RICOH

RP108J SERIES

Low Input Voltage 3A LDO Regulator

NO.EA-203-111018

OUTLINE

The RP108J Series are CMOS-based voltage regulator ICs featuring 3A output with low ON-resistance.

Each IC of this series consists of a voltage reference unit, an error amplifier, resistor-net for voltage setting, a fold-back protection circuit, and a thermal shutdown circuit. This series features both low supply current and high output current, and the dropout voltage is much smaller than bi-polar's. The minimum input voltage is as low as 1.6V and the output voltage can be set from 0.8V, therefore it can be connected with the DC/DC converter as the latter power supply for high density LSI that is operated by low output voltage.

The output voltage of RP108J081x is externally adjustable by using external divide resistors. The CE pin of the RP108J Series can switch the regulator to standby mode. In addition to a fold-back protection circuit, which is already built in the conventional regulators, this series contain a thermal shutdown circuit, a constant slope circuit as a soft-start function and a reverse current protection circuit. Ceramic capacitors can be used.

FEATURES

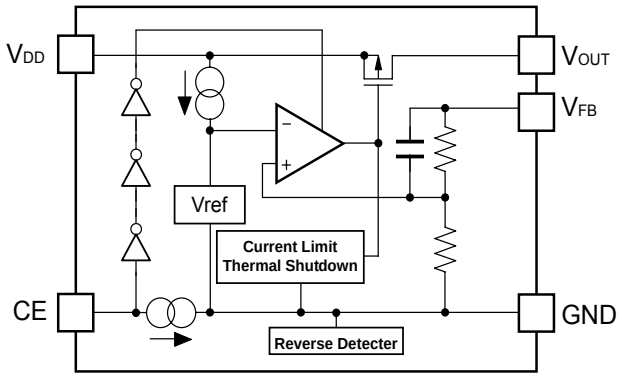
- Output Current ..... Min. 3A
- Supply Current ..... Typ. 350μA
- Standby Current ..... Typ. 2μA
- Input Voltage Range ..... 1.6V to 5.25V
- Output Voltage Range..... 0.8V to 4.2V (0.1V steps)
  (For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy..... ±1.0% (±15mV accuracy, When V_{OUT} ≤ 1.5V)
- Output Voltage Temperature-drift Coefficient ..... Typ. ±100ppm/°C
- Ripple Rejection ..... Typ. 65dB (f =1kHz, V_{OUT}=2.8V)
- Dropout Voltage ..... Typ. 0.51V (V_{OUT}=2.8V)
- Line Regulation ..... Typ. 0.1%/V
- Package TO-252-5-P2
- Built-in Fold-back Protection Circuit..... Typ. 220mA
- Built-in Thermal Shutdown Circuit..... Stops at 165°C
- Built-in Constant Slope Circuit
- Built-in Reverse Current Protection Circuit
- Ceramic capacitors are recommended to be used with this IC ····· 10μF or more

APPLICATIONS

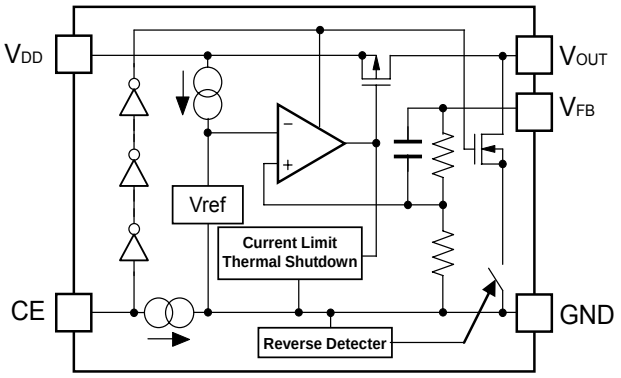
- Power source for battery-powered equipments.
- Power source for portable communication equipments such as cameras and VCRs.
- Power source for electrical home appliances.

BLOCK DIAGRAMS

RP108Jxx1B



RP108Jxx1D



SELECTION GUIDE

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

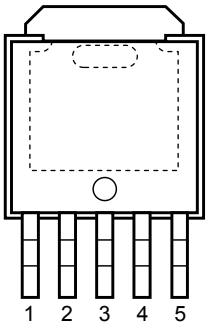
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP108Jxx1∗-T1-FE	TO-252-5-P2	3,000 pcs	Yes	Yes

xx: The output voltage can be designated in the range of 0.8V(08) to 4.2V(42) 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

TO-252-5-P2



PIN DESCRIPTIONS

●TO-252-5-P2

Pin No.	Symbol	Description
1	CE	Chip Enable Pin ("H" Active)
2	V_{DD}	Input Pin
3	GND	Ground Pin
4	V_{OUT}	Output Pin
5	V_{FB}	Feedback Pin

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The V_{OUT} pin should be connected to the V_{FB} pin when using RP108J as an internal fixed output voltage type. In case of using RP108J as an external adjustable type, please refer to "Adjustable Output Voltage Type Settings"

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	6.0	V
V_{CE}	Input Voltage (CE Input Pin)	−0.3 to 6.0	V
V_{FB}	Input Voltage (V_{FB} Pin)	−0.3 to 6.0	V
V_{OUT}	Output Voltage	−0.3 to V_{IN}+0.3	V
P_D	Power Dissipation (TO-252-5-P2)* Standard Land Pattern	1900	mV
	Power Dissipation (TO-252-5-P2)* High Wattage Land Pattern	3800	
Topt	Operating Temperature	−40 to +85	°C
Tstg	Storage Temperature	−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

V_{IN}=Set V_{OUT} +1.0V, I_{OUT}=1mA, C_{IN}=C_{OUT}=10µF, unless otherwise noted.
The specification in ☐ is checked and guaranteed by design engineering at −40°C ≤Topt ≤ 85°C, unless otherwise noted.

- **RP108J**

Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output voltage	Topt=25°C	V_{OUT} > 1.5V	×0.99		×1.01	V
			V_{OUT} ≤ 1.5V	−15		+15	mV
		−40°C ≤ Topt ≤ 85°C	V_{OUT} > 1.5V	☐×0.97		☐×1.02	V
			V_{OUT} ≤ 1.5V	☐−45		☐30	mV
I_{LIM}	Output Current			☐3.0			A
ΔV_{OUT}/ ΔI_{OUT}	Load regulation	1mA ≤ I_{OUT} ≤ 300mA		☐−15	2.0	☐20	mV
		1mA ≤ I_{OUT} ≤ 3000mA		☐−70	3.0	☐50	
V_{DIF}	Dropout Voltage	Refer to "Dropout Voltage"					
I_{SS}	Supply Current	I_{OUT}=0mA			350	☐500	µA
Istandby	Standby Current	V_{CE}=0V			2.0	5.0	µA
ΔV_{OUT}/ ΔV_{IN}	Line regulation	Set V_{OUT}+0.5V ≤ V_{IN} ≤ 5.25V, I_{OUT}=1mA (When V_{OUT} ≤ 1.1V , V_{IN}=1.6V)			0.10	☐0.15	%/V
V_{IN}	Input Voltage*1			☐1.6		☐5.25	V
RR	Ripple Rejection	f=1kHz, Ripple 0.2Vp-p, I_{OUT}=100mA	V_{OUT} ≤ 2.8V		65		dB
			V_{OUT} > 2.8V		55		
ΔV_{OUT}/ ΔTopt	Output Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C			±100		ppm /°C
I_{SC}	Short Current Limit	V_{OUT}=0V			220		mA
I_{PD}	CE Pull-down Current				0.3	☐0.6	µA
V_{CEH}	CE Input Voltage "H"			☐1.0			V
V_{CEL}	CE Input Voltage "L"					☐0.4	V
en	Output Noise	BW=10Hz to 100kHz			70		µVrms
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature			165		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature			95		°C
R_{LOW}	Low Output Nch Tr. ON Resistance (of D version)	V_{IN}=4.0V, V_{CE}=0V			30		Ω
I_{REV}	Reverse Current Limit	V_{OUT} > 0.5V, 0 ≤ V_{IN} ≤ 5.25V			10		µA

All of units are tested and specified under load conditions such that Tj≈Topt=25°C except for Output Noise, Output Voltage Temperature Coefficient, Ripple Rejection and a Thermal Shutdown Circuit.

