VFM STEP-UP DC/DC CONVERTER

NO.EA-045-181012

OUTLINE

The RN5RKxx1A/xx1B/xx2A Series are CMOS-based VFM (Chopper) Step-up DC/DC converter ICs with ultra low supply current and high output voltage accuracy.

Each of the RN5RKxx1A/xx1B 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 RN5RKxx1A/xx1B with only three external components: an inductor, a diode and a capacitor.

The RN5RKxx2A uses the same chip as what is employed in the RN5RKxx1A/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, RN5RKxx2A 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 is SOT-23-5, high density mounting of the ICs on board is possible.

FEATURES

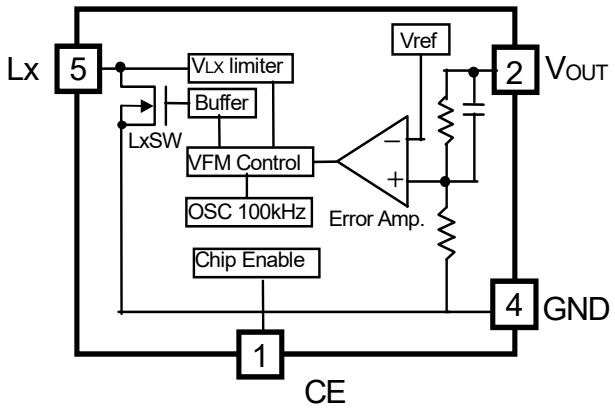
- Small Number of External Components ..... Only an inductor, a diode and a capacitor (RN5RKxx1A/xx1B)
- Standby Current ..... Typ. 0μA
- Low Temperature-Drift Coefficient of Output Voltage..... Typ. ±100ppm/°C
- Output Voltage Range..... 2.0V to 5.5V
- Two Kinds of Duty Ratio..... 77% (xx1A, xx2A)/ 55% (xx1B)
- High Output Voltage Accuracy ..... ±2.5%
- Small Packages SOT-23-5
- High Efficiency ..... Typ. 85% (RN5RK301B, V_{IN}=2V, I_{OUT}=10mA)
- Low Ripple and Low Noise
- Including a Driver Transistor with Low ON Resistance..... Only RN5RKxx1A/xx1B
- Low Start-up Voltage..... Max.0.9V

APPLICATIONS

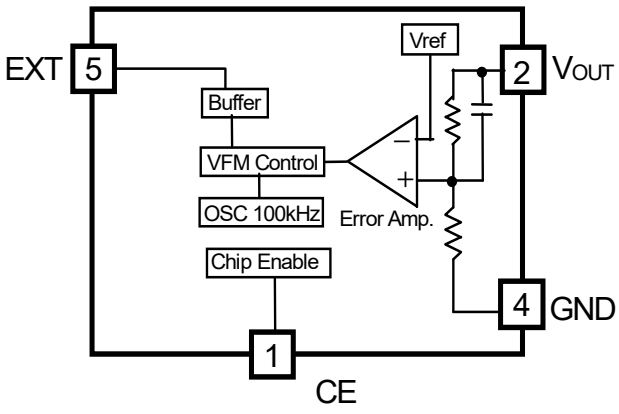
- Power source for battery-powered equipment.
- Power source for cameras, camcorders, VCRs, and hand-held communication equipment.
- Power source for those appliances which require higher cell voltage than that of batteries.

OUTLINE DIAGRAM

RN5RKxx1x



RN5RKxx2A



SELECTION GUIDE

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

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RN5RKxx∗$-TR-FE	SOT-23-5	3,000 pcs	○	○

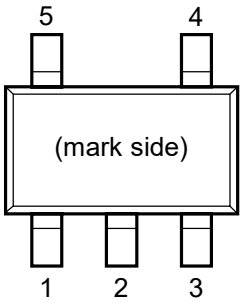
xx : The output voltage can be designed in the range from 2.0V(20) to 5.5V(55) in 0.1V steps.

∗ : Designation of Driver
（1）Internal Lx Tr. Driver
（2）External Tr. Driver

$: Designation of Duty Cycle
（A）77%
（B）55%

PIN CONFIGURATIONS

- **SOT-23-5**



PIN DISCRIPTION

- **RN5RKxx1x**

Pin No.	Symbol	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)

- **RN5RKxx2A**

Pin No.	Symbol	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

- **RN5RKxx1x**

Symbol	Item	Rating	Unit
V_{OUT}	Step-up Output Pin Voltage	-0.3 to 9.0	V
V_{LX}	Lx Pin Voltage	-0.3 to 9.0	V
V_{CE}	CE Pin Voltage	-0.3 to V_{OUT}+0.3	V
I_{LX}	Lx Pin Output Current	500	mA
P_D	Power Dissipation (SOT-23-5)*	420	mW
Topt	Operating Temperature Range	-40 to 85	°C
Tstg	Storage Temperature Range	-55 to 125	°C

- **RN5RKxx2A**

Symbol	Item	Rating	Unit
V_{OUT}	Step-up Output Pin Voltage	-0.3 to 9.0	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_{EXT}	EXT Pin Output Current	±30	mA
P_D	Power Dissipation (SOT-23-5)*1	420	mW
Topt	Operating Temperature Range	-40 to 85	°C
Tstg	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.

ELECTRICAL CHARACTERISTICS

- **RN5RKxx1A/xx1B**

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				8.0	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	0.90	V
$\Delta Vstart/\Delta Topt$	Start-Up Voltage Temperature Coefficient	-40°C ≦ Topt ≦ 85°C V_{IN}=0V→2V*1		-1.6		mV/ °C
Vhold	Hold-on Voltage (xx1A)	V_{IN}=2V→0V*1	0.7			V
Vhold	Hold-on Voltage (xx1B)	V_{IN}=2V→0V*1	0.9			V
I_{DD2}	Supply Current2	V_{OUT}=V_{CE}=Set V_{OUT}+0.5V		2	5	μA
Istandby	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
$\Delta fosc/\Delta Topt$	Frequency Temperature Coefficient	-40°C ≦ Topt ≦ 85°C		0.41		kHz/ °C
Maxduty	Oscillator Duty Cycle (xx1A)	V_{OUT}=V_{CE}=Set V_{OUT}×0.96, ON (V_{LX} "L" side)	70	77	85	%
	Oscillator Duty Cycle (xx1B)		47	55	63	%
V_{LXlim}	V_{LX} 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				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}=0V	-0.5	0	0.5	μA
I_{DD1}	Supply Current1 *2	2.0V ≦ Set V_{OUT} ≦ 2.4V		25	50	μA
		2.5V ≦ Set V_{OUT} ≦ 2.9V		30	55	μA
		3.0V ≦ Set V_{OUT} ≦ 3.4V		35	60	
		3.5V ≦ Set V_{OUT} ≦ 3.9V		40	65	
		4.0V ≦ Set V_{OUT} ≦ 4.4V		45	75	
		4.5V ≦ Set V_{OUT} ≦ 4.9V		50	80	
		5.0V ≦ Set V_{OUT} ≦ 5.5V		55	90	

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I_{LX}	Lx Switching Current	2.0V ≦ Set V_{OUT} ≦ 2.4V, V_{LX}=0.4V	80			mA
		2.5V ≦ Set V_{OUT} ≦ 2.9V, V_{LX}=0.4V	100			
		3.0V ≦ Set V_{OUT} ≦ 3.4V, V_{LX}=0.4V	120			
		3.5V ≦ Set V_{OUT} ≦ 3.9V, V_{LX}=0.4V	140			
		4.0V ≦ Set V_{OUT} ≦ 4.4V, V_{LX}=0.4V	160			
		4.5V ≦ Set V_{OUT} ≦ 4.9V, V_{LX}=0.4V	180			
		5.0V ≦ Set V_{OUT} ≦ 5.5V, V_{LX}=0.4V	200			

*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.

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.

- **RN5RKxx2A**

Topt=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	V_{OUT}=V_{CE}=0V→6V, Judgment is made by the EXT waveform	×0.975		×1.025	V
V_{IN}	Input Voltage				8.0	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	−40°C ≦ Topt ≦ 85°C		±100		ppm /°C
Vstart	Start-Up Voltage	V_{OUT}=V_{CE}=0V→2V		0.7	0.8	V
I_{DD2}	Supply Current2	V_{OUT}=V_{CE}=Set V_{OUT}+0.5V		2	5	μA
Istandby	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_{LX} "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				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}=0V	-0.5	0	0.5	μA
I_{DD1}	Supply Current1 *1	2.0V ≦ V_{OUT} ≦ 2.9V, EXT no load		20	40	μA
		3.0V ≦ V_{OUT} ≦ 3.9V, EXT no load		25	50	μA
		3.0V ≦ V_{OUT} ≦ 3.4V, EXT no load		30	60	
		3.5V ≦ V_{OUT} ≦ 3.9V, EXT no load		35	70	
I_{EXTH}	EXT "H" Output Current	2.0V ≦ V_{OUT} ≦ 2.4V, EXT no load			-1.0	mA
		2.5V ≦ V_{OUT} ≦ 2.9V, EXT no load			-1.5	
		4.0V ≦ V_{OUT} ≦ 5.5V, EXT no load			-2.0	
I_{EXTL}	EXT "L" Output Current	2.0V ≦ V_{OUT} ≦ 2.9V, EXT no load	1.0			
		3.0V ≦ V_{OUT} ≦ 3.9V, EXT no load	1.5			
		4.0V ≦ V_{OUT} ≦ 5.5V, EXT no load	2.0			

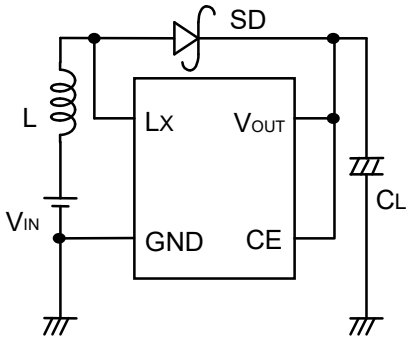
*1) The Supply Current 1 (I_{DD1}) for IC itself is measured when the internal oscillator works continuously. If the oscillator works intermittently, the supply current becomes smaller than the value which is written on the above table.

