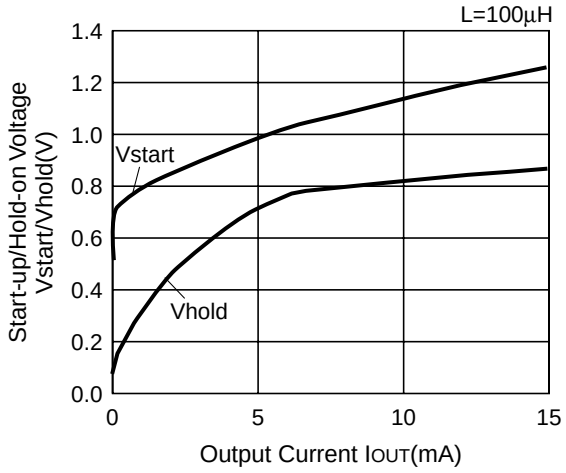


RICOH

4) Start-up/Hold-on Voltage vs. Output Current (Topt=25°C)

RN5RK301A



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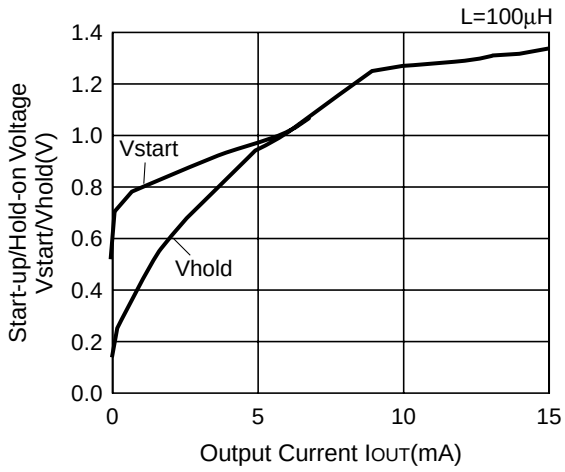

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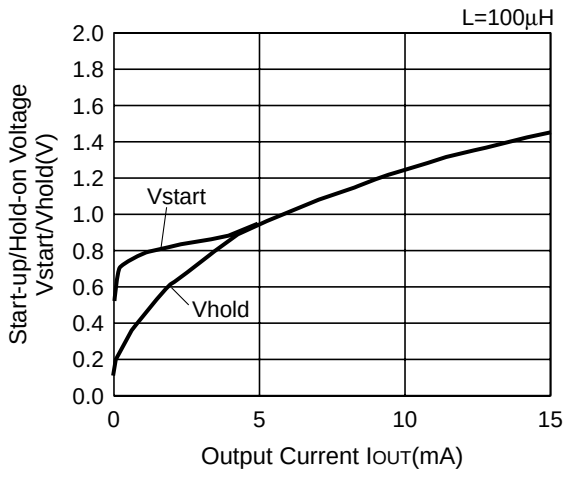

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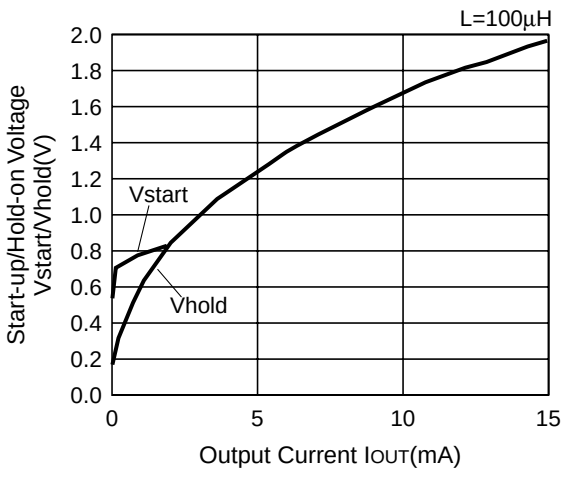
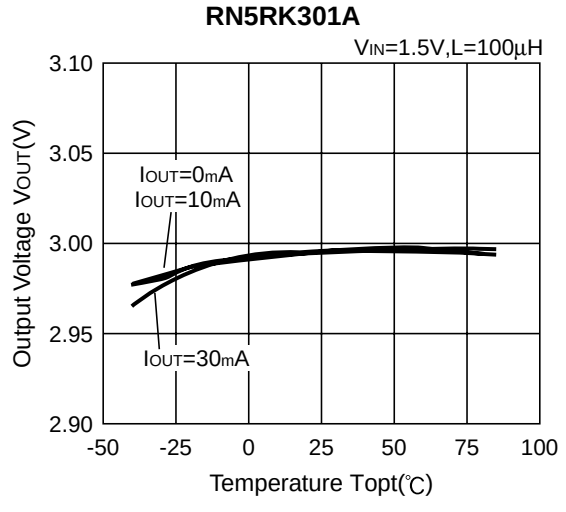


