RICOH

RP171N Series

AEC-Q100 Grade 2 Compliant

150 mA 10 V LDO Regulator for Automotive Applications

NO. EC-245-150210

OUTLINE

The RP171x is a LDO regulator featuring 150 mA output current that is developed with CMOS process technology. The RP171x offers the maximum input voltage of 10 V which makes it ideal for the use in car audio equipment, car navigation system and ETC system. The RP171x provides a supply current as low as Typ. 23 µA and achieves fast-response characteristics.

The RP171x offers an output voltage as low as 1.2 V. Compared to existing high-speed lines, the RP171x provides excellent output voltage accuracy and output voltage temperature coefficient

Internally, the RP171x consists of a fold-back protection circuit and a thermal shutdown circuit. A standby mode with ultra low supply current has been realized by a chip enable function.

The RP171x is available in a 5-pin SOT-23-5 package with high power dissipation.

FEATURES

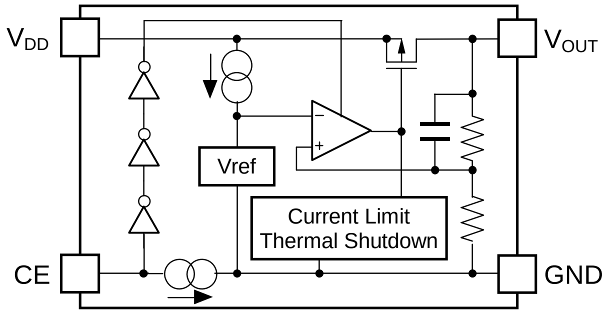
- Input Voltage Range (Absolute Maximum Ratings) ········ 2.6 V to 10 V (12 V)
- Operating Temperature ··· −40°C to 105°C
- Supply Current ·· Typ. 23 µA (V_{IN} = V_{SET} +1.0 V)
- Standby Current ·· Typ. 0.1µA (V_{IN} = 10.0 V, CE = “L”)
- Output Voltage Range ··································· 1.2 V/1.5 V/1.8 V/2.5 V/2.8 V/3.0 V/3.3 V/3.4 V/5.0 V/6.0 V
  * Contact Ricoh sales representatives for other voltages.
- Output Voltage Accuracy ·· ±1.0%
- Output Voltage Temperature Coefficient ····················· Typ. ±80 ppm/°C
- Line Regulation ·· Typ. 0.02%/V
- Dropout Voltage ·· Typ. 0.4 V (I_{OUT} = 150 mA, V_{SET} = 2.8 V)
- Ripple Rejection ··· Typ. 70 dB (f = 1 kHz)
- Fold-back Protection Circuit ····································· Typ. 40 mA
- Constant Slope Circuit (Soft-start Function)
- Thermal Shutdown Circuit ·· Stops at 165°C
- Auto-discharge Function ·· RP171xxxxD
- Package ·· SOT-23-5
- Ceramic Capacitor Compatible ································· 1.0 µF or more

APPLICATIONS

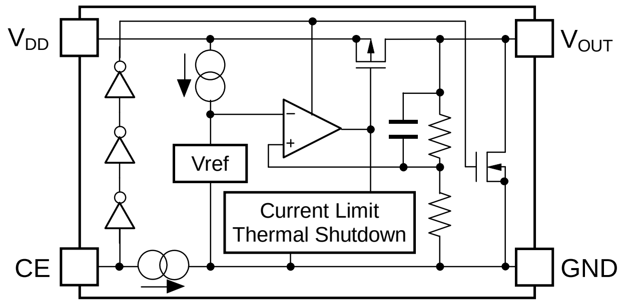
- Power source for car audio equipment, car navigation system, ETC system, etc.

BLOCK DIAGRAM

RP171xxxxB Block Diagram



RP171xxxxD Block Diagram



SELECTION GUIDE

The set output voltage, the auto-discharge function and the automotive class are user-selectable options.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP171Nxx1∗-TR-#E	SOT-23-5	3,000 pcs	Yes	Yes

xx: Specify the set output voltage (V_{SET}) within the range of
1.2 V / 1.5 V / 1.8 V / 2.5 V / 2.8 V / 3.0 V / 3.3 V / 3.4 V / 5.0 V / 6.0 V
* Contact Ricoh sales representatives for other voltages.

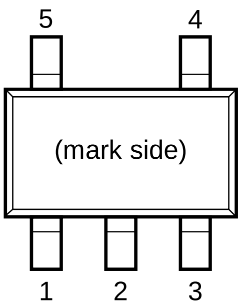
∗: Select from (B) CE = Active-high without auto-discharge function or (D) CE = Active-high with Auto-discharge function.

#: Specify the automotive class code.

	Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
A	−40°C to 105°C	25°C	High temperature
J	−40°C to 105°C	−40°C to 105°C	High and low temperature

[*1] Auto-discharge function quickly lowers the output voltage to 0 V by releasing the electrical charge accumulated in the external capacitor when the chip enable signal is switched from the active mode to the standby mode.

PIN DESCRIPTION



SOT-23-5 Pin Configuration

Pin No.	Symbol	Description
1	V_{DD}	Input Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin, Active-high
4	NC	No Connection
5	V_{OUT}	Output Pin

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	12	V
V_{CE}	Input Voltage (CE Pin)	12	V
V_{OUT}	Output Voltage	−0.3 to V_{IN} +0.3	V
I_{OUT}	Output Current	330	mA
P_D	Power Dissipation (Standard Land Pattern)*1	525	mW
Tj	Junction Temperature	−40 to 150	°C
Tstg	Storage Temperature Range	−55 to 150	°C

*1 Refer to *PACKAGE INFORMATION* for detailed 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

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	2.6 to 10	V
Ta	Operating Temperature Range	−40 to 105	°C

RECOMMENDED OPERATING CONDITIONS
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 ratings 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

$V_{IN} = V_{SET} + 1.0$ V, $I_{OUT} = 1$ mA, unless otherwise noted.

The specifications surrounded by $\boxed{}$ are guaranteed by design engineering at –40°C ≤ Ta ≤ 105°C.

RP171x (-AE) (Ta = 25°C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	1.5 V < V_{SET}	Ta = 25°C	V_{SET} x 0.99		V_{SET} x 1.01	V
			−40°C ≤ Ta ≤ 105°C	$\boxed{V_{SET} \times 0.965}$		$\boxed{V_{SET} \times 1.03}$	
		V_{SET} ≤ 1.5 V	Ta = 25°C	−15		15	mV
			−40°C ≤ Ta ≤ 105°C	$\boxed{-53}$		$\boxed{45}$	
I_{OUT}	Output Current			$\boxed{150}$			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	0.1 mA ≤ I_{OUT} ≤ 150 mA			5	$\boxed{45}$	mV
V_{DIF}	Dropout Voltage	I_{OUT} =150 mA		Refer to the *Product-specific Electrical Characteristics*			
I_{SS}	Supply Current	I_{OUT} = 0 mA			23	$\boxed{45}$	µA
Istandby	Standby Current	V_{IN} = 10.0 V, V_{CE} = GND			0.1	$\boxed{1.2}$	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{SET} + 0.5 V ≤ V_{IN} ≤ 10.0 V Note: When V_{OUT} ≤ 2.1 V, 2.6 V ≤ V_{IN} ≤ 10.0 V			±0.02	$\boxed{\pm 0.25}$	%/V
I_{SC}	Short Current Limit	V_{OUT} = 0 V			40		mA
I_{PD}	CE Pull-down Current				0.30		µA
V_{CEH}	CE Input Voltage "H"			$\boxed{1.7}$			V
V_{CEL}	CE Input Voltage "L"					$\boxed{0.8}$	V
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature			165		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature			110		°C
R_{LOW}	Auto-discharge Nch Tr. ON Resistance (RP171xxxxD)	V_{CE} = 0 V, V_{IN} = 7.0 V			250		Ω

All test items listed under *ELECTRICAL CHARACTERISTICS* are done under the pulse load condition (Tj ≈ Ta = 25°C).

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Product-specific Electrical Characteristics

The specifications surrounded by ☐ are guaranteed by design engineering at –40°C ≤ Ta ≤ 105°C.

Product-specific Electrical Characteristics (Ta = 25°C)

Product Name	V_{OUT} (V) (Ta = 25°C)			V_{OUT} (V) (−40°C ≤ Ta ≤ 105°C)			V_{DIF} (V) (I_{OUT} = 150 mA)	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP171x121x	1.185	1.200	1.215	$\boxed{1.147}$	1.200	$\boxed{1.245}$	−	$\boxed{1.405}$
RP171x151x	1.485	1.500	1.515	$\boxed{1.447}$	1.500	$\boxed{1.545}$	−	$\boxed{1.105}$
RP171x181x	1.782	1.800	1.818	$\boxed{1.737}$	1.800	$\boxed{1.854}$	−	$\boxed{0.805}$
RP171x251x	2.475	2.500	2.525	$\boxed{2.413}$	2.500	$\boxed{2.575}$	0.400	$\boxed{0.600}$
RP171x281x	2.772	2.800	2.828	$\boxed{2.702}$	2.800	$\boxed{2.884}$		
RP171x301x	2.970	3.000	3.030	$\boxed{2.895}$	3.000	$\boxed{3.090}$	0.300	$\boxed{0.500}$
RP171x331x	3.267	3.300	3.333	$\boxed{3.185}$	3.300	$\boxed{3.399}$		
RP171x341x	3.366	3.400	3.434	$\boxed{3.281}$	3.400	$\boxed{3.502}$		
RP171x501x	4.950	5.000	5.050	$\boxed{4.825}$	5.000	$\boxed{5.150}$	0.250	$\boxed{0.420}$
RP171x601x	5.940	6.000	6.060	$\boxed{5.790}$	6.000	$\boxed{6.180}$		

V_{IN} = V_{SET} + 1.0 V, I_{OUT} = 1 mA, unless otherwise noted.