∗1) The maximum Input Voltage of the ELECTRICAL CHARACTERISTICS is 5.25V. In case of exceeding this specification, the IC must be operated on condition that the Input Voltage is up to 5.5V and the total operating time is within 500hrs.

• Dropout Voltage by Output Voltage

Topt=25°C

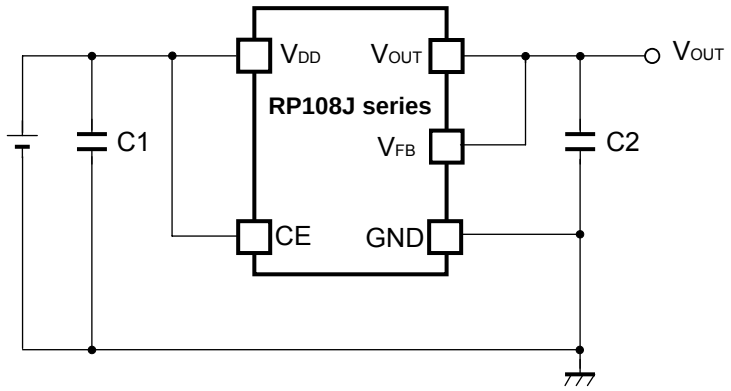
Output Voltage V_{OUT} (V)	Dropout Voltage V_{DIF} (V)		
	Condition	Typ.	Max.
0.8V ≤ V_{OUT} < 0.9V	I_{OUT}=3A	0.910	1.110
0.9V ≤ V_{OUT} < 1.0V		0.865	1.000
1.0V ≤ V_{OUT} < 1.1V		0.810	0.950
1.1V ≤ V_{OUT} < 1.2V		0.755	0.895
1.2V ≤ V_{OUT} < 1.5V		0.720	0.840
1.5V ≤ V_{OUT} < 2.5V		0.630	0.760
2.5V ≤ V_{OUT} < 3.3V		0.510	0.600
3.3V ≤ V_{OUT} ≤ 4.2V		0.480	0.560

The values in □ are applicable under the condition of −40°C ≤ Topt ≤ 85°C.

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



Typical Application

(External Components)

C1,C2: Ceramic Capacitors 10μF Kyocera CMX7R106M06AB

When using the RP108J Series, please consider the following points.

When using an internally fixed output voltage type, please connect the V_{OUT} pin to the V_{FB} pin.

However, in the case of using the Adjustable Output Voltage Type, please follow the "Technical Notes on External Adjustable Output Voltage Type".

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 10μF or more capacitor C2.

In case of using a tantalum capacitor, and its ESR is large, the output may be unstable.

Therefore, select C2 carefully considering its frequency characteristics.

The recommended temperature characteristics for C1 and C2 capacitors are the followings.

- B Characteristics: Temperature range from −25°C to +85°C, Capacitance change of ±10%
- X5R Characteristics: Temperature range from −55°C to +85°C, Capacitance change of ±15%
- X7R Characteristics: Temperature range from −55°C to +125°C, Capacitance change of ±15%

The recommended capacitor's tolerable voltage is twice as large as the voltage of use (C1: Input voltage, C2: Output voltage). The upper limit of the capacitance value for C2 is 100μF.

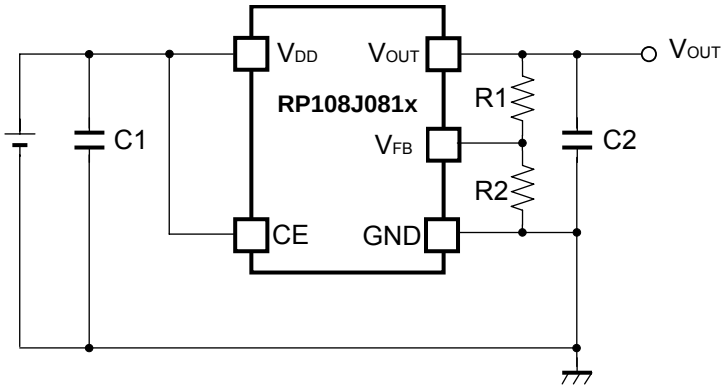
PCB Layout

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 10μF or more between V_{DD} and GND pin, and as close as possible to the pins.

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

Technical Notes on External Adjustable Output Voltage Type



Typical application for adjustable output voltage type

(External Components)
C1,C2: Ceramic Capacitors 10μF Kyocera CMX7R106M06AB

When using RP108J081x, please consider the following points.

The output voltage of the externally adjustable output voltage type should be set to 4.2V or less. Also, total resistors value of R1 and R2 should be 20kΩ or less.

Phase Compensation

Similar to the Internally Fixed Output Voltage Type, phase compensation is made for securing stable operation even if the load current is varied.

For this purpose, use a 10μF or more capacitor C2.

In case of using a tantalum capacitor, and its ESR is large, the output may be unstable.

Therefore, select C2 carefully considering its frequency characteristics.

The recommended temperature characteristics for C1 and C2 capacitors are the followings.

- B Characteristics: Temperature range from −25°C to +85°C, Capacitance change of ±10%
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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 10μF or more between V_{DD} and GND pin, and as close as possible to the pins.

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

Transient Response

When using the Adjustable Output Voltage Type, the transient response could be affected by the external resistors. Evaluate the circuit taking the actual conditions of use into account.

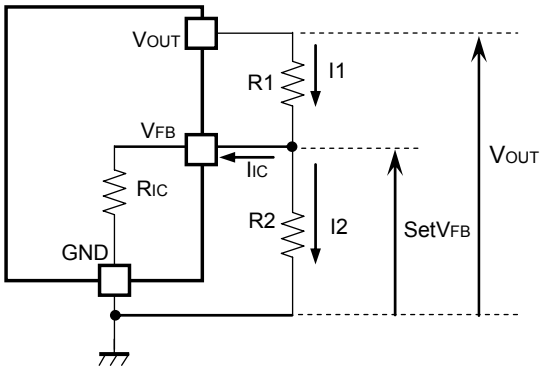
Adjustable Output Voltage Type Settings

- **Output Voltage Setting Method**

RP108J081x can be adjusted the output voltage by using the external divider resistors.

If the V_{FB} voltage fixed into the IC is described as setV_{FB}, the output voltage can be set by using the following equations

SetV_{FB} is equal to 0.8V. The V_{OUT} pin of RP108J081x should be connected to the V_{FB} pin.



$I1 = I_{IC} + I2$ .....(1)

$I2 = setV_{FB} / R2$ .....(2)

Thus,

$I1 = I_{IC} + setV_{FB} / R2$ .....(3)

Therefore,

$V_{OUT} = setV_{FB} \times R1 \times I1$ .....(4)

Put Equation (3) into Equation (4), then

$V_{OUT} = setV_{FB} + R1(I_{IC} + setV_{FB} / R2)$

$= setV_{FB} \times (1+R1/ R2) + R1 \times I_{IC}$ .....(5)

In Equation (5), R1x I_{IC} is the error-causing factor in V_{OUT}.

As for I_{IC},

$I_{IC} = setV_{FB} / R_{IC}$ .....(6)

Therefore, the error-causing factor R1x I_{IC} can be described as follows.

$R1 \times I_{IC} = R1 \times setV_{FB} / R_{IC}$

$= setV_{FB} \times R1 / R_{IC}$ .....(7)

For better accuracy, choosing R1 ($<<R_{IC}$) reduces this error.

