∗R5324D (SON-8) is the discontinued product. As of March in 2015.

RICOH

R5324x SERIES

TRIPLE LDO

NO. EA-099-140530

OUTLINE

The R5324x Series are CMOS-based multi positive voltage regulator ICs with high output voltage accuracy, low supply current, low noise, low dropout and high ripple rejection. The R5324x Series contain three voltage regulators. Each of these voltage regulators in the R5324x Series consists of a voltage reference unit, an error amplifier, resistors for setting output voltage, a short current limit circuit, a chip enable circuit, and so on.

The chip enable function contributes to prolong battery life. Further, regulators in the R5324x Series are with low dropout voltage, excellent load transient response and line transient response, thus the R5324x series are very suitable for the power supply for hand-held communication equipment.

Since the packages for these ICs are SON-8 and DFN(PLP)2527-10, high density mounting of the ICs on boards is possible.

FEATURES

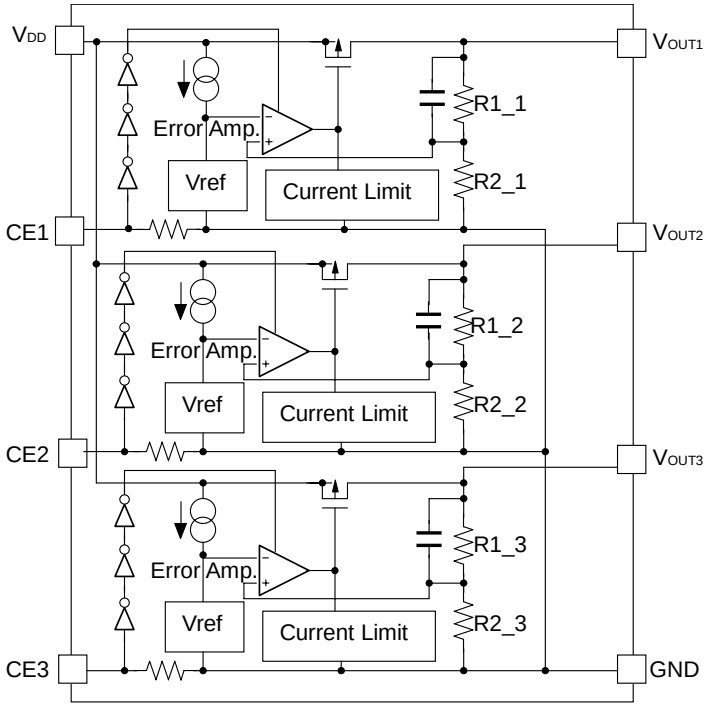
- Supply Current ..... Typ. 90μA (VR1, VR2, VR3)
- Standby Current ..... Typ. 0.1μA
- Output Current ..... Min. 200mA (VR1), 150mA (VR2), 100mA (VR3)
- Dropout Voltage ..... Typ. 0.23V (VR1) (I_{OUT}=200mA, V_{OUT}=2.8V)
  Typ. 0.22V (VR2) (I_{OUT}=150mA, V_{OUT}=2.8V)
  Typ. 0.15V (VR3) (I_{OUT}=100mA, V_{OUT}=2.8V)
- Ripple Rejection ..... Typ. 70dB (f=1kHz), Typ. 65dB (f=10kHz)
- Input Voltage Range ..... 2.0V to 6.0V
- Output Voltage Range ..... 1.5V to 4.0V (0.1V steps)
  (For details, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy ..... ±2.0%
- Temperature-Drift Coefficient of Output Voltage ..... Typ. ±100ppm/°C
- Line Regulation Typ.0.02%/V
- Packages ..... DFN(PLP)2527-10, SON-8
- Built-in fold-back protection circuit Typ.50mA (VR1), Typ.40mA (VR2, VR3)
  (Current at short mode)
- Ceramic capacitors are recommended to be used with this IC .....1.0μF or more

APPLICATIONS

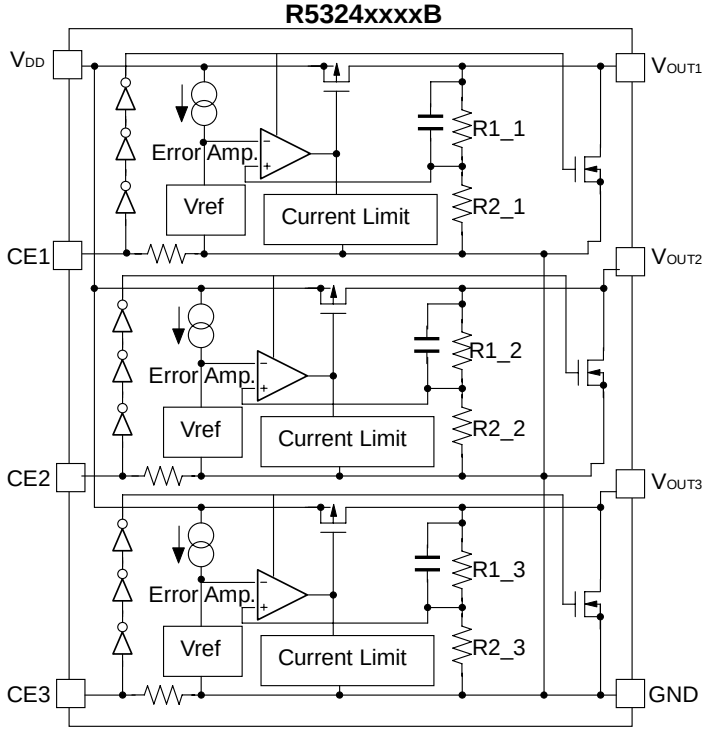
- Power source for cellular phones and portable communication equipment.
- Power source for electrical appliances such as cameras, VCRs.
- Power source for battery-powered equipment.

BLOCK DIAGRAMS

R5324xxxxA



R5324xxxxB



SELECTION GUIDE

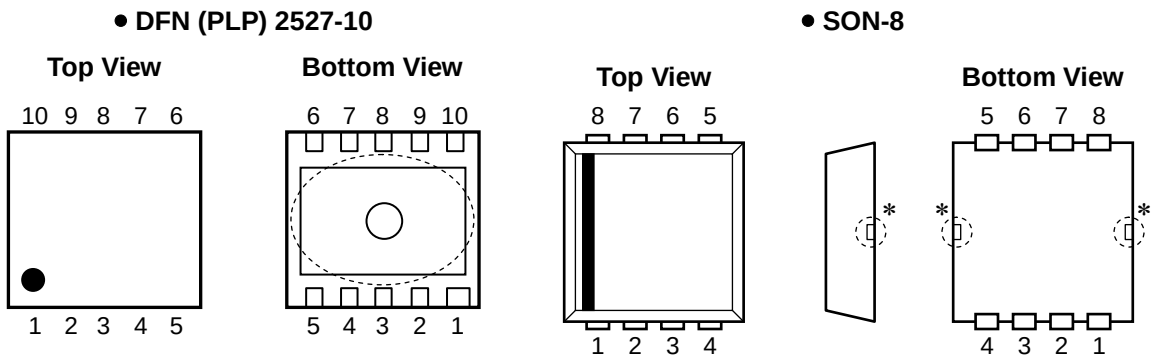
The output voltage, auto discharge function, package, etc. for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R5324Kxxx∗-TR	DFN(PLP)2527-10	5,000 pcs	Yes	Yes
R5324Dxxx∗-TR-F	SON-8	3,000 pcs	Yes	No

xxx : The combination of output voltage for each channel can be designated by serial numbers. (from 001)
The output voltage for each channel can be set in the range from 1.5V to 4.0V in 0.1V steps.
(For details, please refer to MARK INFORMATIONS.)

∗ : The auto discharge function at off state are options as follows.
(A) without auto discharge function at off state
(B) with auto discharge function at off state

PIN CONFIGURATIONS



PIN DESCRIPTIONS

● **DFN(PLP)2527-10**

Pin No	Symbol	Pin Description
1	V_{DD}	Input Pin
2	V_{DD}	Input Pin
3	CE1	Chip Enable Pin 1 ("H" Active)
4	CE2	Chip Enable Pin 2 ("H" Active)
5	CE3	Chip Enable Pin 3 ("H" Active)
6	GND	Ground Pin
7	NC	No Connection
8	V_{OUT3}	Output Pin 3
9	V_{OUT2}	Output Pin 2
10	V_{OUT1}	Output Pin 1

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.
The V_{DD} pin must be wired together when it is mounted on board.

● **SON-8**

Pin No	Symbol	Pin Description
1	V_{DD}	Input Pin
2	CE1	Chip Enable Pin 1 ("H" Active)
3	CE2	Chip Enable Pin 2 ("H" Active)
4	CE3	Chip Enable Pin 3 ("H" Active)
5	GND	Ground Pin
6	V_{OUT3}	Output Pin 3
7	V_{OUT2}	Output Pin 2
8	V_{OUT1}	Output Pin 1

∗) Tab suspension leads are GND level. (They are connected to the reverse side of this IC.)
The tab suspension leads should be open and do not connect to other wires or land patterns.

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	6.5	V
CE	Input Voltage (CE Pin)	-0.3 to 6.5	V
V_{OUT}	Output Voltage	-0.3 to V_{IN}+0.3	V
I_{OUT1}	Output Current (V_{OUT1})	230	mA
I_{OUT2}	Output Current (V_{OUT2})	180	mA
I_{OUT3}	Output Current (V_{OUT3})	180	mA
P_D	Power Dissipation (DFN(PLP)2527-10)*	910	mW
	Power Dissipation (SON-8)*	480	
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.

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

- **R5324xxxxA/B**

VR1 Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	$V_{IN}-V_{OUT}$=1.0V 1mA ≦ I_{OUT} ≦ 30mA		×0.98		×1.02	V
I_{OUT}	Output Current	$V_{IN}-V_{OUT}$=1.0V		200			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$V_{IN}-V_{OUT}$=1.0V, 1mA ≦ I_{OUT} ≦ 200mA			25	50	mV
V_{DIF}	Dropout Voltage	I_{OUT}=200mA	V_{OUT}=1.5V		0.36	0.65	V
			V_{OUT}=1.6V		0.34	0.58	
			V_{OUT}=1.7V		0.33	0.56	
			1.8V ≦ V_{OUT} ≦ 2.0V		0.31	0.53	
			2.1V ≦ V_{OUT} ≦ 2.7V		0.28	0.46	
			2.8V ≦ V_{OUT} ≦ 4.0V		0.23	0.35	
I_{SS}	Supply Current	$V_{IN}-V_{OUT}$=1.0V			90	140	μA
$I_{standby}$	Standby Current	$V_{IN}-V_{OUT}$=1.0V, V_{CE}=GND			0.1	1.0	μA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=30mA, V_{OUT}+0.5V ≦ V_{IN} ≦ 6.0V (V_{OUT} ≦ 1.6V: 2.2V ≦ V_{IN} ≦ 6.0V)			0.02	0.10	%/V
RR	Ripple Rejection	sinusoidal Ripple 0.5Vp-p $V_{IN}-V_{OUT}$=1.0V, I_{OUT}=30mA ∗V_{OUT} ≦ 1.7V, $V_{IN}-V_{OUT}$=1.2V, I_{OUT}=30mA	f=1kHz		70		dB
			f=10kHz		65		
			f=10kHz (V_{OUT} ≧ 2.5V)		60		
V_{IN}	Input Voltage			2		6	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=30mA −40°C ≦ Topt ≦ 85°C			±100		ppm /°C
I_{SC}	Short Current Limit	V_{OUT}=0V			50		mA
R_{PD}	CE Pull-down Resistance			0.7	2.0	5.0	MΩ
V_{CEH}	CE Input Voltage "H"			1.5		6.0	V
V_{CEL}	CE Input Voltage "L"			0		0.3	V
en	Output Noise	BW=10Hz to 100kHz			30		μVrms
R_{LOW}	On Resistance of Nch Tr. for Auto-discharge (Applied to B version)	V_{CE}=0V			50		Ω