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.

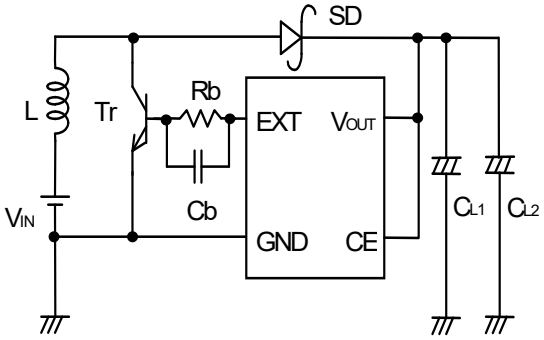
TYPICAL APPLICATIONS AND TECHNICAL NOTES

RN5RKxx1x



L : 100μH (Sumida, CD54NP)
SD : MA721 (Matsushita Electronics, Schottky Type)
CL : 47μF (Tantalum Type)

RN5RKxx2A



L : 27μH (Sumida, CD105NP)
SD : RB111C (Rohm, Schottky Type)
CL1 : 47μF (Tantalum Type)
CL2 : 47μF (Tantalum Type)
Tr : 2SD1628G
Rb : 300Ω
Cb : 0.01μF

When you use these ICs, consider the following issues;

·Set external components as close as possible to the IC and minimize the connection between the components and the IC. In particular, a capacitor should be connected to V_{OUT} pin with the minimum connection.

·Make sufficient grounding. A large current flows through GND pin by switching. When the impedance of the GND connection is high, the potential within the IC is varied by the switching current. This may result in unstable operation of the IC.

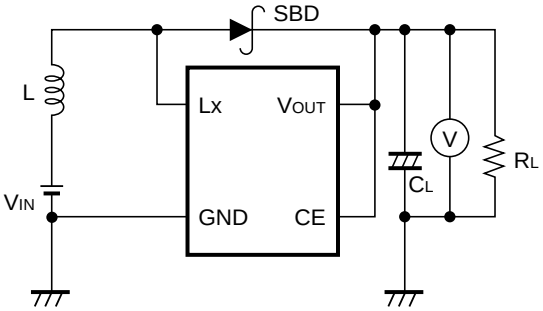
·Use capacitors with a capacity of 22μF or more, and with good high frequency characteristics such as tantalum capacitors.
We recommend you to use output capacitors with an allowable voltage at least 3 times as much as setting output voltage. This is because there may be a case where a spike-shaped high voltage is generated by an inductor when an Lx transistor is off.

·Choose an inductor that has sufficiently small D.C. resistance and large allowable current and is hard to reach magnetic saturation.
And if the value of inductance of an inductor is extremely small, the I_{LX} may exceed the absolute maximum rating at the maximum loading.
Use an inductor with appropriate inductance.

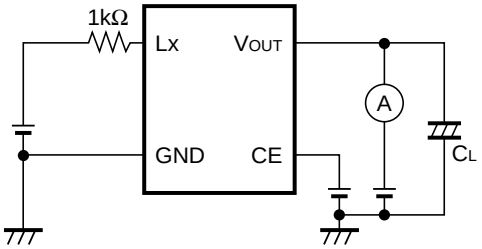
·Use a diode of a Schottky type with high switching speed, and also pay attention to its current capacity.

∗The performance of power circuit with using this IC depends on external components. Choose the most suitable components for your application.

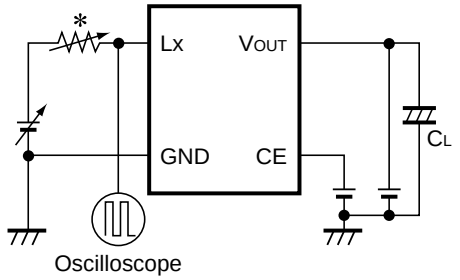
TEST CIRCUITS



Test Circuit 1



Test Circuit 2



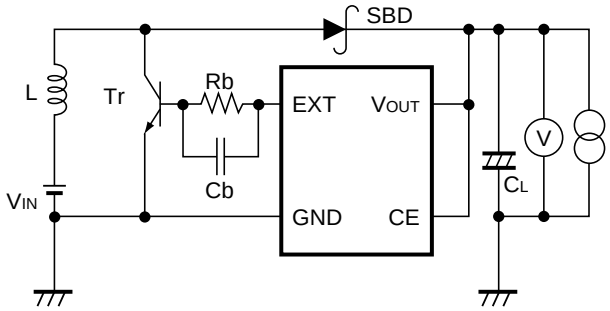
Test Circuit 3

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

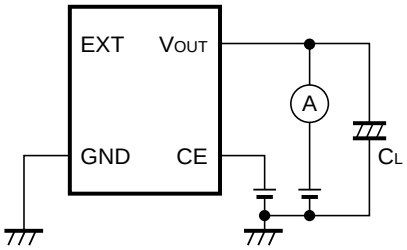
Components Inductor	(L)	: 100μH, 220μH (Sumida Electric Co., Ltd; CD-54)
Diode	(SBD)	: MA721 (Matsushita Electronics Corporation; Schottky Type)
Capacitor	(C_L)	: 47μF (Tantalum Type)

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

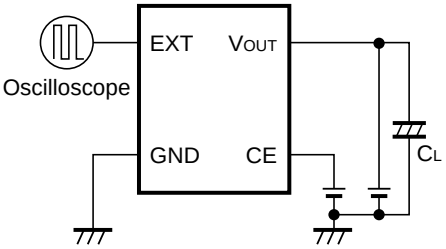
Test Circuit 1: Typical Characteristics (1)-(7)
Test Circuit 2: Typical Characteristics (9)-(11)
Test Circuit 3: Typical Characteristics (8), (12)-(16)



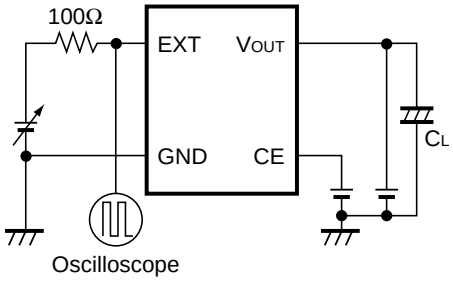
Test Circuit 1



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	(CL)	: 47μF×2(Tantalum Type)
Transistor	(Tr)	: 2SD1628G
Base Resistor	(Rb)	: 300W Base Capacitor (Cb): 0.01μF

The typical characteristics were obtained with using these test circuits.

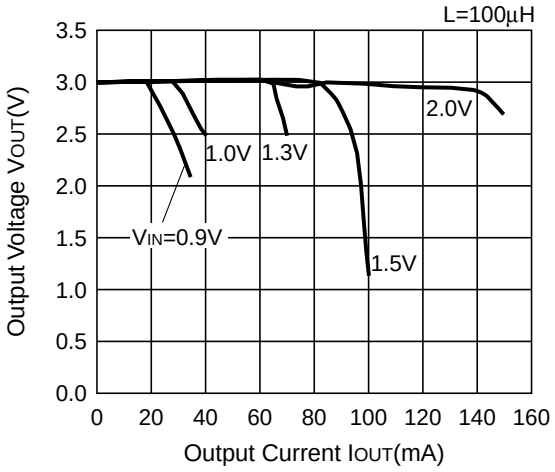
Test Circuit 1: Typical Characteristics (1)-(5)
Test Circuit 2: Typical Characteristics (8)-(10)
Test Circuit 3: Typical Characteristics (11)-(14)
Test Circuit 4: Typical Characteristics (6), (7)