Without the error-causing factor R1x I_{IC}, the output voltage can be calculated by the following equation

$V_{OUT} = setV_{FB} \times ((R1 + R2) / R2)$ .....(8)

R_{IC} of RP108J is approximately Typ.1.6MΩ (Topt=25°C, this value is guaranteed by design.).

The value could be affected by the temperature, therefore evaluate the circuit taking the actual conditions of use into account.

REVERSE CURRENT PROTECTION CIRCUIT

The RP108J Series include a Reverse Current Protection Circuit, which stops the reverse current from V_{OUT} pin to V_{DD} pin or to GND pin when V_{OUT} becomes higher than V_{IN}.

Usually, the LDO using Pch output transistor contains a parasitic diode between V_{DD} pin and V_{OUT} pin. Therefore, if V_{OUT} is higher than V_{IN}, the parasitic diode becomes forward direction. As a result, the current flows from V_{OUT} pin to V_{DD} pin.

The ICs of this series switches the mode to the reverse current protection mode before V_{IN} becomes lower than V_{OUT} by connecting the parasitic diode of Pch output transistor to the backward direction, and connecting the gate to V_{OUT} pin. As a result, the Pch output transistor is turned off and the all the current pathways from V_{OUT} pin to GND pin are shut down to maintain the reverse current lower than 10μA.

Switching to either the normal mode or to the reverse current protection mode is determined by the magnitude of V_{IN} voltage and V_{OUT} voltage. For the stable operation, offset and hysteresis are set as the threshold. Offset is set to 30mV (Typ.25°C) and hysteresis is set to 5mV (Typ.25°C).

Therefore, the minimum dropout voltage under the small load current condition is restricted by the value of 35mV (Typ.25°C).

Fig.1 and Fig.2 show the diagrams of each mode, and Fig.3 shows the load characteristics of each mode. When giving the V_{OUT} pin a constant-voltage and decreasing the V_{IN} voltage, the dropout voltage will become lower than 30mV (Typ.25°C). As a result, the reverse current protection starts to function to stop the load current. By increasing the dropout voltage higher than 35mV (Typ.25°C), the protection mode will be released to let the load current to flow. If the dropout voltage to be used is lower than 30mV (Typ.25°C), the detection and the release may be repeated.

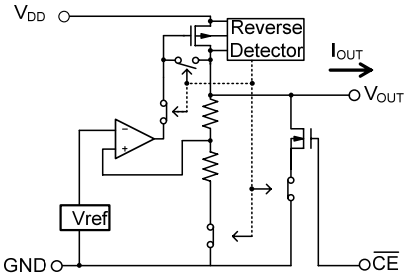


Fig. 1 Normal Mode

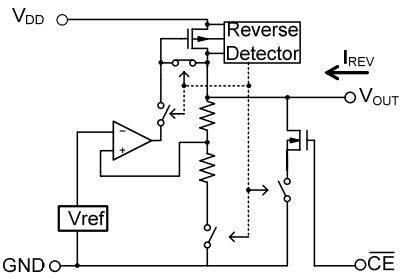


Fig. 2 Reverse Current Protection Mode

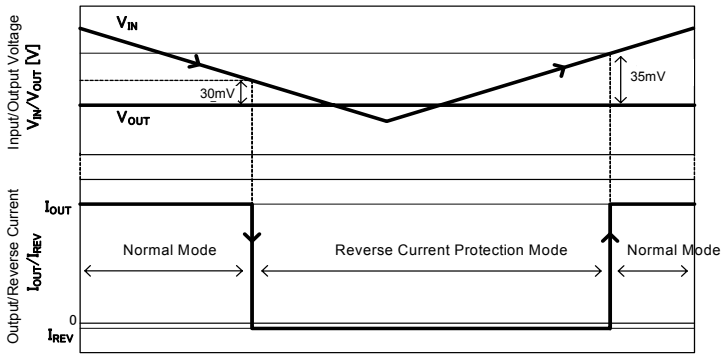


Fig. 3 Reverse Current Protection Mode Detection/ Release &
Reverse Current/ Output Current Characteristics

CONSTANT SLOPE CIRCUIT

RP108J Series has a Constant Slope Circuit as a function which prevents the overshoot of the output voltage.

The constant slope is a kind of soft-start circuit which allows the output voltage to start up gradually.

The capacitor to create the start-up slope is built-in the IC that doesn't require any external components.

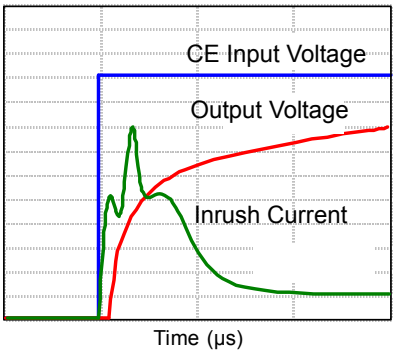
The start-up time and start-up slope angle are fixed inside the IC.

If the capacitance of the external output capacitor becomes more than the certain capacitance, the output current limit circuit minimizes the incoming current of the output capacitor at the start-up. As a result, the start-up time becomes longer and the start-up slope angle becomes more gentle.

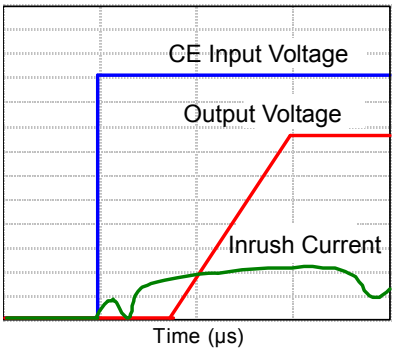
The constant slope circuit is an especially effective function for large current product like 3A output, because driver's ability is high, and it allows a large current to flow at the start-up.

Inrush current limit circuit of conventional products

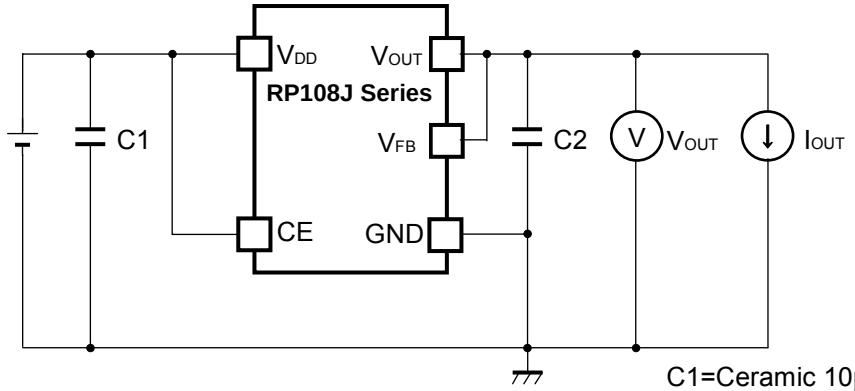
(Imaginary graph)