RP171x (-JE) (−40°C ≤ Ta ≤ 105°C)

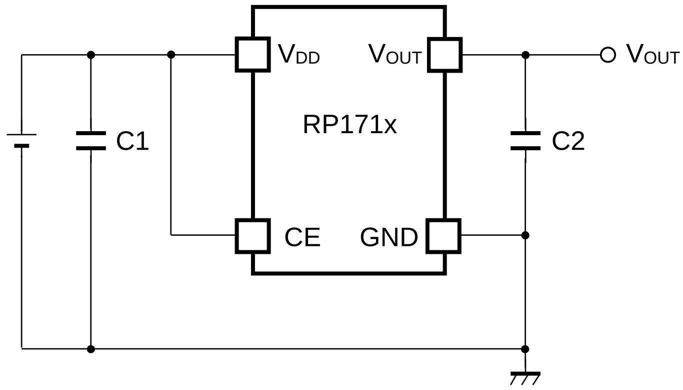
Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	1.5 V < V_{SET}	Ta = 25°C	V_{SET} x 0.99		V_{SET} x 1.01	V
			−40°C ≤ Ta ≤ 105°C	V_{SET} x 0.965		V_{SET} x 1.03	
		V_{SET} ≤ 1.5 V	Ta = 25°C	−15		15	mV
			−40°C ≤ Ta ≤ 105°C	−53		45	
I_{OUT}	Output Current			150			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	0.1 mA ≤ I_{OUT} ≤ 150 mA			5	45	mV
V_{DIF}	Dropout Voltage	I_{OUT} = 150 mA		Refer to the *Product-specific Electrical Characteristics*			
I_{SS}	Supply Current	I_{OUT} = 0 mA			23	45	µA
Istandby	Standby Current	V_{IN} = 10.0 V, V_{CE} = GND			0.1	1.2	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{SET} + 0.5 V ≤ V_{IN} ≤ 10.0 V Note: When V_{OUT} ≤ 2.1 V, 2.6 V ≤ V_{IN} ≤ 10.0 V			±0.02	±0.25	%/V
I_{SC}	Short Current Limit	V_{OUT} = 0 V			40		mA
I_{PD}	CE Pull-down Current				0.30		µA
V_{CEH}	CE Input Voltage "H"			1.7			V
V_{CEL}	CE Input Voltage "L"					0.8	V
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature			165		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature			110		°C
R_{LOW}	Auto-discharge Nch Tr. ON Resistance (RP171xxxxD)	V_{CE} = 0 V, V_{IN} = 7.0 V			250		Ω

Product-specific Electrical Characteristics

Product-specific Electrical Characteristics (−40°C ≤ Ta ≤ 105°C)

Product Name	V_{OUT} (V) (Ta = 25°C)			V_{OUT} (V) (−40°C ≤ Ta ≤ 105°C)			V_{DIF} (V) (I_{OUT} = 150 mA)	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP171x121x	1.185	1.200	1.215	1.147	1.200	1.245	−	1.405
RP171x151x	1.485	1.500	1.515	1.447	1.500	1.545	−	1.105
RP171x181x	1.782	1.800	1.818	1.737	1.800	1.854	−	0.805
RP171x251x	2.475	2.500	2.525	2.413	2.500	2.575	0.400	0.600
RP171x281x	2.772	2.800	2.828	2.702	2.800	2.884		
RP171x301x	2.970	3.000	3.030	2.895	3.000	3.090	0.300	0.500
RP171x331x	3.267	3.300	3.333	3.185	3.300	3.399		
RP171x341x	3.366	3.400	3.434	3.281	3.400	3.502		
RP171x501x	4.950	5.000	5.050	4.825	5.000	5.150	0.250	0.420
RP171x601x	5.940	6.000	6.060	5.790	6.000	6.180		

TYPICAL APPLICATION



RP171x Typical Application

External Components

Symbol	Description
C2 (C_{OUT})	1.0 μF, Ceramic Capacitor, MURATA GRM155B31A105KE15

TECHNICAL NOTES

Phase Compensation

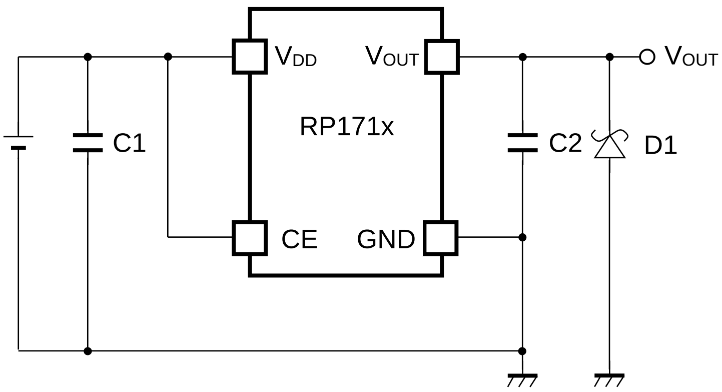
In the RP171x, phase compensation is provided to secure stable operation even when the load current is varied. For this purpose, use a 1.0 μF or more output capacitor (C2) with good frequency characteristics and proper ESR (Equivalent Series Resistance).

In case of using a tantalum type capacitor and the ESR value of the capacitor is large, the output might be unstable. Evaluate the circuit including consideration of frequency characteristics.

PCB Layout

Ensure the V_{DD} and GND lines are sufficiently robust. If their impedance is too high, noise pickup or unstable operation may result. Connect a 1.0 μF or more output capacitor (C1) with suitable values between the V_{DD} and GND pins, and as close as possible to the pins.

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION



When a sudden surge of electrical current travels along the V_{OUT} pin and GND due to a short-circuit, electrical resonance of a circuit involving an output capacitor (C2) and a short circuit inductor generates a negative voltage and may damage the device or the load devices. Connecting a schottky diode (D1) between the V_{OUT} pin and GND has the effect of preventing damage to them.

PACKAGE INFORMATION

Power Dissipation (SOT-23-5)

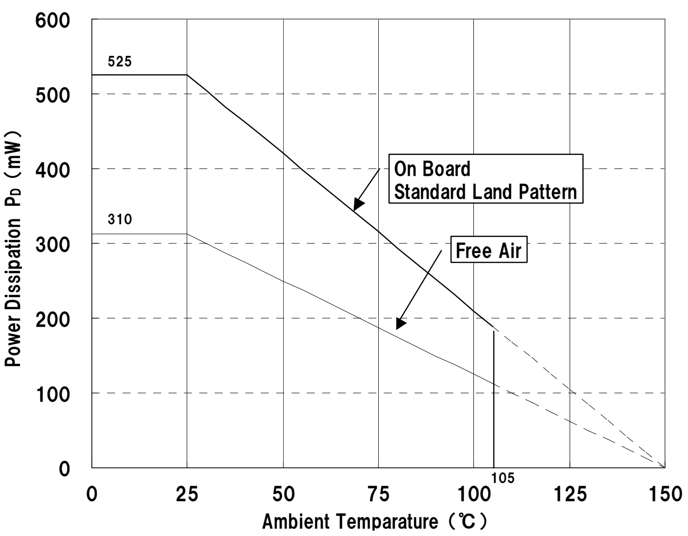
Power Dissipation (P_D) of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement. This data is taken from the SOT-23-6 package data.