VR2

Topt=25°C

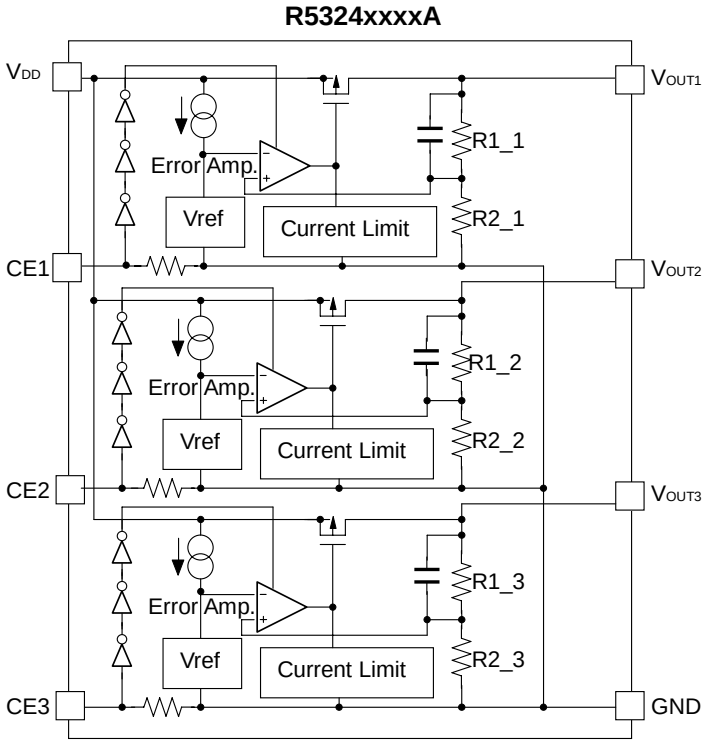
Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	$V_{IN}-V_{OUT}$=1.0V 1mA ≦ I_{OUT} ≦ 30mA		×0.98		×1.02	V
I_{OUT}	Output Current	$V_{IN}-V_{OUT}$=1.0V		150			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$V_{IN}-V_{OUT}$=1.0V 1mA ≦ I_{OUT} ≦ 150mA			15	40	mV
V_{DIF}	Dropout Voltage	I_{OUT}=150mA	V_{OUT}=1.5V		0.34	0.60	V
			V_{OUT}=1.6V		0.32	0.56	
			V_{OUT}=1.7V		0.31	0.53	
			1.8V ≦ V_{OUT} ≦ 2.0V		0.29	0.50	
			2.1V ≦ V_{OUT} ≦ 2.7V		0.26	0.44	
			2.8V ≦ V_{OUT} ≦ 4.0V		0.22	0.33	
I_{SS}	Supply Current	$V_{IN}-V_{OUT}$=1.0V			90	120	μA
$I_{standby}$	Standby Current	$V_{IN}-V_{OUT}$=1.0V, V_{CE}=GND			0.1	1.0	μA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=30mA, V_{OUT}+0.5V ≦ V_{IN} ≦ 6.0V (V_{OUT} ≦ 1.6V: 2.2V ≦ V_{IN} ≦ 6.0V)			0.02	0.10	%/V
RR	Ripple Rejection	sinusoidal Ripple 0.5Vp-p $V_{IN}-V_{OUT}$=1.0V, I_{OUT}=30mA ∗V_{OUT} ≦ 1.7V, $V_{IN}-V_{OUT}$=1.2V, I_{OUT}=30mA	f=1kHz		70		dB
			f=10kHz		65		
			f=10kHz (V_{OUT} ≧ 2.5V)		60		
V_{IN}	Input Voltage			2		6	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=30mA −40°C ≦ Topt ≦ 85°C			±100		ppm /°C
I_{SC}	Short Current Limit	V_{OUT}=0V			40		mA
R_{PD}	CE Pull-down Resistance			0.7	2.0	5.0	MΩ
V_{CEH}	CE Input Voltage "H"			1.5		6.0	V
V_{CEL}	CE Input Voltage "L"			0		0.3	V
en	Output Noise	BW=10Hz to 100kHz			30		μVrms
R_{LOW}	On Resistance of Nch Tr. for Auto-discharge (Applied to B version)	V_{CE}=0V			50		Ω

R5324x

VR3 Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	$V_{IN}-V_{OUT}$=1.0V 1mA ≦ I_{OUT} ≦ 30mA		×0.98		×1.02	V
I_{OUT}	Output Current	$V_{IN}-V_{OUT}$=1.0V		100			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$V_{IN}-V_{OUT}$=1.0V 1mA ≦ I_{OUT} ≦ 100mA			8	20	mV
V_{DIF}	Dropout Voltage	I_{OUT}=100mA	V_{OUT}=1.5V		0.24	0.44	V
			V_{OUT}=1.6V		0.22	0.40	
			V_{OUT}=1.7V		0.21	0.38	
			1.8V ≦ V_{OUT} ≦ 2.0V		0.20	0.37	
			2.1V ≦ V_{OUT} ≦ 2.7V		0.18	0.33	
			2.8V ≦ V_{OUT} ≦ 4.0V		0.15	0.25	
I_{SS}	Supply Current	$V_{IN}-V_{OUT}$=1.0V			90	120	μA
$I_{standby}$	Standby Current	$V_{IN}-V_{OUT}$=1.0V, V_{CE}=GND			0.1	1.0	μA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	I_{OUT}=30mA, V_{OUT}+0.5V ≦ V_{IN} ≦ 6.0V (V_{OUT} ≦ 1.6V: 2.2V ≦ V_{IN} ≦ 6.0V)			0.02	0.10	%/V
RR	Ripple Rejection	sinusoidal Ripple 0.5Vp-p $V_{IN}-V_{OUT}$=1.0V, I_{OUT}=30mA ∗V_{OUT} ≦ 1.7V, $V_{IN}-V_{OUT}$=1.2V, I_{OUT}=30mA	f=1kHz		70		dB
			f=10kHz		65		
			f=10kHz (V_{OUT} ≧ 2.5V)		60		
V_{IN}	Input Voltage			2		6	V
$\Delta V_{OUT}/\Delta Topt$	Output Voltage Temperature Coefficient	I_{OUT}=30mA −40°C ≦ Topt ≦ 85°C			±100		ppm/°C
I_{SC}	Short Current Limit	V_{OUT}=0V			40		mA
R_{PD}	CE Pull-down Resistance			0.7	2.0	5.0	MΩ
V_{CEH}	CE Input Voltage "H"			1.5		6.0	V
V_{CEL}	CE Input Voltage "L"			0		0.3	V
en	Output Noise	BW=10Hz to 100kHz			30		μVrms
R_{LOW}	On Resistance of Nch Tr. for Auto-discharge (Applied to B version)	V_{CE}=0V			50		Ω

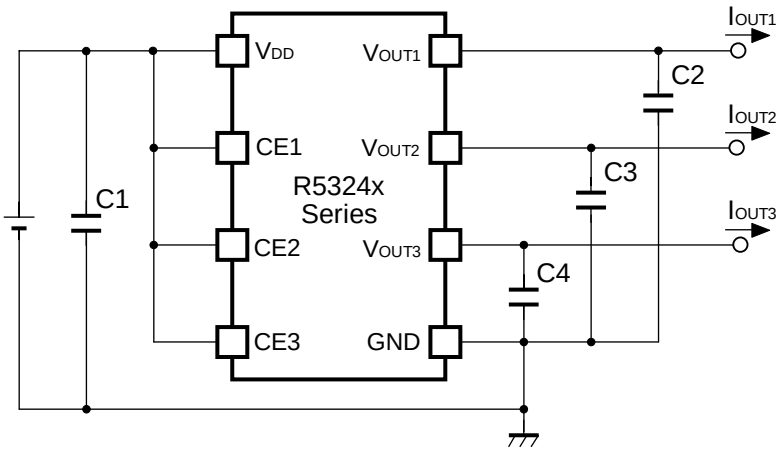
OPERATION



Fluctuation of each regulator's output voltage, or V_{OUT1}, V_{OUT2}, V_{OUT3} is detected individually. Then it is put back to an error amplifier through feedback resistors, or R1_1, R2_1, R1_2, R2_2, R1_3, R2_3 and compared with a reference voltage and compensated for the result and make a constant voltage.

In each regulator, short protection is made with a current limit circuit and stand-by mode is available by a chip enable circuit.

TYPICAL APPLICATION



(External Components)

Output Capacitor : Ceramic 1.0μF or more

TECHNICAL NOTES

When using these ICs, consider the following points:

Phase Compensation

In these ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, use a capacitor C2, C3 and C4 with 1.0μF or more.

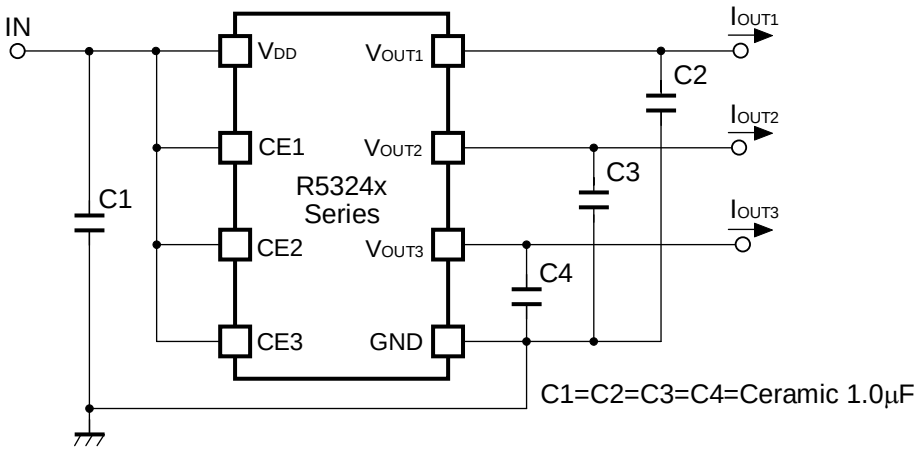
If a tantalum capacitor is used, and its ESR (Equivalent Series Resistance) of C2, C3 and C4 is large, the loop oscillation may result. Because of this, select C2, C3 and C4 carefully considering its frequency characteristics.

PCB Layout

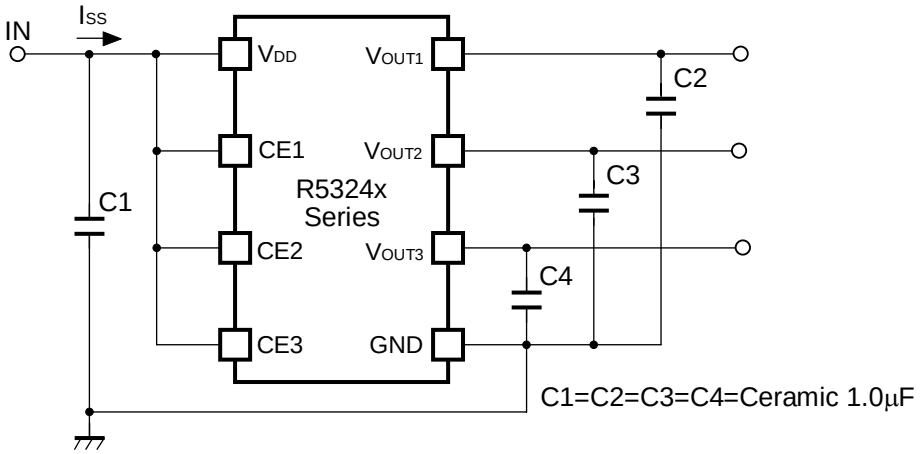
Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as 1.0μF or more between V_{DD} and GND pin, and as close as possible to the pins.

Set external components, especially the output capacitor C2, C3 and C4 as close as possible to the ICs, and make wiring as short as possible.