Constant Slope Circuit

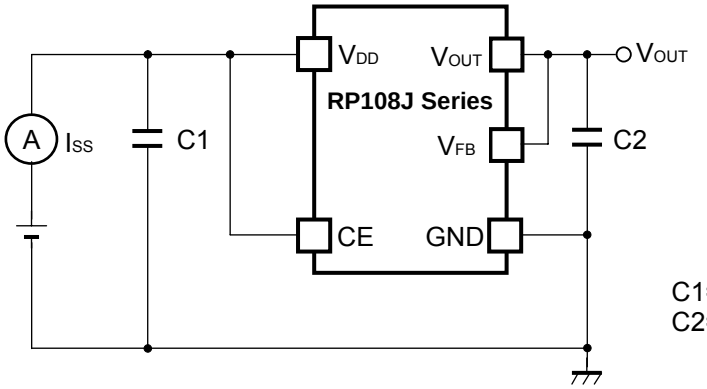


TEST CIRCUITS



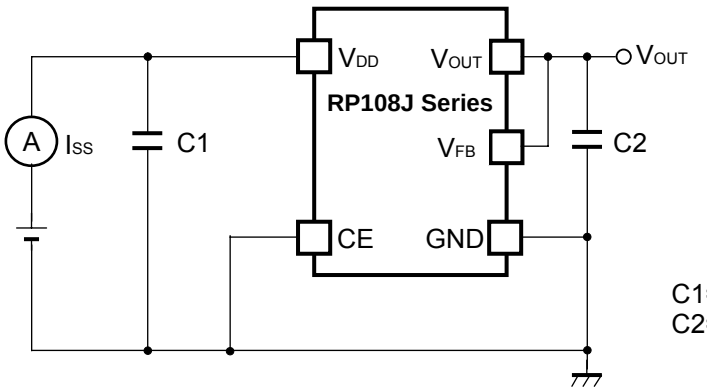
C1=Ceramic 10µF
C2=Ceramic 10µF

Basic Test Circuit



C1=Ceramic 10µF
C2=Ceramic 10µF

Test Circuit for Supply Current

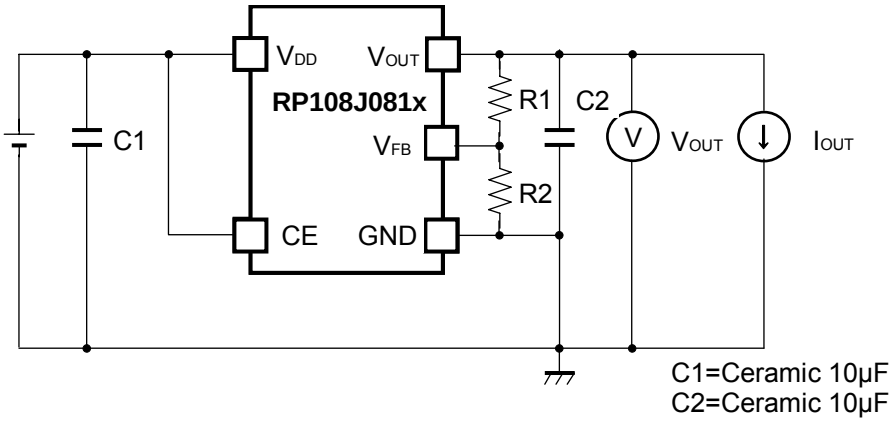


C1=Ceramic 10µF
C2=Ceramic 10µF

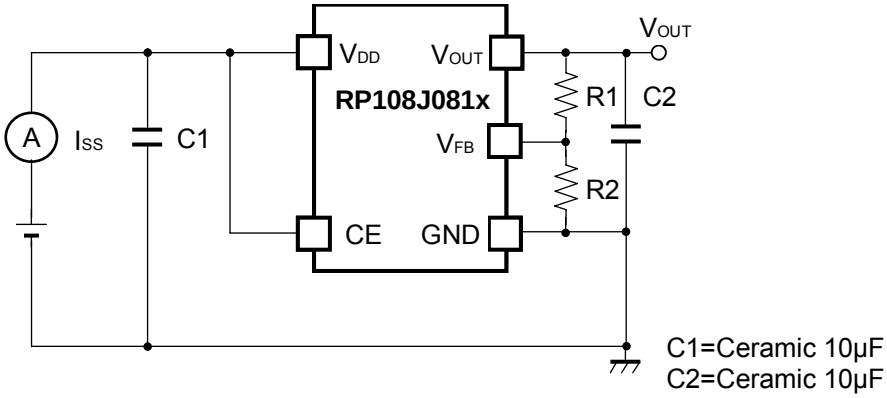
Test Circuit for Standby Current

TEST CIRCUITS for Adjustable Output Voltage Type (RP108J081x)

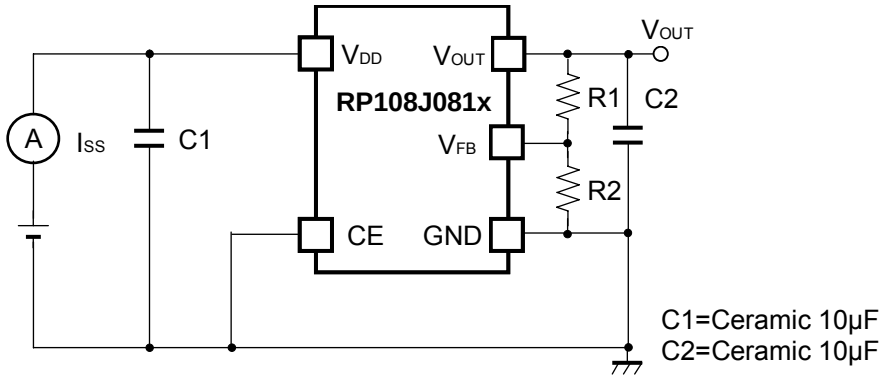
Please refer to "Technical Notes on Adjustable Output Voltage Type" when using R1 and R2 as output capacitors.