5) Output Voltage vs. Temperature

RN5RK301A



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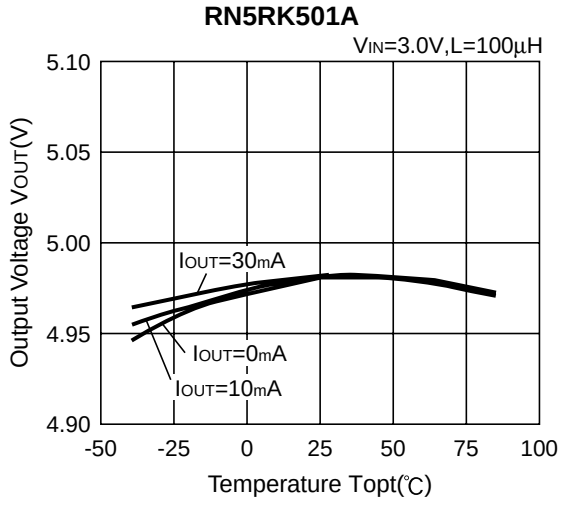
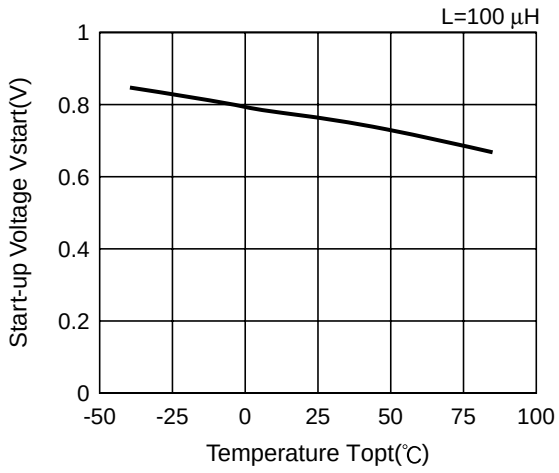


6) Start-up Voltage vs. Temperature

RN5RK501A



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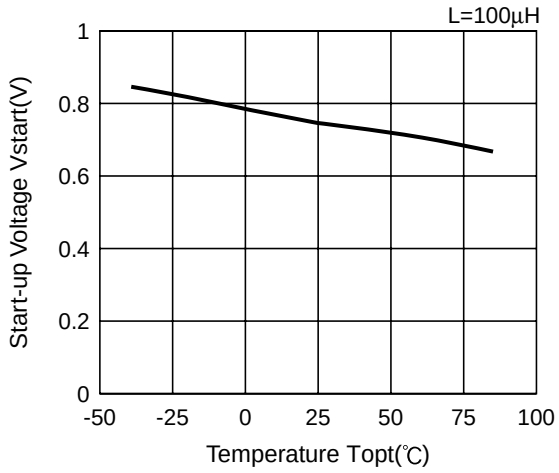
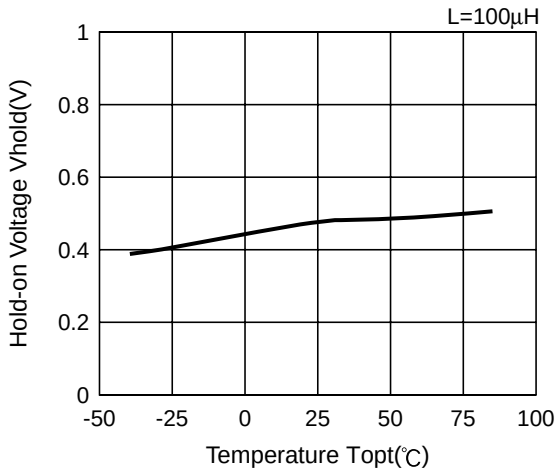


7) Hold-on Voltage vs. Temperature

RN5RK501A



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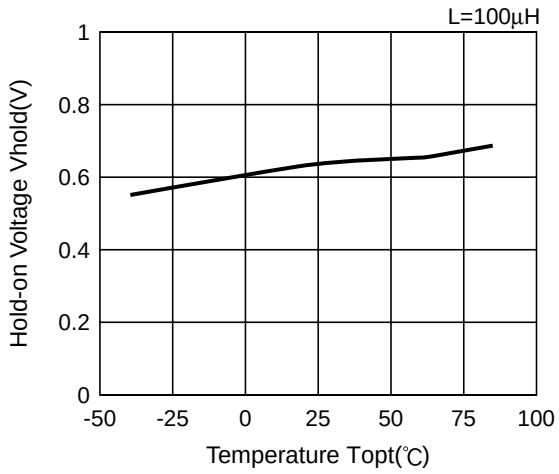
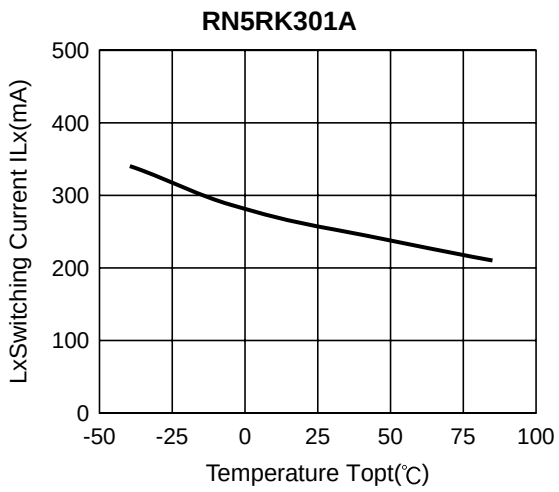
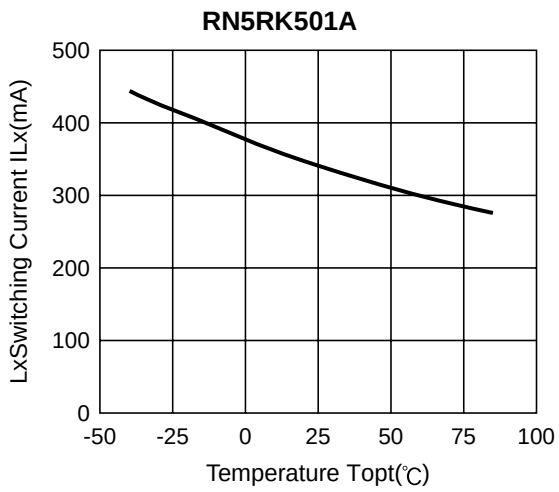