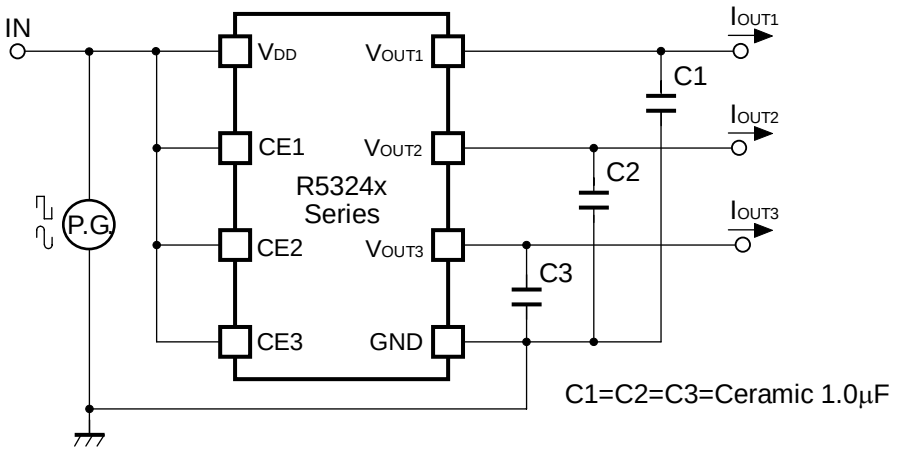
TEST CIRCUIT



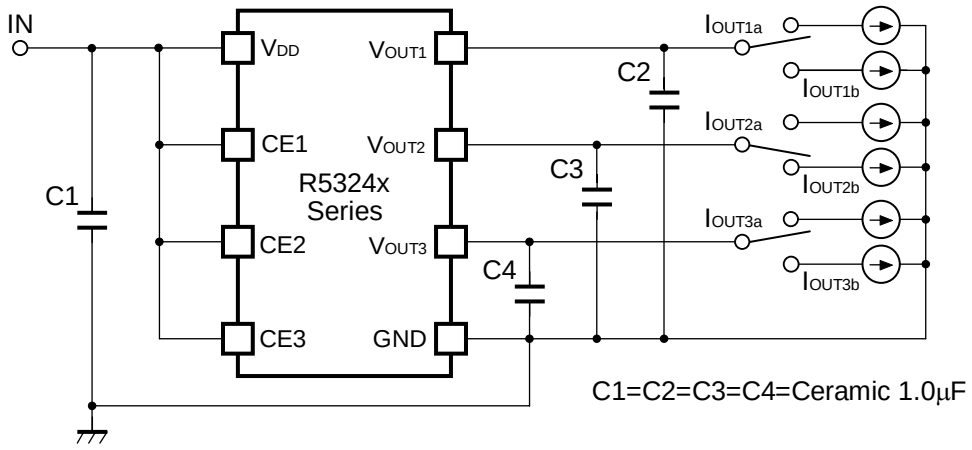
Basic Test Circuit



Test Circuit for Supply Current



Test Circuit for Ripple Rejection, Input Transient Response

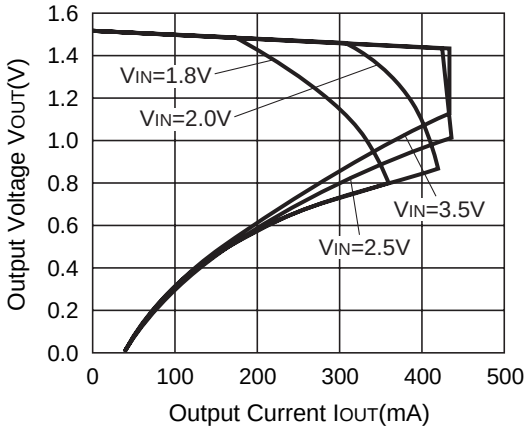


Test Circuit for Load Transient Response

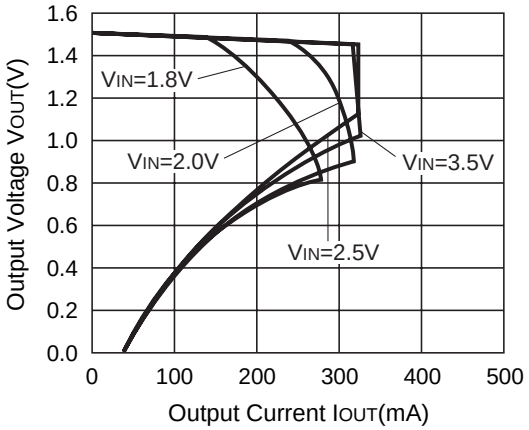
TYPICAL CHARACTERISTICS

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

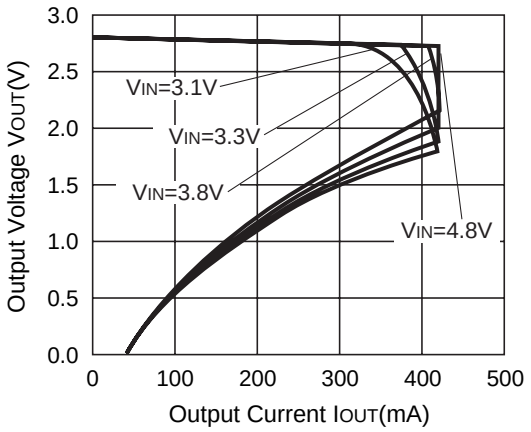
1.5V (VR1)



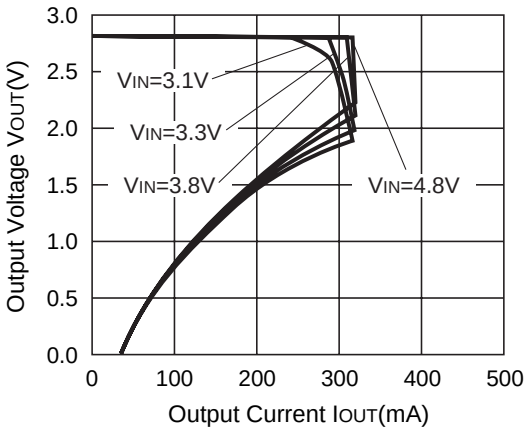
1.5V (VR2/VR3)



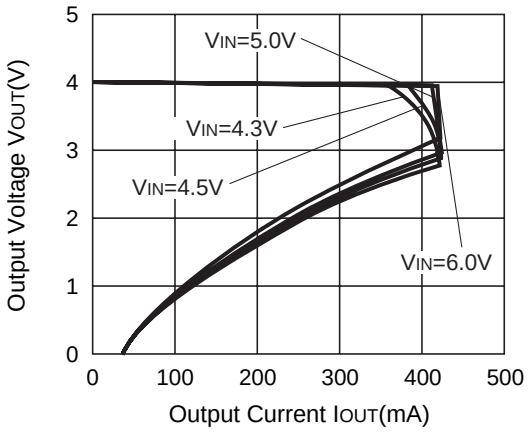
2.8V (VR1)



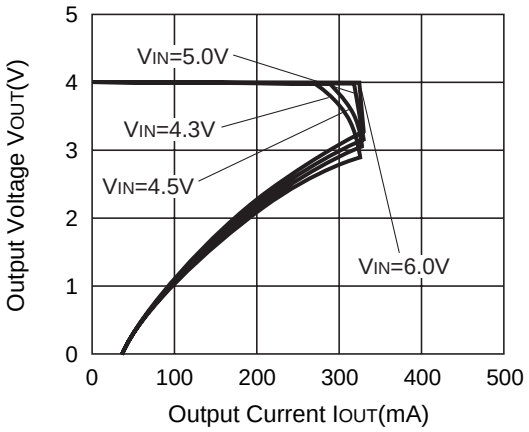
2.8V (VR2/VR3)



4.0V (VR1)

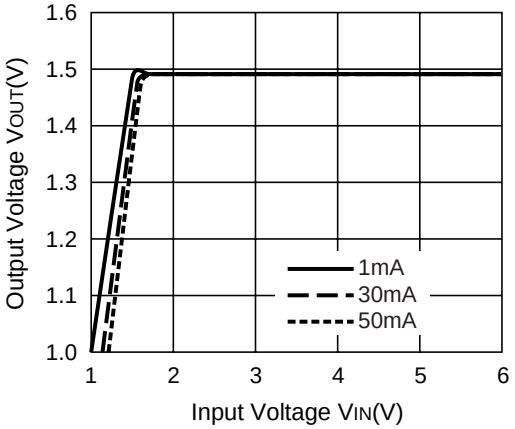


4.0V (VR2/VR3)

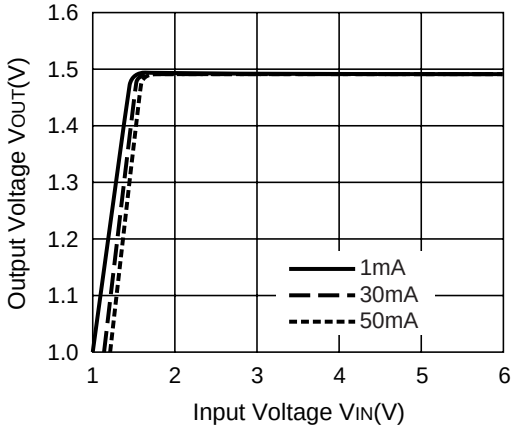


2) Output Voltage vs. Input Voltage (Topt=25°C)

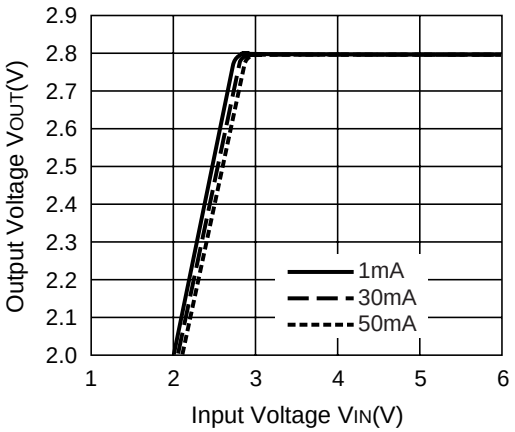
1.5V (VR1)



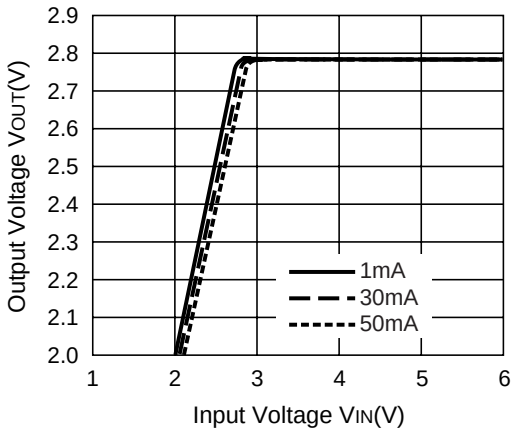
1.5V (VR2/VR3)



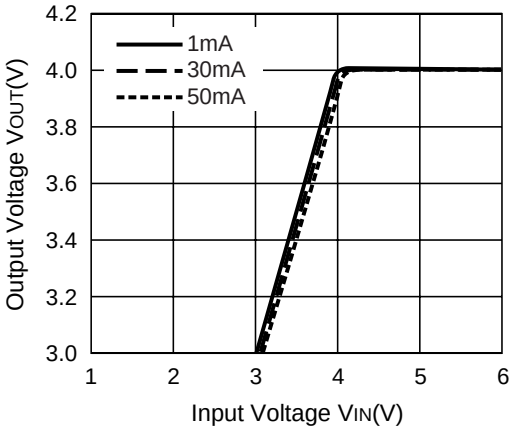
2.8V (VR1)



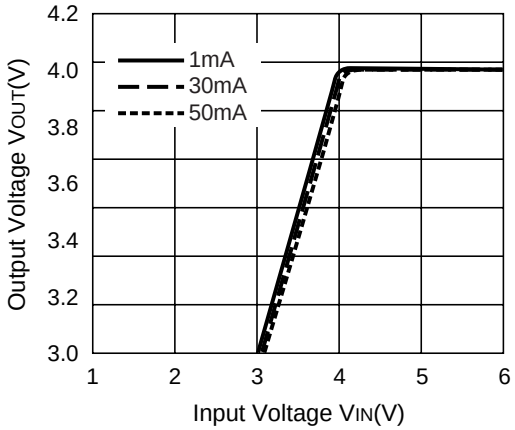
2.8V (VR2/VR3)



4.0V (VR1)

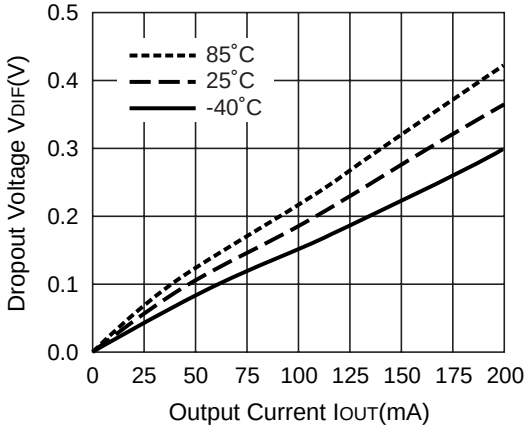


4.0V (VR2/VR3)

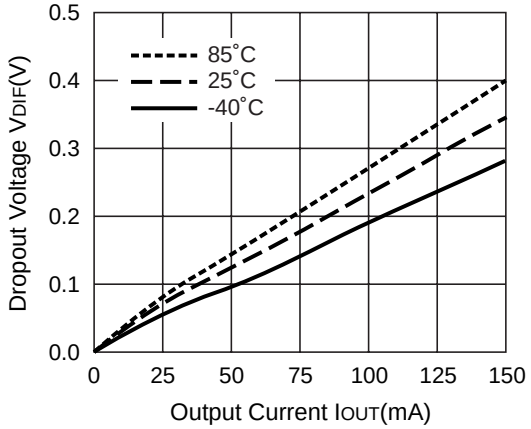


3) Dropout Voltage vs. Output Current

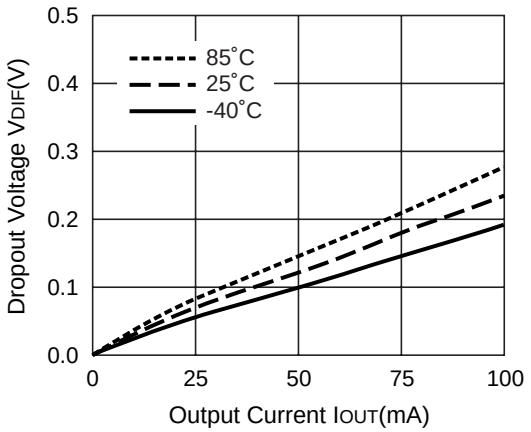
1.5V (VR1)