Basic Test Circuit



Test Circuit for Supply Current

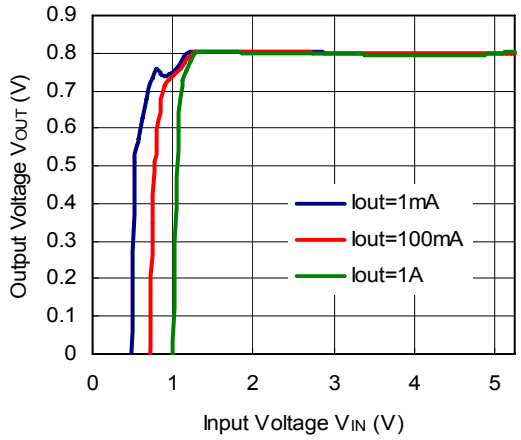


Test Circuit for Standby Current

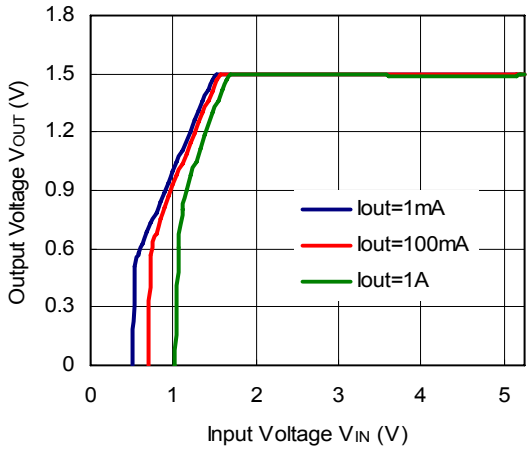
TYPICAL CHARACTERISTICS

1）Output Voltage vs. Input Voltage（C1=Ceramic10μF, C2=Ceramic10μF, Topt=25°C）

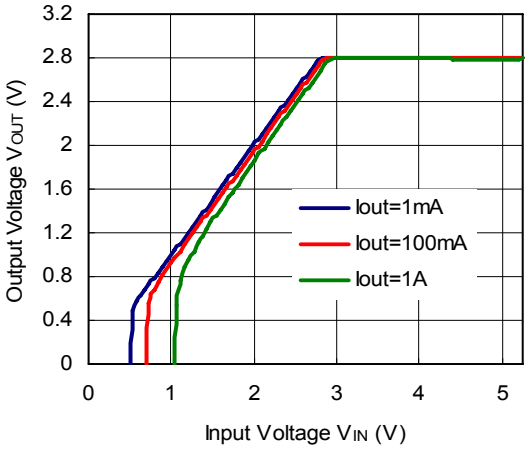
RP108x081x



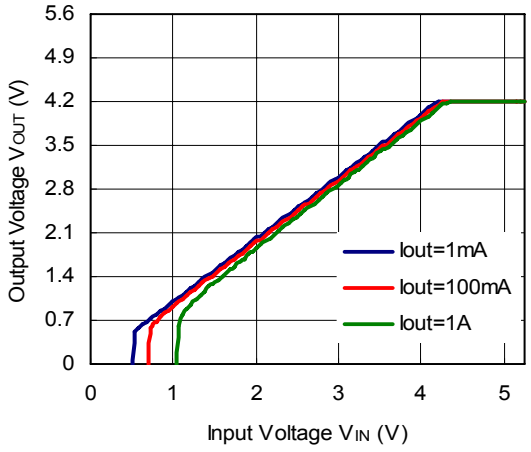
RP108x151x



RP108x281x

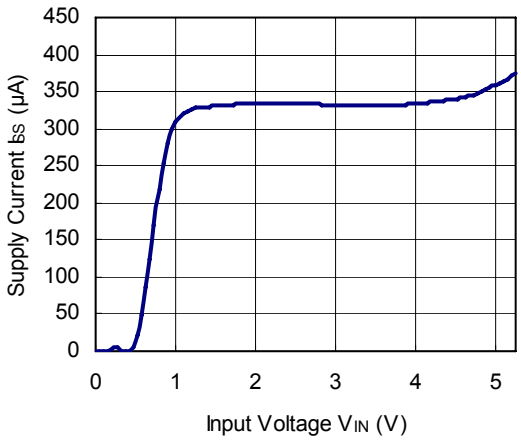


RP108x421x

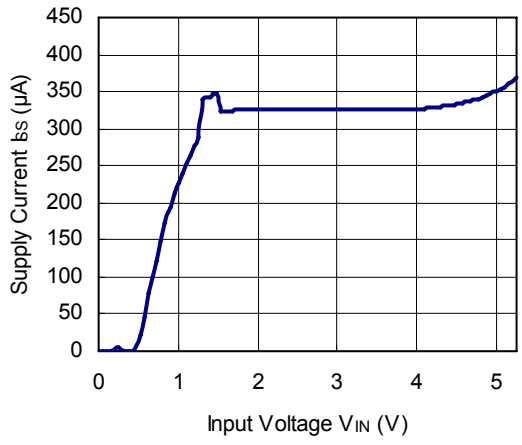


2）Supply Current vs. Input Voltage（C1=Ceramic10μF, C2=Ceramic10μF, IOUT=0mA, Topt=25°C）

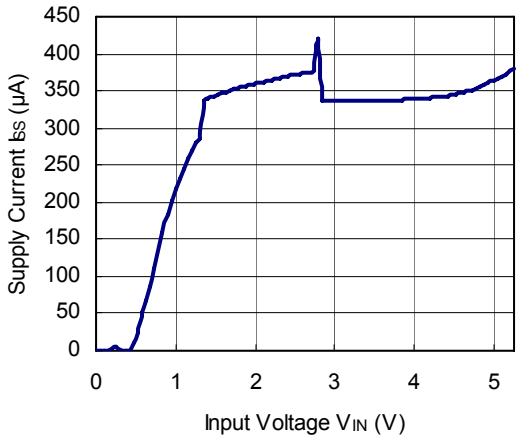
RP108x081x



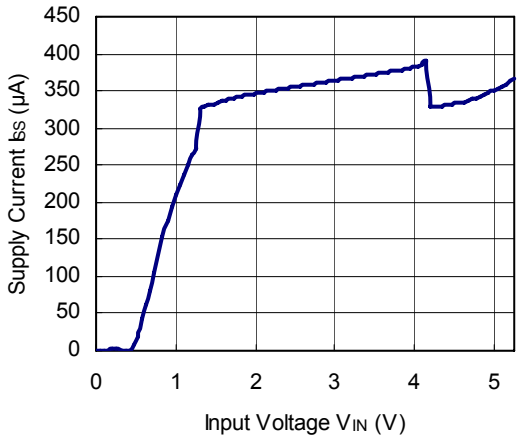
RP108x151x



RP108x281x



RP108x421x

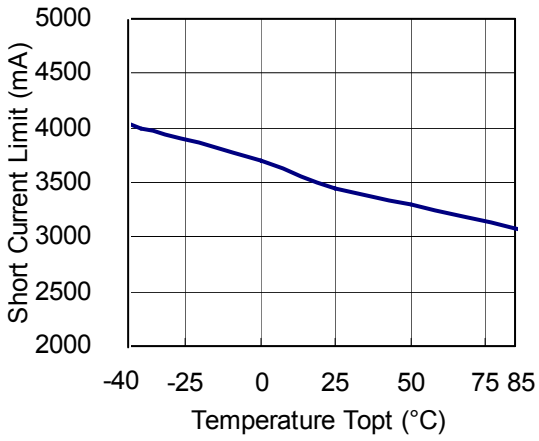


3）Short Current Limit vs. Temperature/ Current Limit vs. Temperature

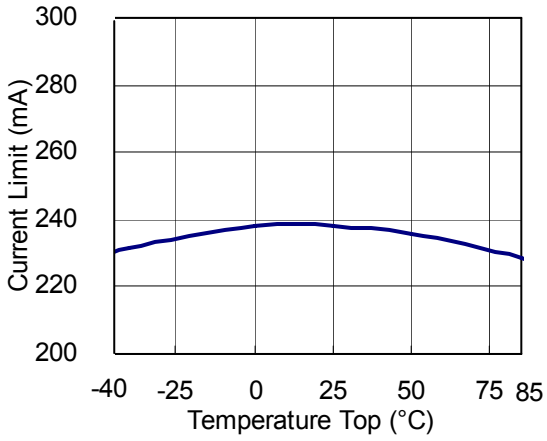
RP108J includes a Fold-back Protection Circuit, while a Fold-back Protection Circuit is operated, Thermal Shutdown Circuit starts to operate. Therefore RP108J isn't allowed to test "Output voltage vs. Output Current" on condition that a Thermal Shutdown Circuit is operated to prevent heat generated by itself.

Refer to " 3) Short Current Limit vs. Temperature / Current Limit vs. Temperature for short current limit and current limit characteristics.