8) Lx Switching Current vs. Temperature

RN5RK301A

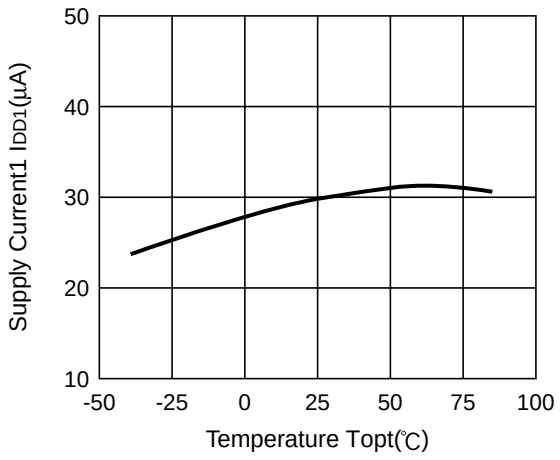


RN5RK501A



9) Supply Current 1 vs. Temperature

RN5RK301A



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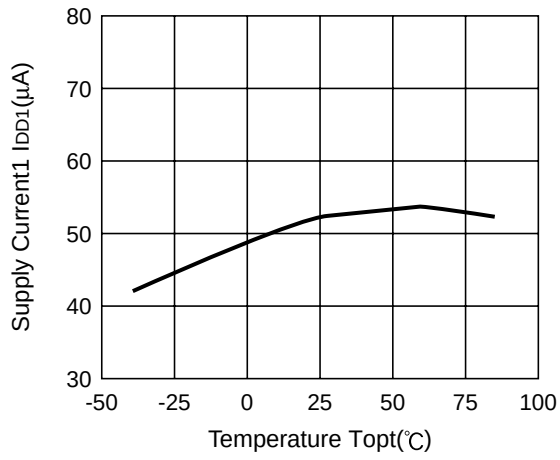
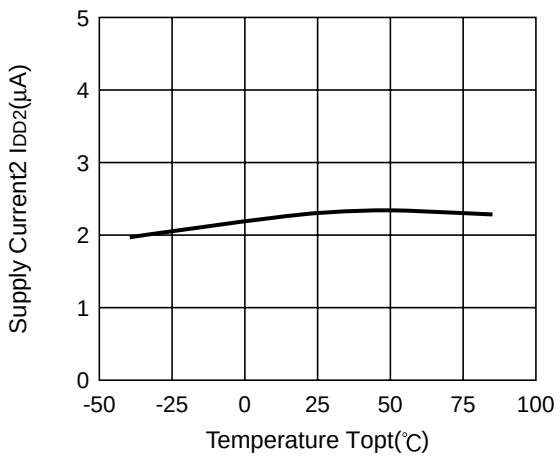