TYPICAL CHARACTERISTICS

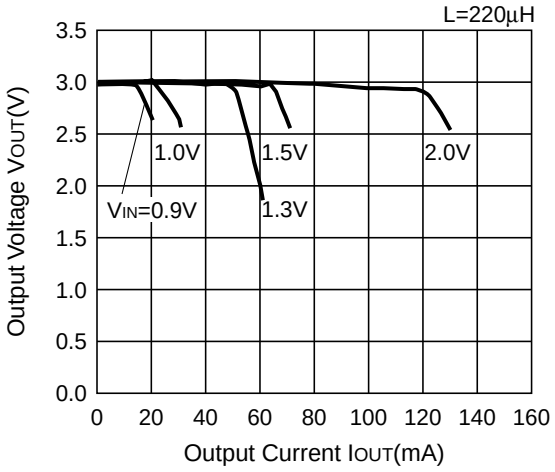
- **RN5RKxx1A/B**

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

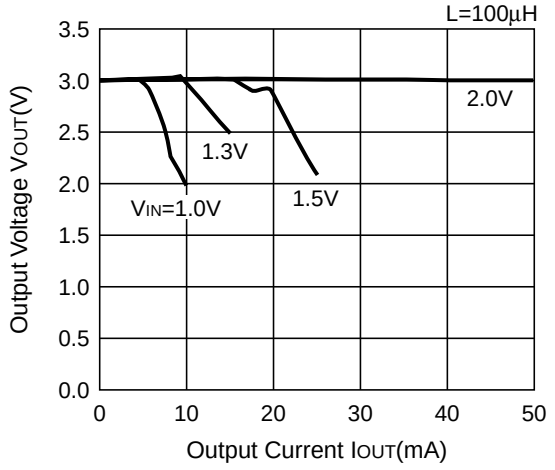
RN5RK301A



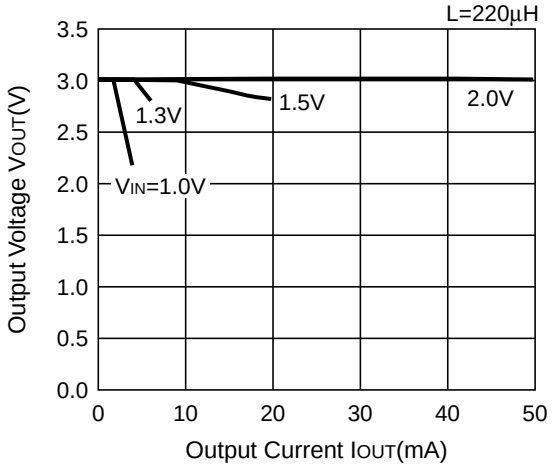
RN5RK301A



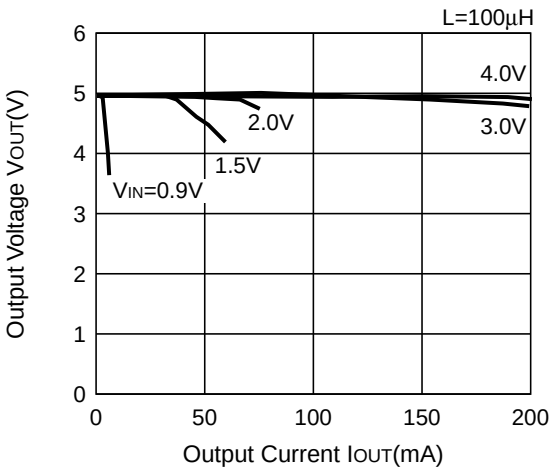
RN5RK301B



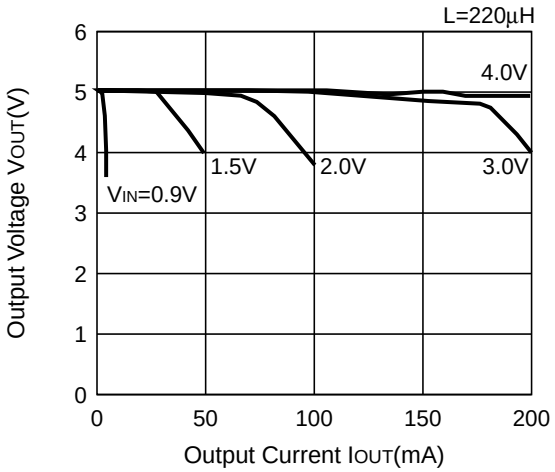
RN5RK301B



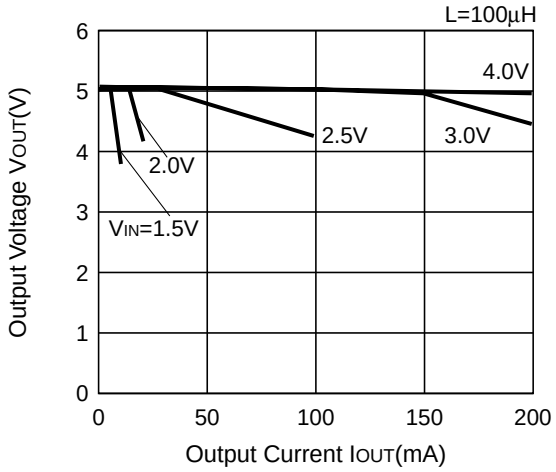
RN5RK501A



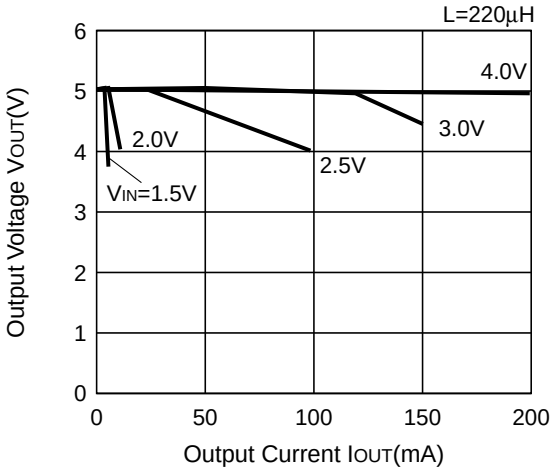
RN5RK501A



RN5RK501B

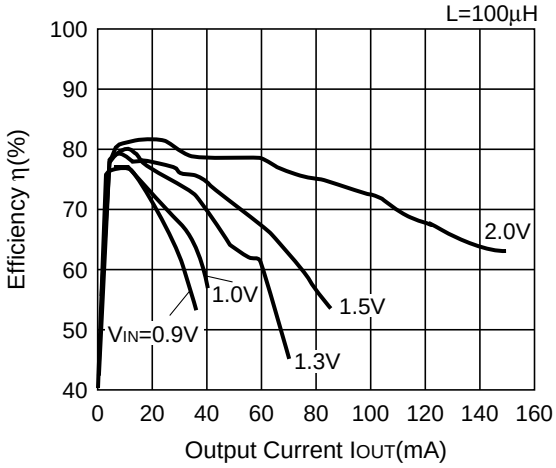


RN5RK501B

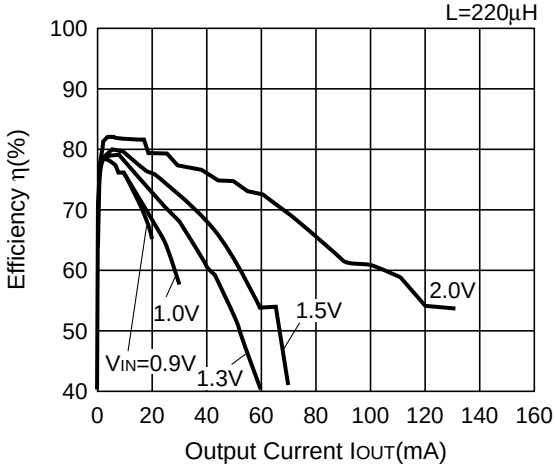


2) Efficiency vs. Output Current (Topt=25°C)

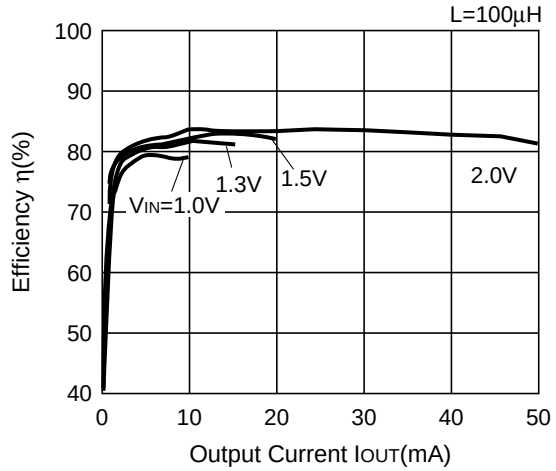
RN5RK301A



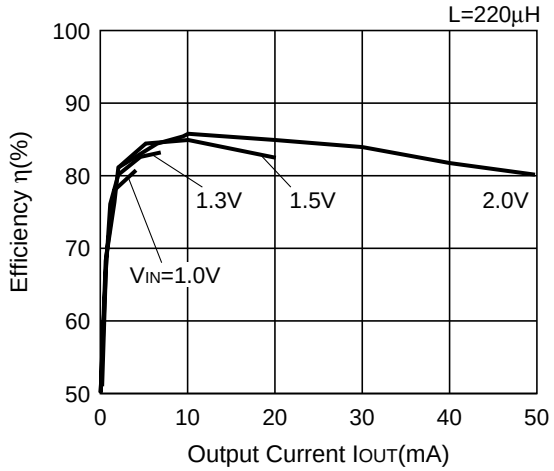
RN5RK301A



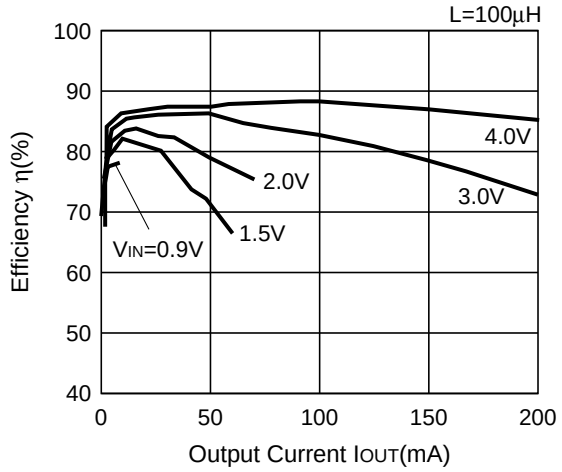
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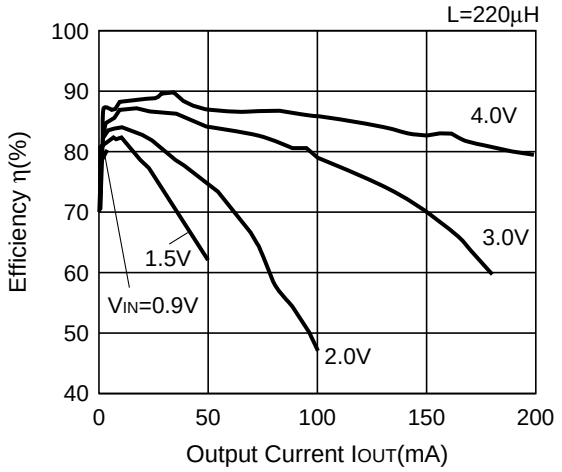
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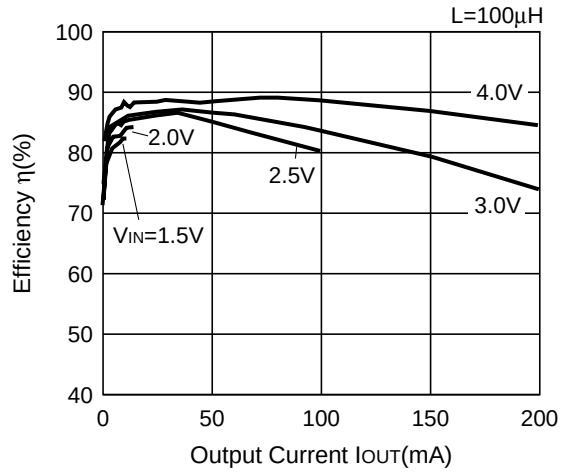
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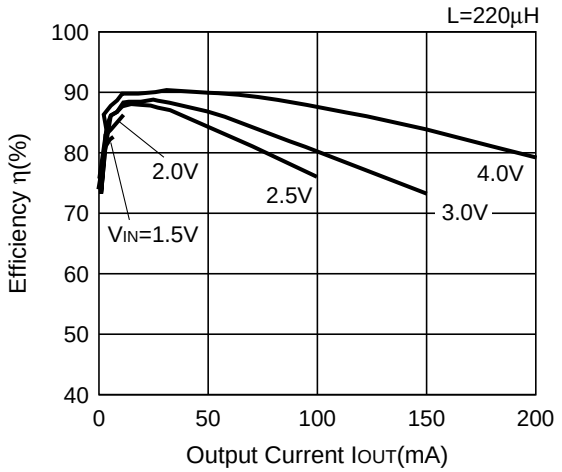
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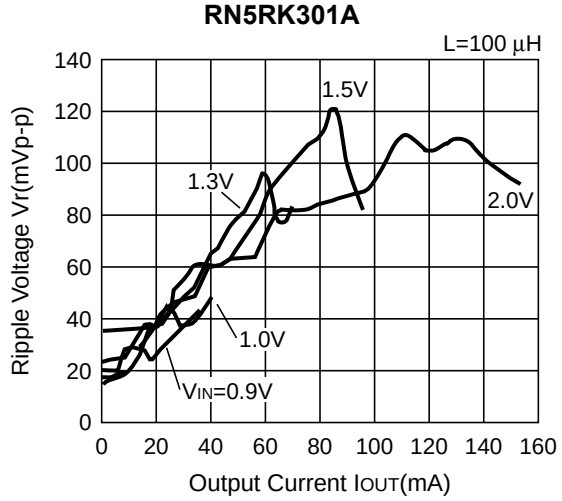