RP108x081x

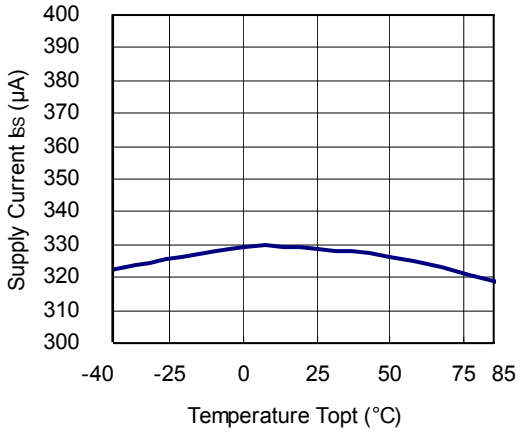


RP108x081x

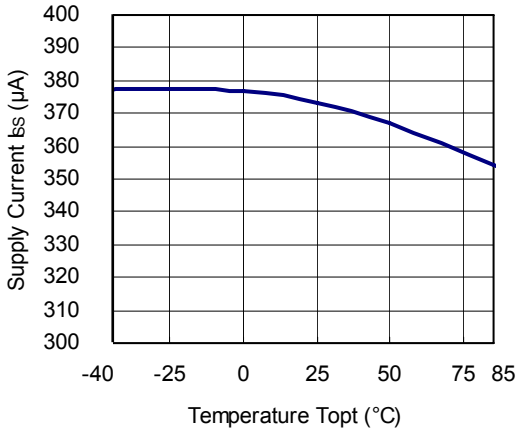


4）Supply Current vs. Temperature（C1=Ceramic10μF, C2=Ceramic10μF,I_{OUT}=0mA）

RP108x081x

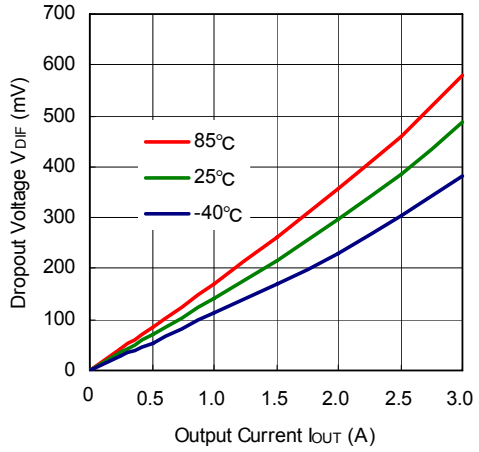


RP108x151x

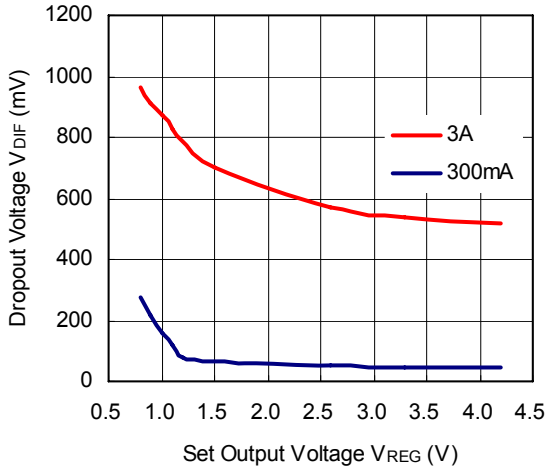


5）Dropout Voltage vs. Output Current（C1=Ceramic10μF, C2=Ceramic10μF）

RP108x251x

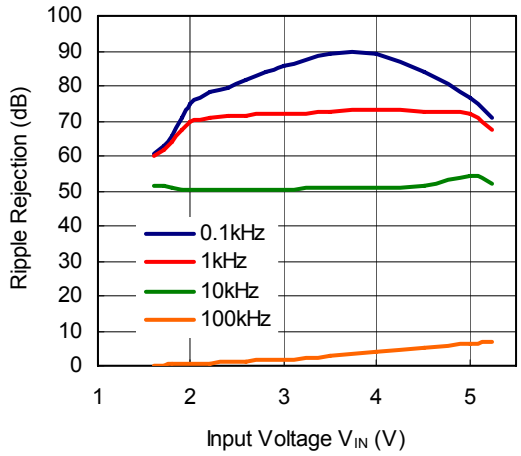


6）Dropout Voltage vs. Set Output Voltage（C1=Ceramic10μF, C2=Ceramic10μF, Topt=25°C）

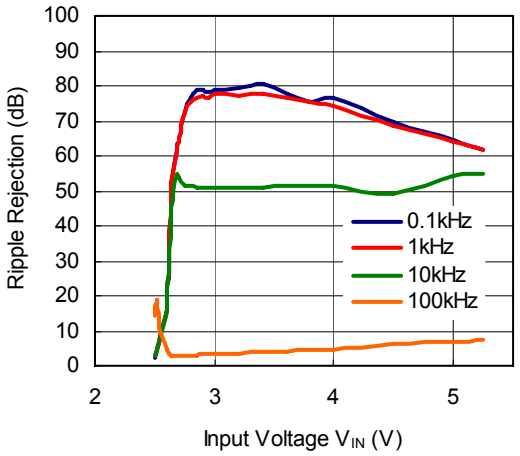


7）Ripple Rejection vs. Input Voltage（C1=C2=10μF, Ripple=0.2Vp-p, I_{OUT}=100mA Topt=25°C）

RP108x081x



RP108x251x



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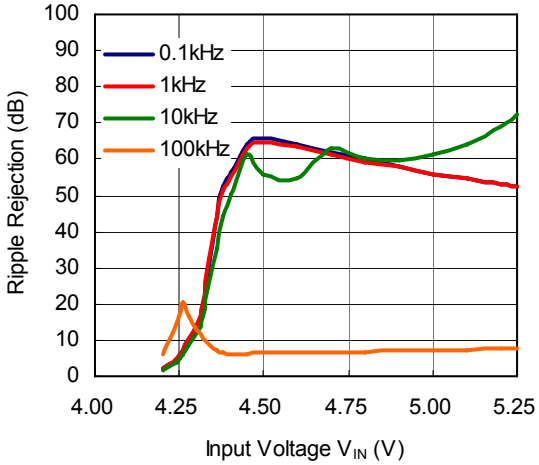
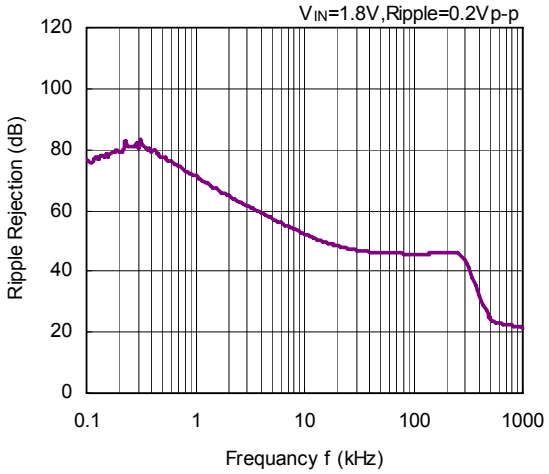


8）Ripple Rejection vs. Frequency（C1=none, C2=10μF, I_{OUT}=100mA, Topt=25°C）

RP108x081x



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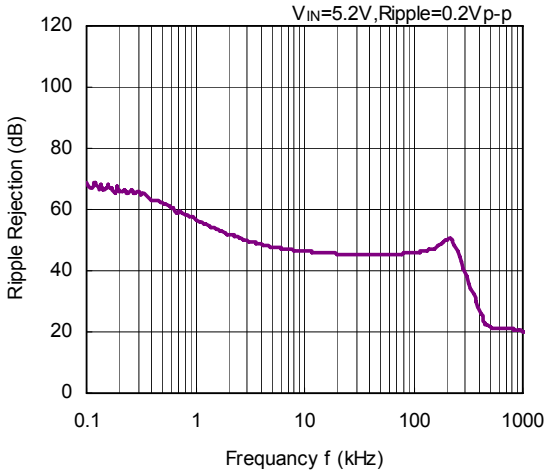
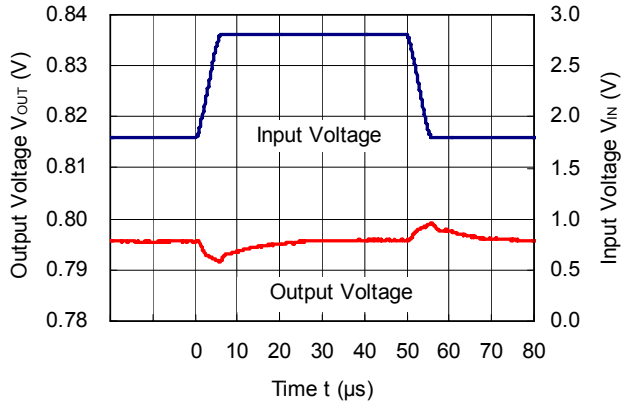
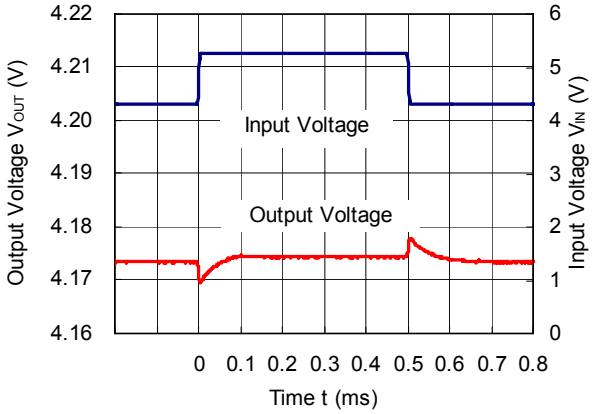