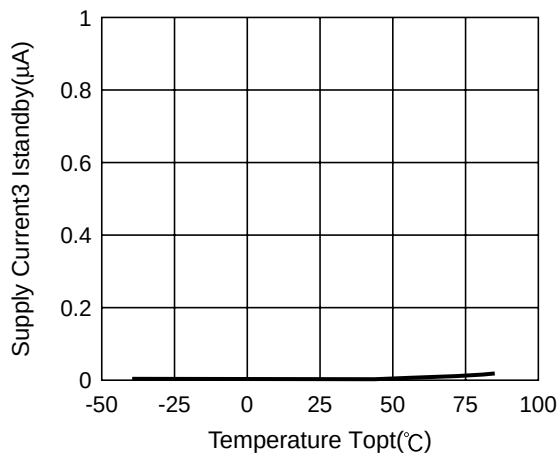
10) Supply Current 2 vs. Temperature

RN5RK301A



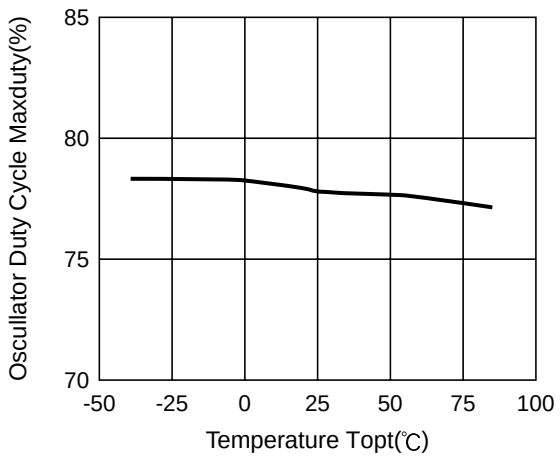
11) Standby Current 3 vs. Temperature

RN5RK301A

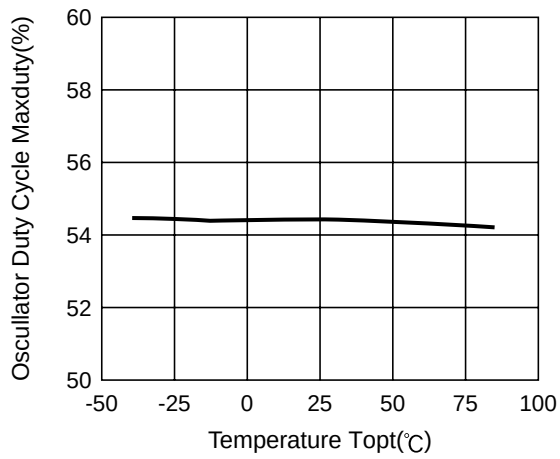


12) Oscillator Duty Cycle vs. Temperature

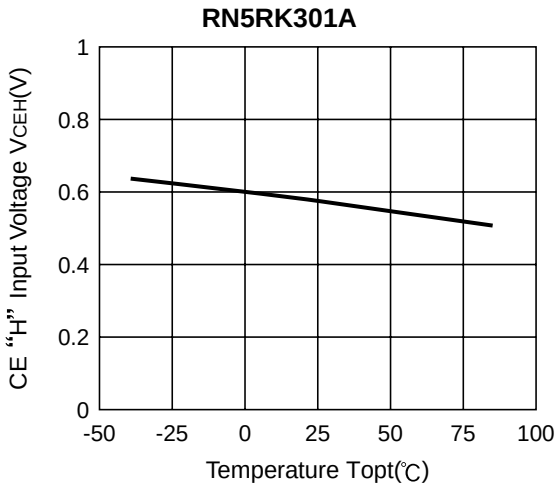
RN5RK301A



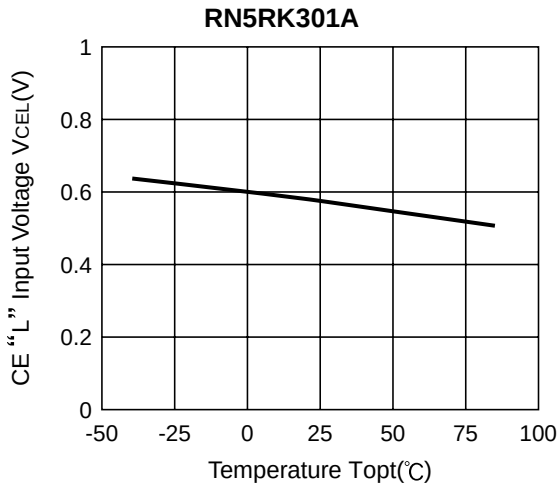
RN5RK301B



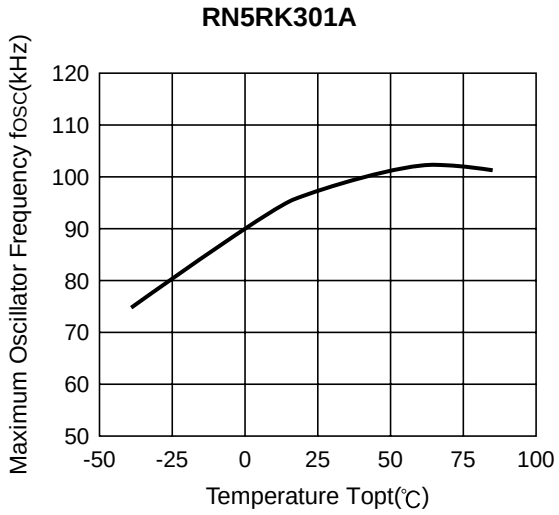
13) CE “H” Input Voltage vs. Temperature



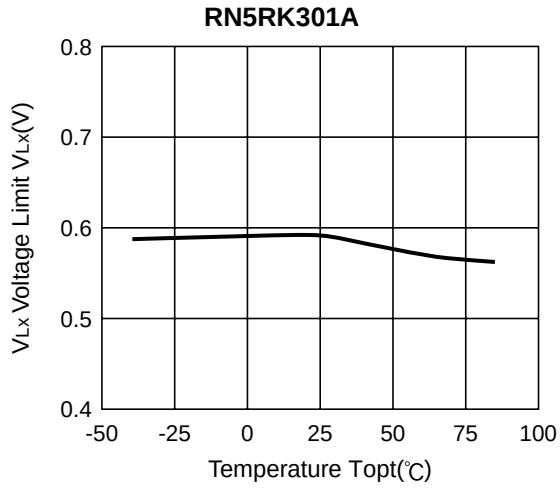
14) CE “L” Input Voltage vs. Temperature