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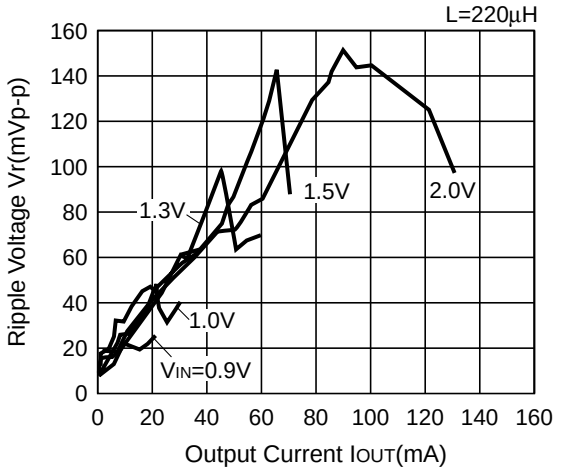


3) Ripple Voltage vs. Output Current (Topt=25°C)

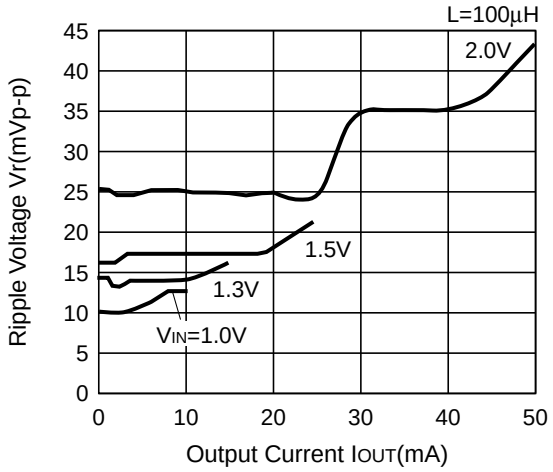
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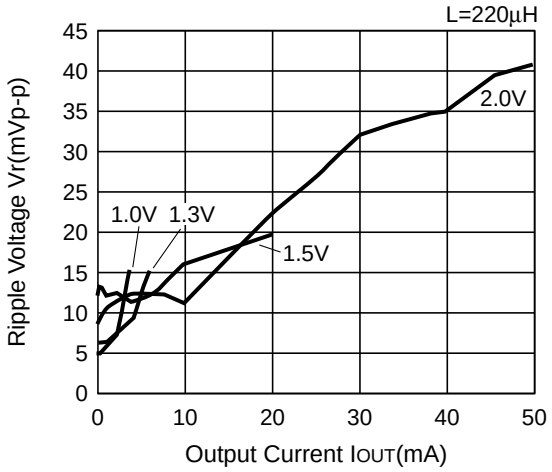
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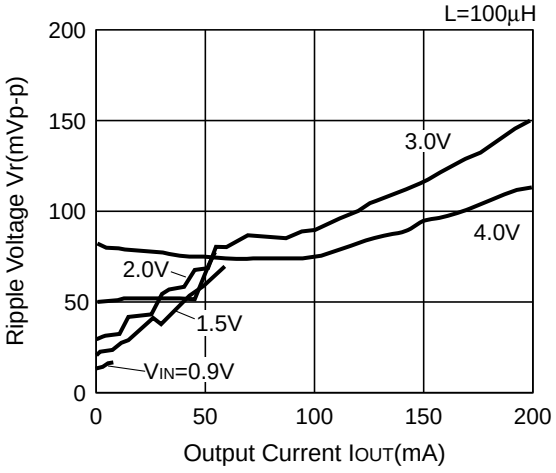
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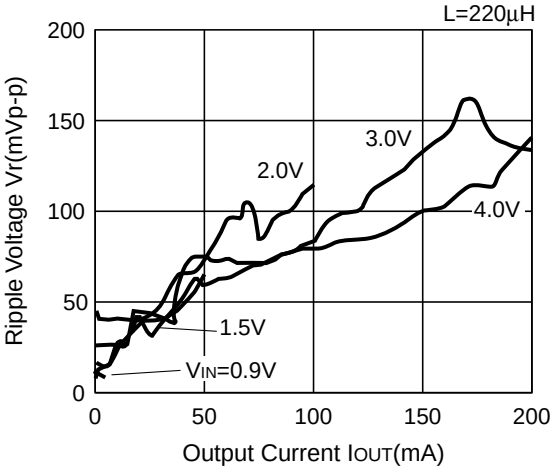
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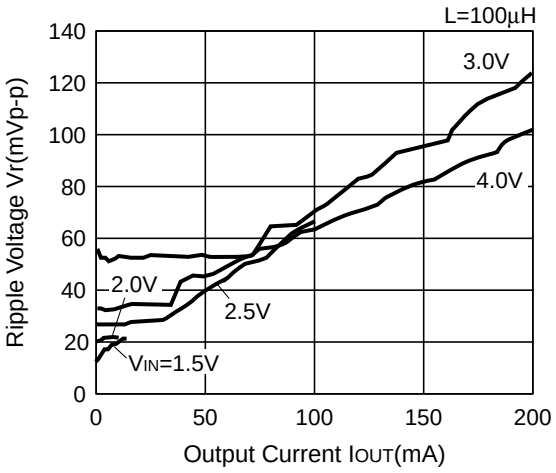
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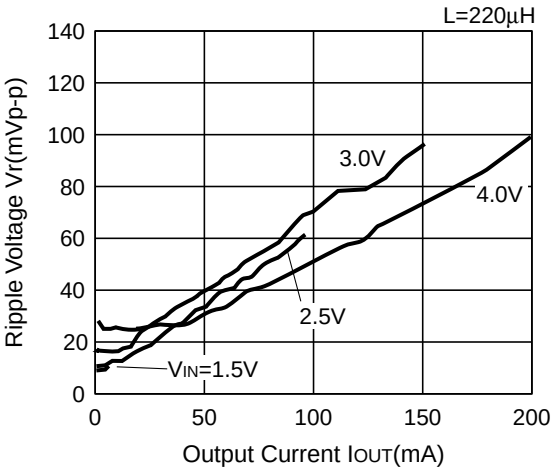
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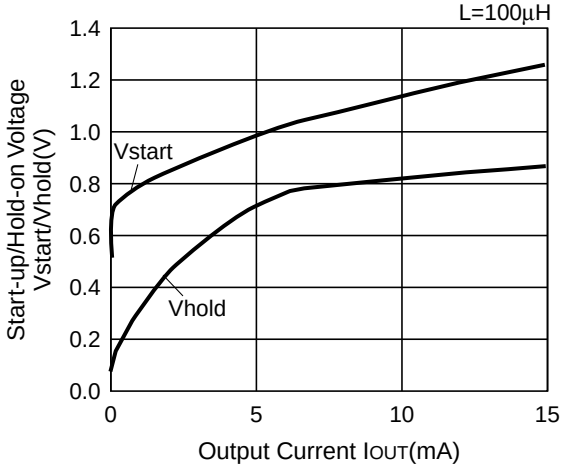


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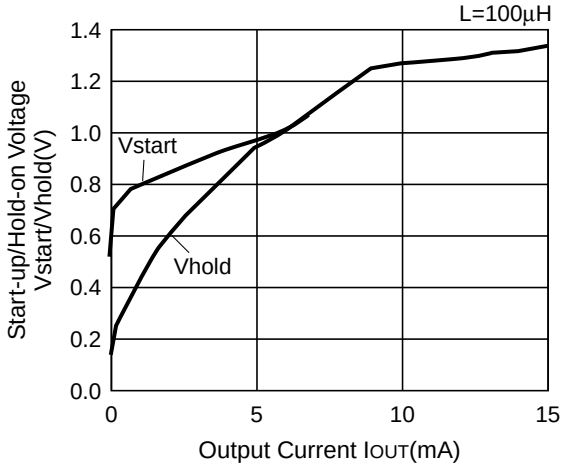


