RICOH

R1190x SERIES

1A VOLTAGE REGULATOR (Operating Voltage up to 16V)

NO.EA-183-161011

OUTLINE

The R1190x series are a low supply current voltage regulator with high output voltage accuracy. The maximum operating voltage is 16V and the output current is 1A. Each of these ICs consists of a voltage reference unit, an error amplifier, a resistor-net for voltage setting, as a short current protection, a peak current protection, a thermal shutdown, an inrush current limit and a chip enable circuit. The wide input voltage range (Max. 16V). Additionally, the output voltage is fixed internally, in the range from 2.0V to 12.0V by the 0.1V steps. The supply current of R1190x series is excellent (Typ. 150μA) moreover R1190x series has the standby mode (Typ. 0.1μA) by the chip enable function.

Since the package for these ICs are TO-252-5-P2, SOT-89-5 and HSOP-6J with high power dissipation, high density mounting of the ICs on boards is possible.

FEATURES

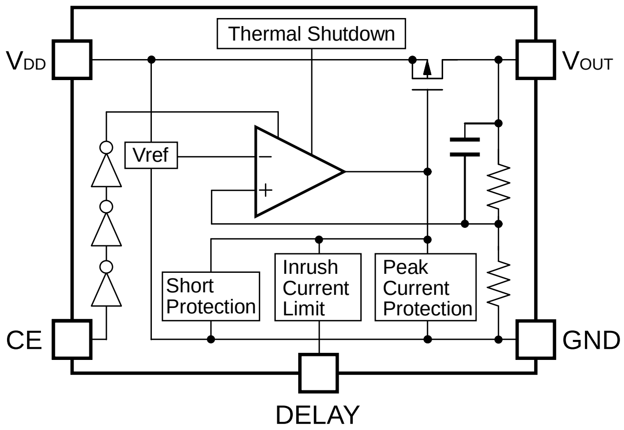
- Input Voltage Range .... 3.5V to 16V
- Supply Current .... Typ. 150μA
- Standby Current .... Typ. 0.1μA
- Output Voltage Range.. 2.0V to 12.0V (0.1V steps)
  (For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy....................................... ±1.5%
- Temperature-Drift Coefficient of Output Voltage ... Typ. ±100ppm/°C
- Dropout Voltage .... Typ. 1.1V (I_{OUT}=1A, V_{OUT}=5V)
- Output Current .... Min. 1A (3.3V ≤ V_{OUT} ≤ 12.0V)
- Line Regulation .... Typ. 0.02%/V
- Packages SOT-89-5, HSOP-6J, TO-252-5-P2
- Built-in Fold Back Protection Circuit .... Typ.300mA (Current at short mode)
- Built-in Thermal Shutdown Circuit
- Built-in Inrush Current Limit Circuit .... The Delay Pin for setting Inrush Current Limit Time

APPLICATIONS

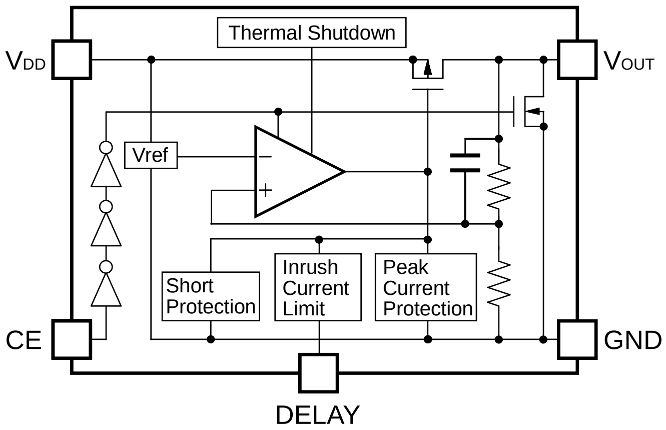
- Power source for digital home appliances.
- Power source for audio visual equipments.

BLOCK DIAGRAMS

R1190xxxxB



R1190xxxxD



SELECTION GUIDE

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

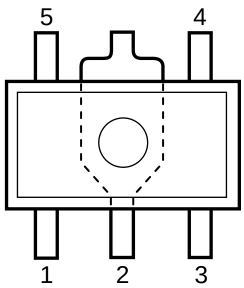
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1190Hxxx∗-T1-FE	SOT-89-5	1,000 pcs	Yes	Yes
R1190Sxxx∗-E2-FE	HSOP-6J	1,000 pcs	Yes	Yes
R1190Jxxx∗-T1-FE	TO-252-5-P2	3,000 pcs	Yes	Yes

xxx : The output voltage can be designated in the range of 2.0V(020) to 12.0V(120) in 0.1V steps.
(For other voltages, please refer to MARK INFORMATIONS.)

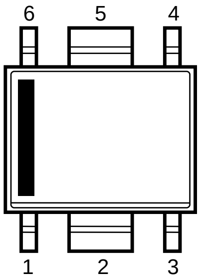
∗ : The auto discharge function at off state are options as follows.
(B) without auto discharge function at off state
(D) with auto discharge function at off state

PIN CONFIGURATIONS

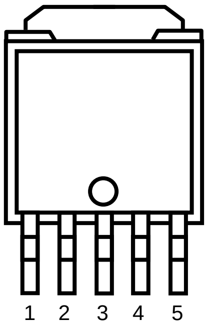
- **SOT-89-5**



- **HSOP-6J**



- **TO-252-5-P2**



PIN DESCRIPTIONS

- **SOT-89-5**

Pin No.	Symbol	Description
1	V_{OUT}	Output Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin ("H" Active)
4	DELAY	Delay Pin (for setting Inrush Current Limit Time)
5	V_{DD}	Input Pin

- **HSOP-6J**

Pin No.	Symbol	Description
1	V_{OUT}	Output Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin ("H" Active)
4	DELAY	Delay Pin (for setting Inrush Current Limit Time)
5	GND	Ground Pin
6	V_{DD}	Input Pin

- **TO-252-5-P2**

Pin No.	Symbol	Description
1	DELAY	Delay Pin (for setting Inrush Current Limit Time)
2	V_{DD}	Input Pin
3	GND	Ground Pin
4	V_{OUT}	Output Pin
5	CE	Chip Enable Pin ("H" Active)

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	–0.3 to 18	V
V_{CE}	Input Voltage (CE Pin)	–0.3 to V_{IN}+0.3 ≤ 18	V
V_{OUT}	Output Voltage	–0.3 to V_{IN}+0.3 ≤ 18	V
P_D	Power Dissipation (SOT-89-5) *	900	mW
	Power Dissipation (HSOP-6J) *	1700	
	Power Dissipation (TO-252-5-P2) *	1900	
T_{opt}	Operating Temperature Range	–40 to 85	°C
T_{stg}	Storage Temperature Range	–55 to 125	°C

∗) For Power Dissipation, please refer to PACKAGE INFORMATION.

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field.
The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

V_{IN}=V_{CE}=Set V_{OUT}+2.0V, C_{IN}=C_{OUT}=4.7µF, I_{OUT}=1mA, unless otherwise noted.

The specification in ☐ is checked and guaranteed by design engineering at –40°C ≤ Topt ≤ 85°C.

- **R1190x**

Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	I_{OUT}=1mA	Topt=25°C	×0.985		×1.015	V
			–40°C ≤ Topt ≤ 85°C	×0.973		×1.027	
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	Refer to the following table					
V_{DIF}	Dropout Voltage	Refer to the following table					
I_{SS}	Supply Current	I_{OUT}=0mA			150	220	µA
Istandby	Standby Current (CE Off State)	V_{IN}=16V V_{CE}=0V			0.1	1.0	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{OUT}+0.5V (Min.3.5V) ≤ V_{IN} ≤ 16V I_{OUT}=1mA			0.02	0.10	%/V
RR	Ripple Rejection	f=1kHz, I_{OUT}=100mA			60		dB
V_{IN}	Input Voltage			3.5		16	V
ΔV_{OUT} /ΔTopt	Output Voltage Temperature Coefficient	I_{OUT}=1mA, –40°C ≤ Topt ≤ 85°C			±100		ppm /°C
I_{LIM}	Output Current	Refer to the following table					
I_{SC}	Short Current Limit	V_{OUT}=0V			300		mA
V_{CEH}	CE Input Voltage "H"			1.6		V_{IN}	V
V_{CEL}	CE Input Voltage "L"			0		0.6	V
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature			150		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature			130		°C
R_{LOW}	Low Output Nch Tr. ON Resistance (of D version)	V_{IN}=5.0V V_{CE}=0V V_{OUT}=0.3V			150		Ω

All of units are tested and specified under pulse load conditions such that Tj≈Topt=25°C except for Ripple Rejection, Output Voltage Temperature Coefficient, Thermal Shutdown, Load Regulation at 600mA (2.0V ≤ V_{OUT} < 2.5V) and at 700mA (2.5V≤ V_{OUT} < 3.3V) and at 1000mA (3.3V ≤ V_{OUT} ≤ 12.0V), Dropout Voltage at 600mA (2.0V ≤ V_{OUT} < 2.5V) and at 700mA (2.5V ≤ V_{OUT} < 3.3V) and at 1000mA (3.3V ≤ V_{OUT} ≤ 12.0V).

The specification in ☐ is checked and guaranteed by design engineering at $-40°C \leq Topt \leq 85°C$.