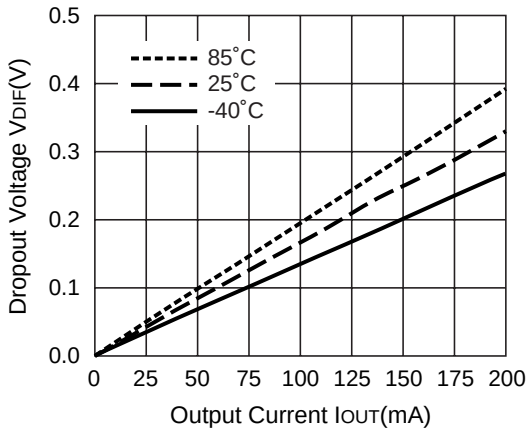
1.5V (VR2)



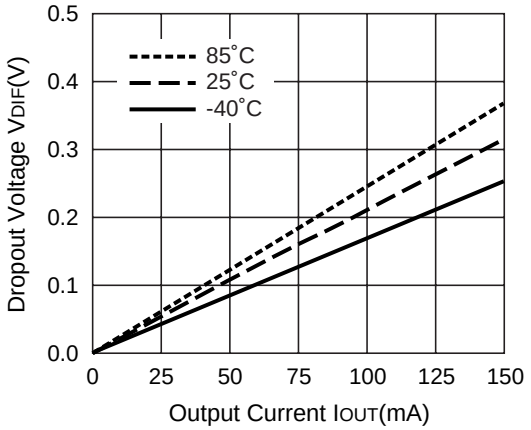
1.5V (VR3)



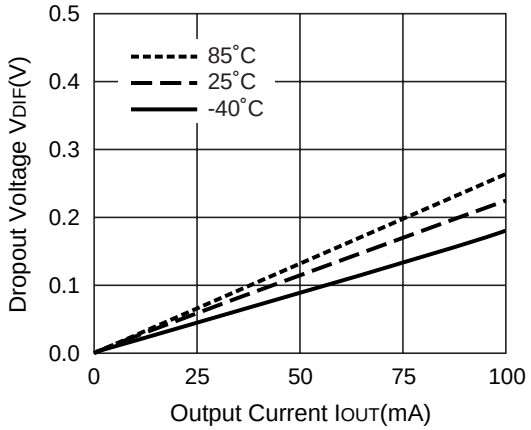
1.6V (VR1)



1.6V (VR2)



1.6V (VR3)



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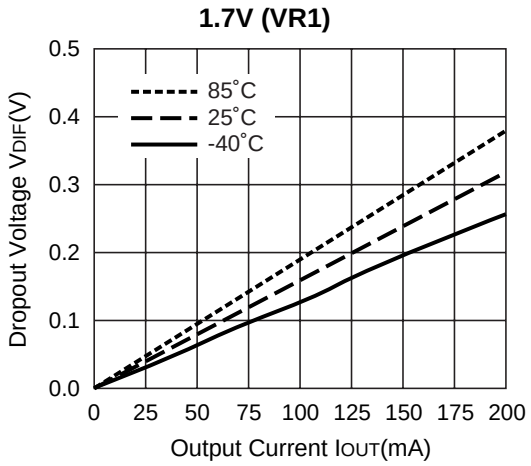
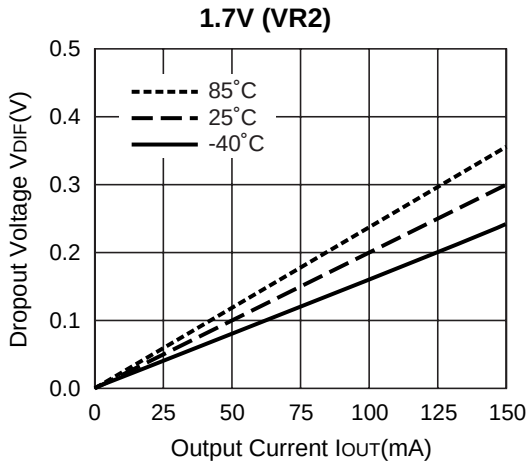
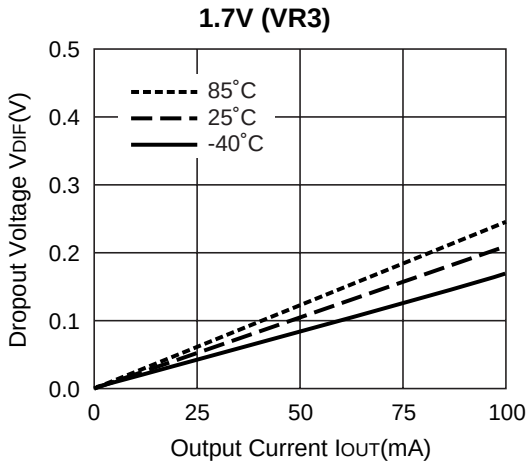
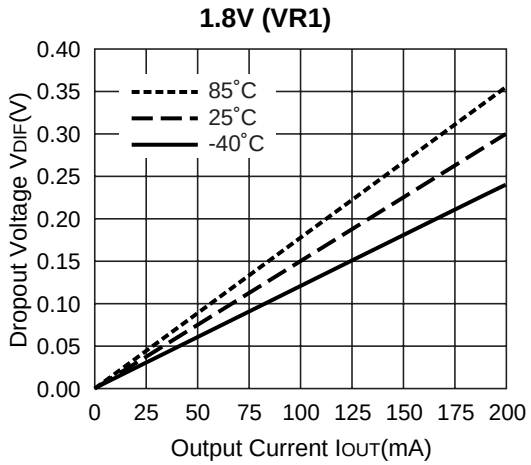
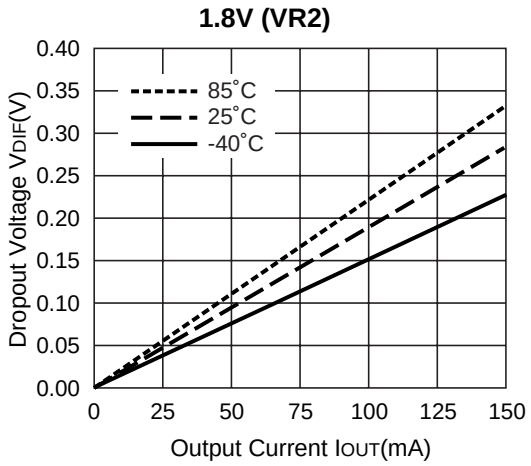
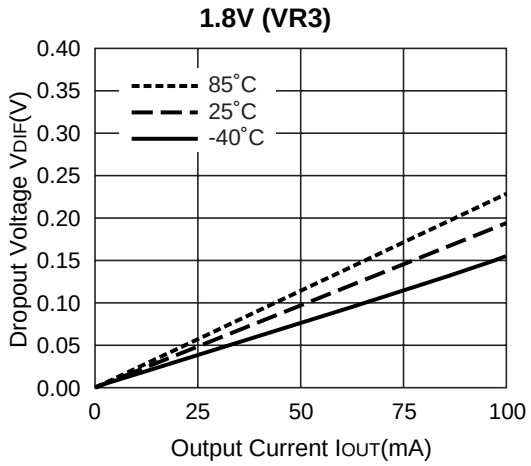

1.7V (VR1)
Dropout Voltage VDIF(V)
0.5
0.4
0.3
0.2
0.1
0.0
85˚C
25˚C
-40˚C
0 25 50 75 100 125 150 175 200
Output Current IOUT(mA)


1.7V (VR2)
Dropout Voltage VDIF(V)
0.5
0.4
0.3
0.2
0.1
0.0
85˚C
25˚C
-40˚C
0 25 50 75 100 125 150
Output Current IOUT(mA)

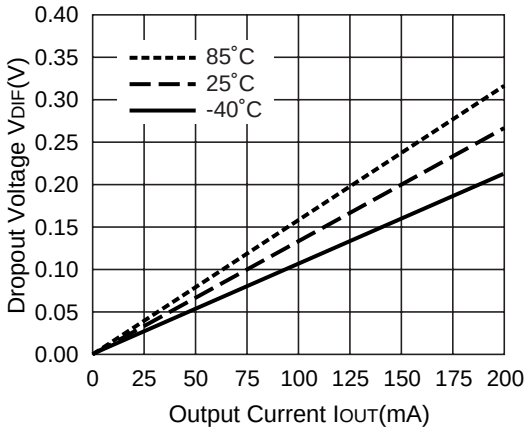

1.7V (VR3)
Dropout Voltage VDIF(V)
0.5
0.4
0.3
0.2
0.1
0.0
85˚C
25˚C
-40˚C
0 25 50 75 100
Output Current IOUT(mA)


1.8V (VR1)
Dropout Voltage VDIF(V)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
85˚C
25˚C
-40˚C
0 25 50 75 100 125 150 175 200
Output Current IOUT(mA)

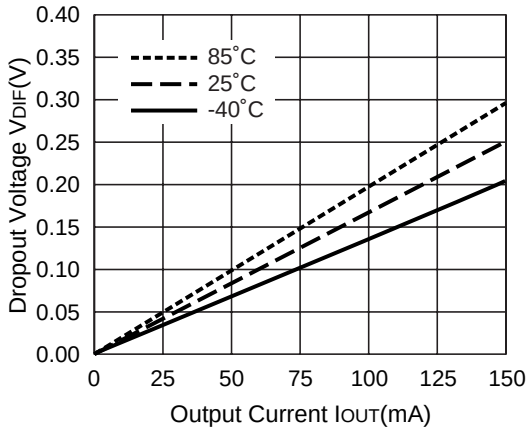

1.8V (VR2)
Dropout Voltage VDIF(V)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
85˚C
25˚C
-40˚C
0 25 50 75 100 125 150
Output Current IOUT(mA)


1.8V (VR3)
Dropout Voltage VDIF(V)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
85˚C
25˚C
-40˚C
0 25 50 75 100
Output Current IOUT(mA)

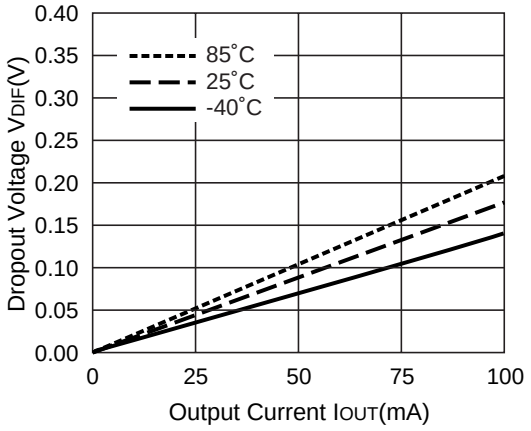
2.1V (VR1)



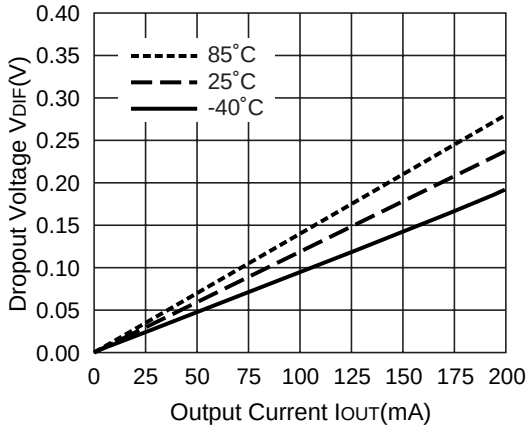
2.1V (VR2)



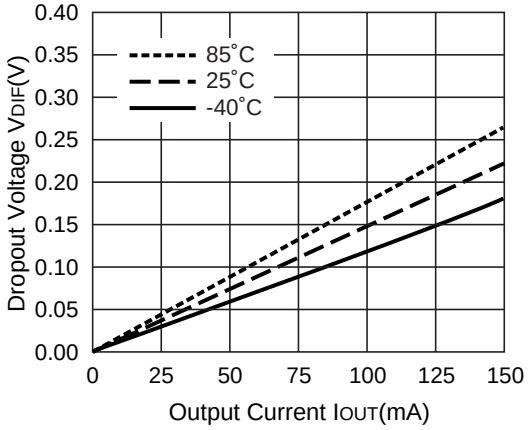
2.1V (VR3)