15) Maximum Oscillator Frequency vs. Temperature



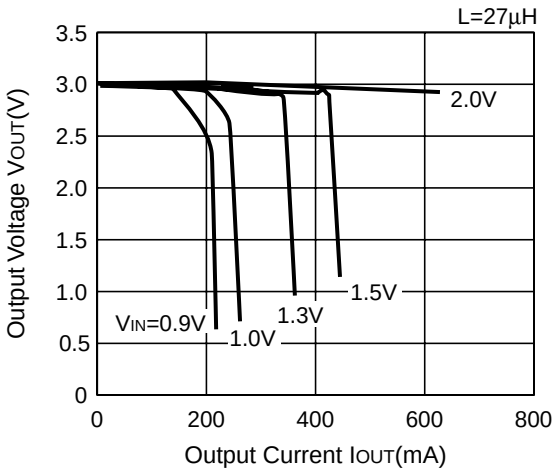
16) VLX Voltage Limit vs. Temperature



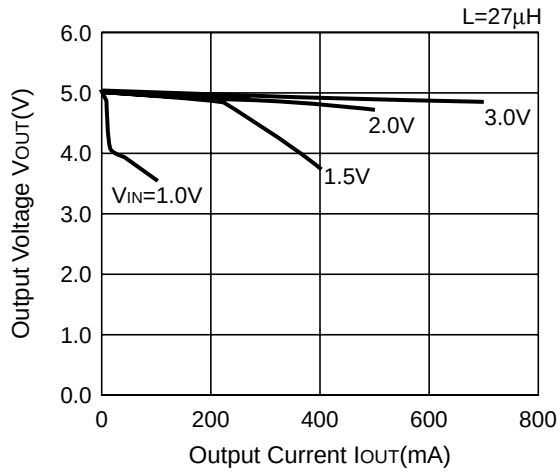
- **RN5RK××2A**

1) Output Voltage vs. Output Current (Topt=25°C)

RN5RK302A

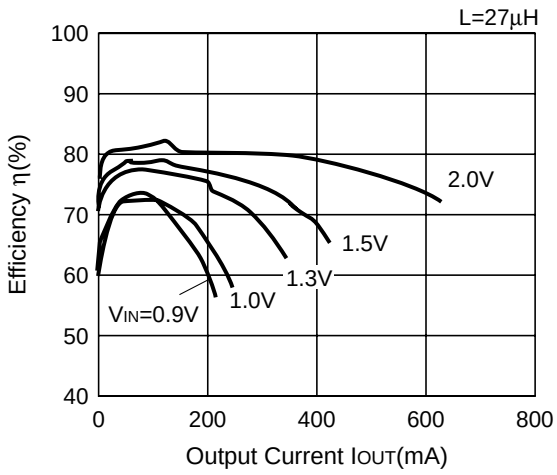


RN5RK502A

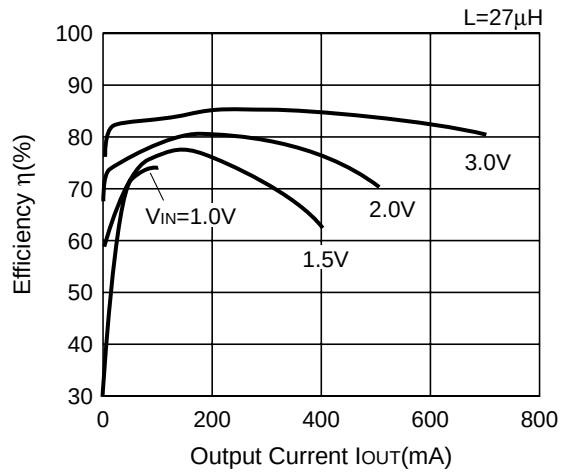


2) Efficiency vs. Output Current (Topt=25°C)