- **Output Current by Output Voltage**

Output Voltage V_{OUT}	Output Current I_{LIM} (mA)	
	Condition	Min.
$2.0V \leq V_{OUT} < 2.5V$	$V_{IN}=V_{OUT}+2.3V$	600
$2.5V \leq V_{OUT} < 3.3V$		700
$3.3V \leq V_{OUT} \leq 12.0V$		1000

- **Load Regulation by Output Voltage**

Topt=25°C

Output Voltage V_{OUT}	Load Regulation $\Delta V_{OUT}/\Delta I_{OUT}$ (mV)		
	Condition	Typ.	Max.
$2.0V \leq V_{OUT} < 5.0V$	$V_{IN}=V_{OUT}+2.3V$, $1mA \leq I_{OUT} \leq 200mA$	20	60
$5.0V \leq V_{OUT} \leq 12.0V$		40	100
$2.0V \leq V_{OUT} < 2.5V$	$V_{IN}=V_{OUT}+2.3V$, $1mA \leq I_{OUT} \leq 600mA$	80	180
$2.5V \leq V_{OUT} < 3.3V$	$V_{IN}=V_{OUT}+2.3V$, $1mA \leq I_{OUT} \leq 700mA$	90	200
$3.3V \leq V_{OUT} < 5.0V$	$V_{IN}=V_{OUT}+2.3V$, $1mA \leq I_{OUT} \leq 1A$	120	230
$5.0V \leq V_{OUT} \leq 12.0V$		130	250

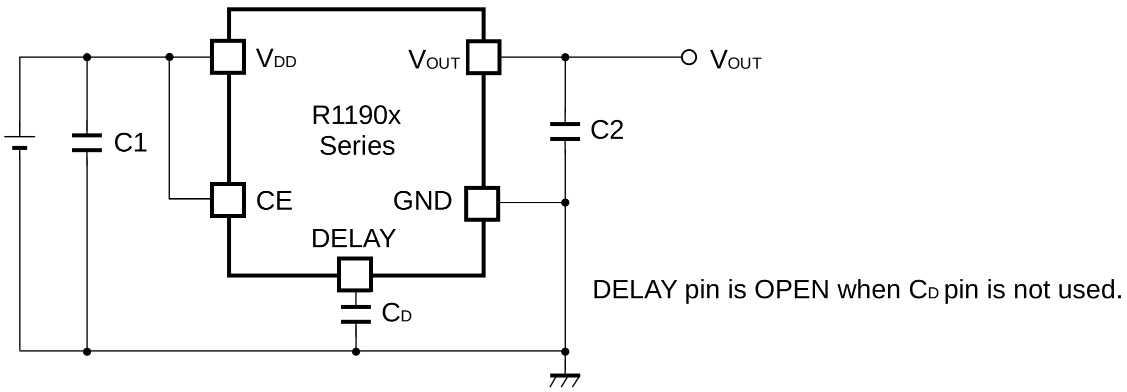
- **Dropout Voltage by Output Voltage**

Topt=25°C

Output Voltage V_{OUT}	Dropout Voltage V_{DIF} (V)					
	Condition	Typ.	Max.	Condition	Typ.	Max.
2.0V	$I_{OUT}=200mA$		1.5	$I_{OUT}=600mA$	1.6	2.2
2.1V			1.4			
2.2V			1.3			
2.3V			1.2			
2.4V			1.1			
2.5V			1.0	$I_{OUT}=700mA$	1.5	2.15
2.6V			0.9			
2.7V			0.8			
$2.8V \leq V_{OUT} < 3.1V$			0.7			
$3.1V \leq V_{OUT} < 3.3V$		0.4	0.7			
$3.3V \leq V_{OUT} < 4.0V$		0.3	0.53	$I_{OUT}=1A$	1.6	2.3
$4.0V \leq V_{OUT} < 5.0V$		0.25	0.42		1.4	2.1
$5.0V \leq V_{OUT} < 9.0V$		0.19	0.31		1.1	1.85
$9.0V \leq V_{OUT} \leq 12.0V$		0.1	0.18		0.8	1.30

All of units are tested and specified under pulse load conditions such that $Tj \approx Topt=25°C$ except for Ripple Rejection, Output Voltage Temperature Coefficient, Thermal Shutdown, Load Regulation at 600mA ($2.0V \leq V_{OUT} < 2.5V$) and at 700mA ($2.5V \leq V_{OUT} < 3.3V$) and at 1000mA ($3.3V \leq V_{OUT} \leq 12.0V$), Dropout Voltage at 600mA ($2.0V \leq V_{OUT} < 2.5V$) and at 700mA ($2.5V \leq V_{OUT} < 3.3V$) and at 1000mA ($3.3V \leq V_{OUT} \leq 12.0V$).

TYPICAL APPLICATION



(External Components)
C1, C2: Ceramic Capacitor 4.7μF Nippon Chemi-con Corporation KTD500B475M43A0T00

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 C_{OUT} with good frequency characteristics and ESR (Equivalent Series Resistance). (Note: If additional ceramic capacitors are connected with parallel to the output pin with an output capacitor for phase compensation, the operation might be unstable. Because of this, test these ICs with as same external components as ones to be used on the PCB.)

PCB Layout

Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor with a capacitance value as much as 4.7μF or more between V_{DD} and GND pin, and as close as possible to the pins.

Set external components, especially the output capacitor, as close as possible to the ICs, and make wiring as short as possible. (Refer to the TYPICAL APPLICATION diagram above.)

Thermal Shutdown

There is the built-in thermal-shutdown function in R1190x series. It discontinues operation of the IC when the junction temperature becomes over 150°C (Typ.) and IC re-operates when the junction temperature under 130°C. If the temperature increasing keeps the IC repeats ON and OFF operating. The output becomes the pulse condition.

Chip Enable Circuit

For the output voltage stability, please do not use the intermediate electric potential (the voltage value between V_{CEH} and V_{CEL}) that causes the supply current increasing and the unstable of output voltage.

Inrush-Current Limit Function

R1190x Series has the function to limit the inrush-current, it limited approximately 0.3A when the voltage regulator is turn ON. It is also possible to set time of the rush-current limitation by connecting capacitor with DELAY pin. The rush-current time (t_D) and the value of capacitor (C_D(F)) is calculatable by the following formula;

$$t_D=(0.000198+(3.79\times10^7\times C_D))\times V_{IN}$$

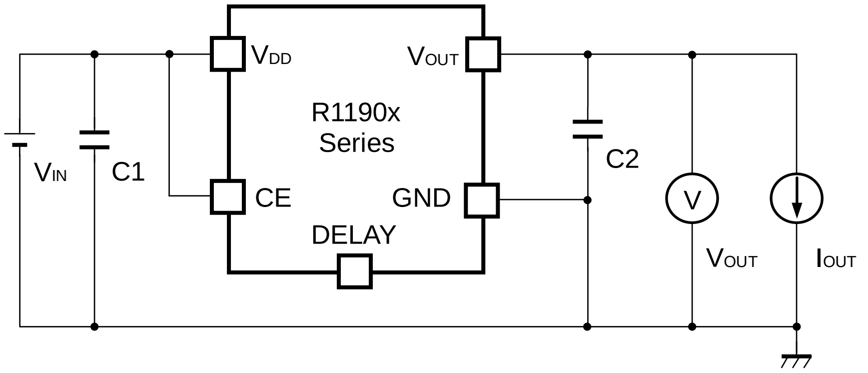
The inrush-current is limited even if the capacitor is not connected with the DELAY pin. In this case, the time is calculated as $C_D=0$ by the formula above.

Though, if the value of time is insufficient for controlling the inrush-current, please connect the capacitor with DELAY pin. The DELAY pin is used as OPEN when the capacitor is not used. Please use the DELAY pin as OPEN when the capacitor is not used.

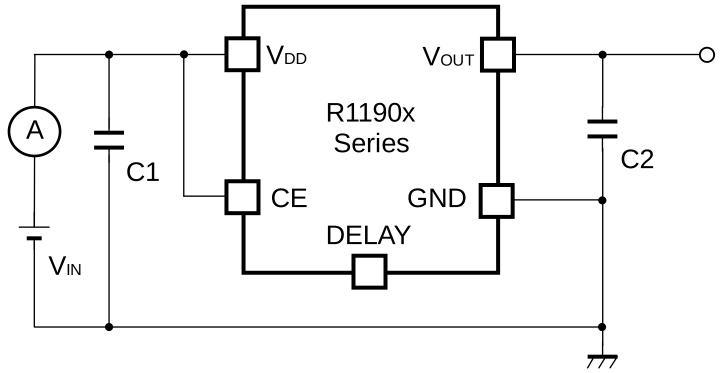
Auto-Discharge Function

R1190xxxxD series has the auto-discharge function. When "L" signal is put into the Chip-enable pin (CE), the switch between V_{OUT} and GND is turned ON and the charge at capacitor is discharge rapidly by the auto-discharge function.

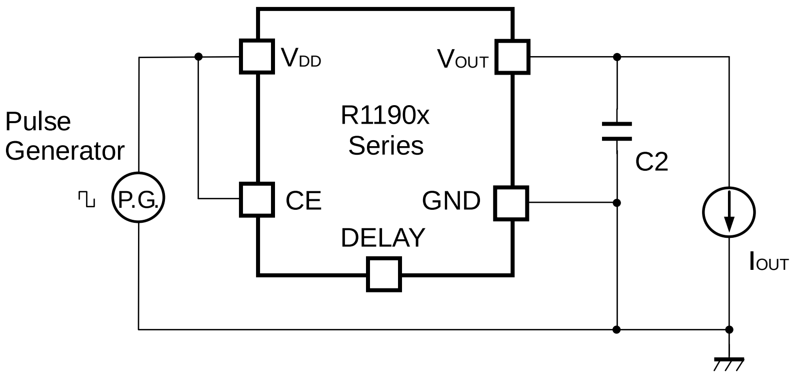
TEST CIRCUITS



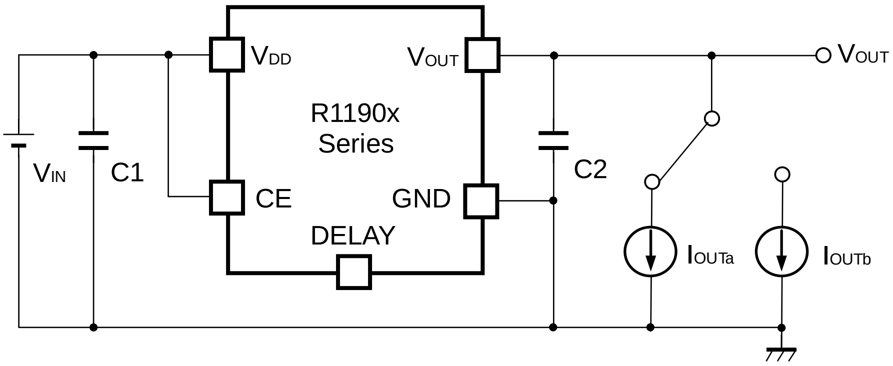
Basic Test Circuit



Test Circuit for Supply Current



Test Circuit for Ripple Rejection



Test Circuit for Load Transient Response

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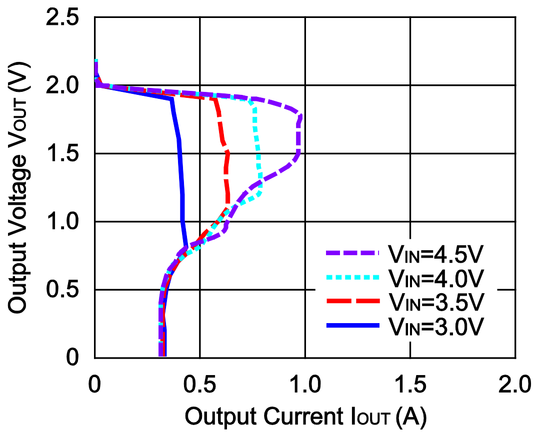
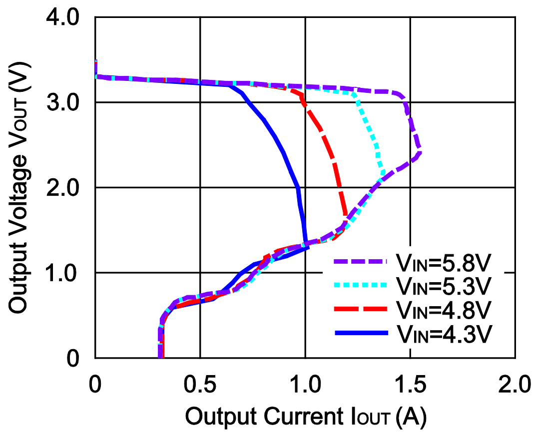
TYPICAL CHARACTERISTIC