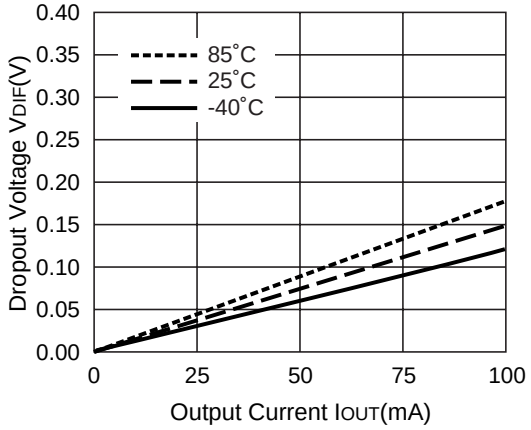
2.8V (VR1)



2.8V (VR2)



2.8V (VR3)



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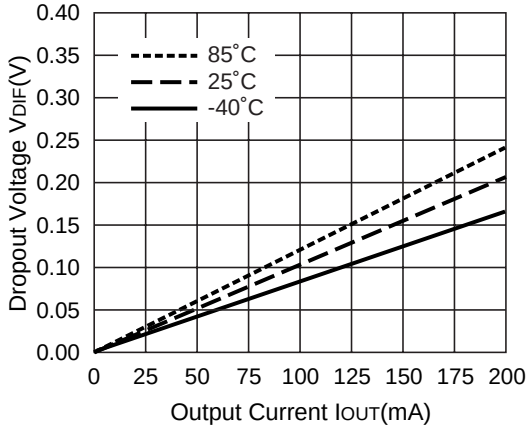
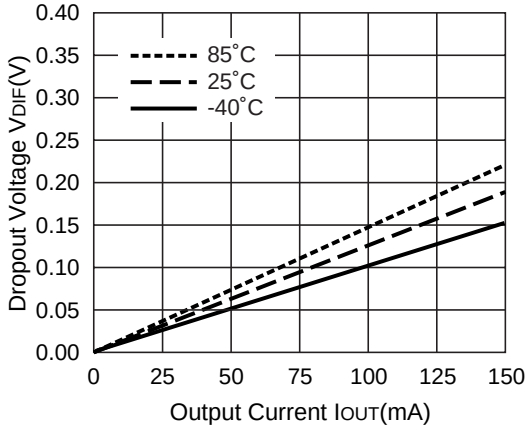
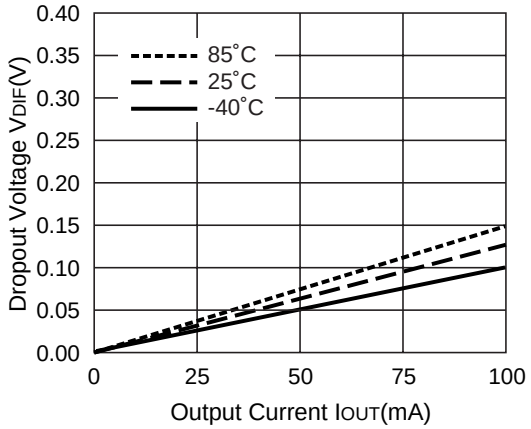
4.0V (VR1)



4.0V (VR2)

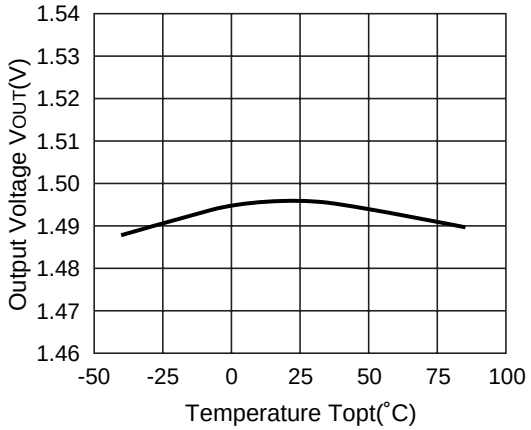


4.0V (VR3)

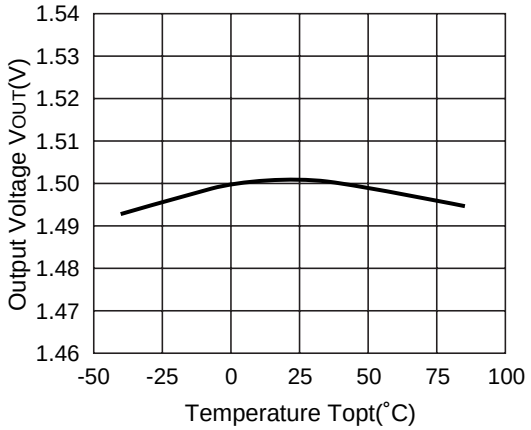


4) Output Voltage vs. Temperature (I_{OUT}=30mA)

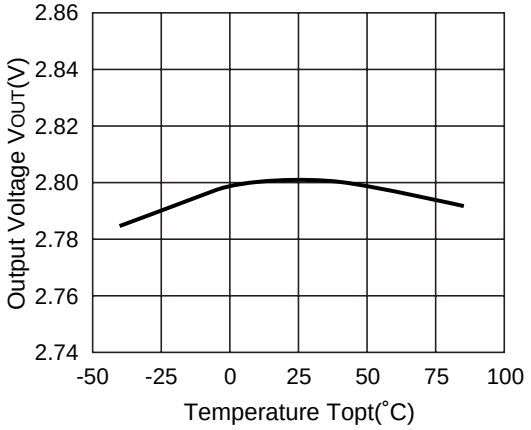
1.5V (VR1) V_{IN}=2.5V



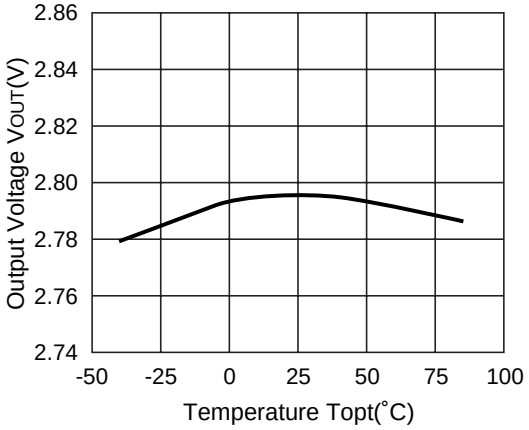
1.5V (VR2/VR3) V_{IN}=2.5V



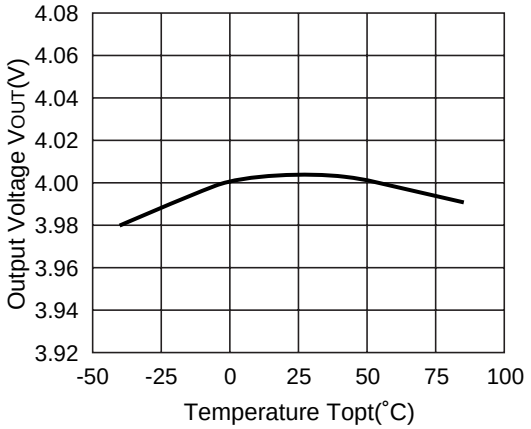
2.8V (VR1) V_{IN}=3.8V



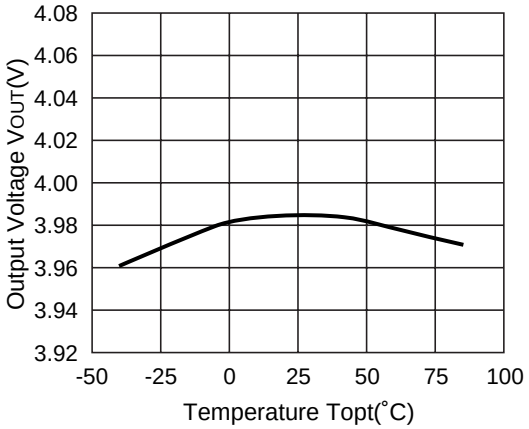
2.8V (VR2/VR3) V_{IN}=3.8V



4.0V (VR1) V_{IN}=5.0V

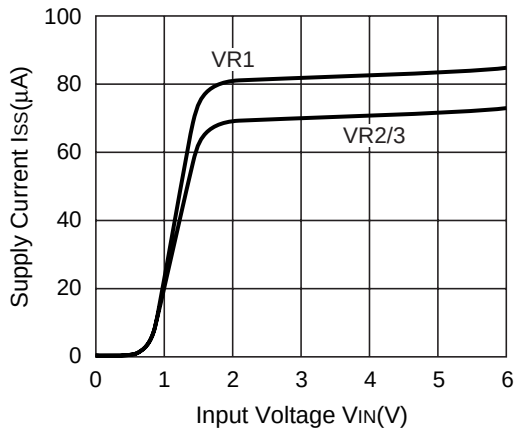


4.0V (VR2/VR3) V_{IN}=5.0V

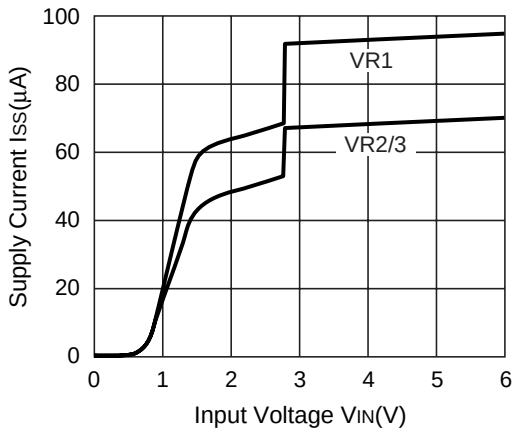


5) Supply Current vs. Input Voltage (Topt=25°C)