Measurement Conditions

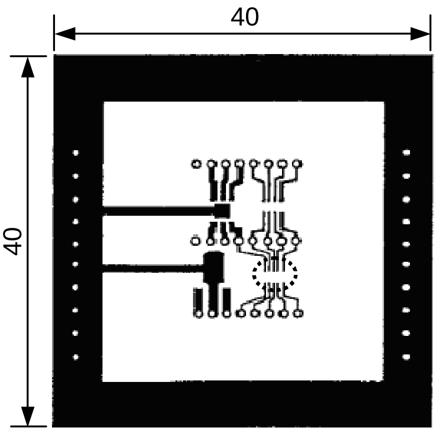
	Standard Land Pattern
Environment	Mounting on Board (Wind Velocity = 0m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-sided)
Board Dimensions	40 mm x 40 mm x 1.6 mm
Copper Ratio	Top-side: Approx. 50%, Back-side: Approx. 50%
Through-hole	ϕ0.5 mm x 44 pcs

Measurement Result (Ta = 25°C, Tjmax = 150°C)

	Standard Land Pattern	Free Air
Power Dissipation	525 mW	310 mW
Thermal Resistance	θ ja = (150 − 25°C) / 0.525W = 238°C/W	400°C/W



Power Dissipation



Measurement Board Pattern

IC Mount Area (Unit: mm)

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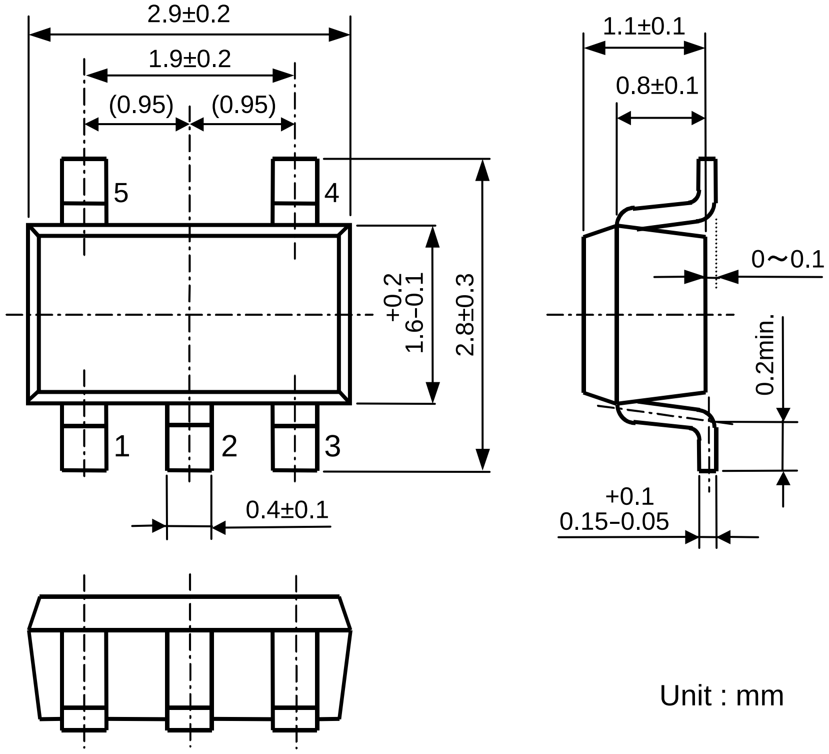
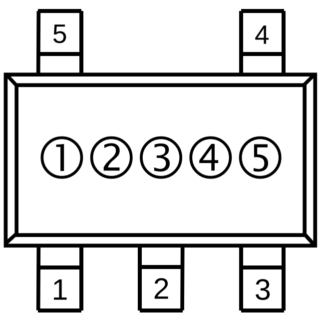
PACKAGE DIMENSIONS (SOT-23-5)



SOT-23-5 Package Dimensions

MARK SPECIFICATION (SOT-23-5)

①②③: Product Code … **Refer to *MARK SPECIFICATION TABLE (SOT-23-5).***
④⑤: Lot Number … Alphanumeric Serial Number



SOT-23-5 Mark Specification

MARK SPECIFICATION TABLE (SOT-23-5)

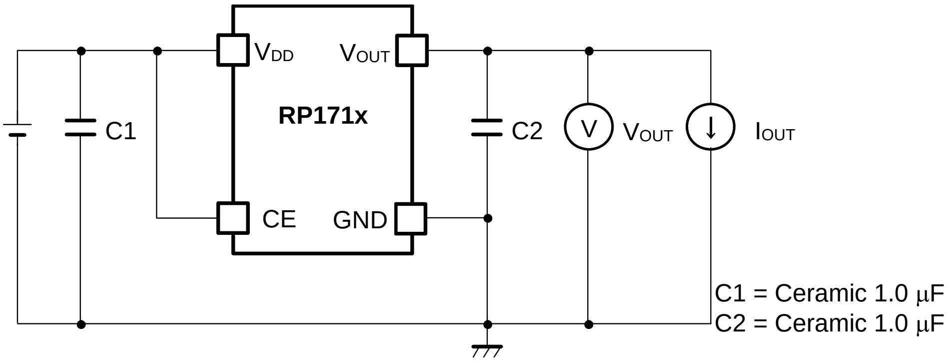
RP171Nxx1B

Product Name	①②③	V_{SET}
RP171N121B	J A A	1.2 V
RP171N151B	J A E	1.5 V
RP171N181B	J A H	1.8 V
RP171N251B	J A R	2.5 V
RP171N281B	J A U	2.8 V
RP171N301B	J A X	3.0 V
RP171N331B	K A A	3.3 V
RP171N341B	K A B	3.4 V
RP171N501B	K A T	5.0 V
RP171N601B	L A D	6.0 V

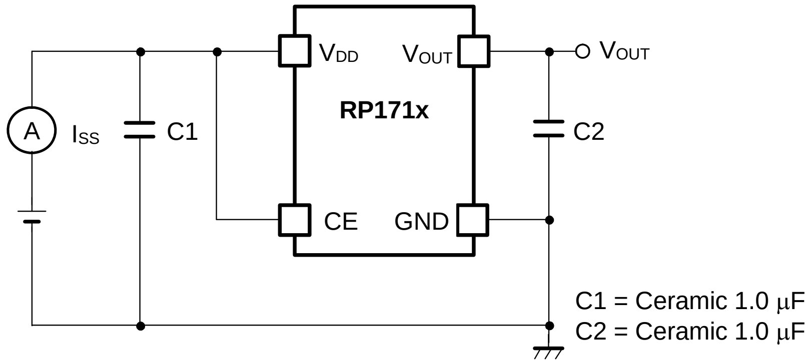
RP171Nxx1D

Product Name	①②③	V_{SET}
RP171N121D	J B A	1.2 V
RP171N151D	J B E	1.5 V
RP171N181D	J B H	1.8 V
RP171N251D	J B R	2.5 V
RP171N281D	J B U	2.8 V
RP171N301D	J B X	3.0 V
RP171N331D	K B A	3.3 V
RP171N341D	K B B	3.4 V
RP171N501D	K B T	5.0 V
RP171N601D	L B D	6.0 V

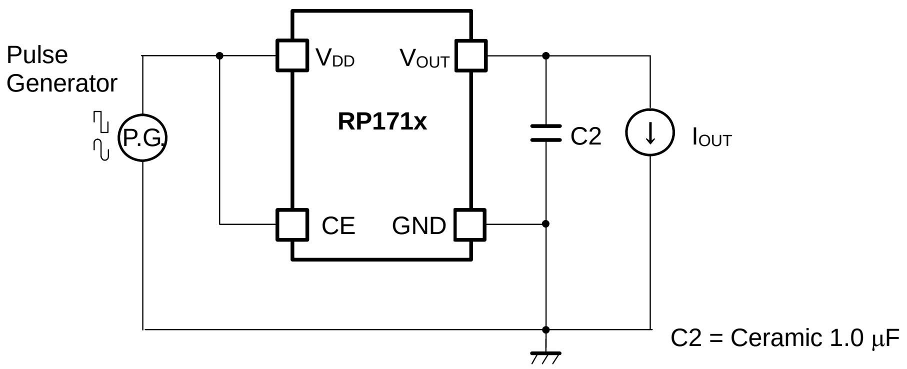
TEST CIRCUITS



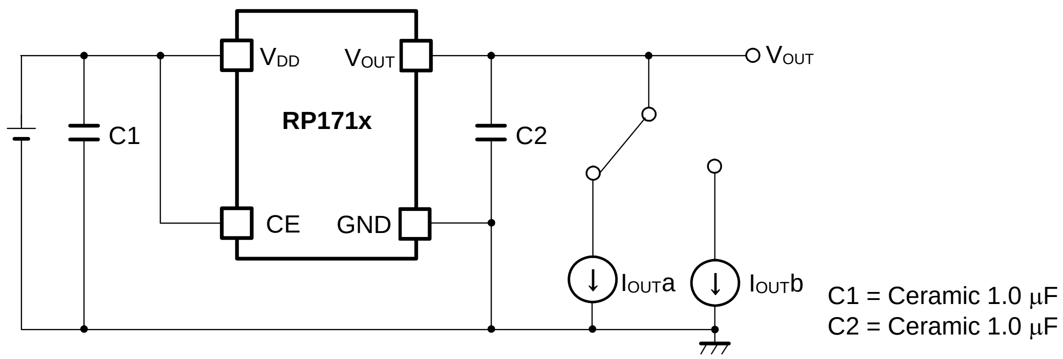
Basic Test Circuit



Test Circuit for Supply Current



Test Circuit for Ripple Rejection



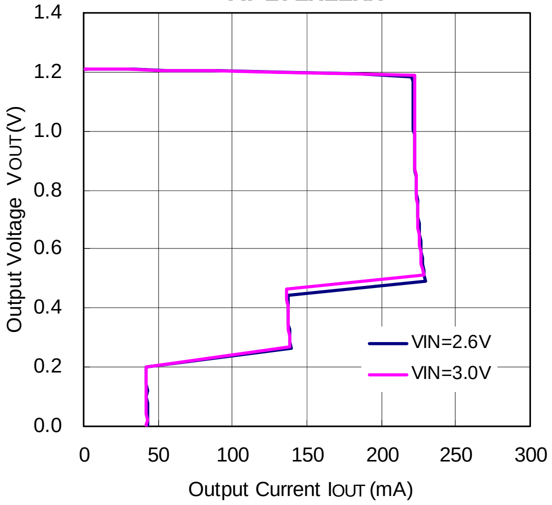
Test Circuit for Load Transient Response