1) Output Voltage vs. Output Current (C1=C2=4.7µF, Topt=25°C)

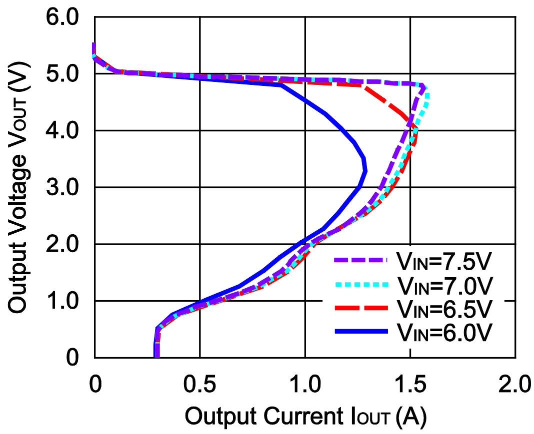
R1190x020x



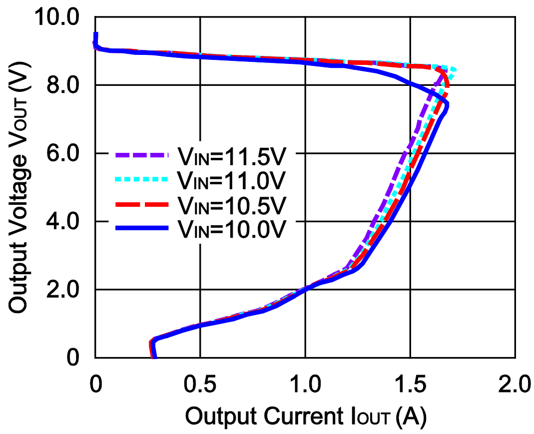
R1190x033x



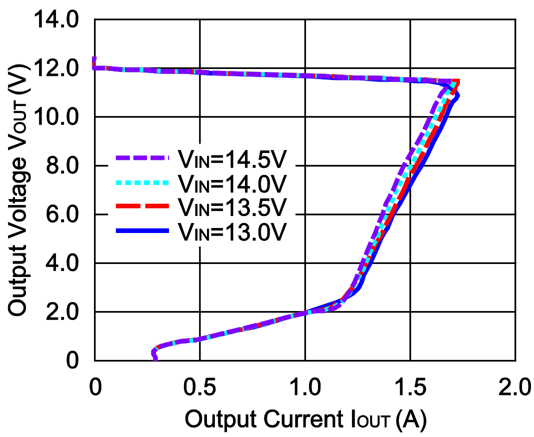
R1190x050x



R1190x090x

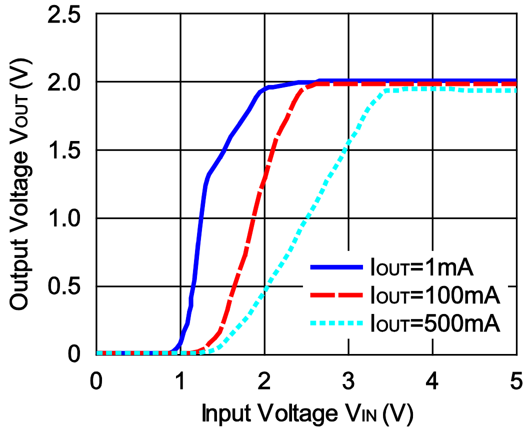


R1190x120x



2) Output Voltage vs. Input Voltage (C1=C2=4.7µF, Topt=25°C)

R1190x020x



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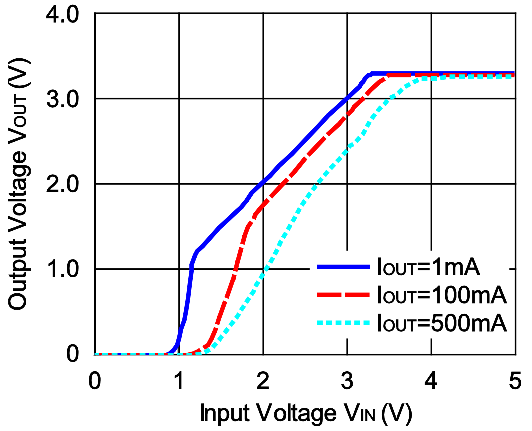

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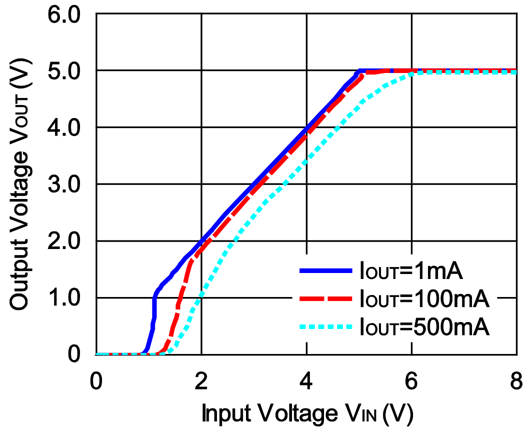

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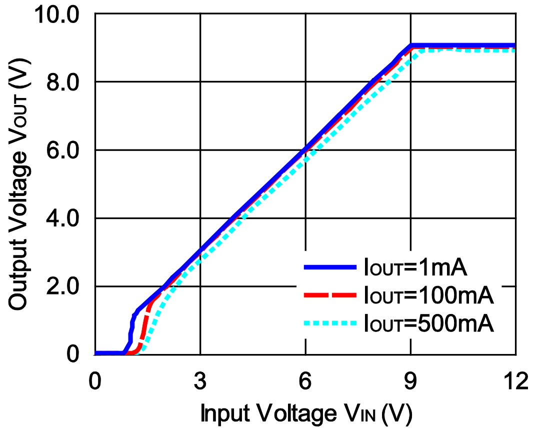

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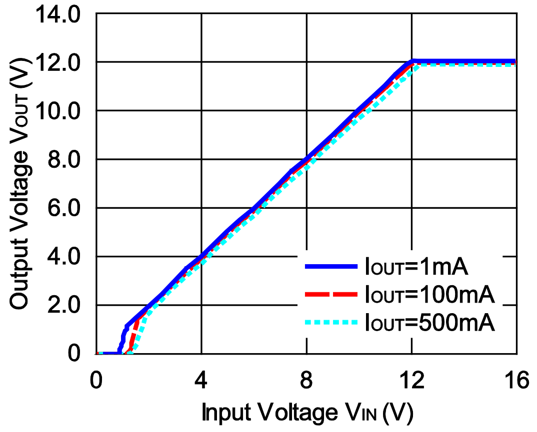
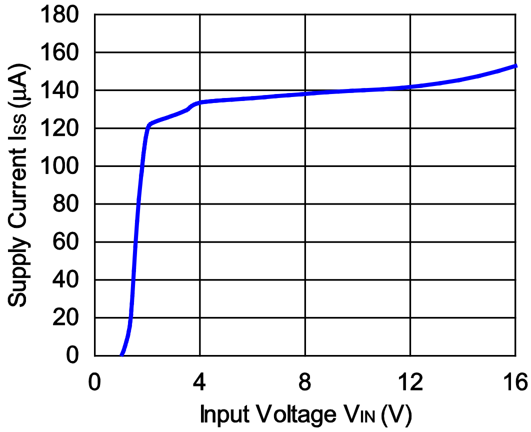


3) Supply Current vs. Input Voltage (C1=C2=4.7µF, Topt=25°C)

R1190x020x



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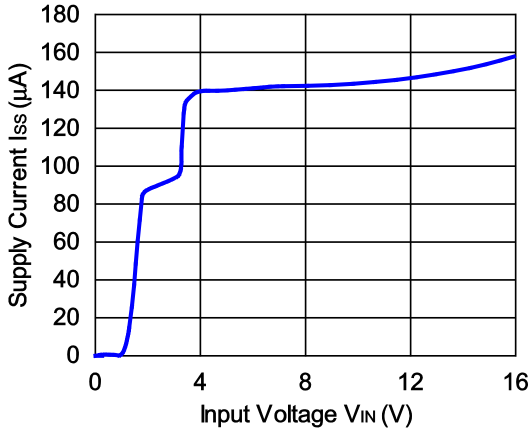

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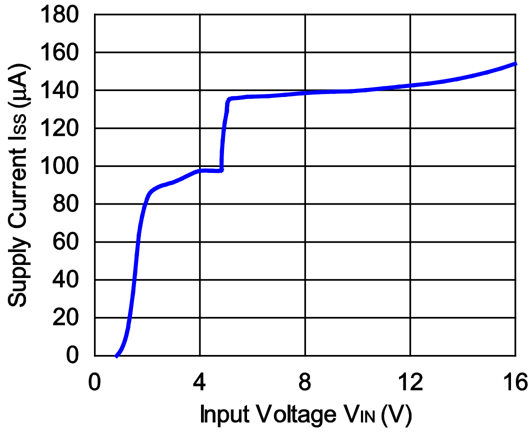

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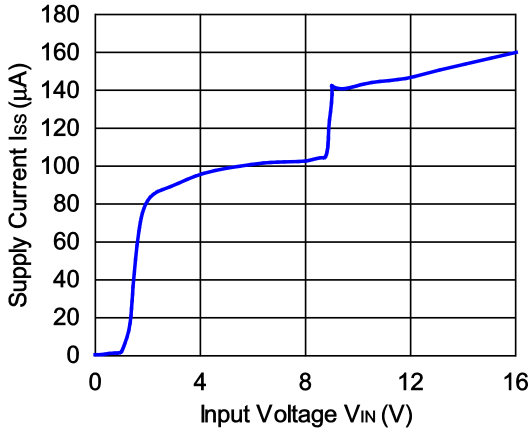