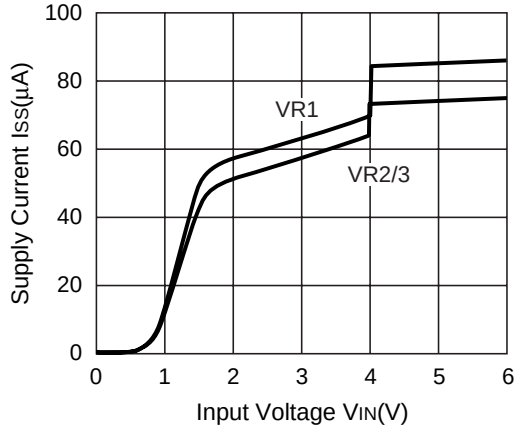
1.5V



2.8V

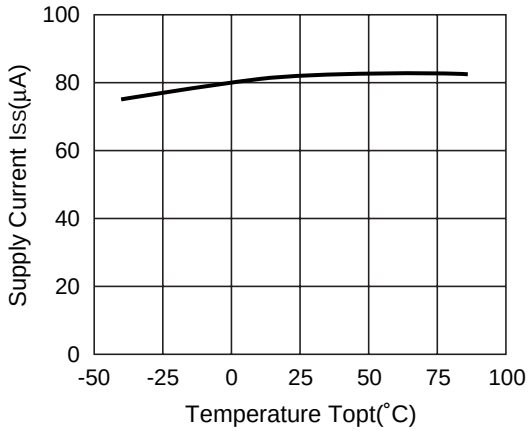


4.0V

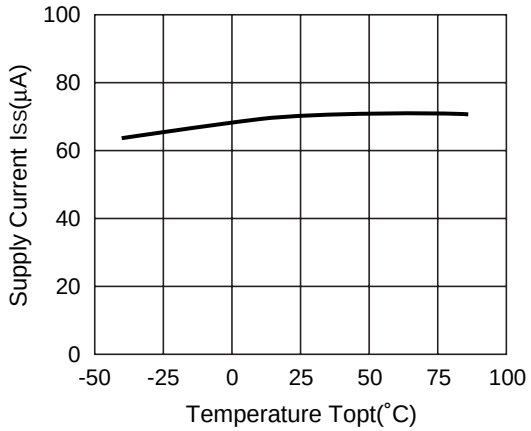


6) Supply Current vs. Temperature

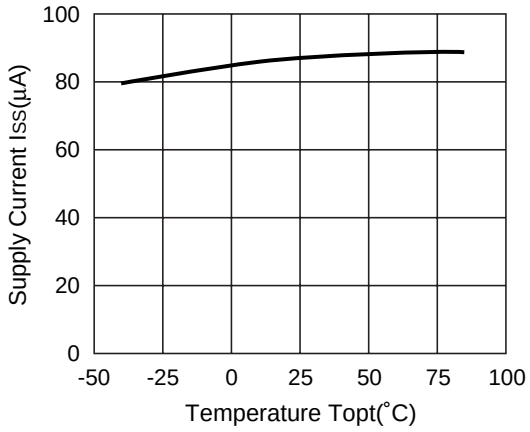
1.5V (VR1) V_{IN}=2.5V



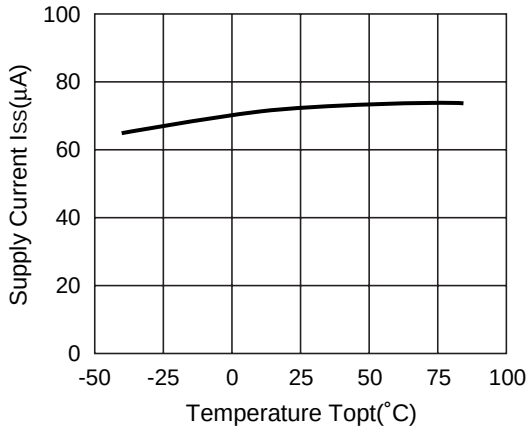
1.5V (VR2/VR3) V_{IN}=2.5V

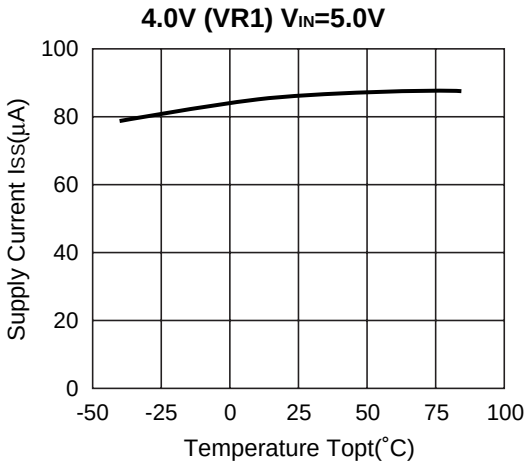


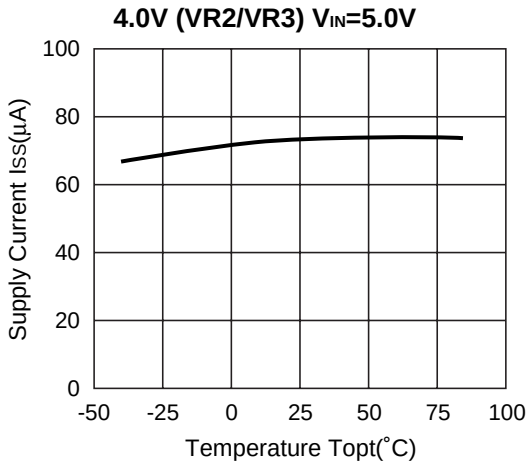
2.8V (VR1) V_{IN}=3.8V



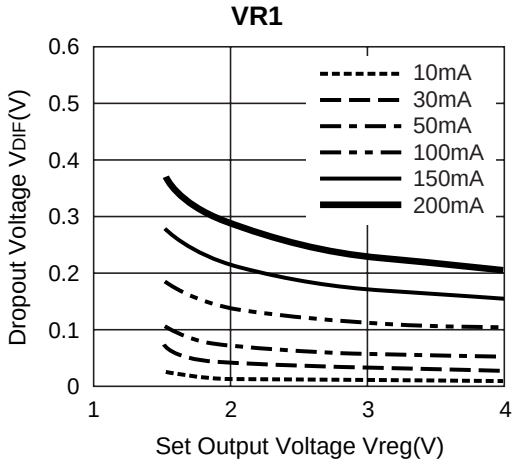
2.8V (VR2/VR3) V_{IN}=3.8V

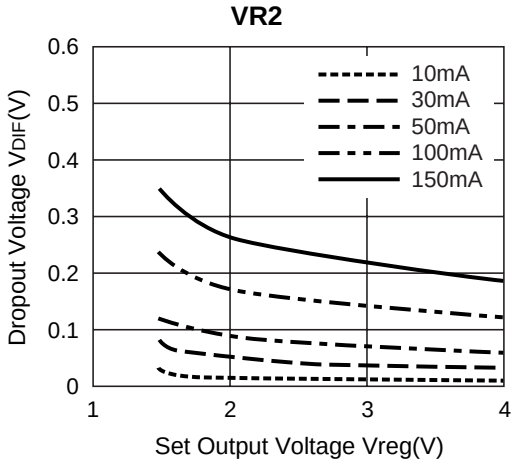


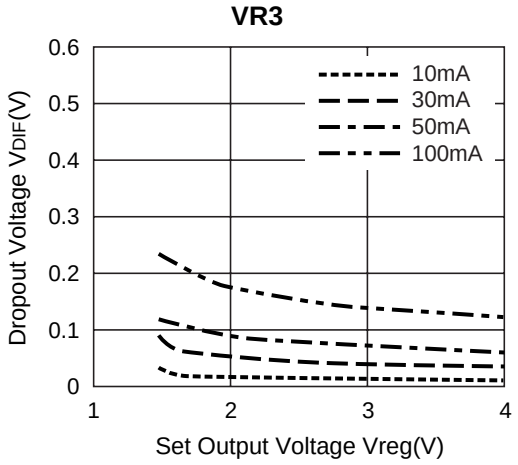




7) Dropout Voltage vs. Set Output Voltage (Topt=25°C)

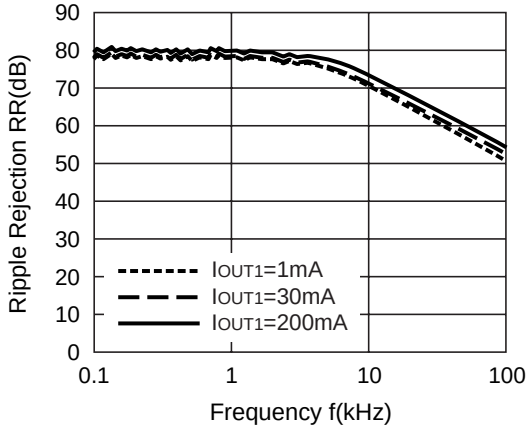




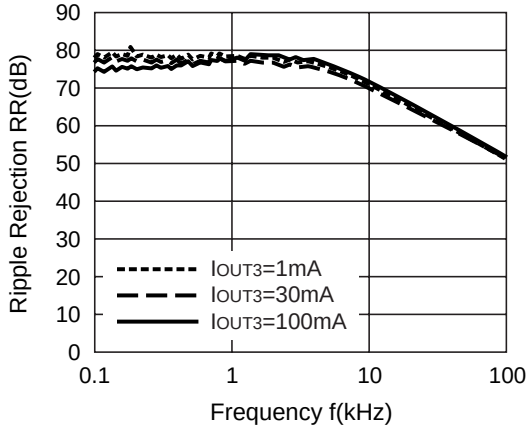


8) Ripple Rejection vs. Frequency (Topt=25°C, C_{OUT}=Ceramic 1.0μF)

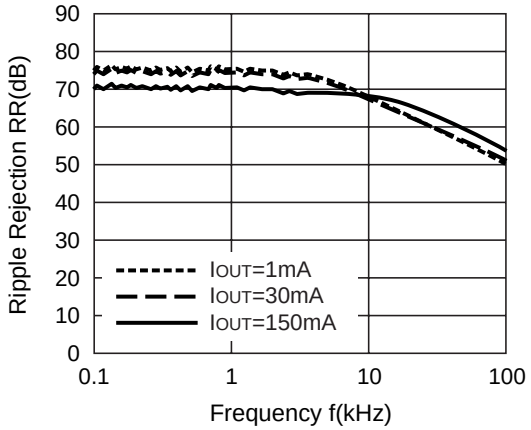
1.5V (VR1) V_{IN}=2.7V_{DC}+0.5Vp-p



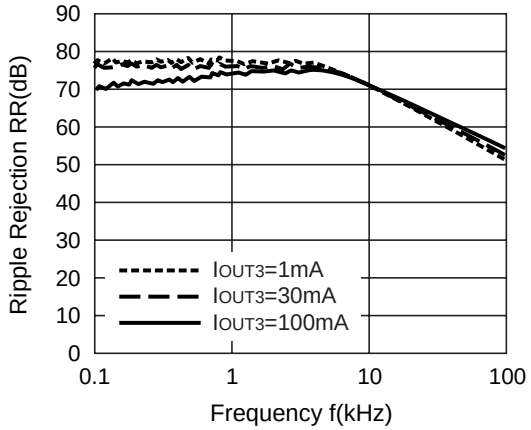
1.5V (VR1) (I_{OUT3} dependence) V_{IN}=2.7V_{DC}+0.5Vp-p



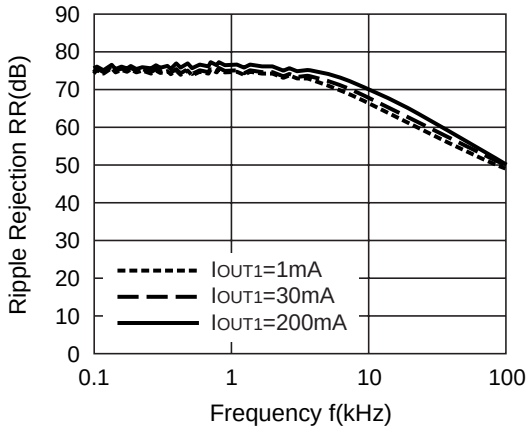
1.5V (VR2) V_{IN}=2.7V_{DC}+0.5Vp-p



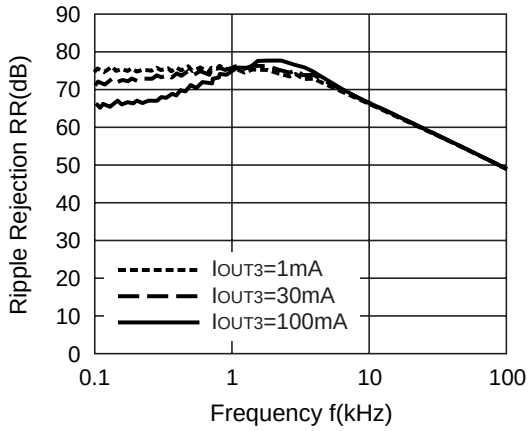
1.5V (VR3) V_{IN}=2.7V_{DC}+0.5Vp-p



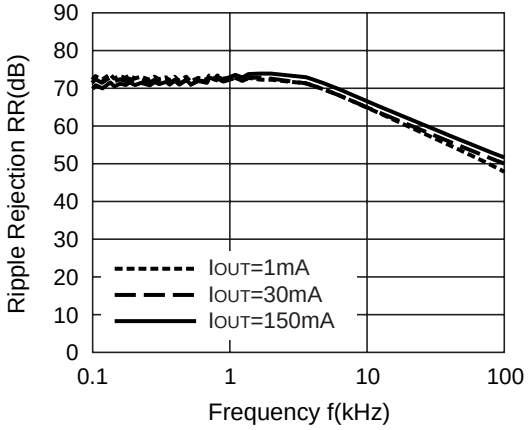
2.8V (VR1) V_{IN}=3.8V_{DC}+0.5Vp-p



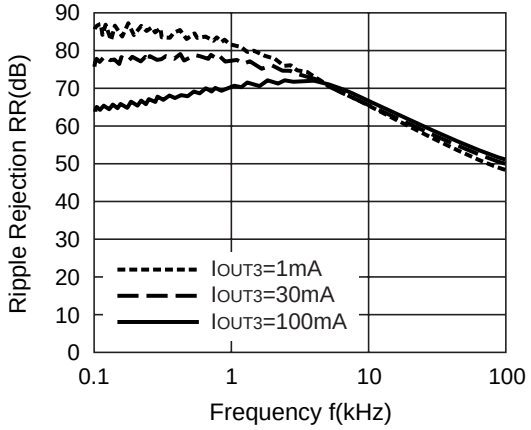
2.8V (VR1) (I_{OUT3} dependence) V_{IN}=3.8V_{DC}+0.5Vp-p