TYPICAL CHARACTERISTICS

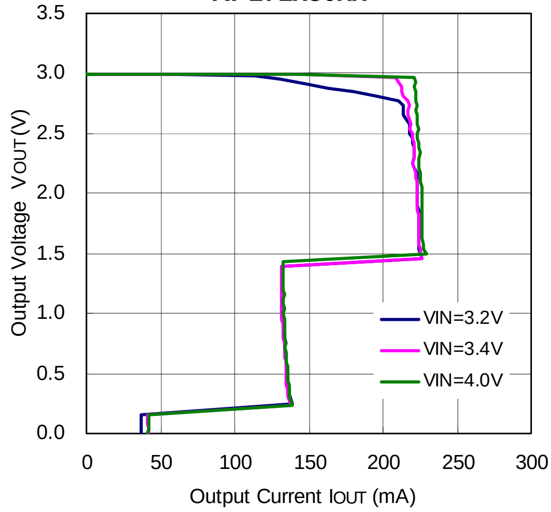
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

1) Output voltage vs. Output Current (Ta = 25°C)

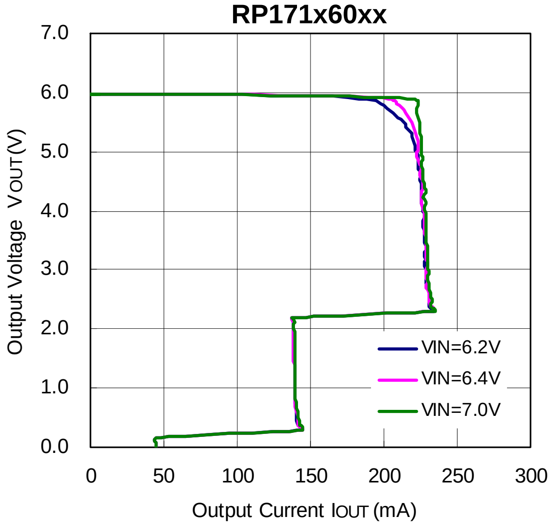
RP171x12xx



RP171x30xx

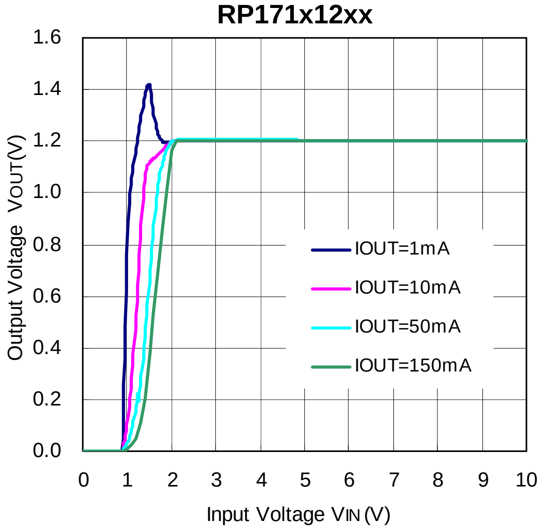


RP171x60xx

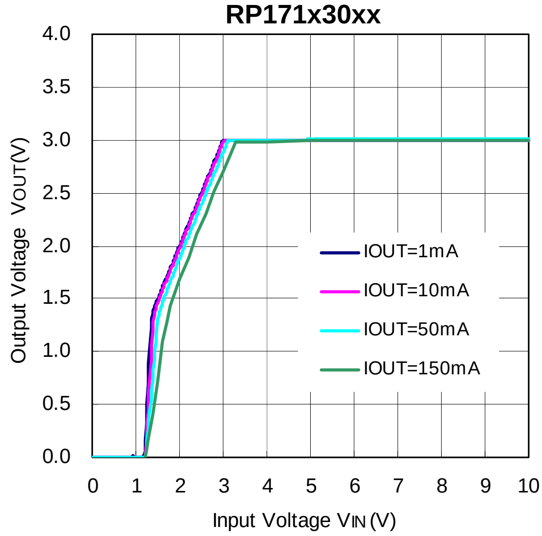


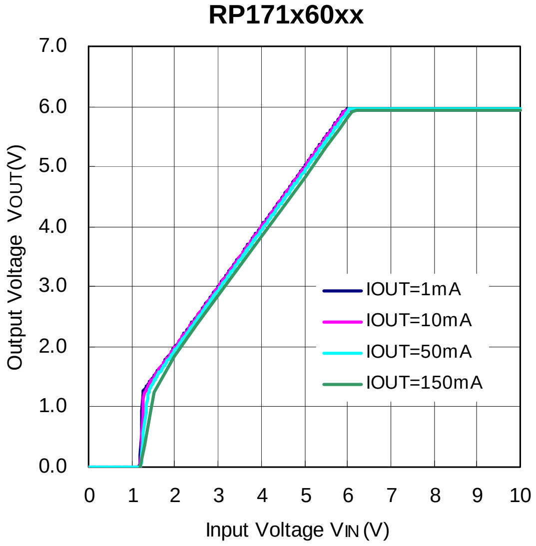
2) Output Voltage vs. Input Voltage (Ta = 25°C)

RP171x12xx

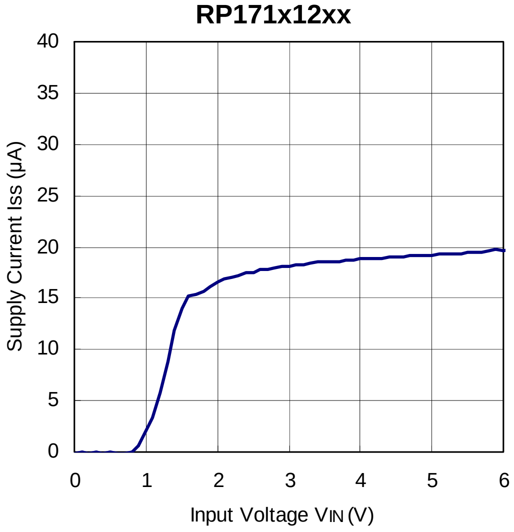


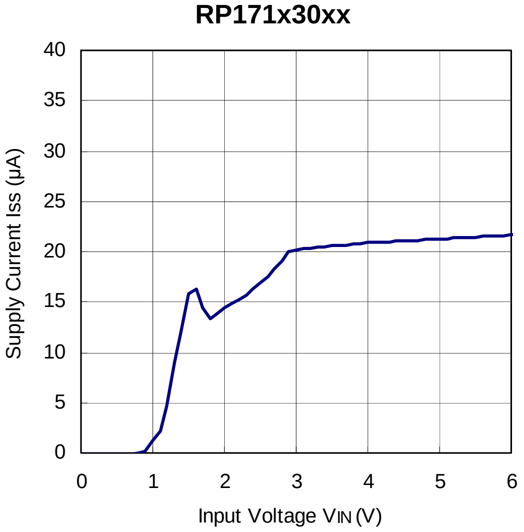
RP171x30xx

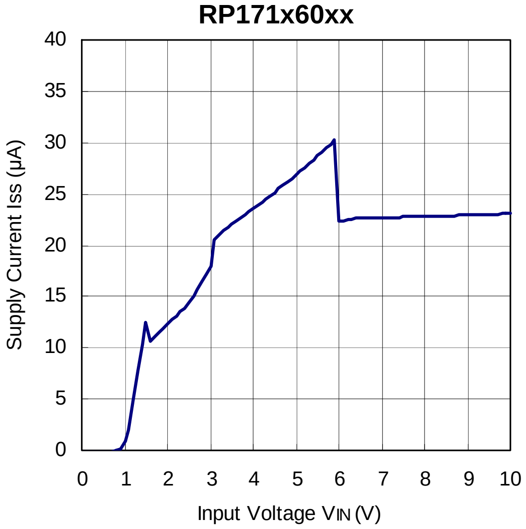




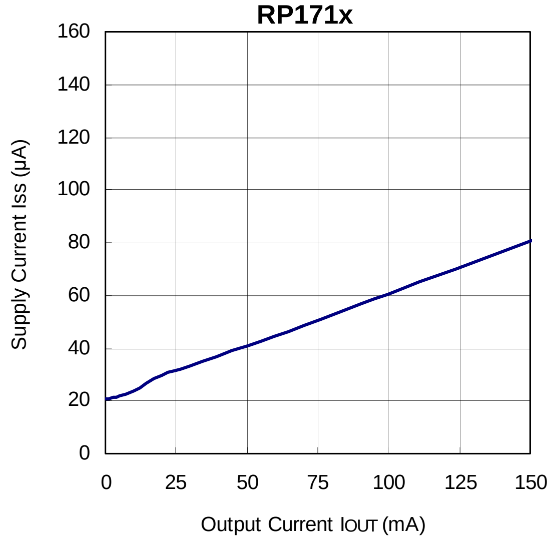
3) Supply Current vs. Input Voltage (Ta = 25°C)