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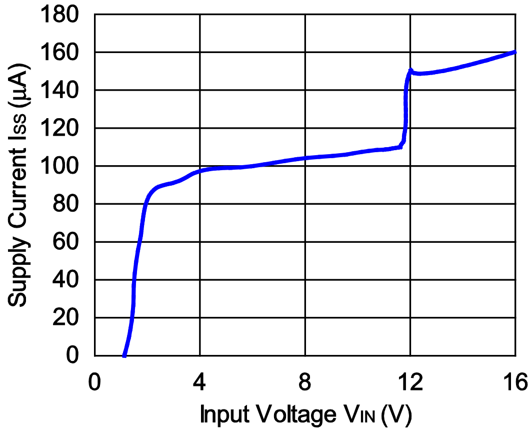
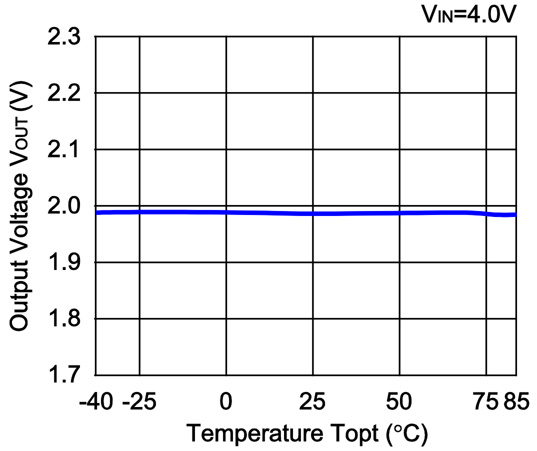


4) Output Voltage vs. Temperature (C1=C2=4.7µF, I_{OUT}=1mA)

R1190x020x



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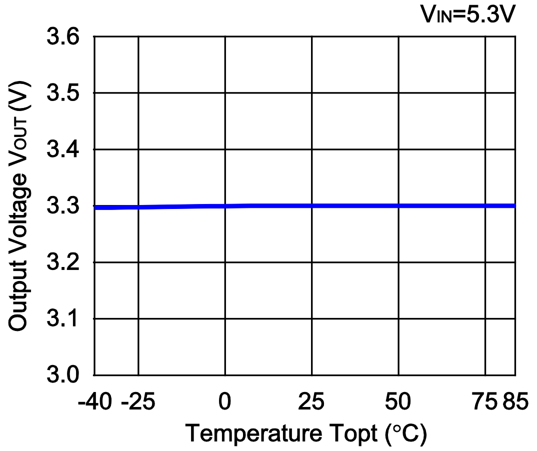

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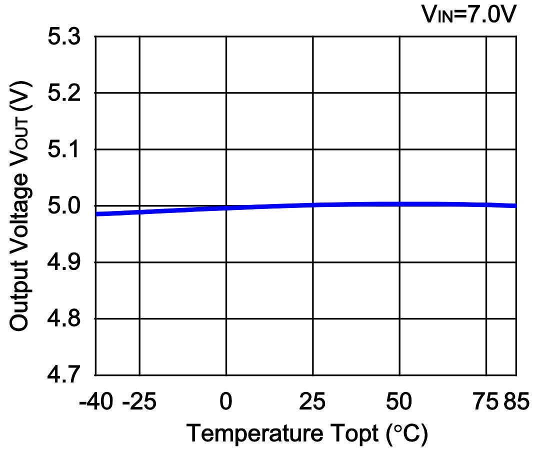

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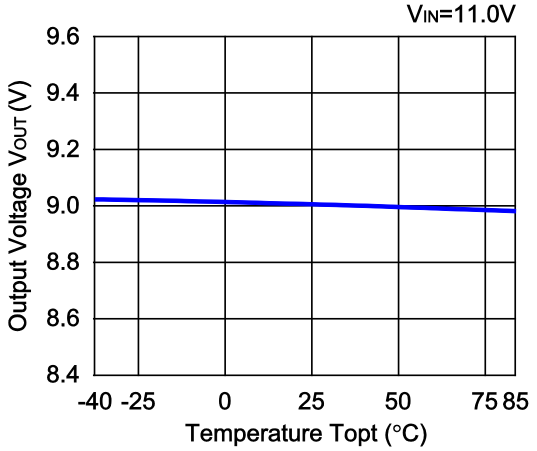

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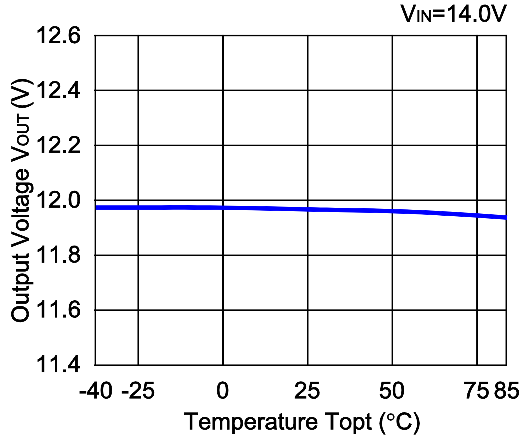
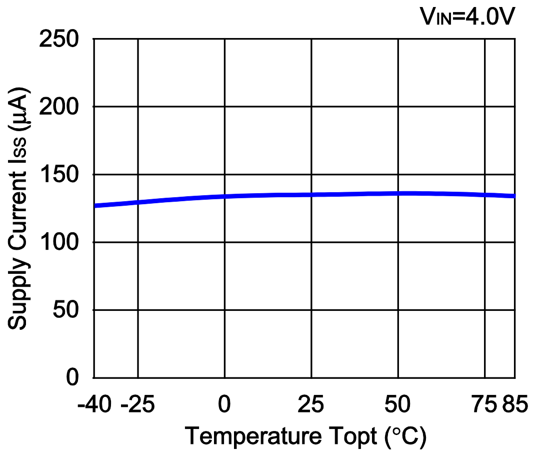
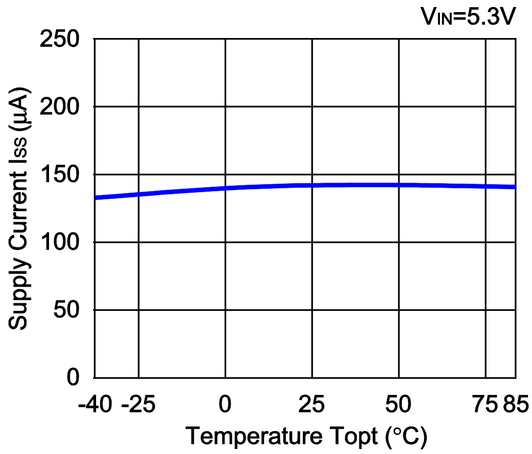


5) Supply Current vs. Temperature (C1=C2=4.7μF)

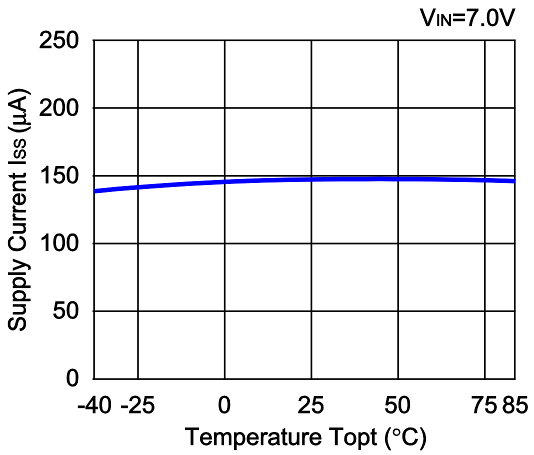
R1190x020x



R1190x033x



R1190x050x



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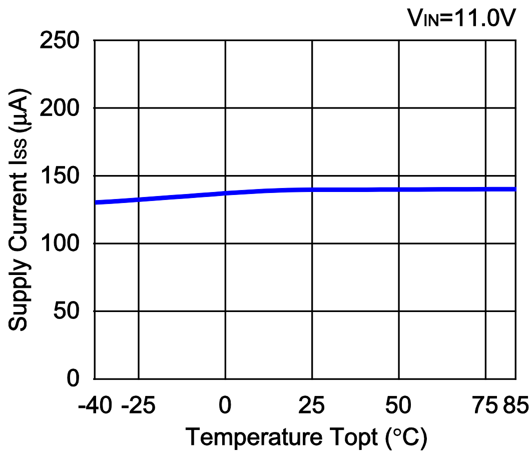

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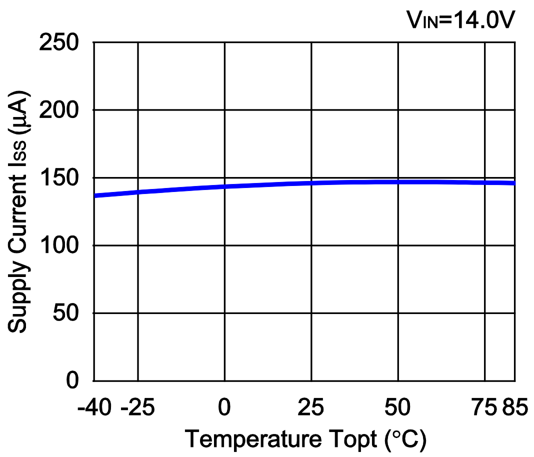
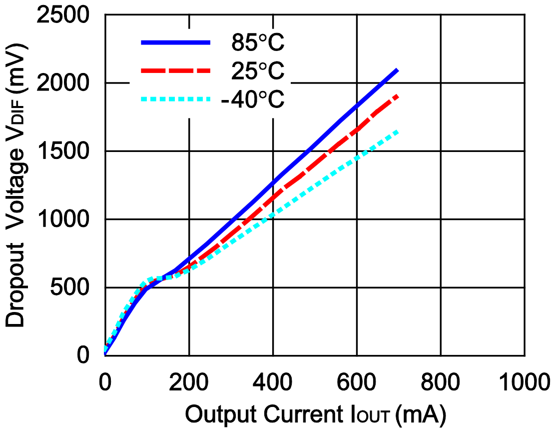


6) Dropout Voltage vs. Output Current (C1=C2=4.7μF)

R1190x020x



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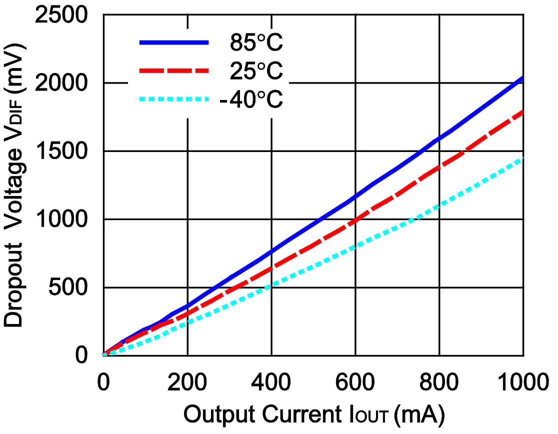