RN5RK302A

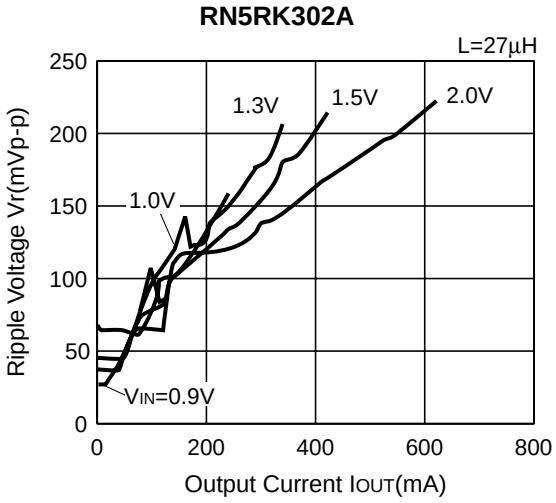


RN5RK502A

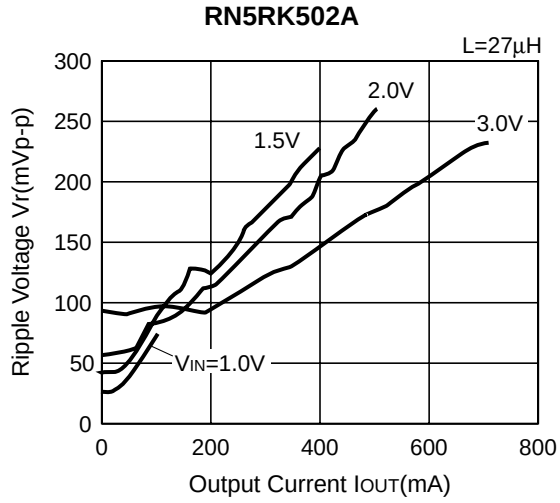


3) Ripple Voltage vs. Output Current (Topt=25°C)

RN5RK302A

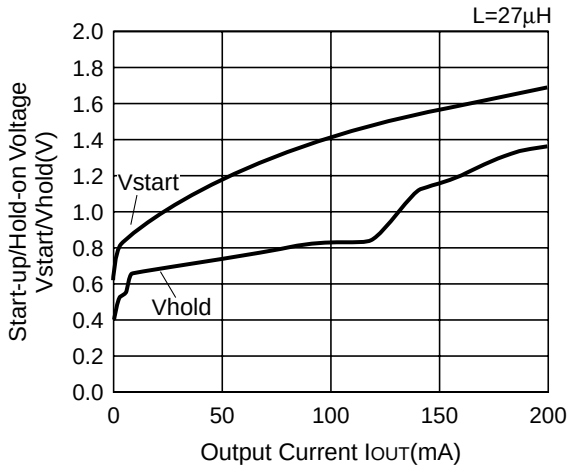


RN5RK502A

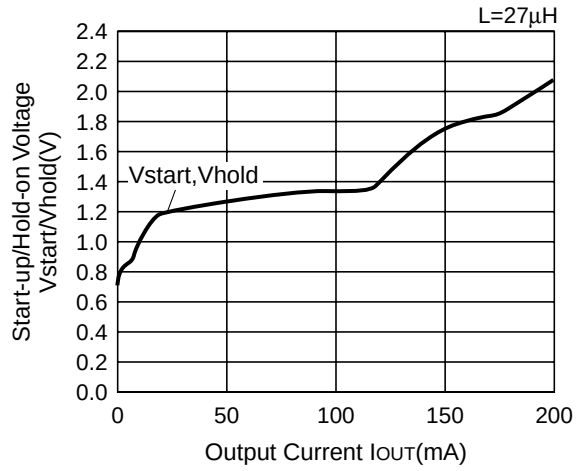


4) Start-up/Hold-on Voltage vs. Output Current (Topt=25°C)