4) Start-up/Hold-on Voltage vs. Output Current (Topt=25 °C)

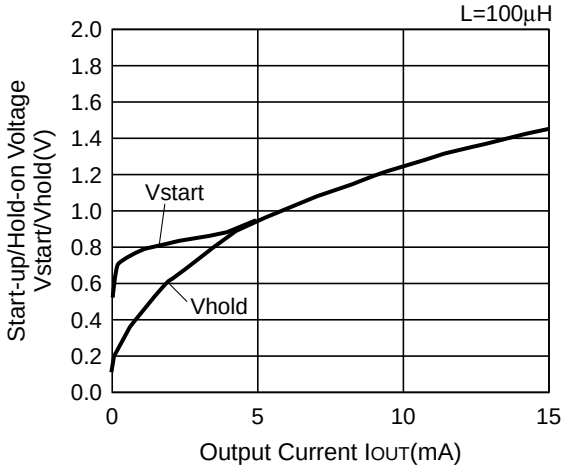
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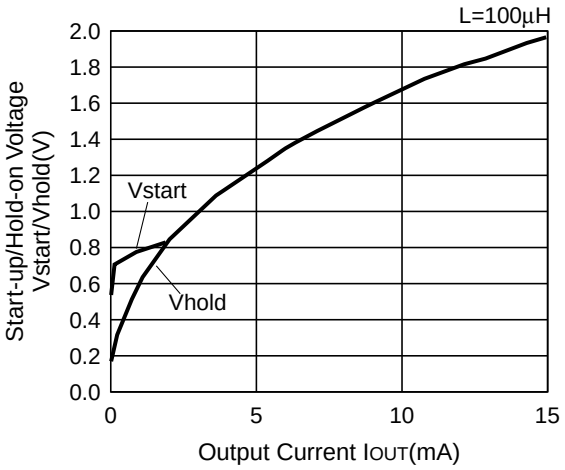
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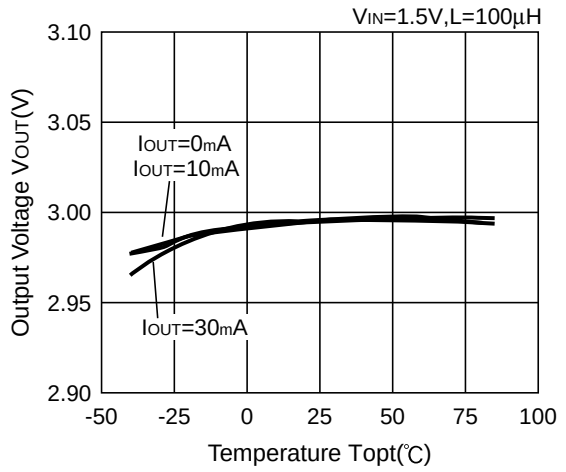


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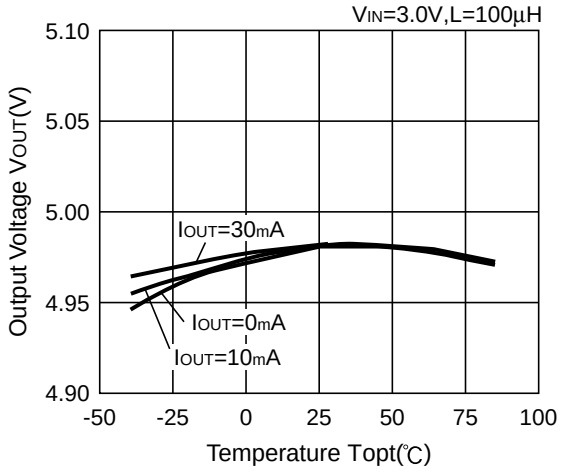


5) Output Voltage vs. Temperature

RN5RK301A

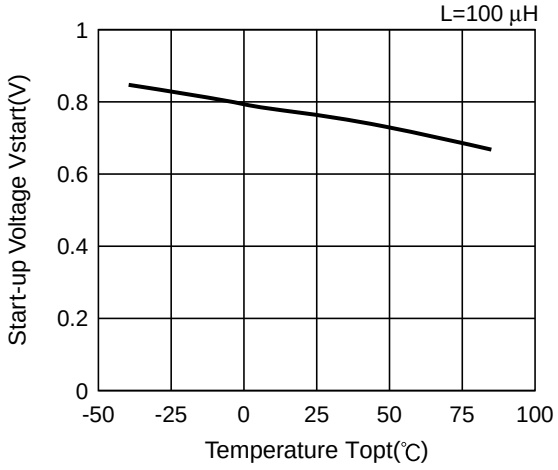


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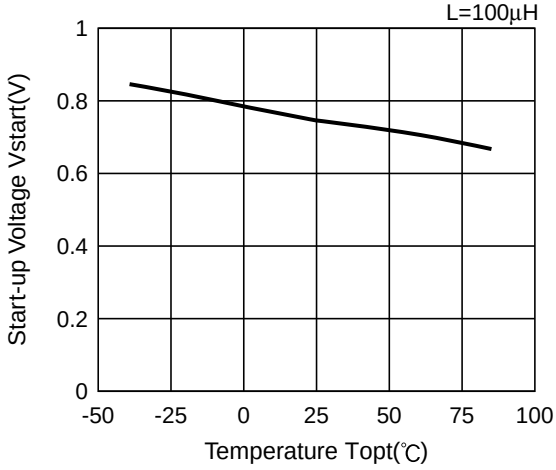


6) Start-up Voltage vs. Temperature

RN5RK501A

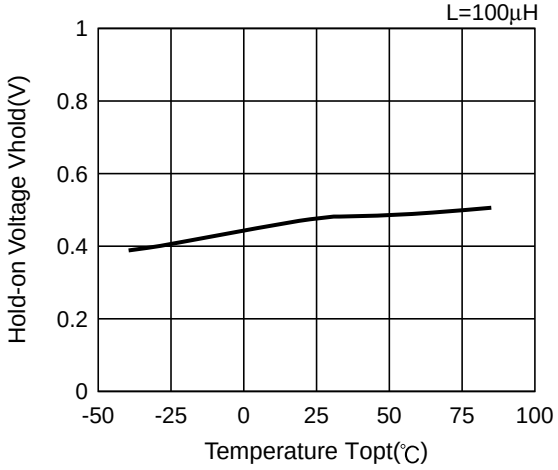


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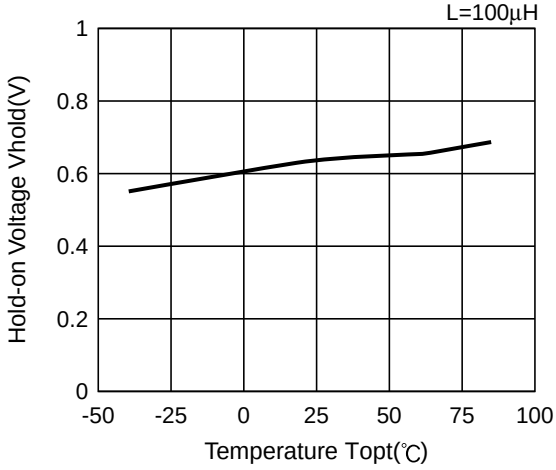


7) Hold-on Voltage vs. Temperature

RN5RK501A

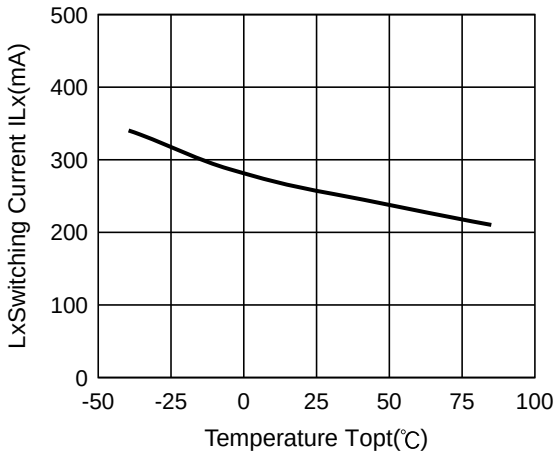


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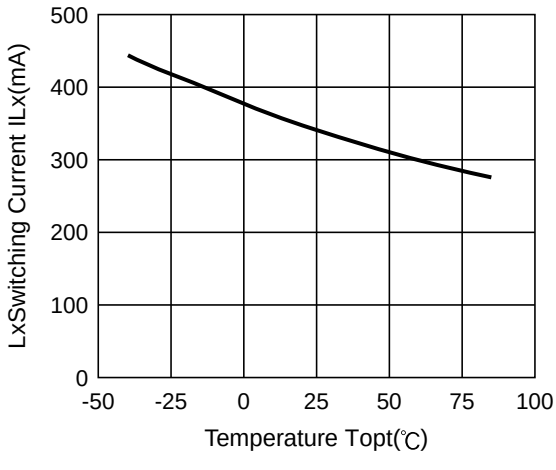