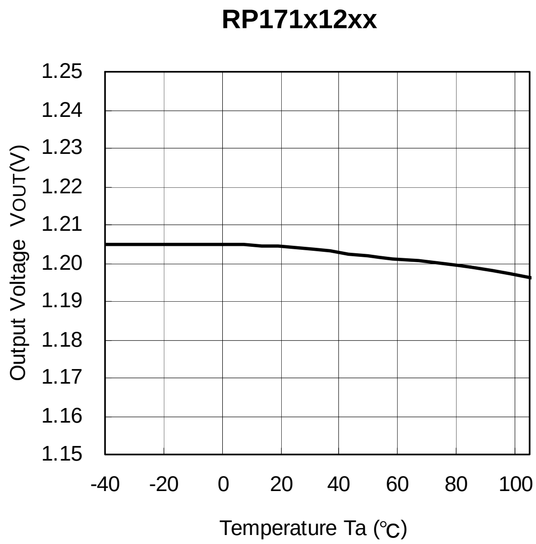


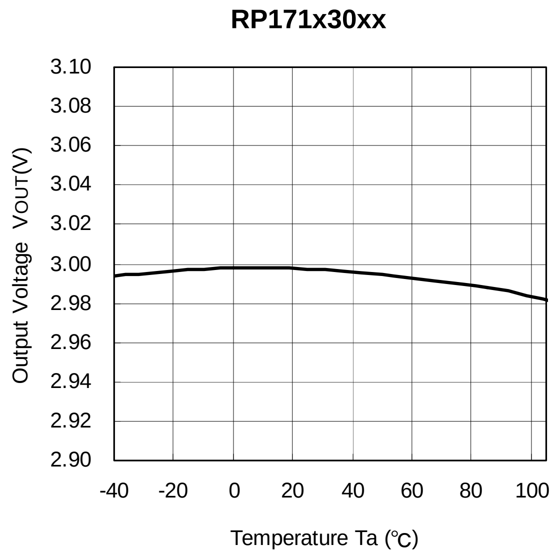


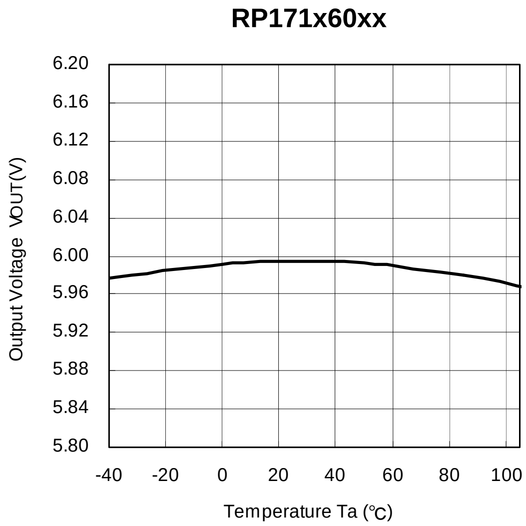
4) Supply Current vs. Output Current (Ta = 25°C)