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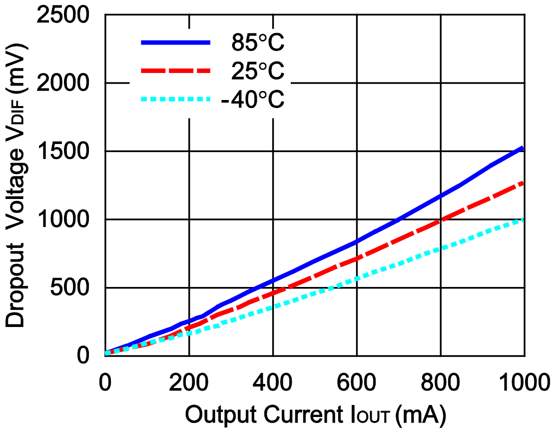

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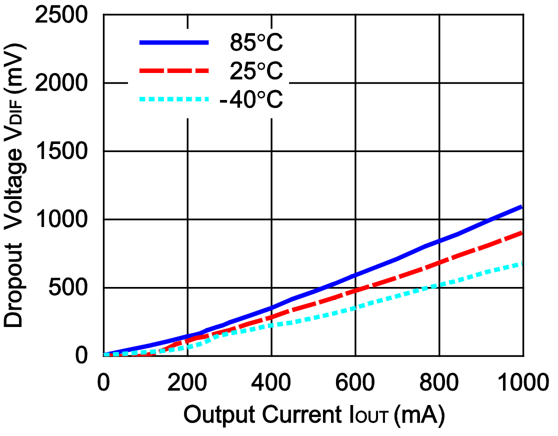

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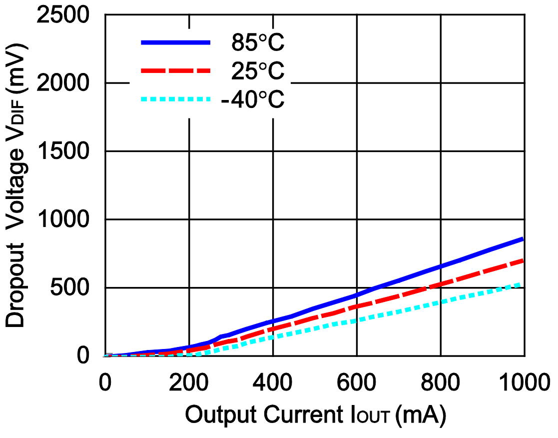
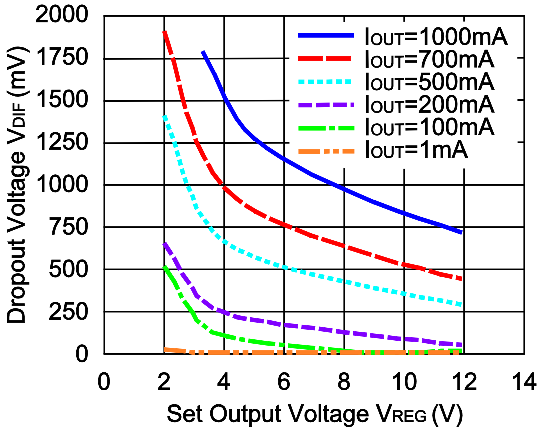


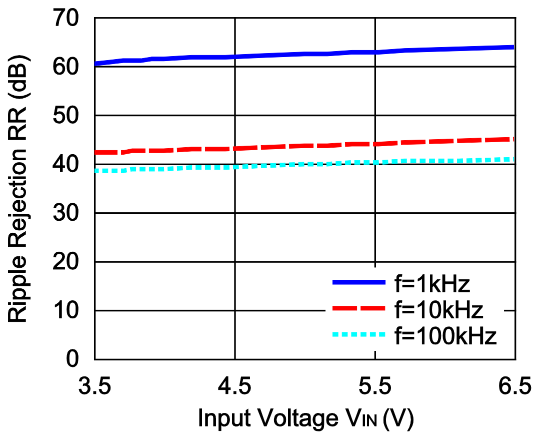
RICOH

7) Dropout Voltage vs. Set Output Voltage (C1=C2=4.7µF, Topt=25°C)



8) Ripple Rejection vs. Input Voltage (C1=none, C2=4.7µF, IOUT=100mA, Ripple=0.2Vp-p, Topt=25°C)

R1190x020x



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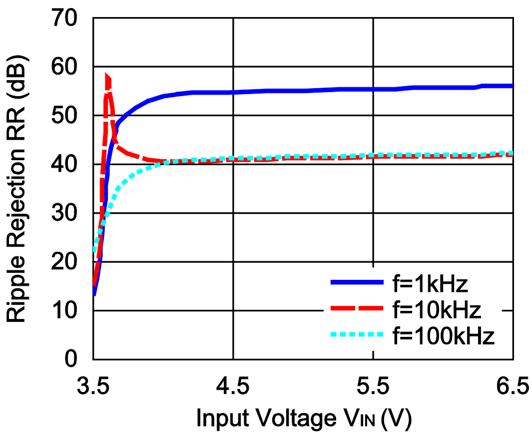

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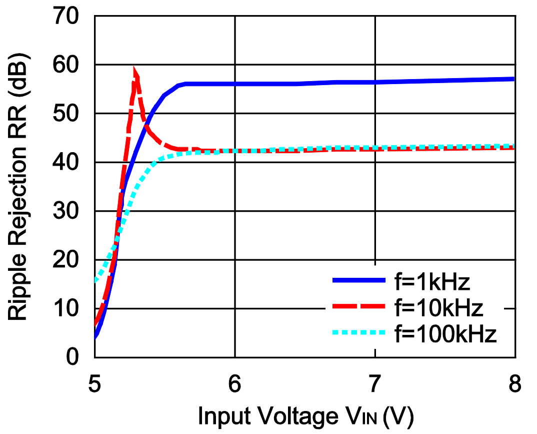

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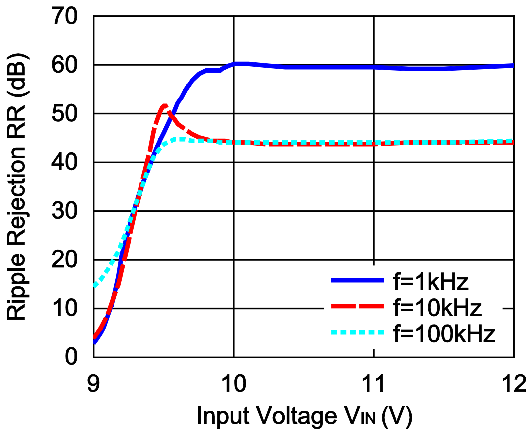

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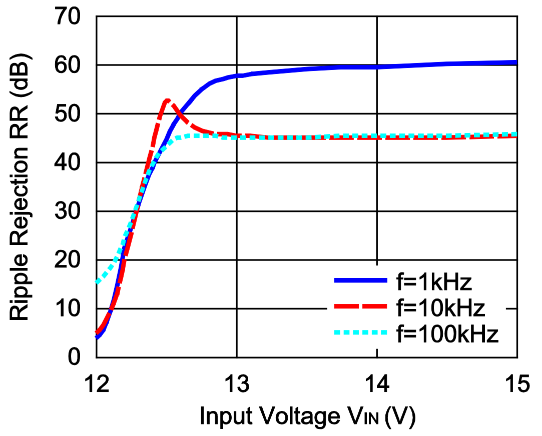
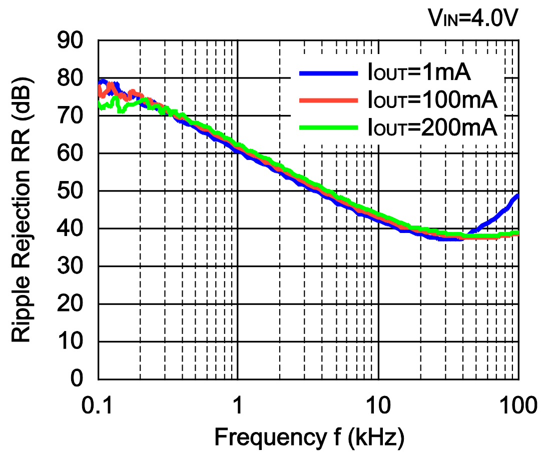


9) Ripple Rejection vs. Frequency (C1=none, C2=4.7µF, Ripple=0.2Vp-p, Topt=25°C)

R1190x020x



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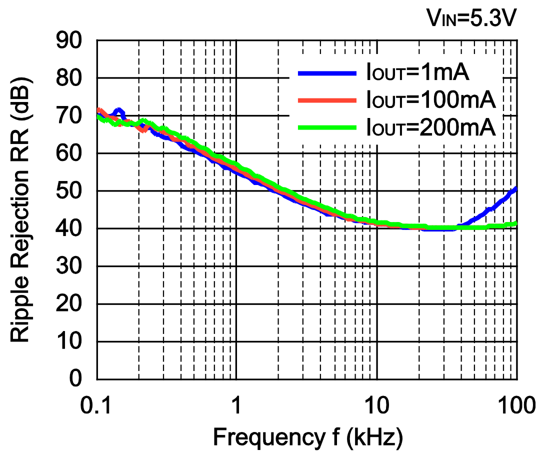

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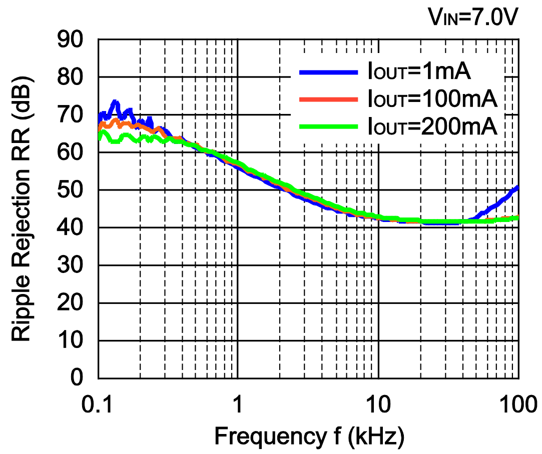

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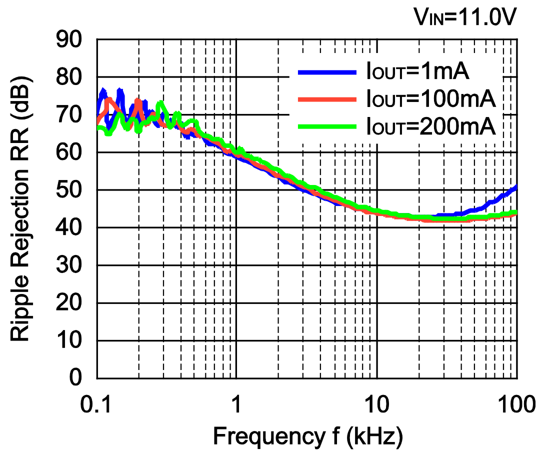