8) Lx Switching Current vs. Temperature

RN5RK301A

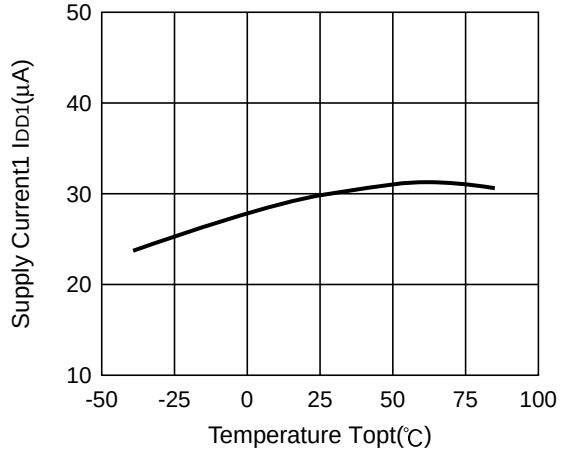


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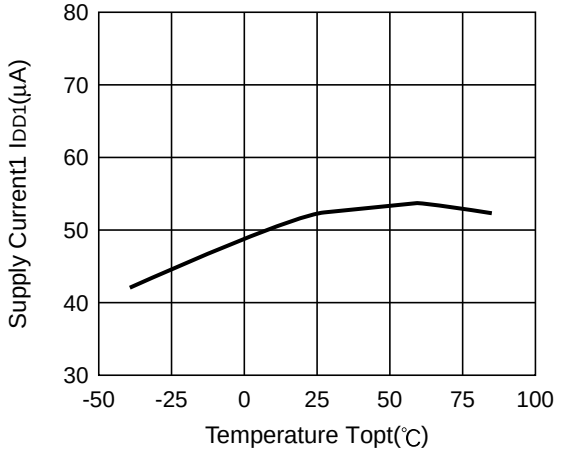


9) Supply Current 1 vs. Temperature

RN5RK301A

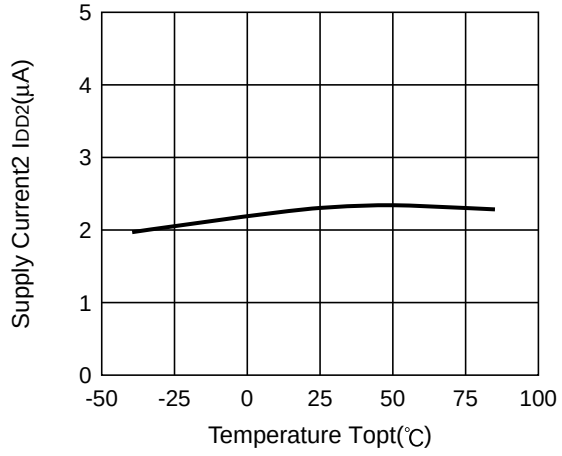


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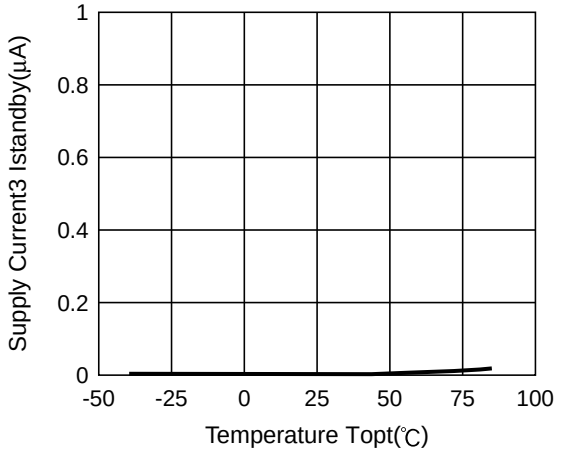
10) Supply Current 2 vs. Temperature

RN5RK301A



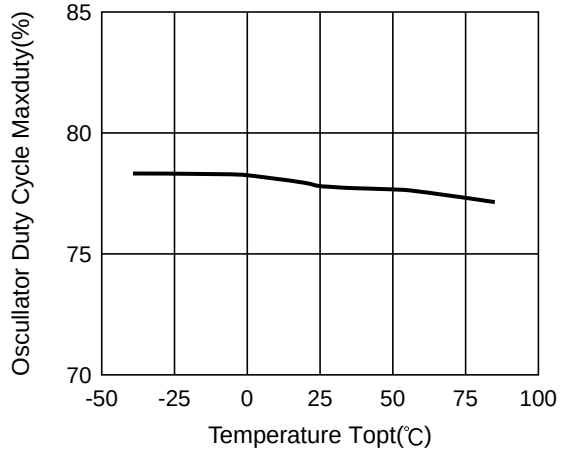
11) Standby Current 3 vs. Temperature

RN5RK301A

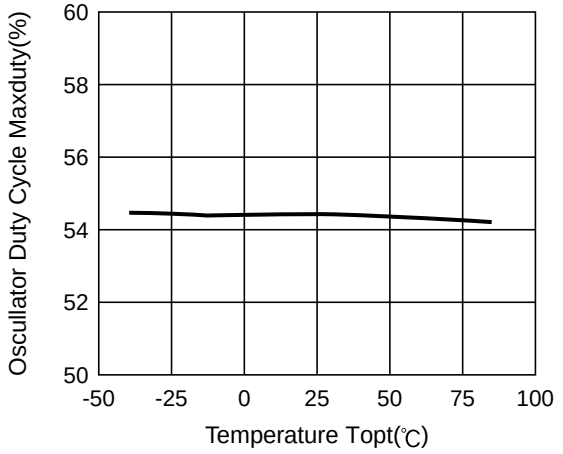


12) Oscillator Duty Cycle vs. Temperature

RN5RK301A

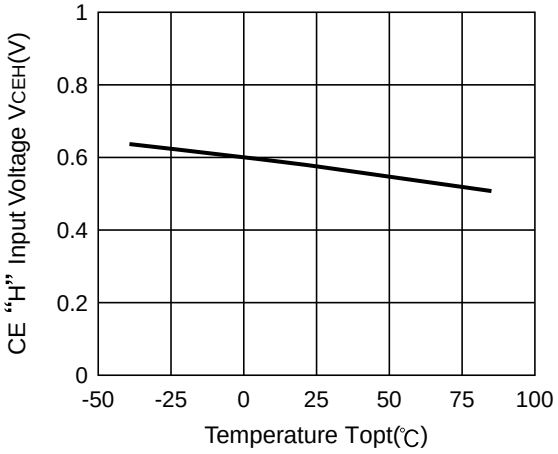


RN5RK301B



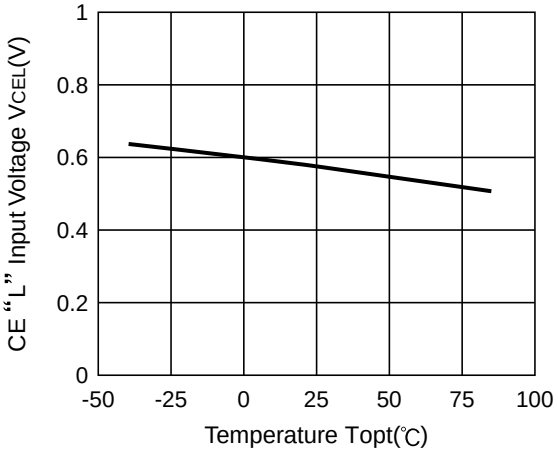
13) CE “H” Input Voltage vs. Temperature

RN5RK301A



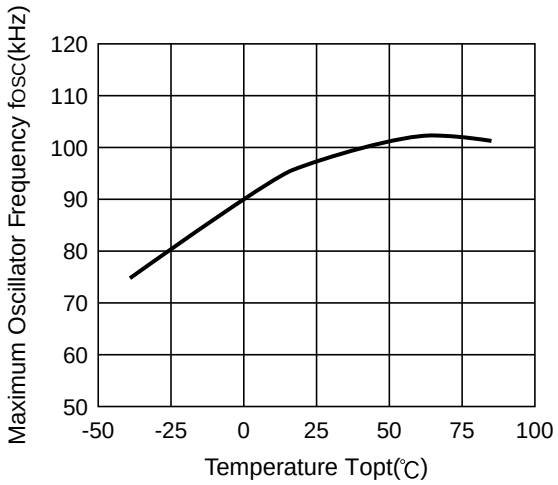
14) CE “L” Input Voltage vs. Temperature

RN5RK301A



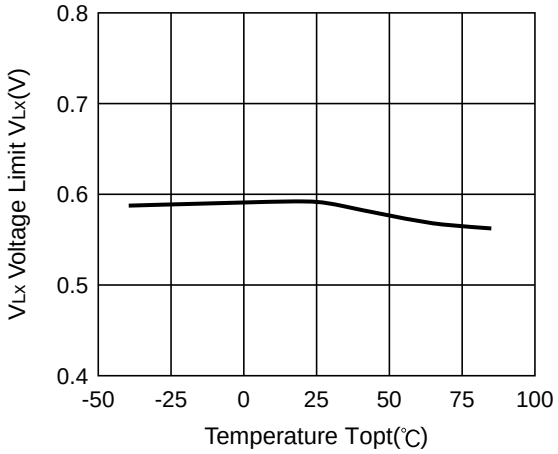
15) Maximum Oscillator Frequency vs. Temperature

RN5RK301A



16) V_{LX} Voltage Limit vs. Temperature

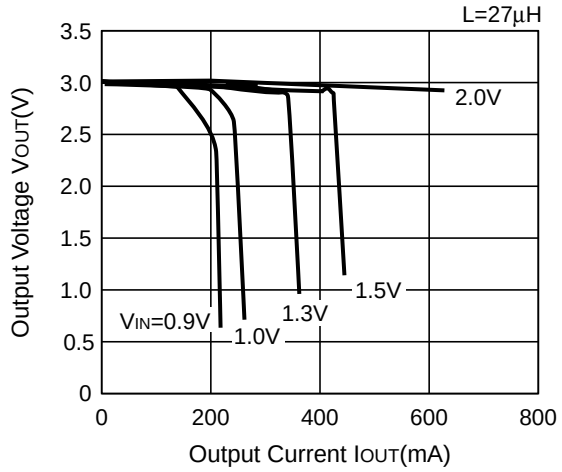
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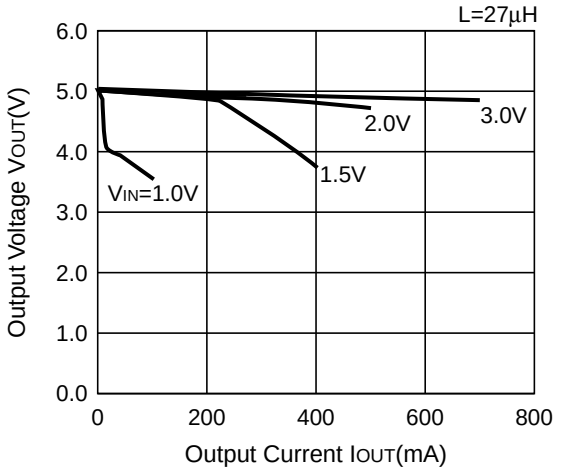
- **RN5RKxx2A**