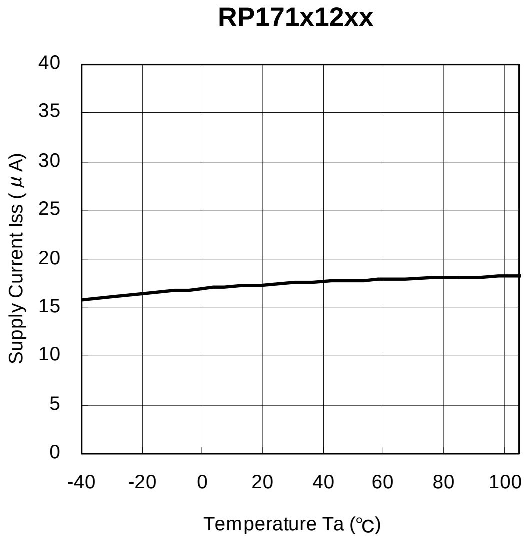
5) Output Voltage vs. Temperature

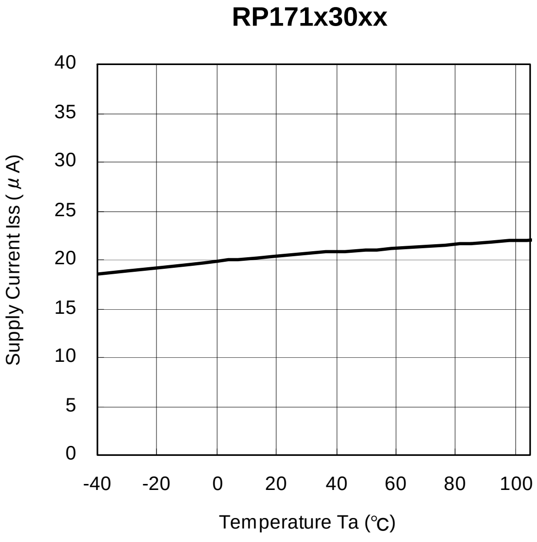


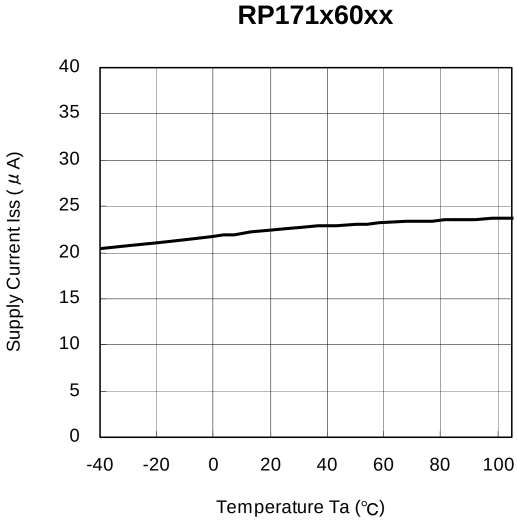




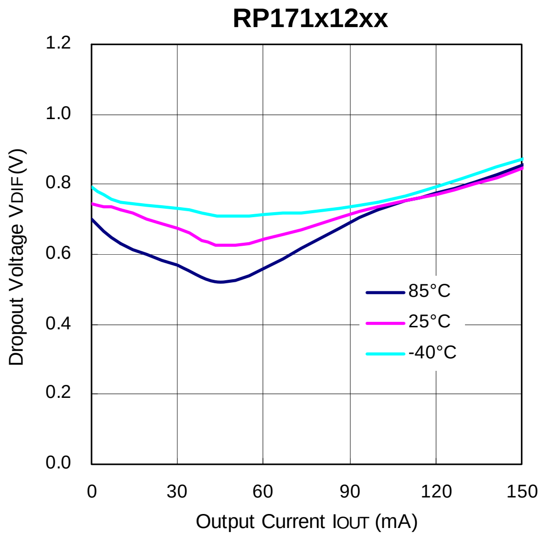
6) Supply Current vs. Temperature

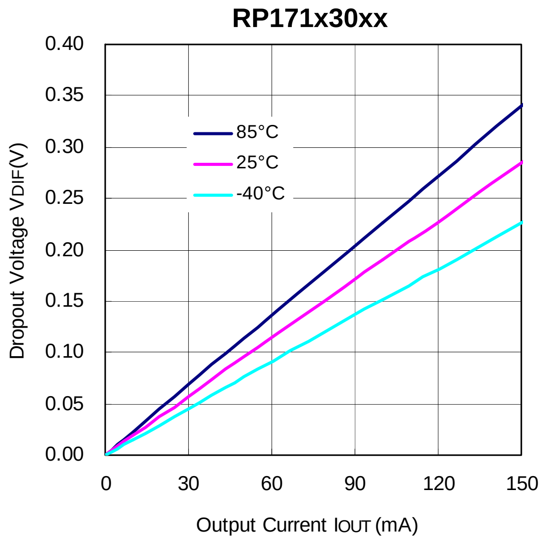


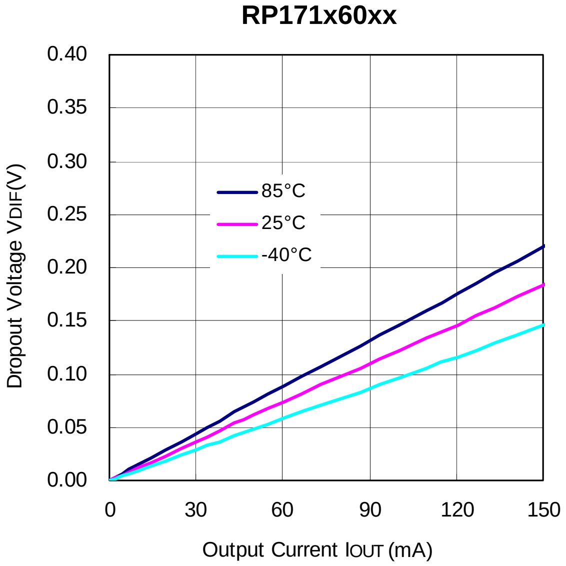




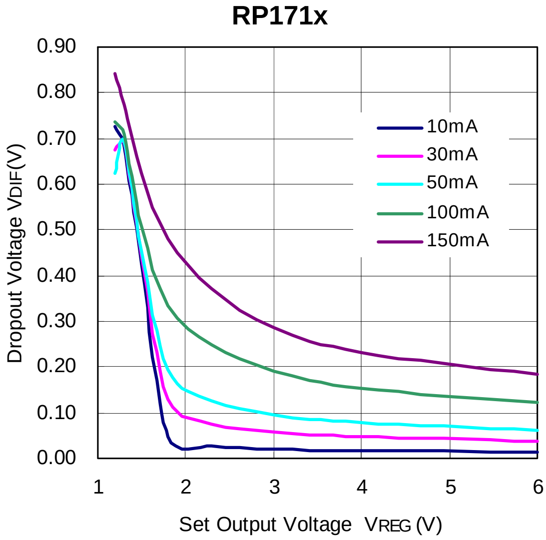
7) Dropout Voltage vs. Output Current



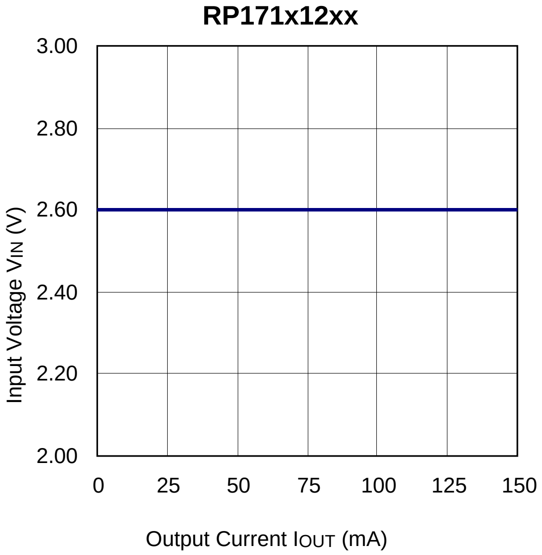




8) Dropout Voltage vs. Set Output Voltage (Ta = 25°C)

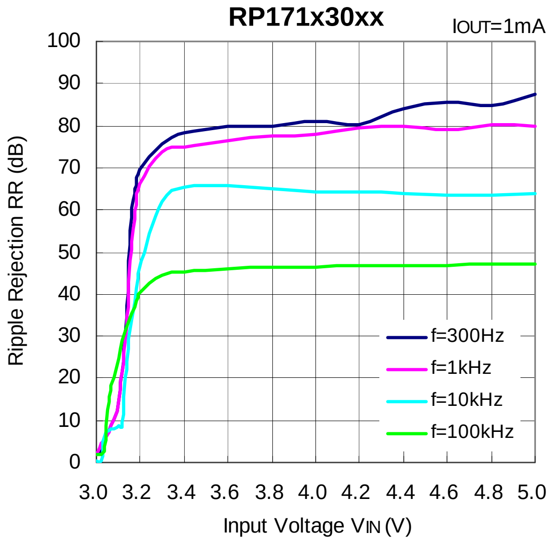


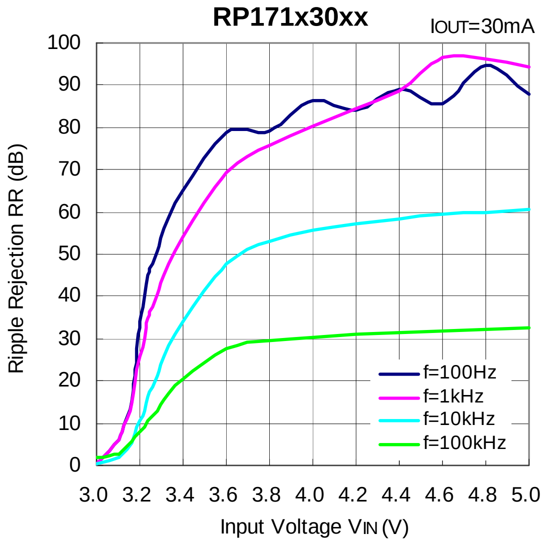
9) Minimum Operating Voltage

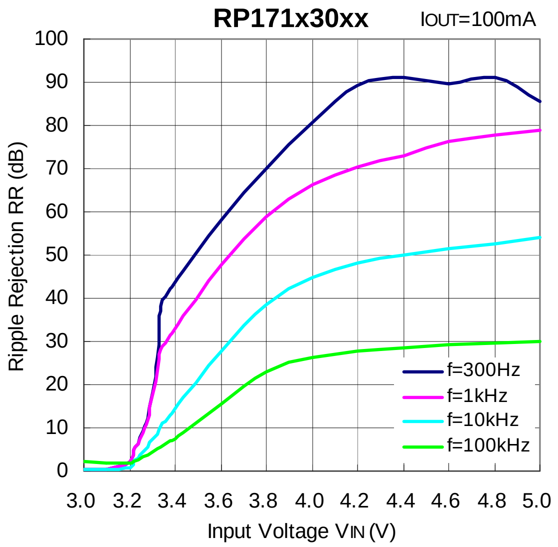


RICOH

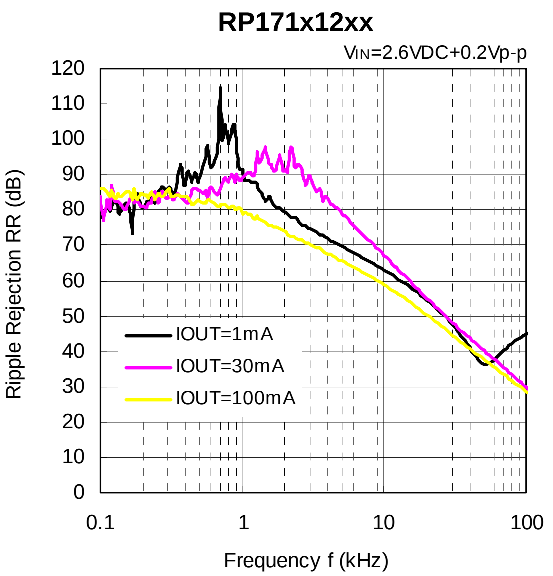
10) Ripple Rejection vs. Input Bias Voltage (C1 = none, C2 = Ceramic 1.0 µF, Ripple = 0.2 Vp-p, Ta = 25°C)

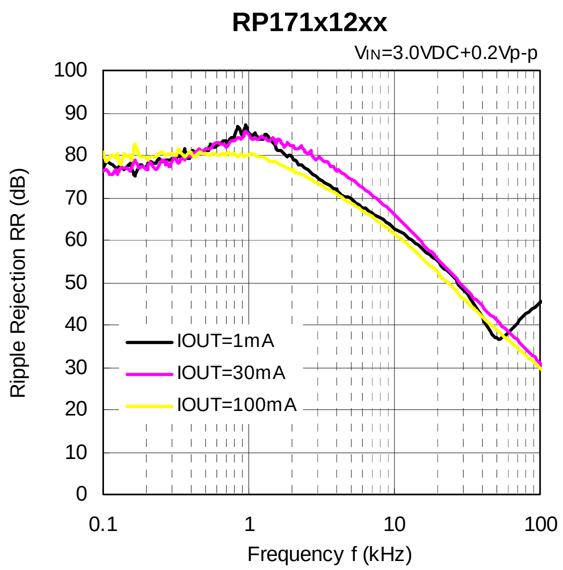




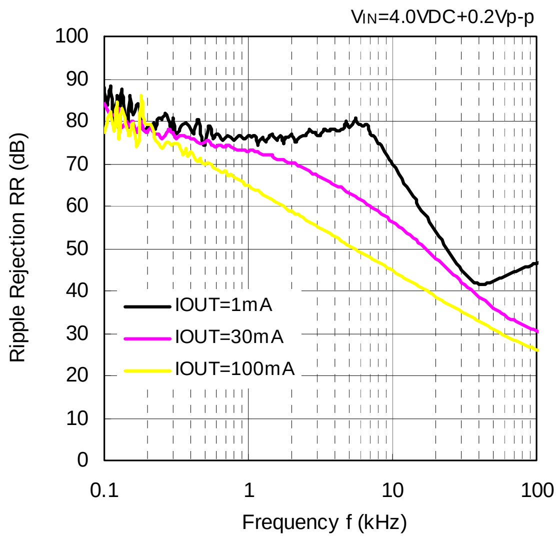


11) Ripple Rejection vs. Frequency (C1 = none, C2 = Ceramic 1.0 µF, Ta = 25°C)