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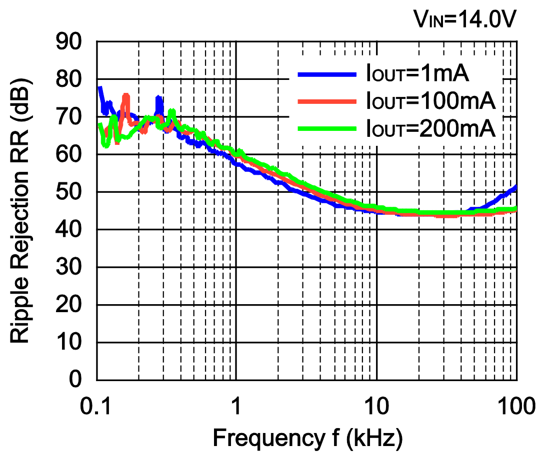
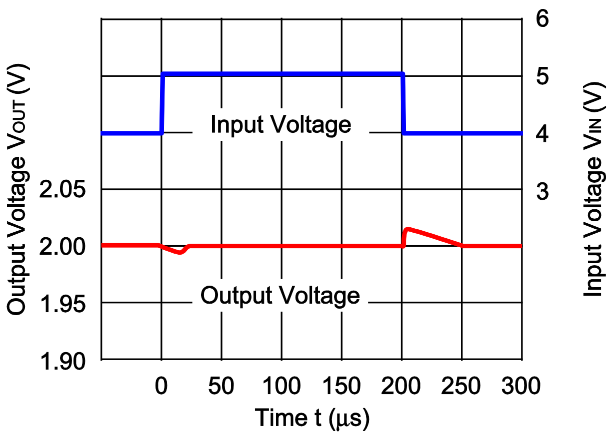


10) Input Transient Response (C1=none, C2=4.7μF, I_{OUT}=1mA, tr=tf=0.5μs)

R1190x020x



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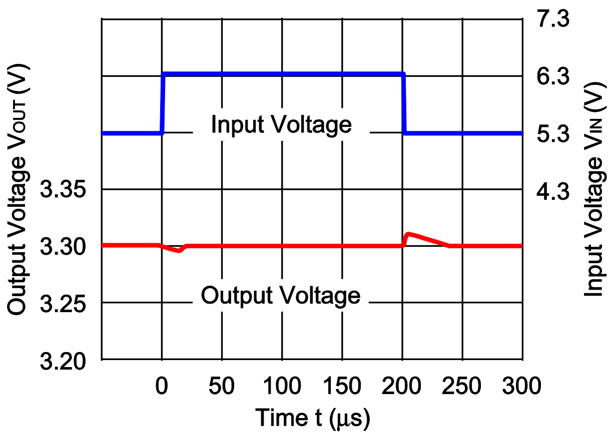

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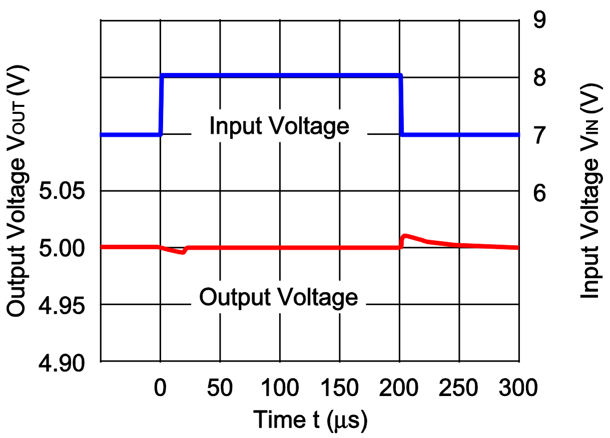

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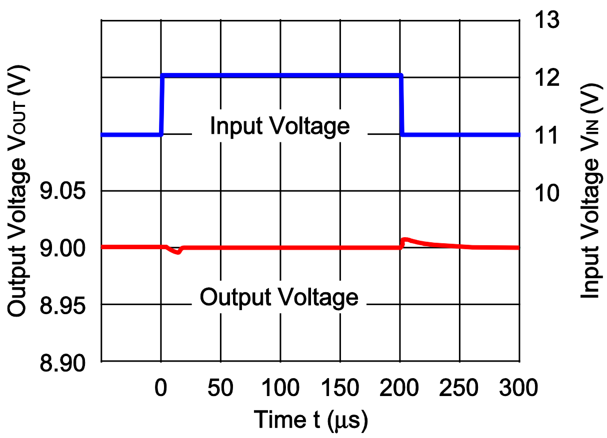
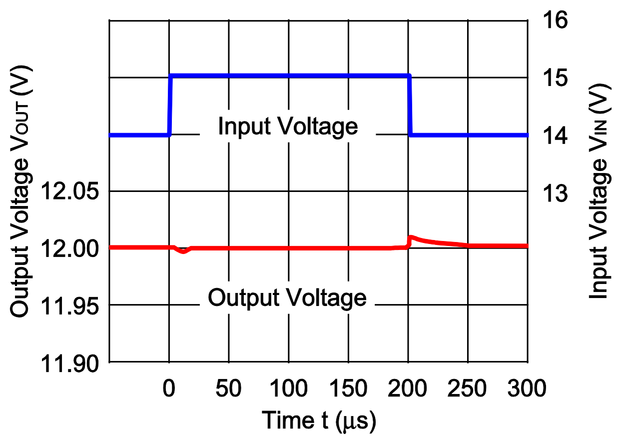
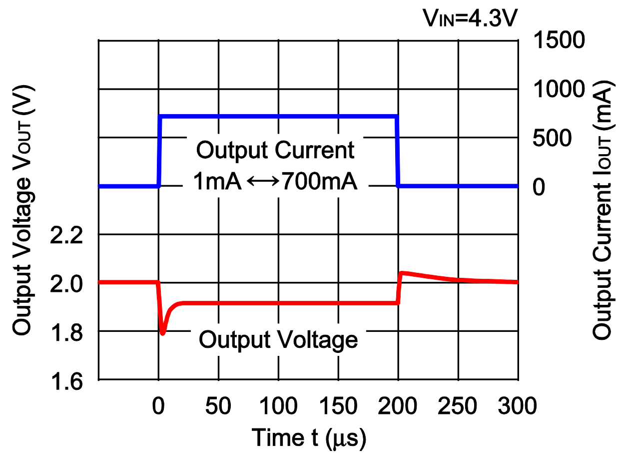
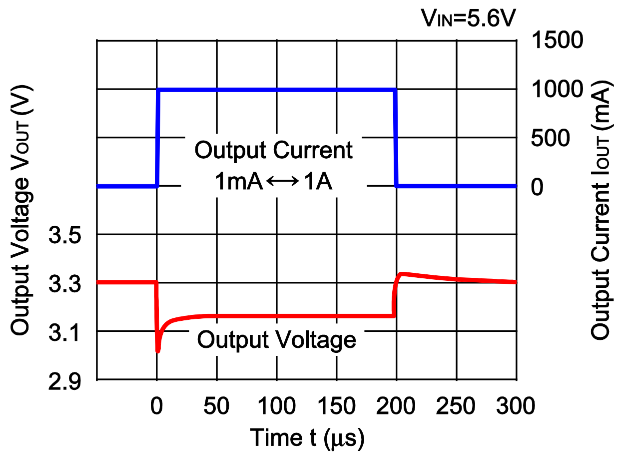
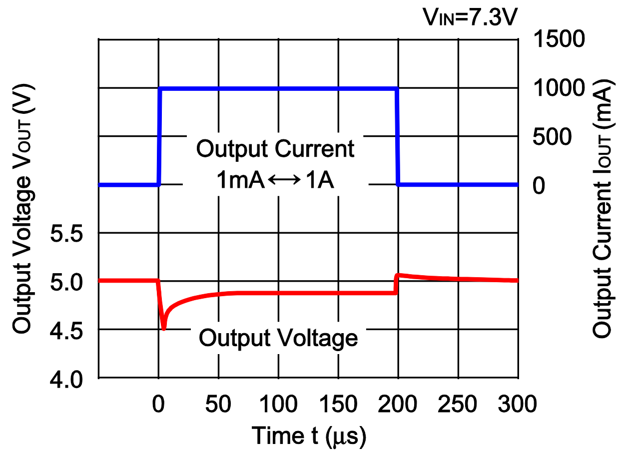


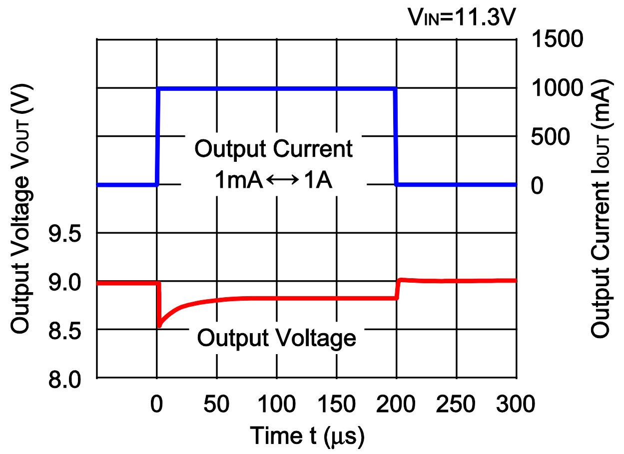


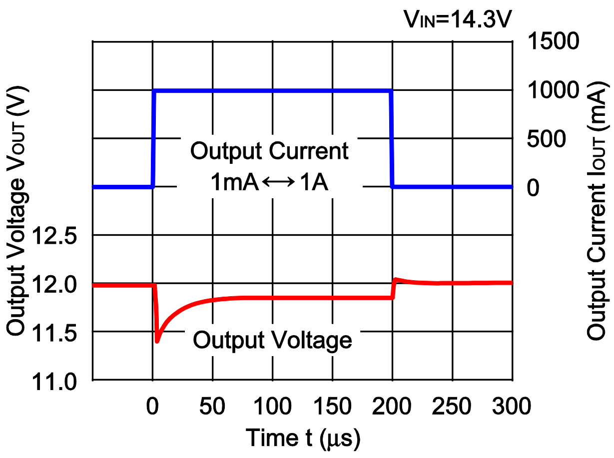
11) Load Transient Response (C1=C2=4.7µF, tr=tf=0.5µs)