RN5RK302A

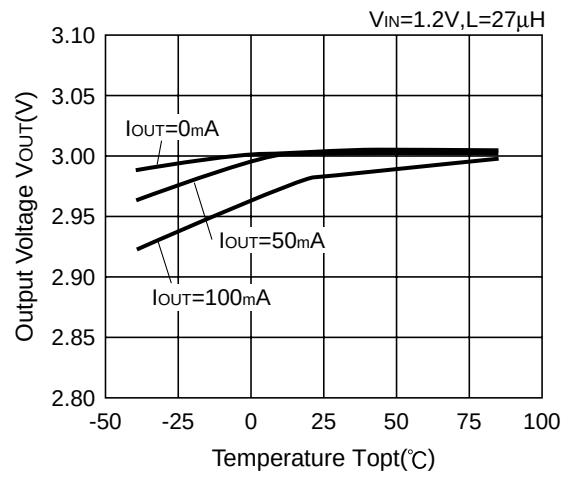


RN5RK502A

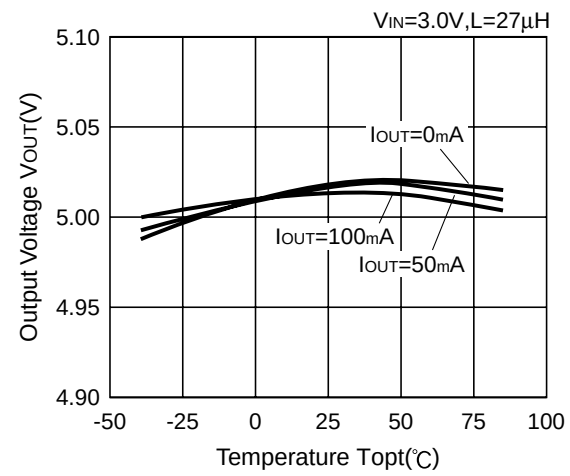


5) Output Voltage vs. Temperature

RN5RK302A

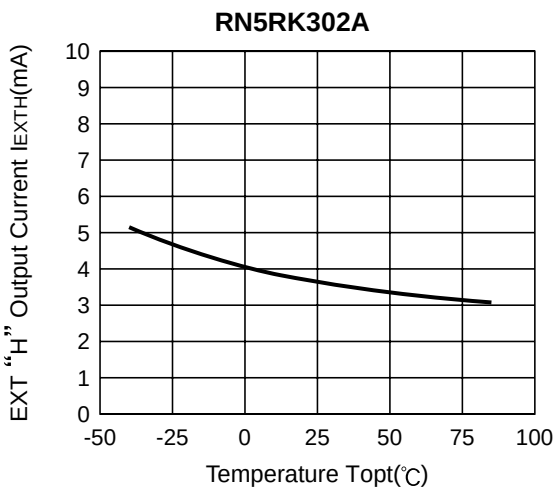


RN5RK502A

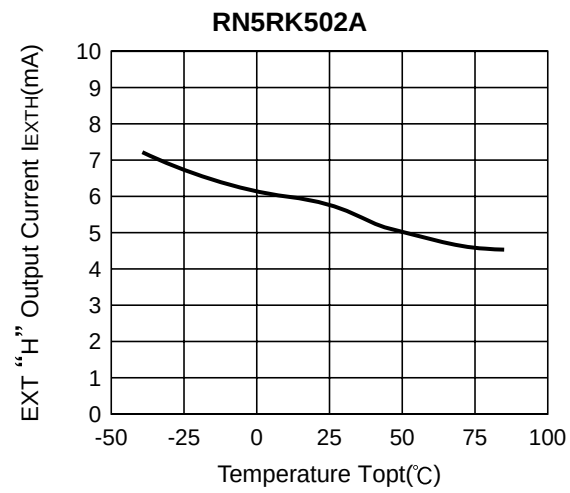


6) EXT "H" Output Current vs. Temperature

RN5RK302A

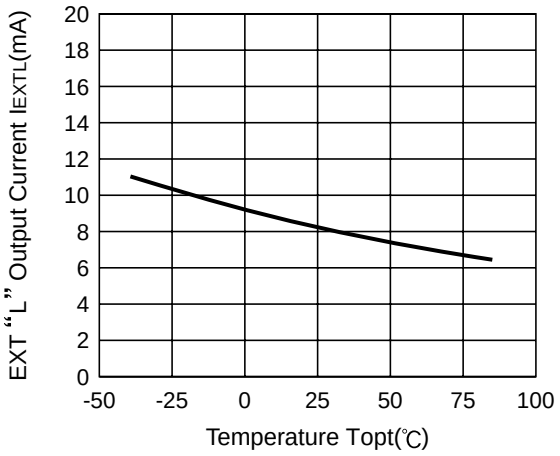


RN5RK502A

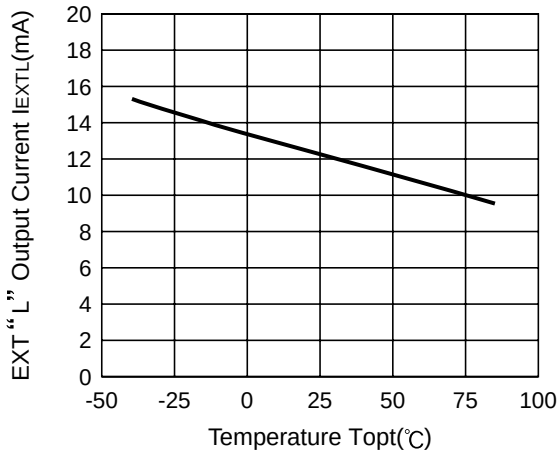


7) EXT “L” Output Current vs. Temperature

RN5RK302A

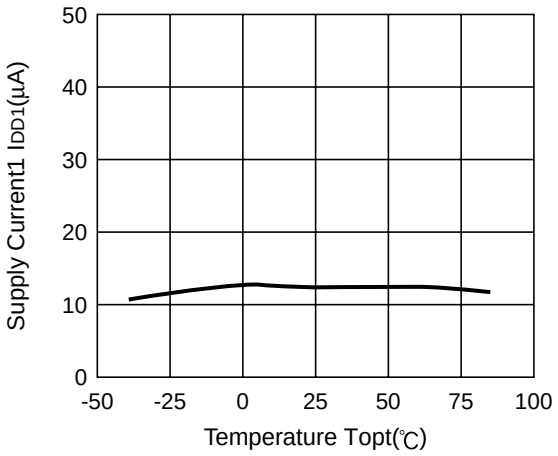


RN5RK502A

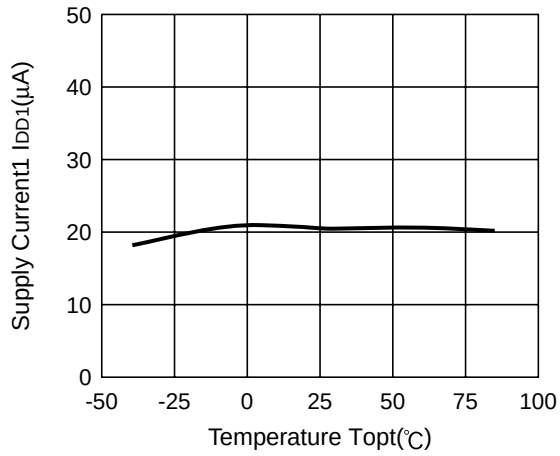