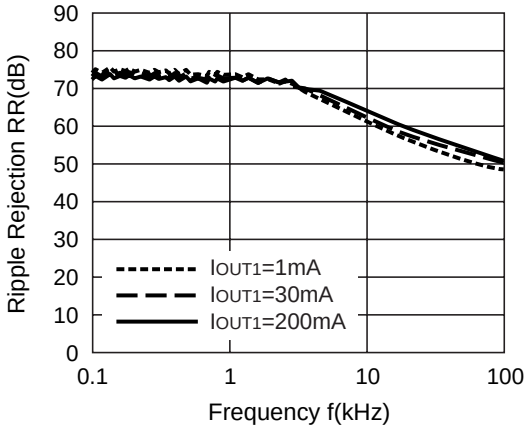
2.8V (VR2) V_{IN}=3.8V_{DC}+0.5Vp-p



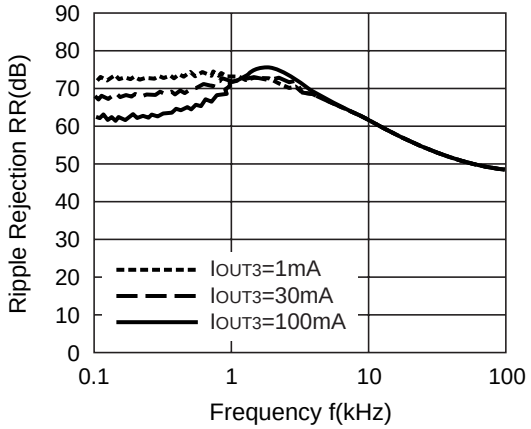
2.8V (VR3) V_{IN}=3.8V_{DC}+0.5Vp-p



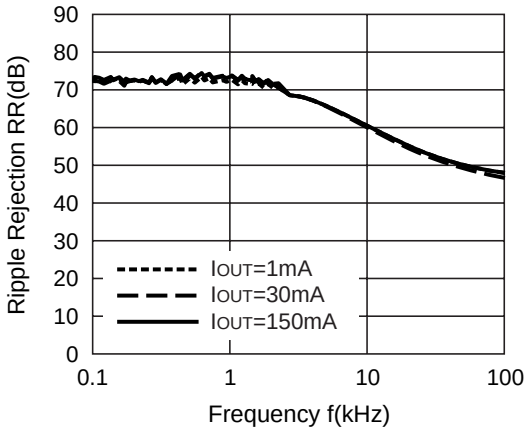
4.0V (VR1) V_{IN}=5.0V_{DC}+0.5Vp-p



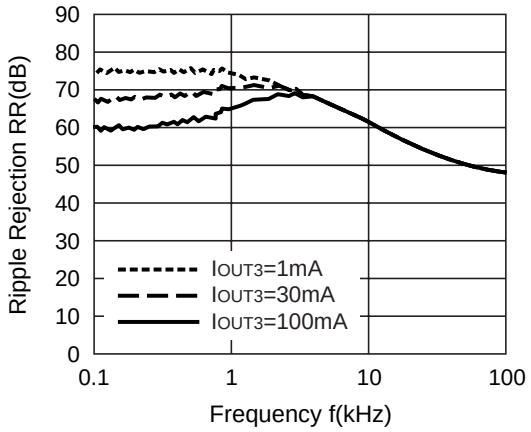
4.0V (VR1) (I_{OUT3} dependence) V_{IN}=5.0V_{DC}+0.5Vp-p



4.0V (VR2) V_{IN}=5.0V_{DC}+0.5Vp-p

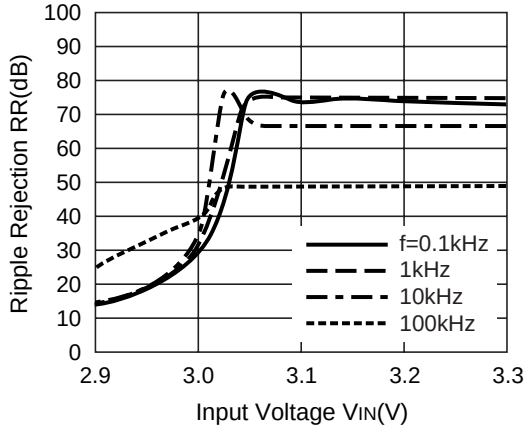


4.0V (VR3) V_{IN}=5.0V_{DC}+0.5Vp-p

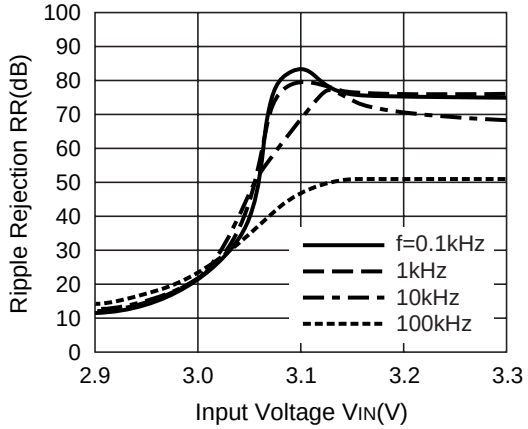


9) Ripple Rejection vs. DC Input Bias (Topt=25°C, C_{OUT}=1.0μF)

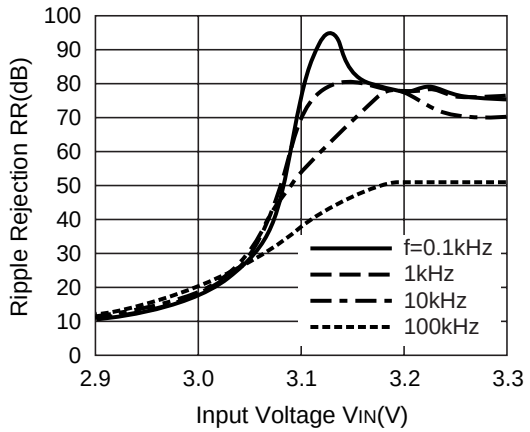
2.8V (VR1) I_{OUT}=1mA



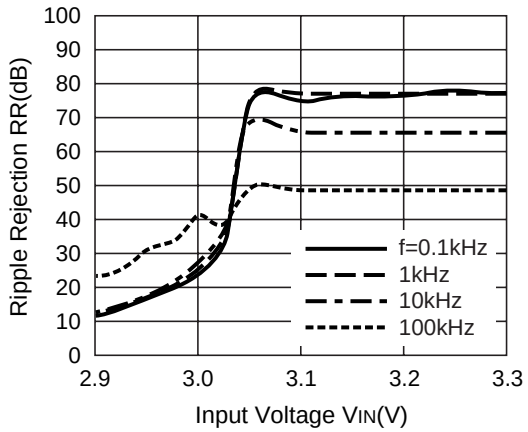
2.8V (VR1) I_{OUT}=30mA



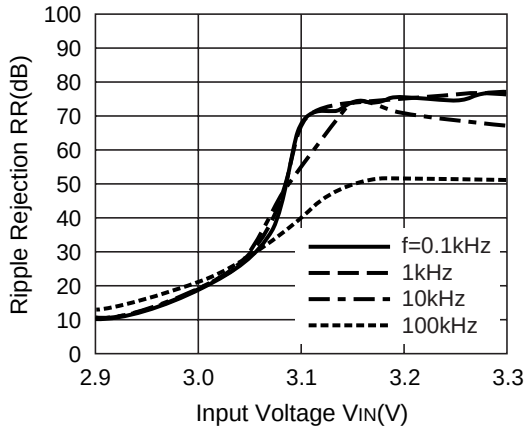
2.8V (VR1) I_{OUT}=50mA



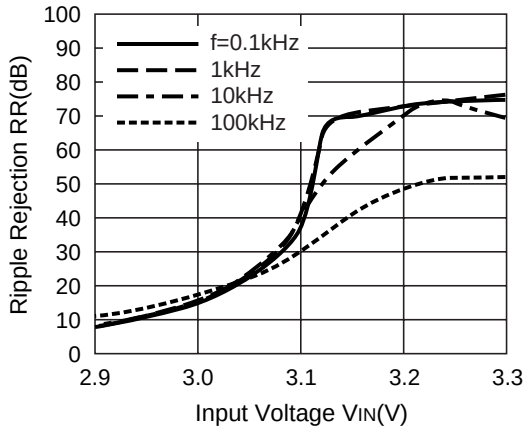
2.8V (VR2) I_{OUT}=1mA



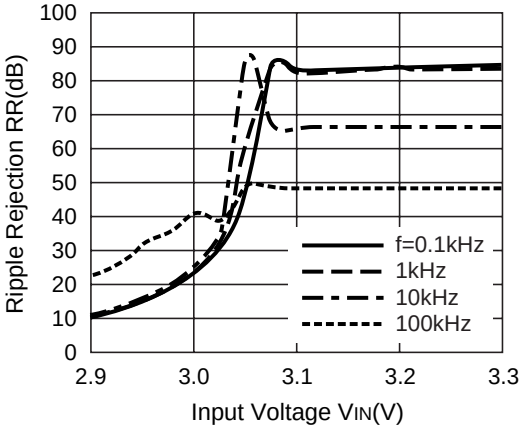
2.8V (VR2) I_{OUT}=30mA



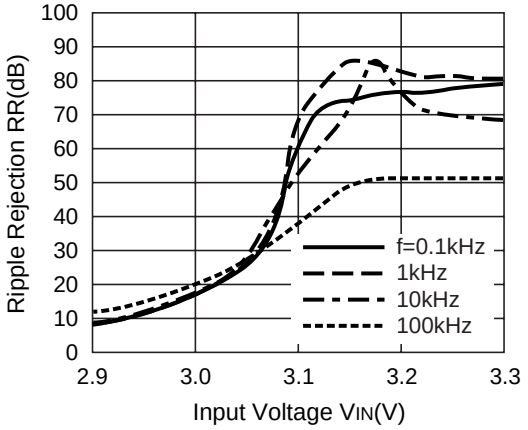
2.8V (VR2) I_{OUT}=50mA



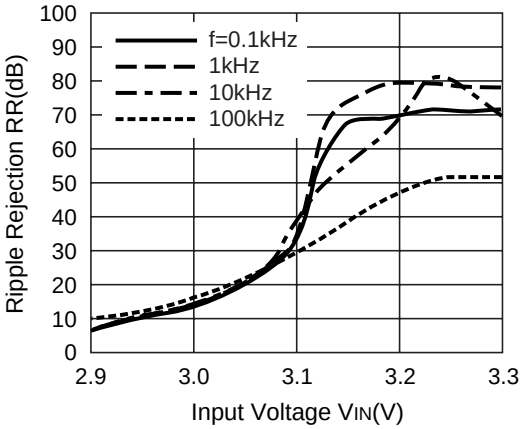
2.8V (VR3) I_{OUT}=1mA



2.8V (VR3) I_{OUT}=30mA

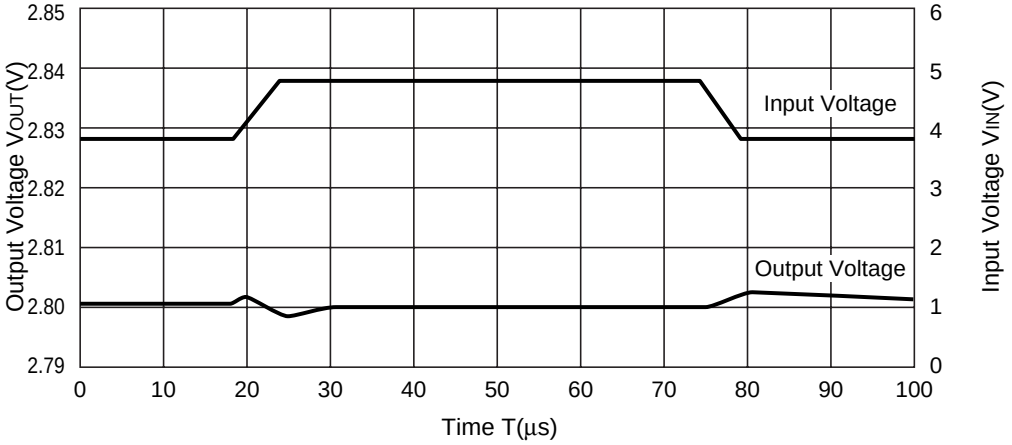


2.8V (VR3) I_{OUT}=50mA

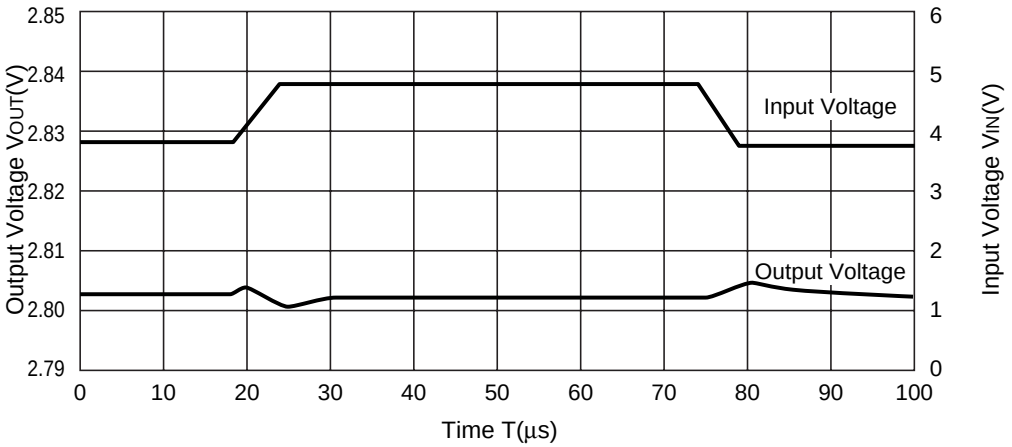


10) Line Transient Response (I_{OUT}=30mA, C_{IN}=none, tr=tf=5μs, C_{OUT}=Ceramic 1μF)