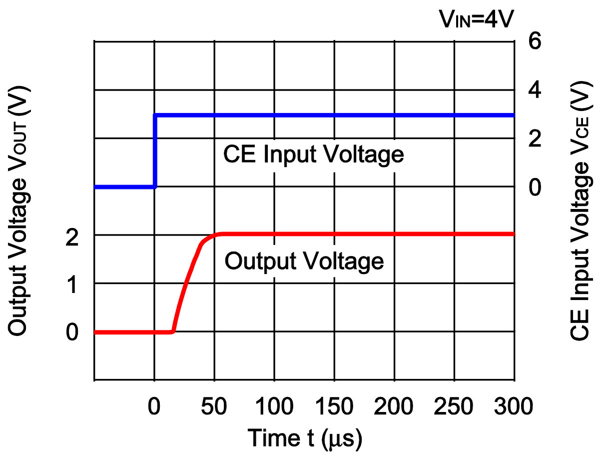


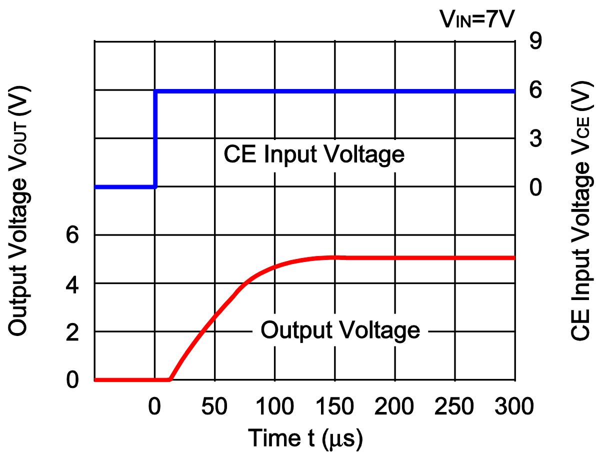


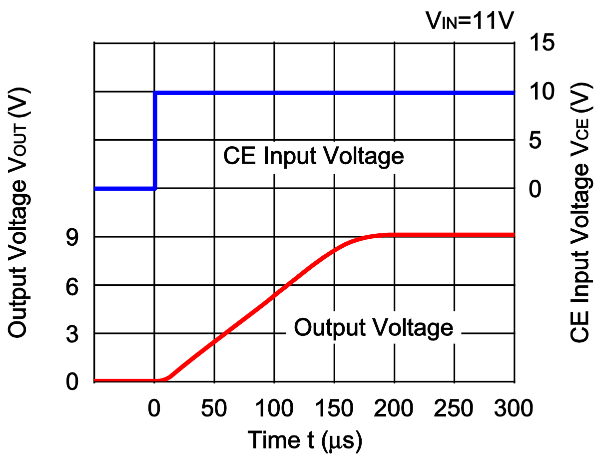


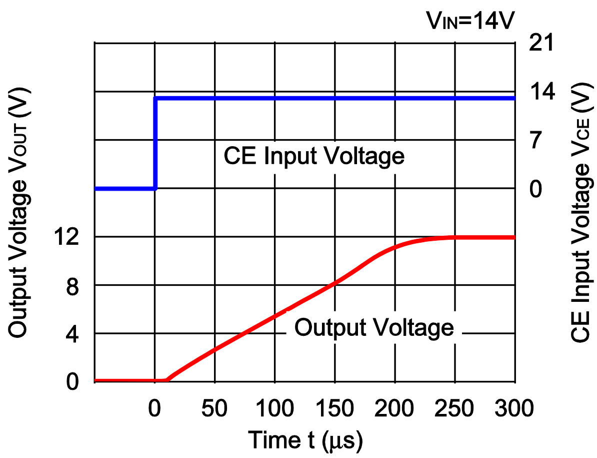


12) Turn On Speed with CE Pin (I_{OUT}=1mA, C1=C2=4.7μF, tr=tf=0.5μs)



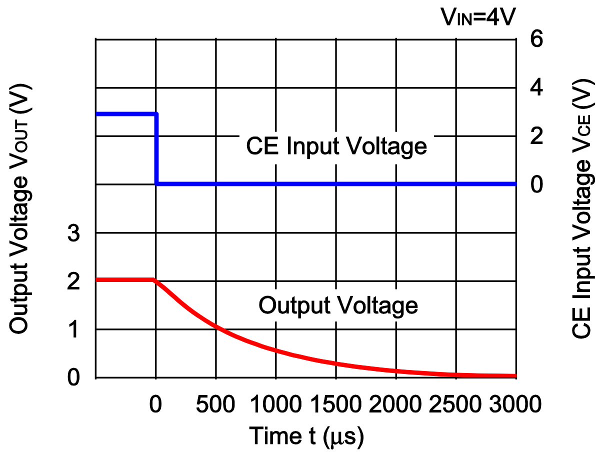






13) Turn Off Speed with CE Pin (D Version) (I_{OUT}=1mA, C1=C2=4.7µF, tr=tf=0.5µs)

R1190x020x



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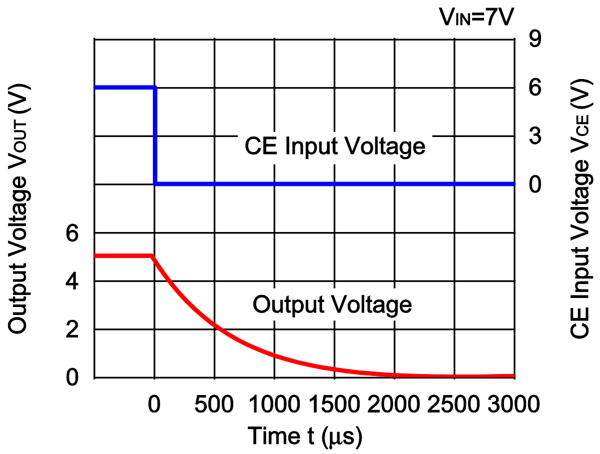

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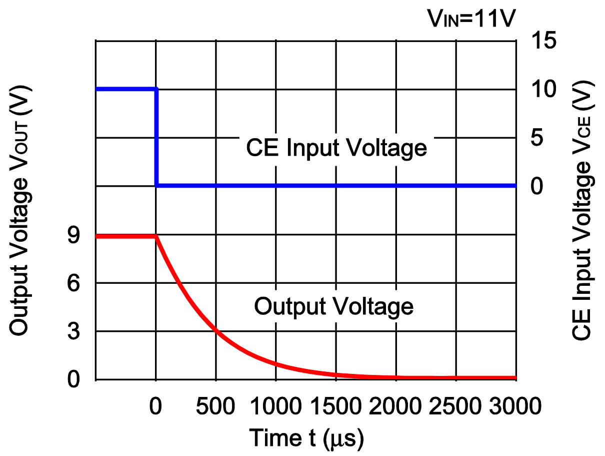
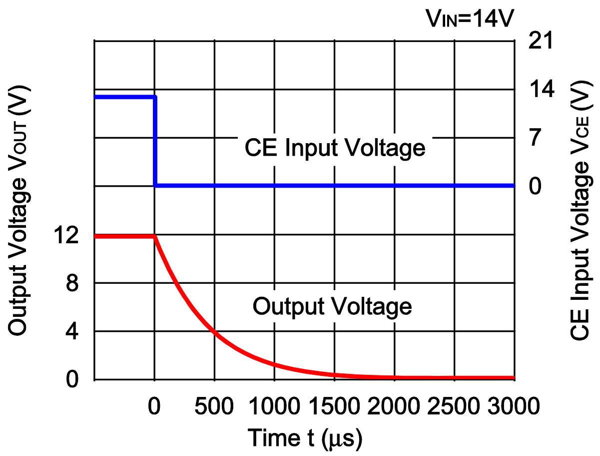
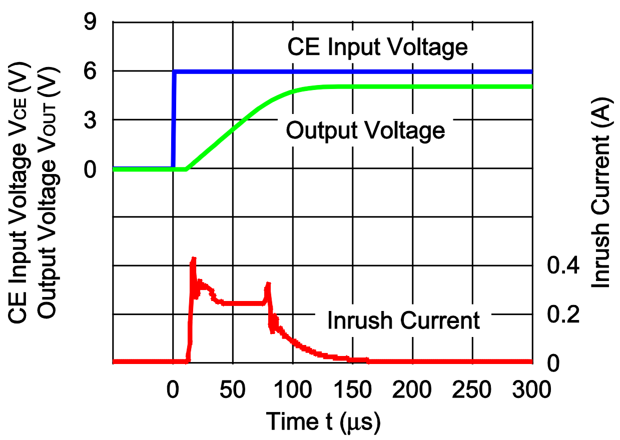


R1190x120x

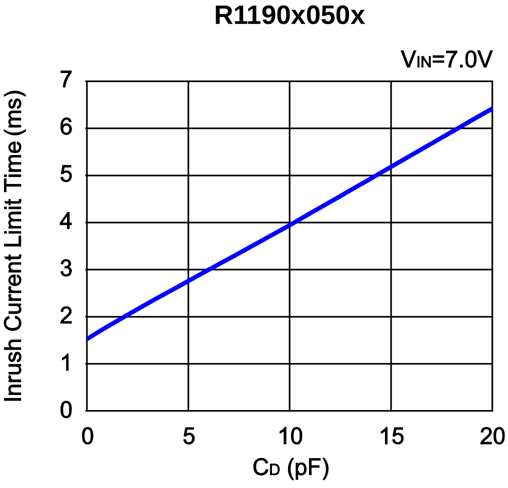


14) Inrush Current at Turn On (V_{IN}=7.0V, C1=C2=4.7µF, C_D=none, tr=tf=0.5µs)

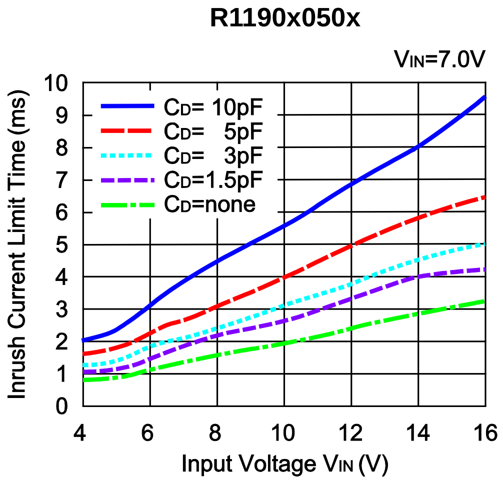


RICOH

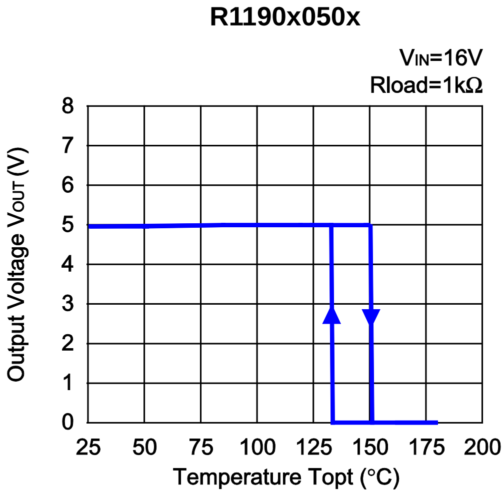
15) Inrush Current Limit vs. C_D Capacitance (C1=C2=4.7µF)



16) Inrush Current Limit Delay Time vs. Input Voltage (C1=C2=4.7µF)



17) Thermal Shutdown vs. Temperature (C1=C2=4.7µF)



ESR vs. Output Current

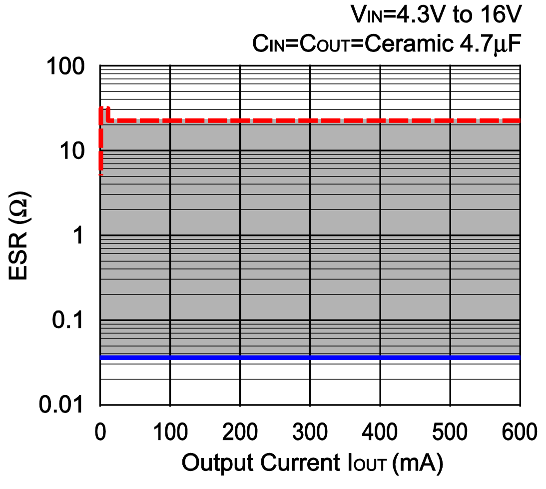
When using these ICs, consider the following points:

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 40μVrms (Avg.) are marked as the hatched area in the graph.