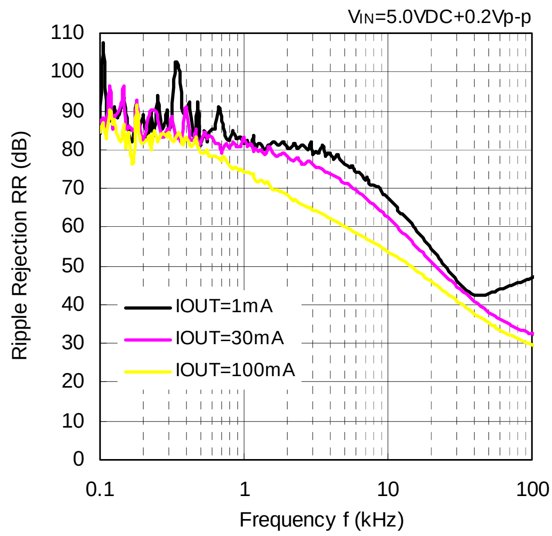




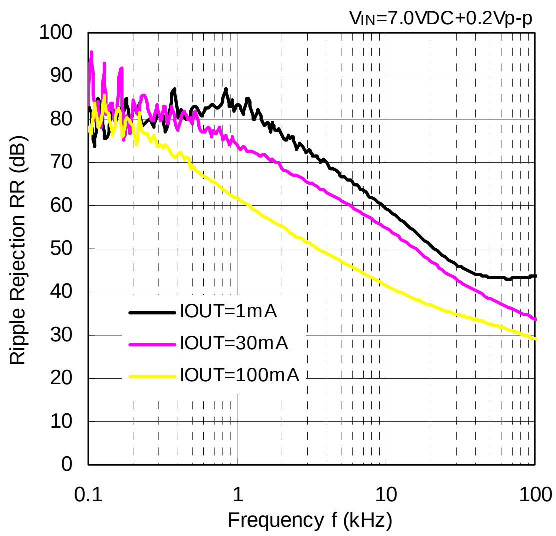
RP171x30xx



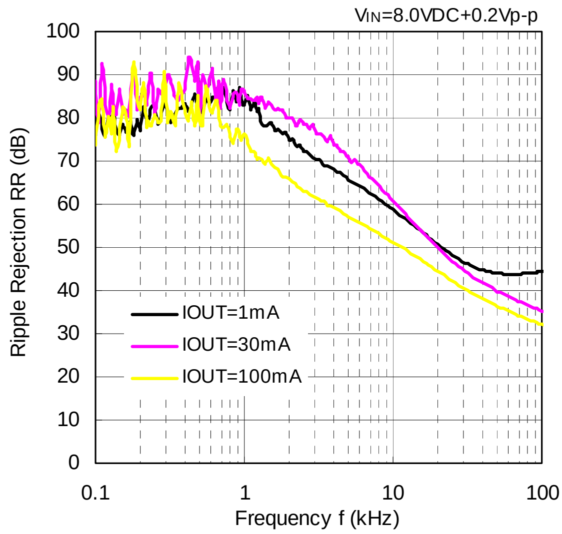
RP171x30xx



RP171x60xx

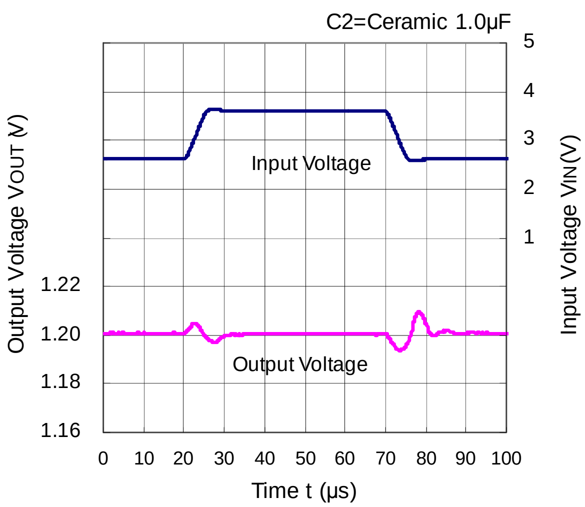


RP171x60xx

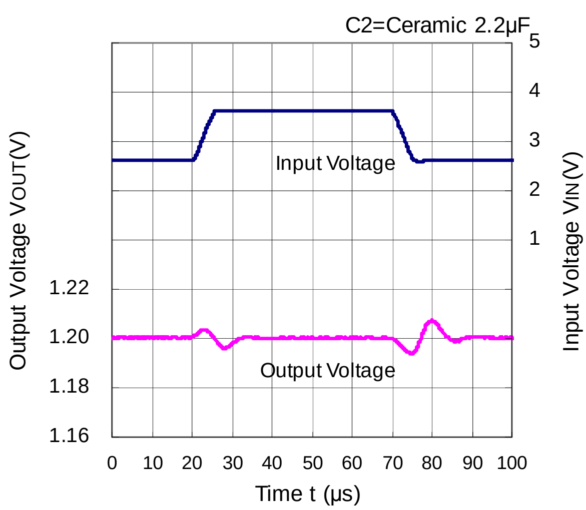


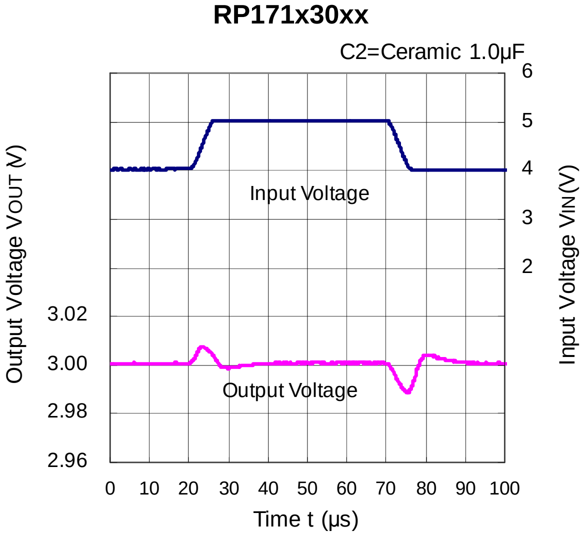
12) Input Transient Response (C1 = none, I_{OUT} = 30 mA, tr = tf = 5μs, Ta = 25°C)