9）Input Transient Response（C1=none, C2=10μF, I_{OUT}=30mA, tr=tf=5μs, Topt=25°C）

RP108x081x

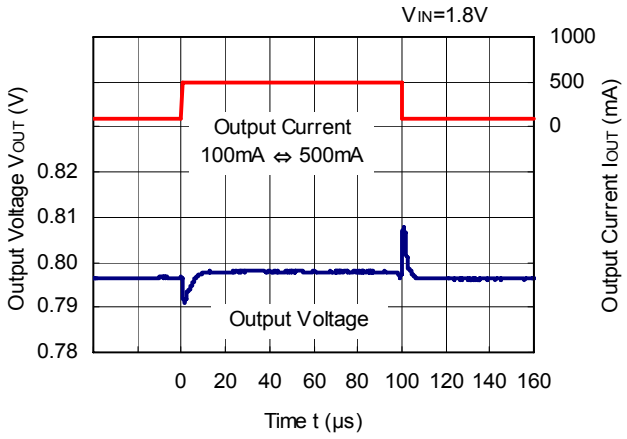


RP108x421x

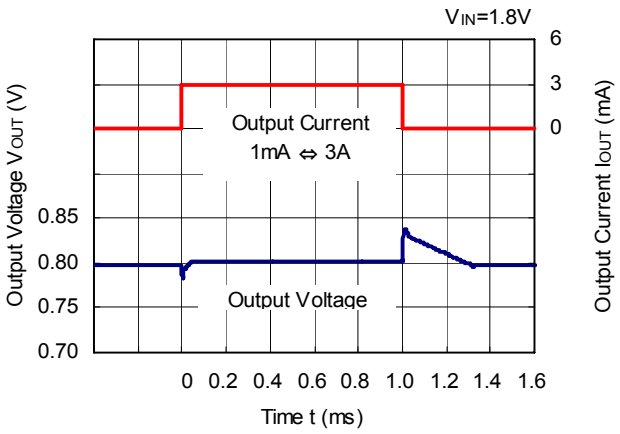


10）Load Transient Response（C1=C2=10μF, tr=tf=0.5μs, Topt=25°C）

RP108x081x



RP108x081x



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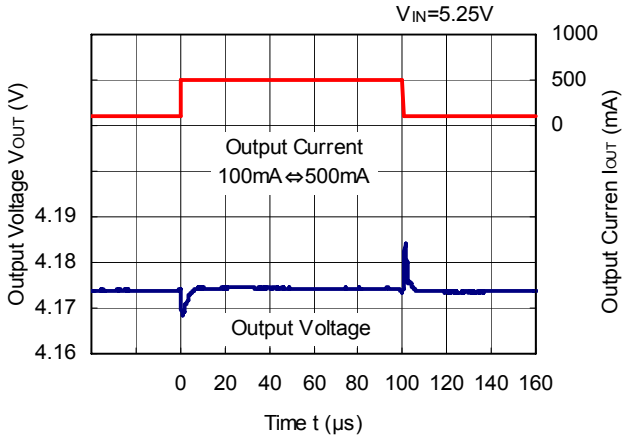
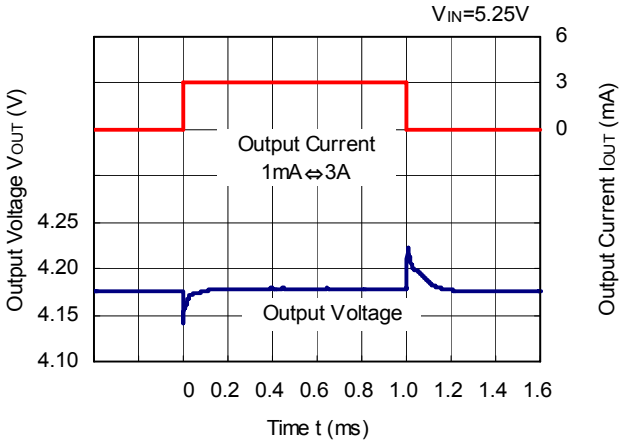
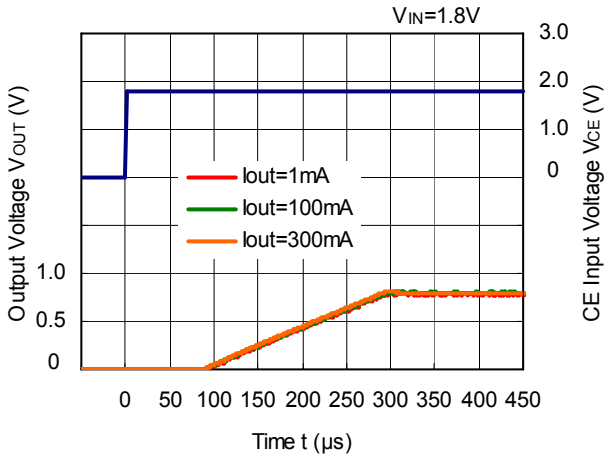


RP108x421x

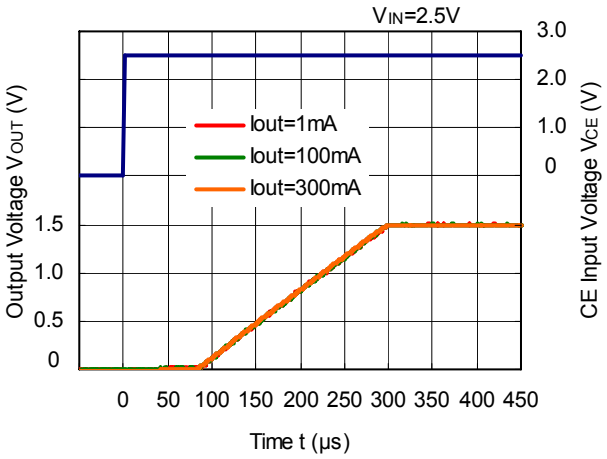


11）Turn on Speed with CE pin（C1=Ceramic10μF, C2=Ceramic10μF, Topt=25°C）

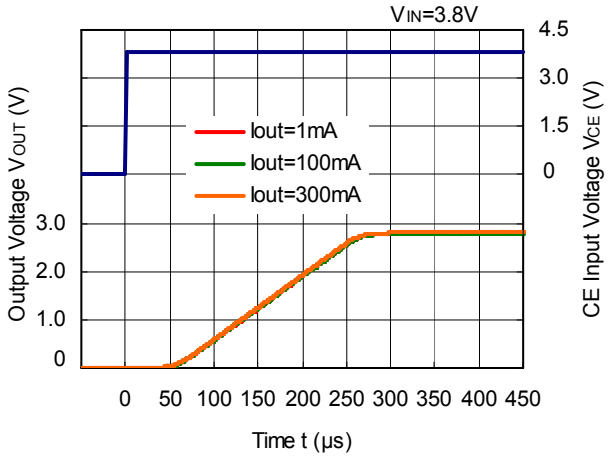
RP108x081x



RP108x151x



RP108x281x



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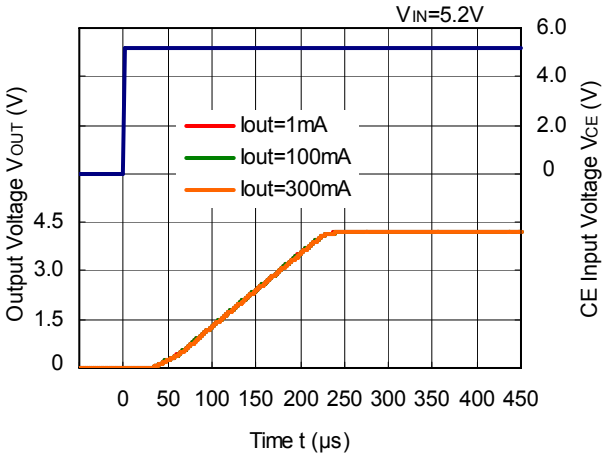
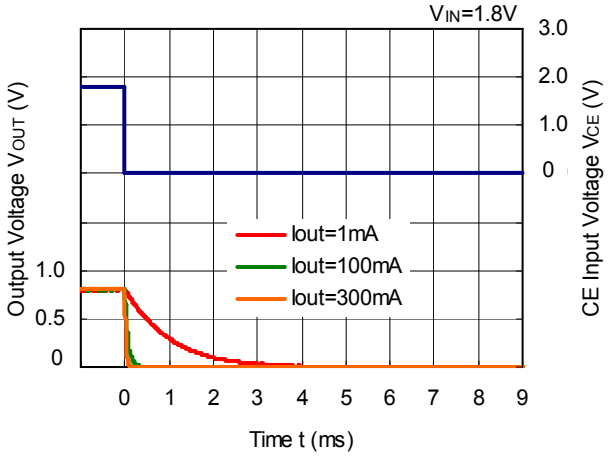