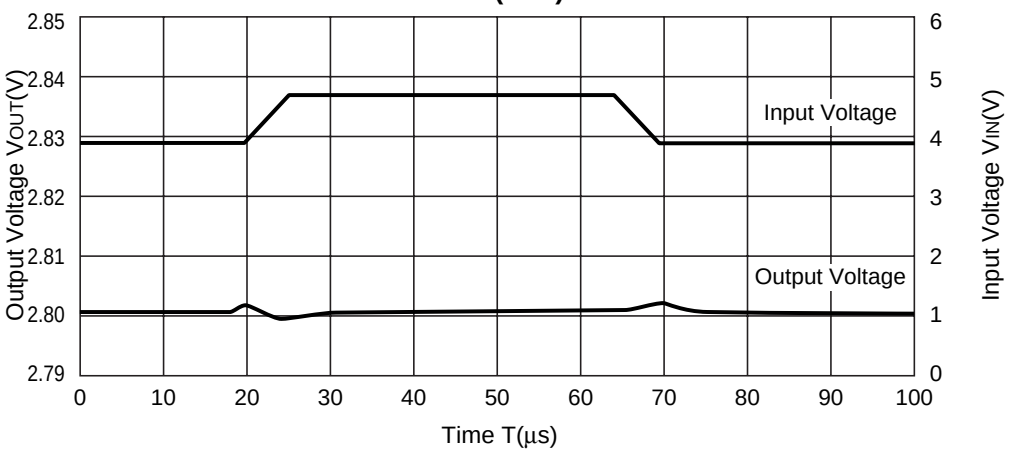
2.8V(VR1)



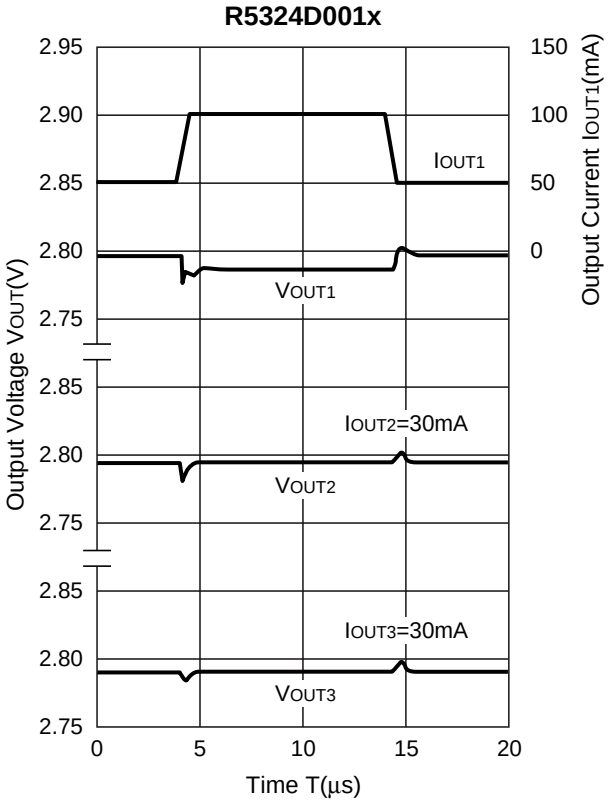
2.8V(VR2)

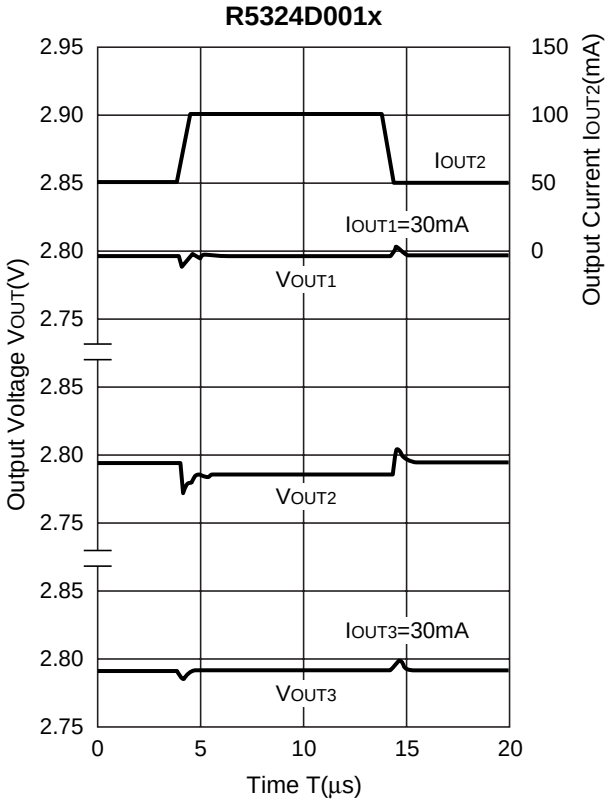


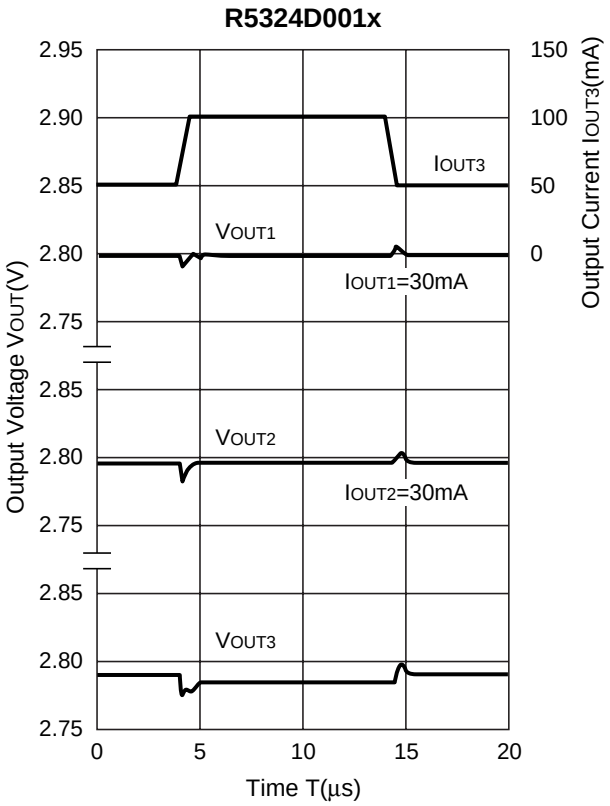
2.8V(VR3)



11) Load Transient Response (C_{IN}=Ceramic 1.0μF, C_{OUT}=Ceramic 1.0μF)







ESR vs. Output Current

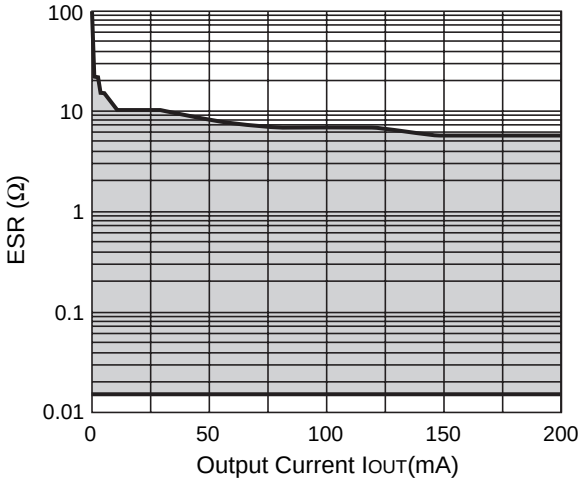
When using these ICs, consider the following points:

The relations between I_{OUT} (Output Current) and ESR of an output capacitor are shown below.
The conditions when the white noise level is under 40μV (Avg.) are marked as the hatched area in the graph.

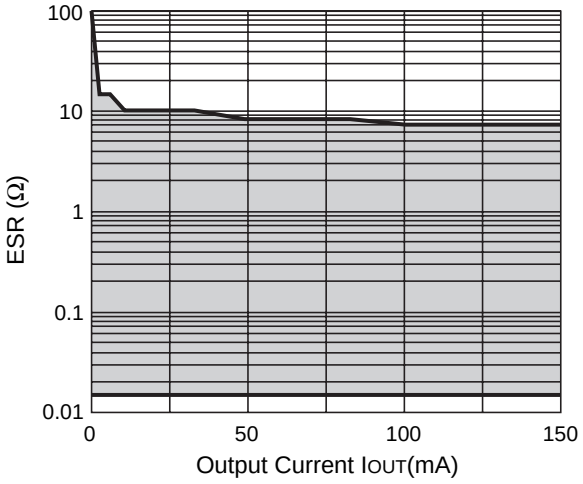
Measurement conditions

Frequency Band : 10Hz to 2MHz
Temperature : –40°C to 85°C

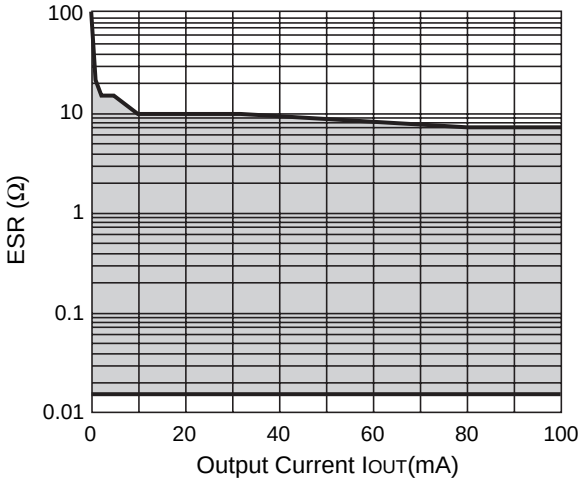
1.5V(VR1)



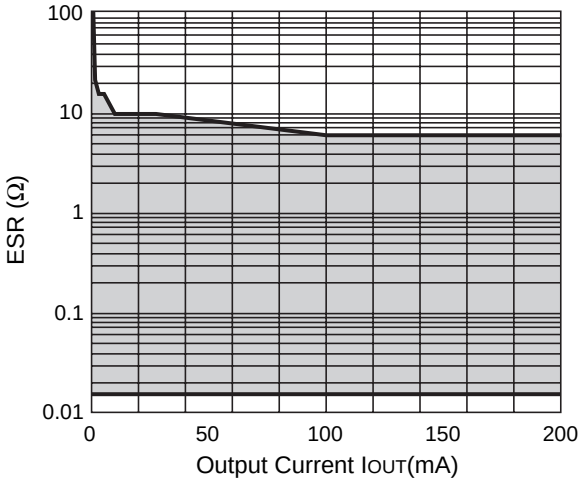
1.5V(VR2)



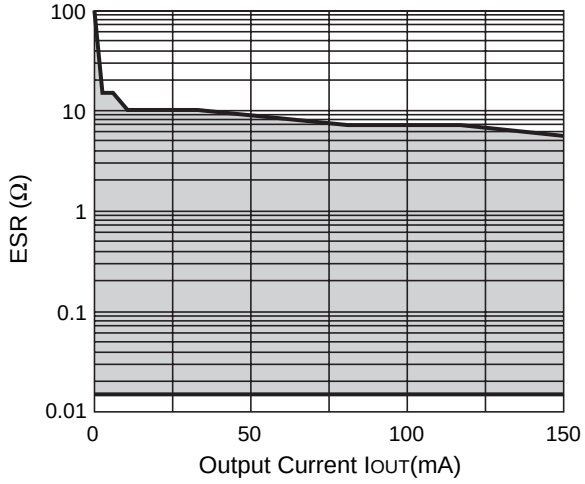
1.5V(VR3)



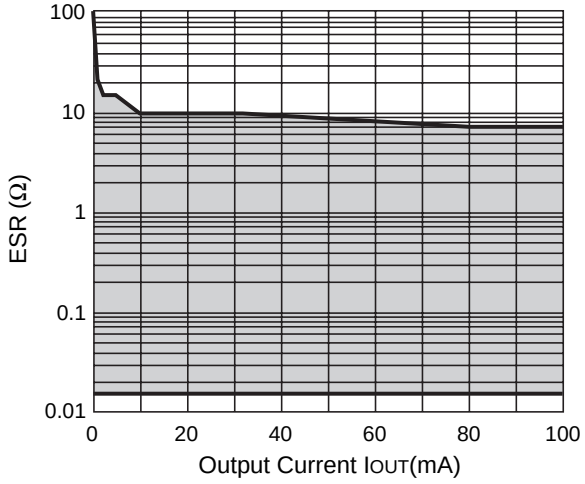
2.8V(VR1)



2.8V(VR2)



2.8V(VR3)



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