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

RN5RK302A

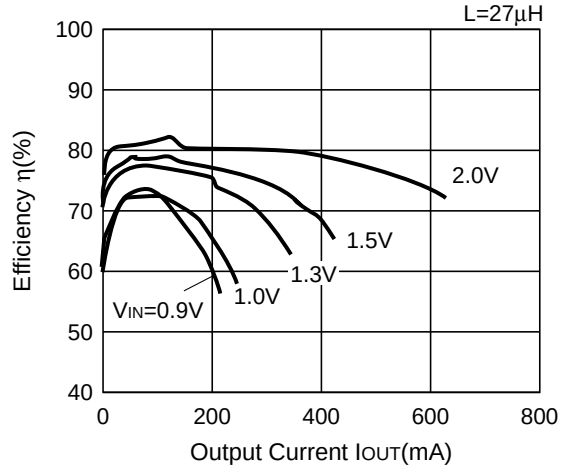


RN5RK502A

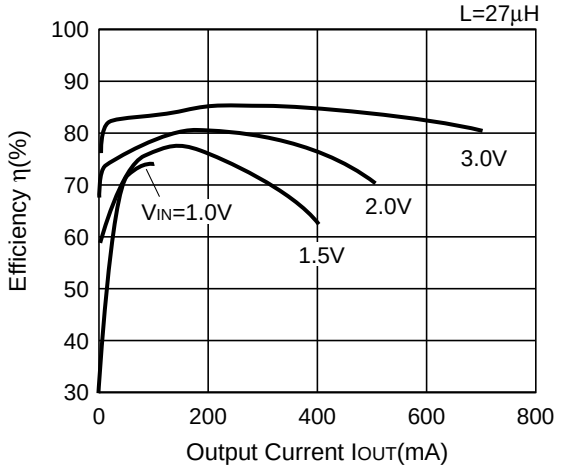


2) Efficiency vs. Output Current (Topt=25°C)

RN5RK302A

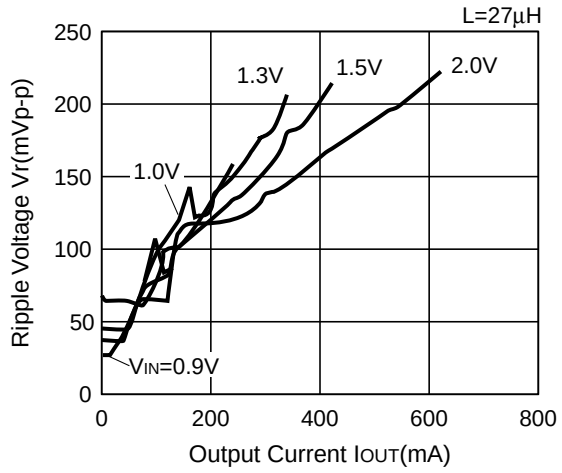


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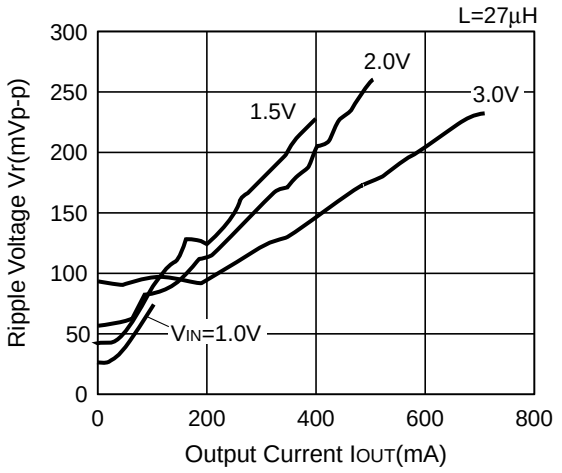


3) Ripple Voltage vs. Output Current (Topt=25°C)

RN5RK302A

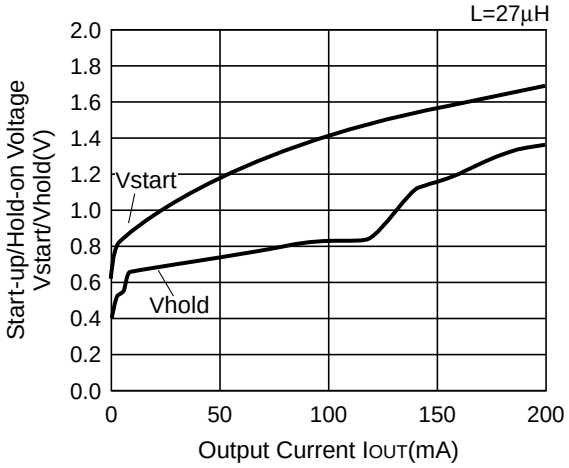


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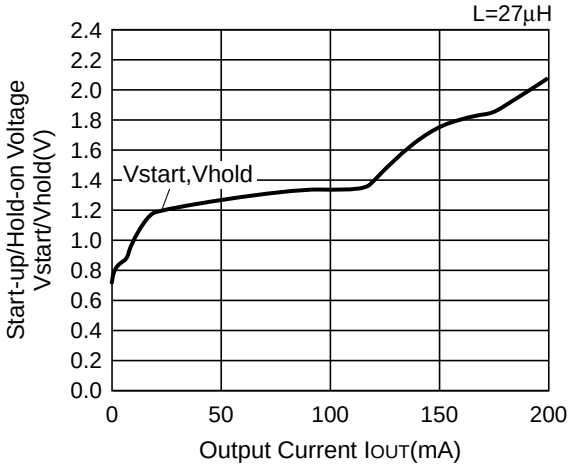


4) Start-up/Hold-on Voltage vs. Output Current (Topt=25°C)

RN5RK302A

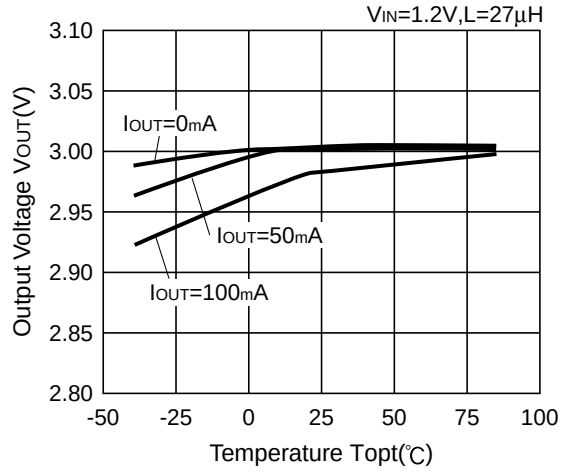


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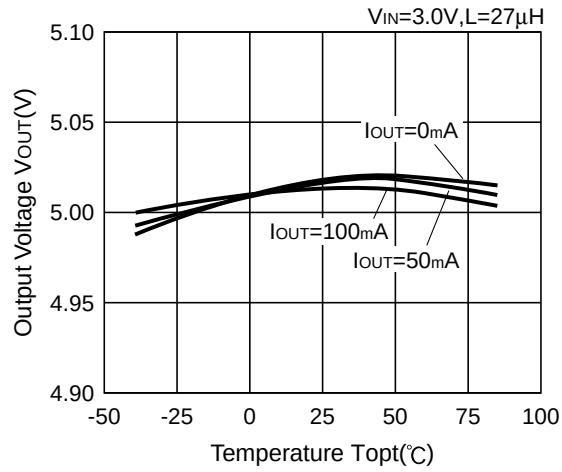


5) Output Voltage vs. Temperature

RN5RK302A

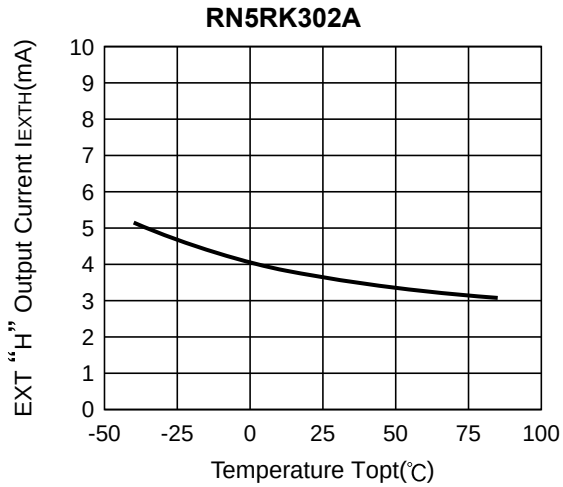


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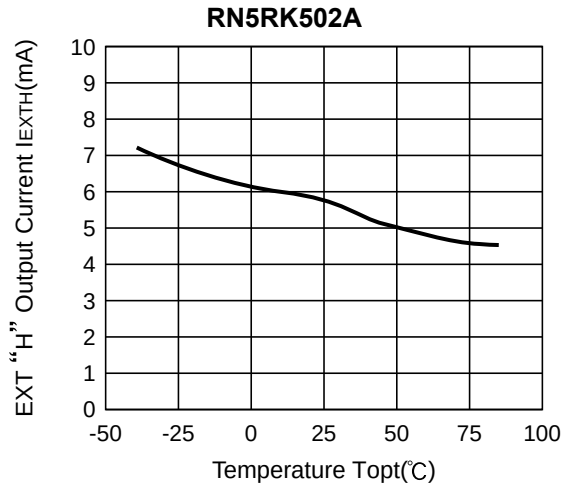