12）Turn off Speed with CE pin（C1=Ceramic10μF, C2=Ceramic10μF, Topt=25°C）

RP108x081x



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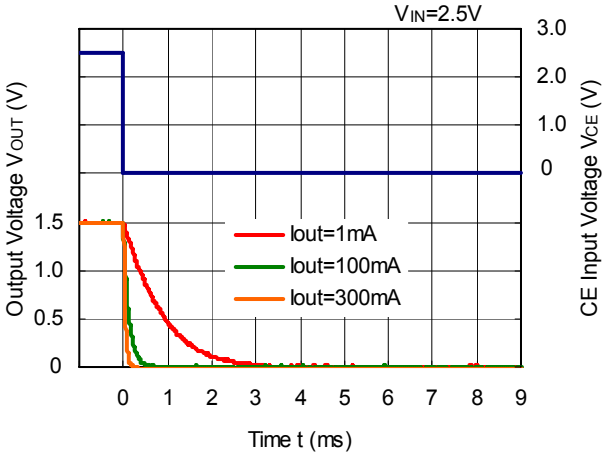

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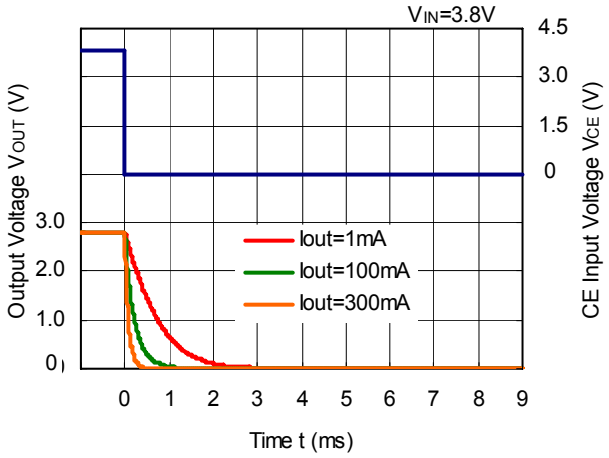

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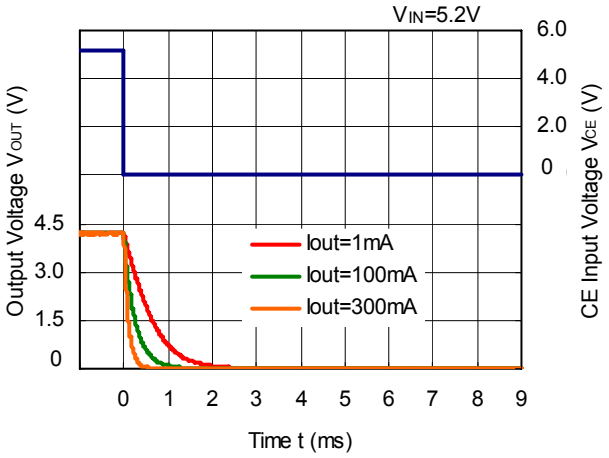
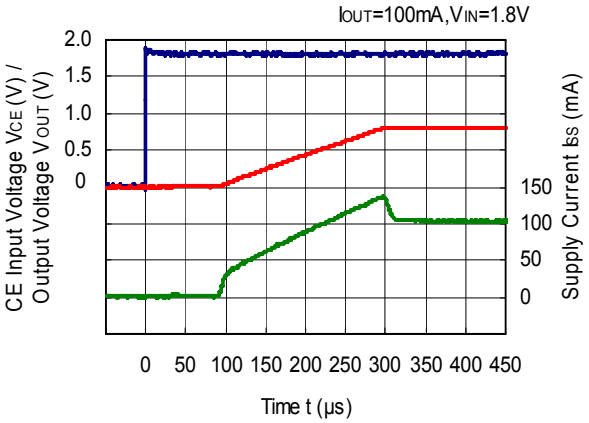
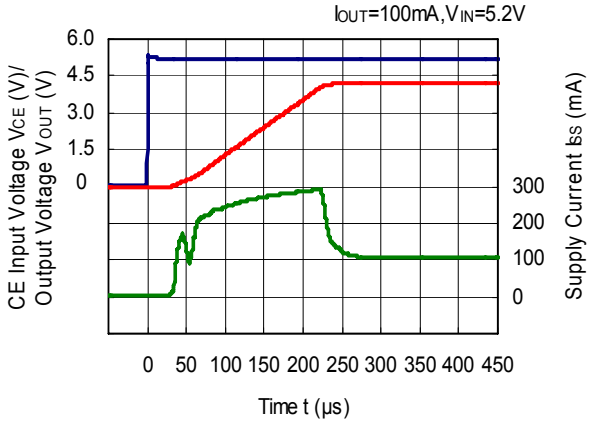


13）Inrush Current

RP108x081x



RP108x421x



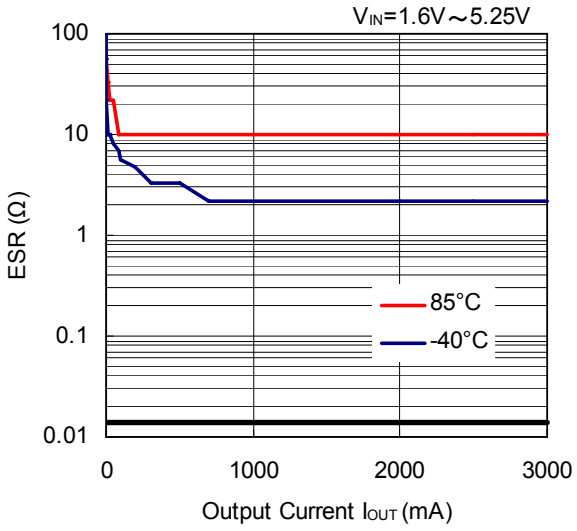
ESR vs. Output Current

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
Hatched area : Noise level is under 40μV
C1,C2 :10.0μF or more

RP108x081x



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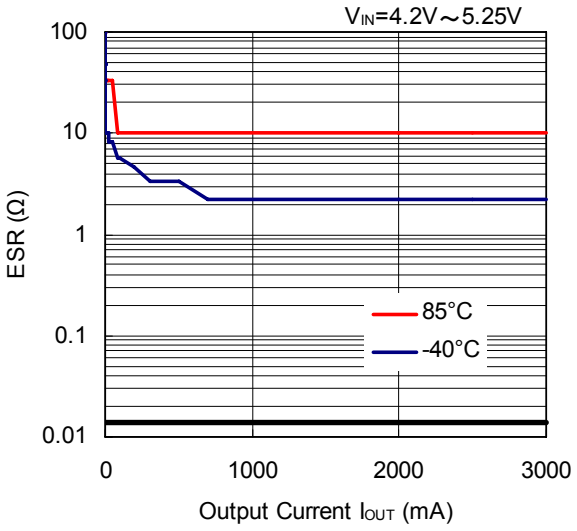

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■Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

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