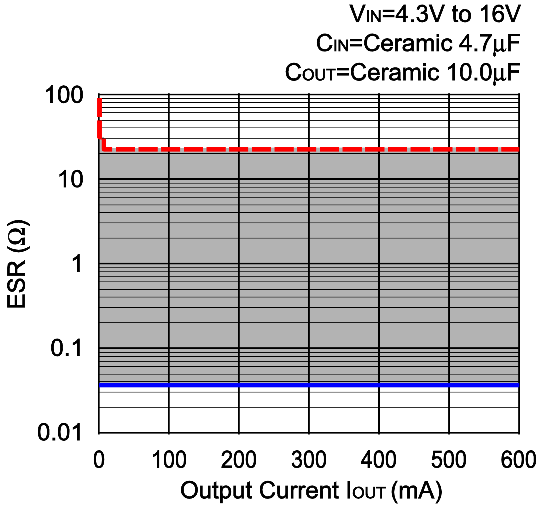
Measurement conditions

- Frequency Band : 10Hz to 1MHz
- Temperature : –40°C to 85°C
- Hatched Area : Noise level is under 40μVrms (Avg.)
- C_{IN} : 4.7μF (KTD500B475M43A0T00)
- C_{OUT} : 4.7μF (KTD500B475M43A0T00)
  : 10.0μF (FK22Y5V1H106Z)

R1190x020x



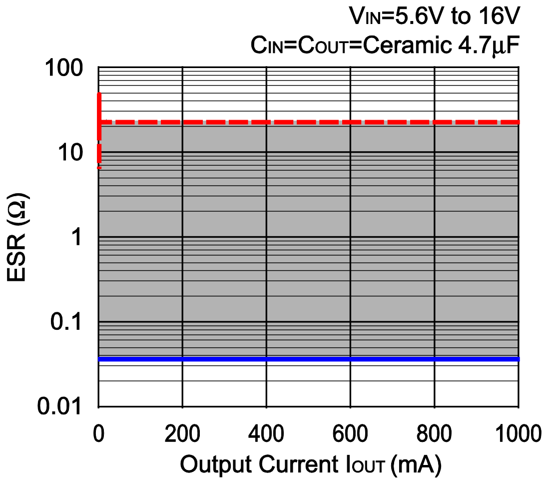
R1190x020x

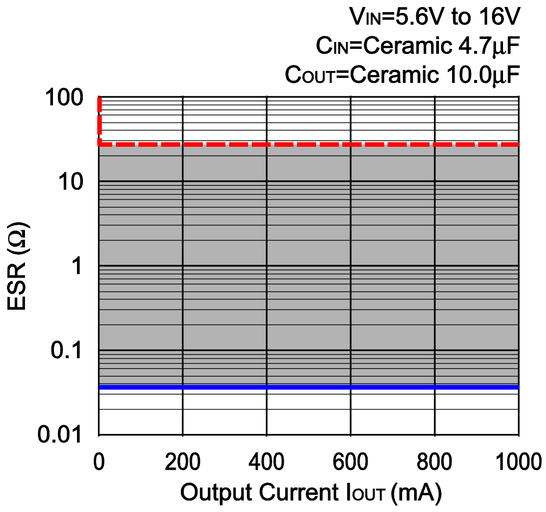


R1190x033x

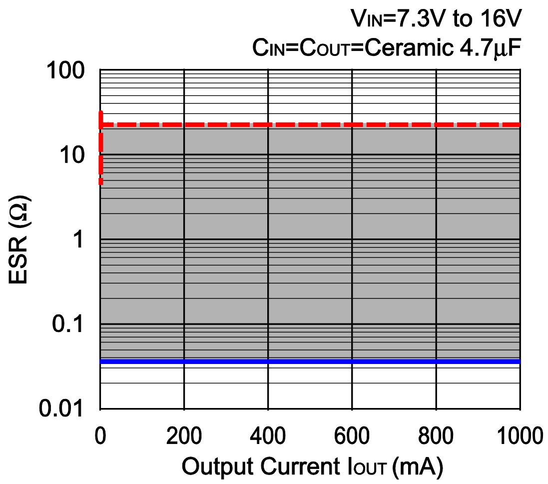
R1190x033x

RICOH


VIN=5.6V to 16V
CIN=COUT=Ceramic 4.7µF
100
10
1
0.1
0.01
ESR (Ω)
0
200
400
600
800
1000
Output Current IOUT (mA)


VIN=5.6V to 16V
CIN=Ceramic 4.7µF
COUT=Ceramic 10.0µF
100
10
1
0.1
0.01
ESR (Ω)
0
200
400
600
800
1000
Output Current IOUT (mA)

R1190x050x



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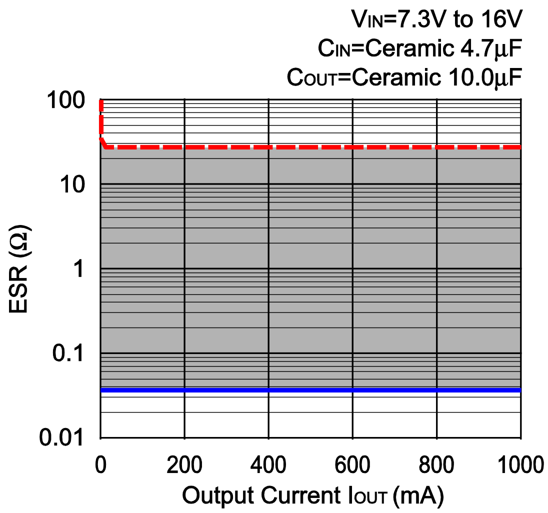
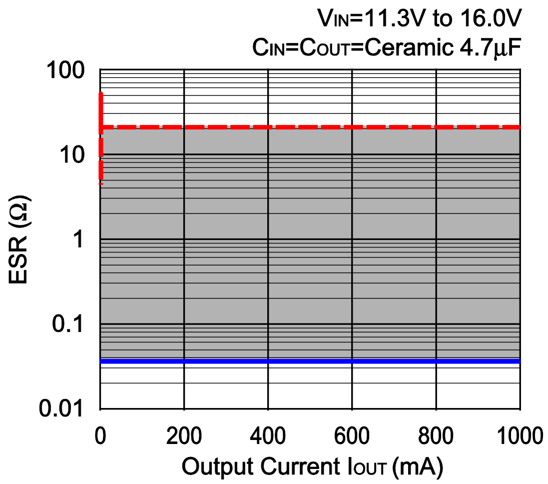


R1190x090x



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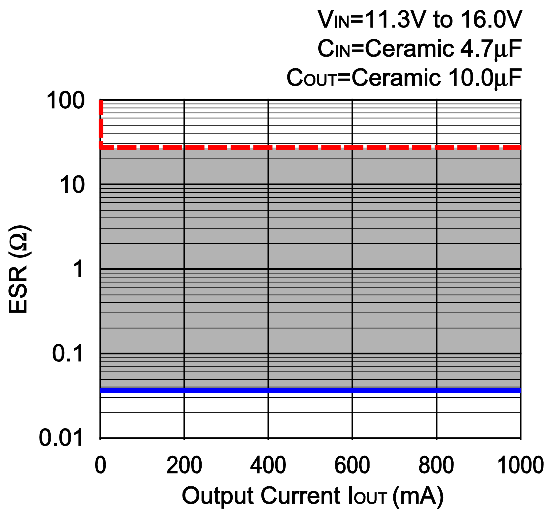
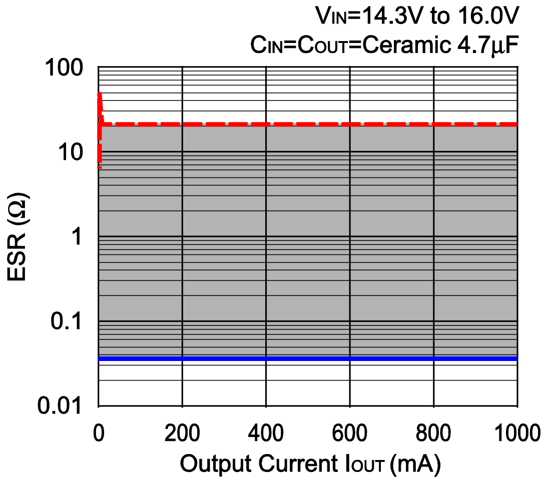
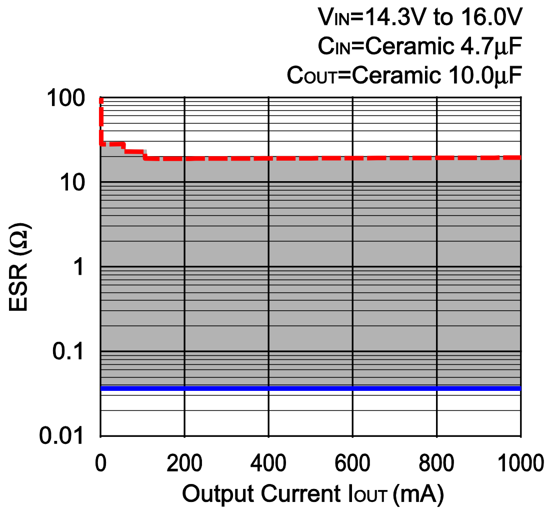


R1190x120x



R1190x120x



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