6) EXT "H" Output Current vs. Temperature

RN5RK302A

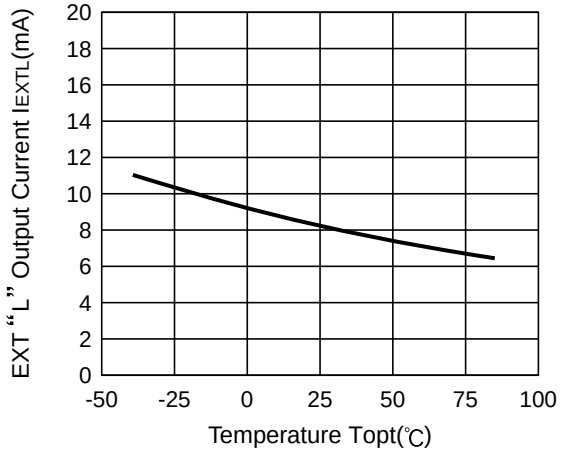


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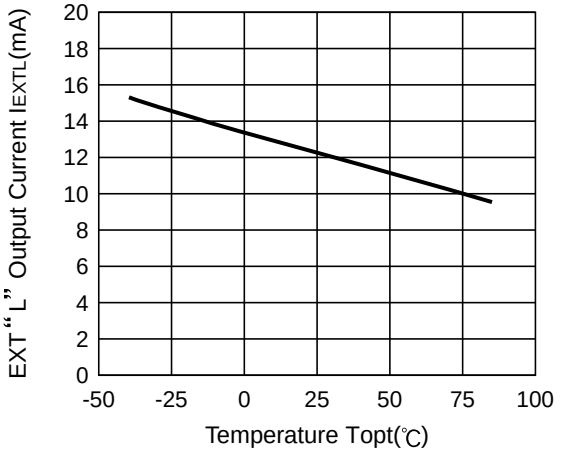


7) EXT “L” Output Current vs. Temperature

RN5RK302A

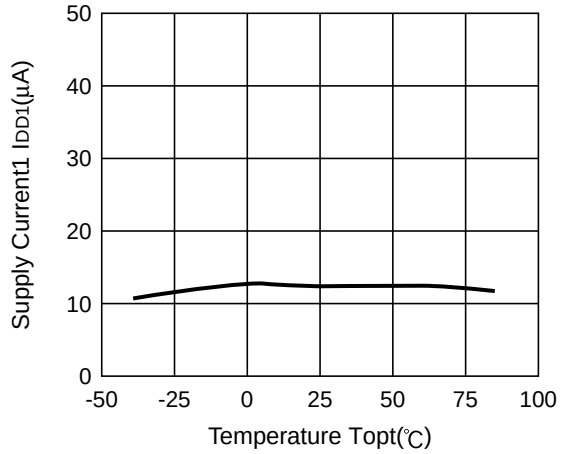


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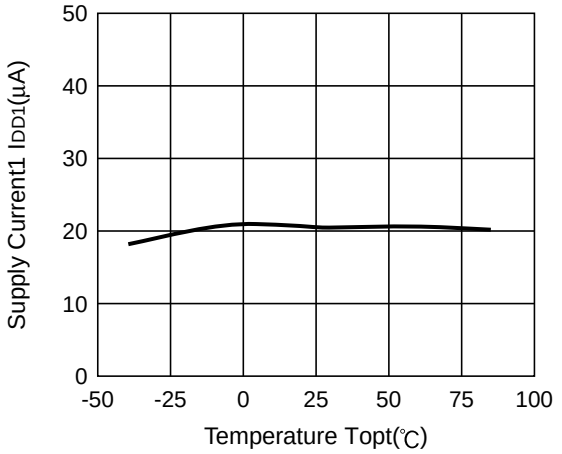


8) Supply Current 1 vs. Temperature

RN5RK302A

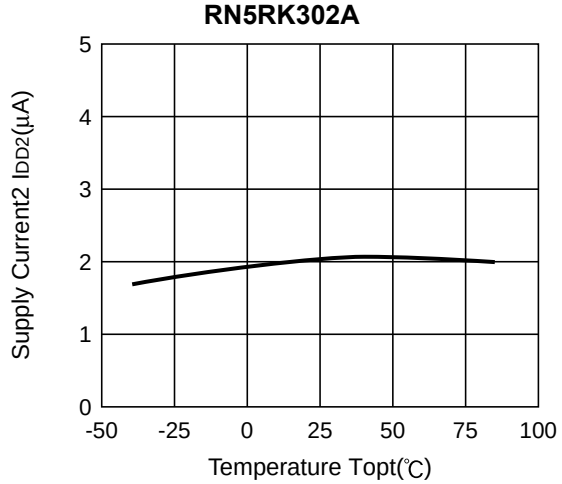


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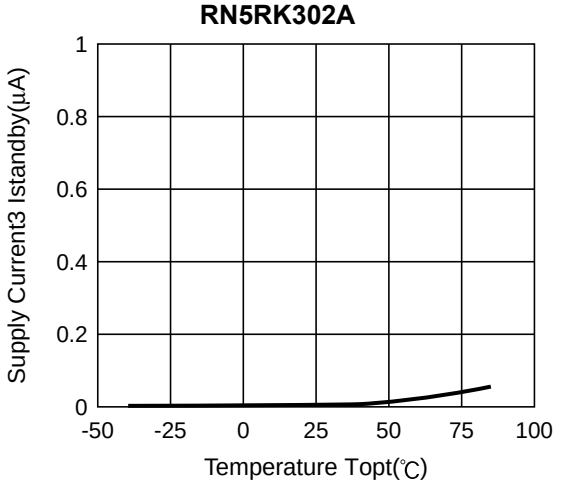
9) Supply Current 2 vs. Temperature

RN5RK302A

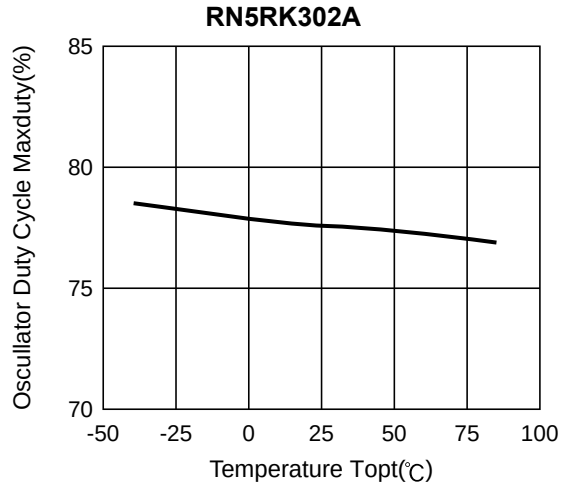


10) Standby Current vs. Temperature

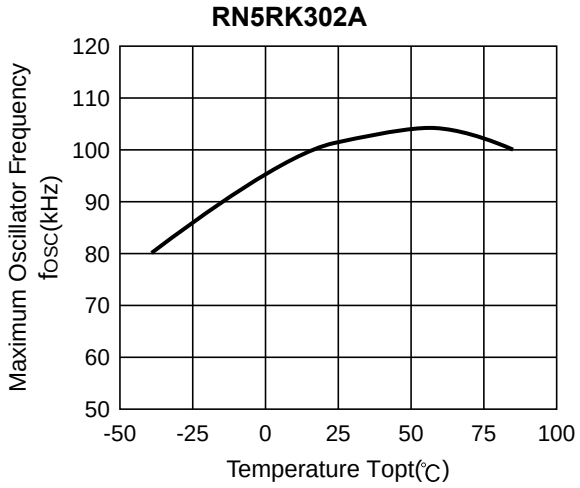
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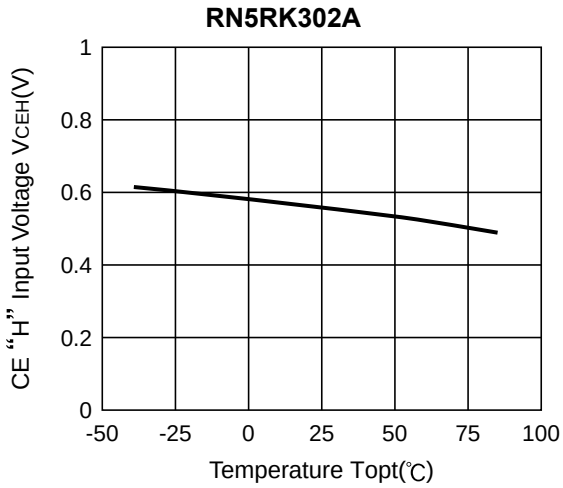
11) Oscillator Duty Cycle vs. Temperature



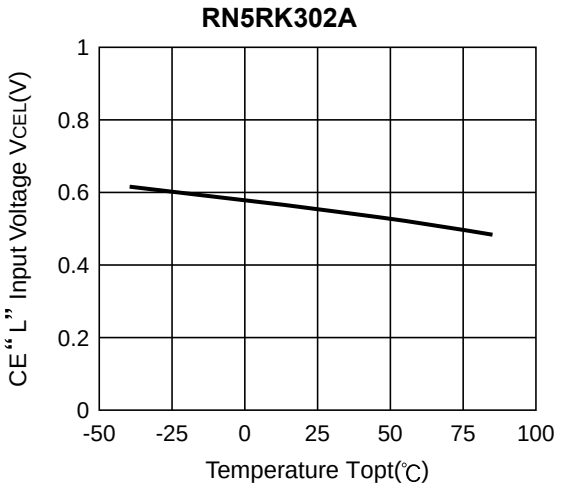
12) Maximum Oscillator Frequency vs. Temperature



13) CE "H" Input Voltage vs. Temperature



14) CE "L" Input Voltage vs. Temperature



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