8) Supply Current 1 vs. Temperature

RN5RK302A

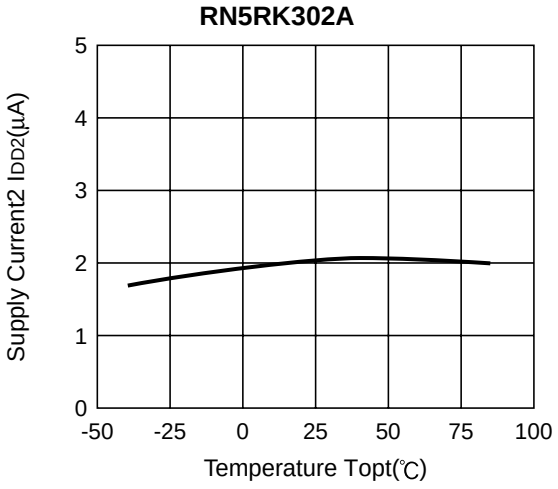


RN5RK502A



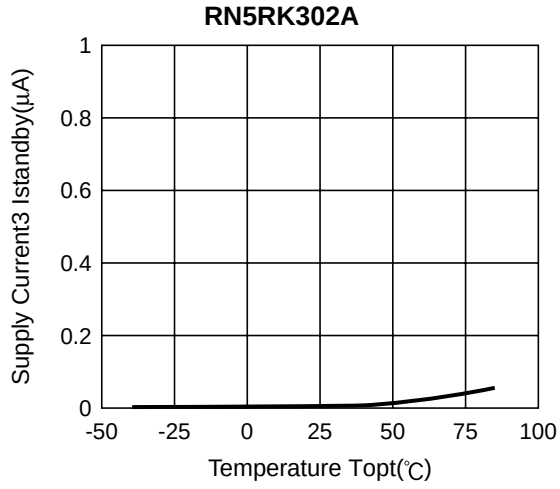
9) Supply Current 2 vs. Temperature

RN5RK302A

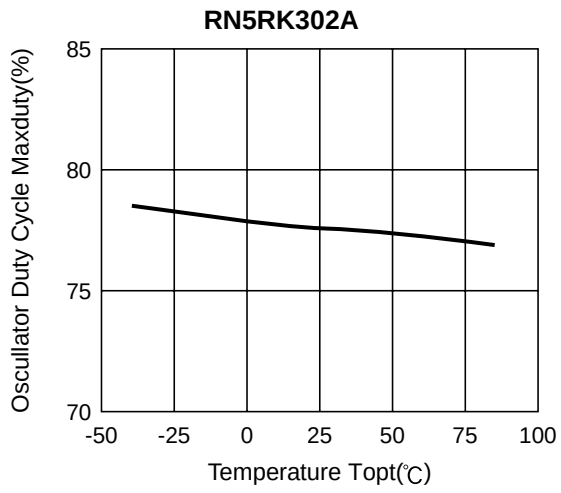


10) Standby Current vs. Temperature

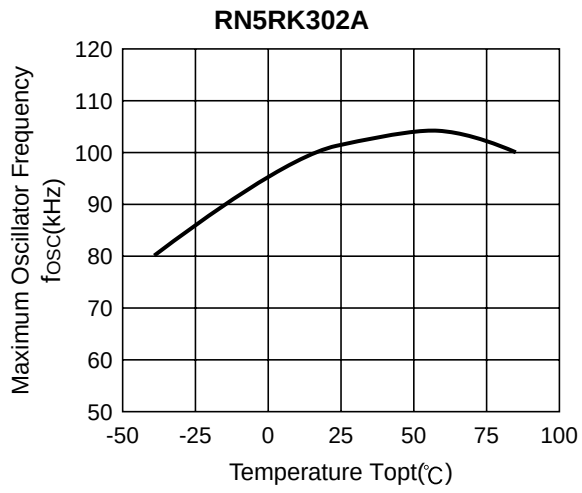
RN5RK302A



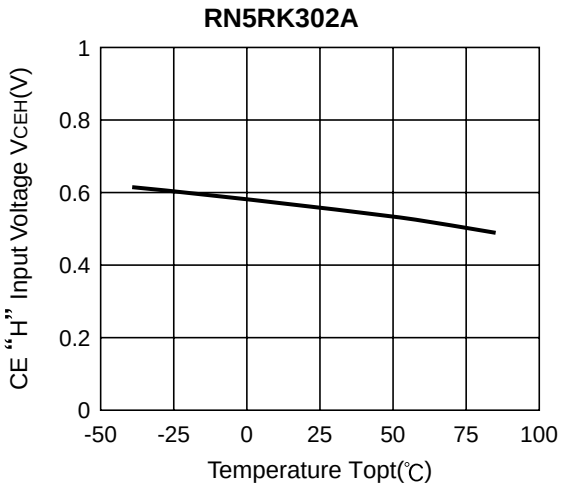
11) Oscillator Duty Cycle vs. Temperature



12) Maximum Oscillator Frequency vs. Temperature



13) CE "H" Input Voltage vs. Temperature



14) CE "L" Input Voltage vs. Temperature