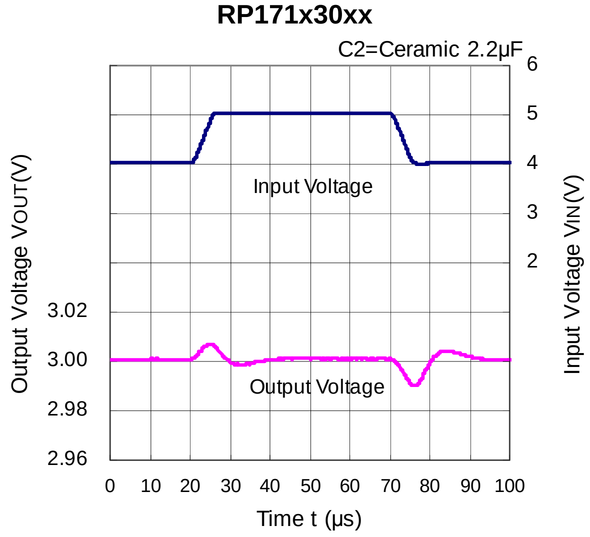
RP171x12xx

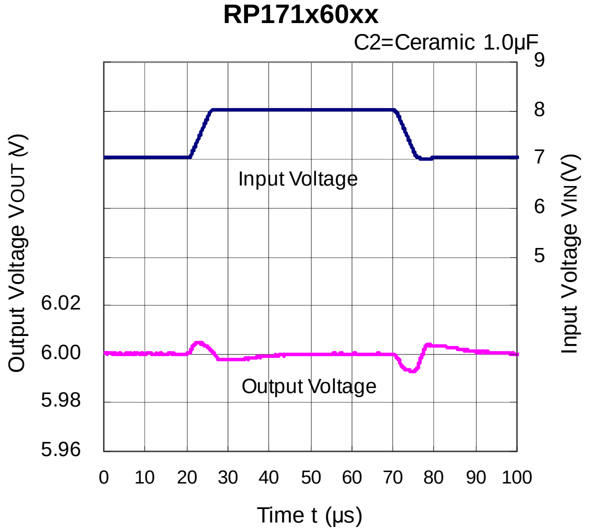


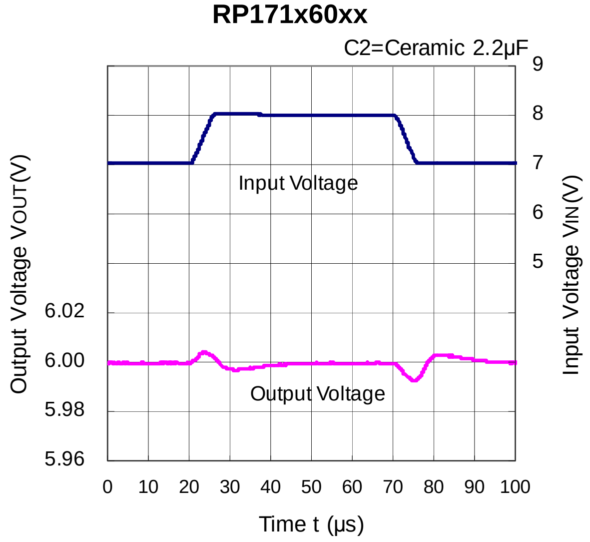
RP171x12xx



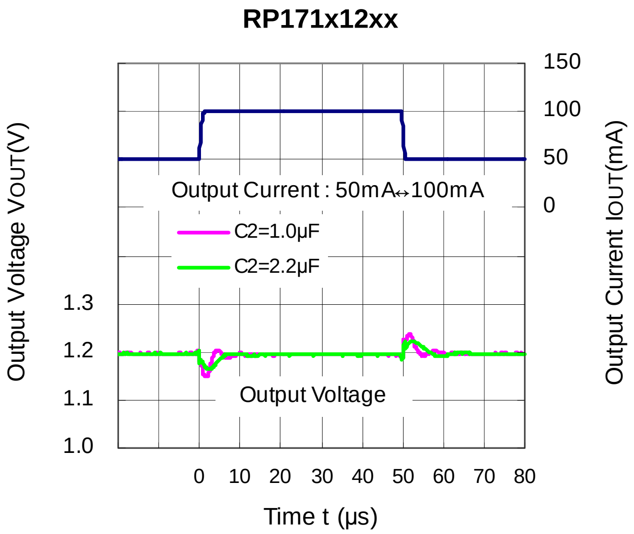


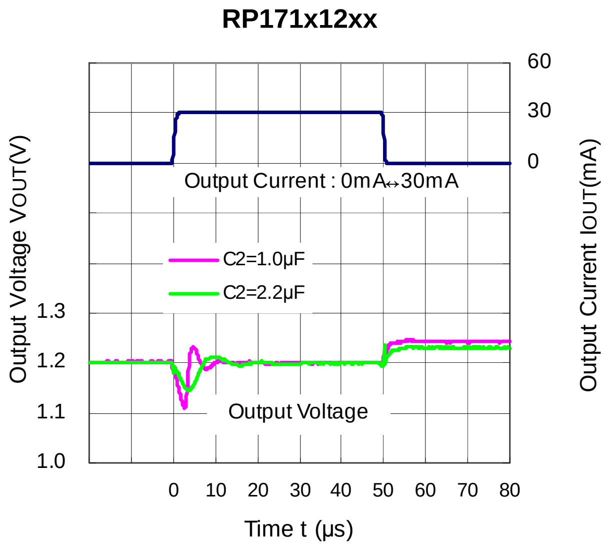


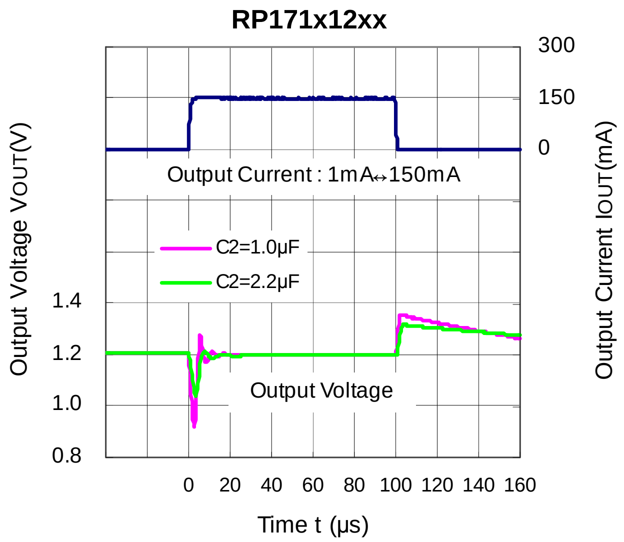


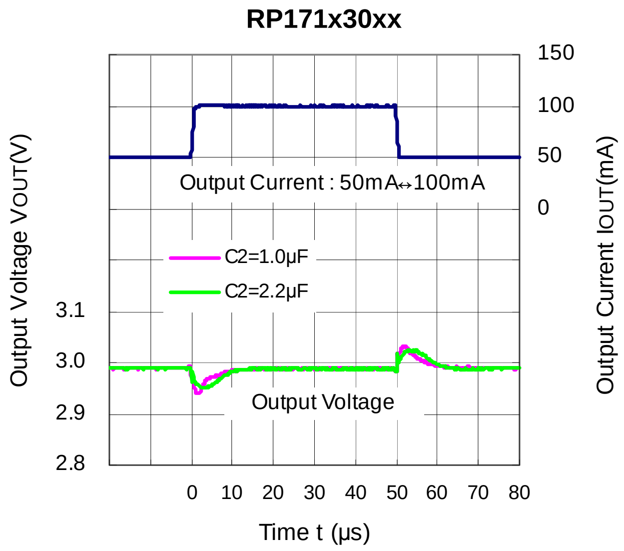


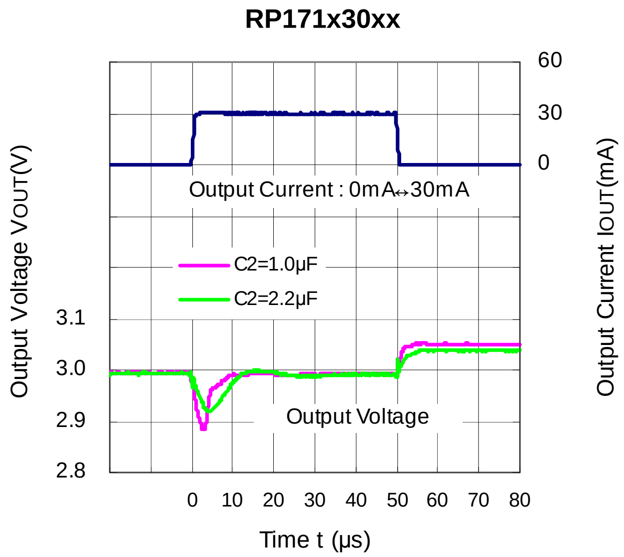
13) Load Transient Response (C1 = Ceramic 1.0 μF, tr = tf = 500 ns, Ta = 25°C)

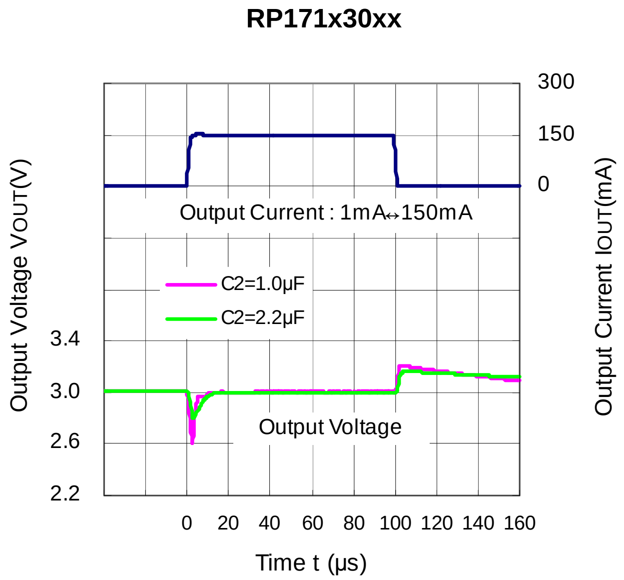





RP171x12xx
Output Voltage VOUT(V)
Output Current IOUT(mA)
300
150
0
1.4
1.2
1.0
0.8
Output Current : 1mA↔150mA
C2=1.0μF
C2=2.2μF
Output Voltage
0 20 40 60 80 100 120 140 160
Time t (μs)

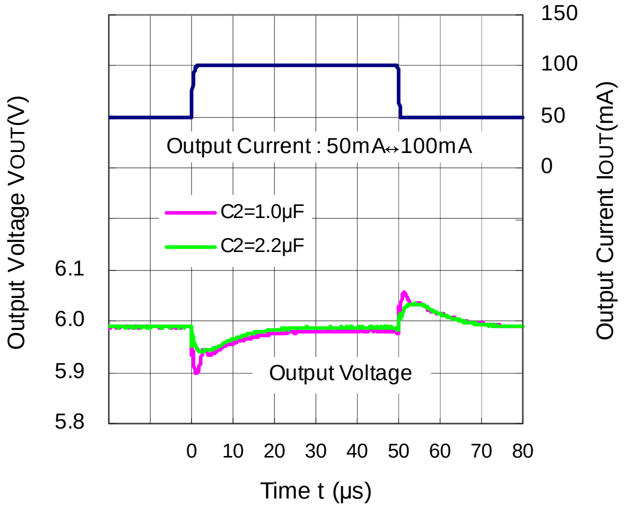

RP171x30xx
Output Voltage VOUT(V)
Output Current IOUT(mA)
150
100
50
0
3.1
3.0
2.9
2.8
Output Current : 50mA↔100mA
C2=1.0μF
C2=2.2μF
Output Voltage
0 10 20 30 40 50 60 70 80
Time t (μs)


RP171x30xx
Output Voltage VOUT(V)
Output Current IOUT(mA)
60
30
0
3.1
3.0
2.9
2.8
Output Current : 0mA↔30mA
C2=1.0μF
C2=2.2μF
Output Voltage
0 10 20 30 40 50 60 70 80
Time t (μs)

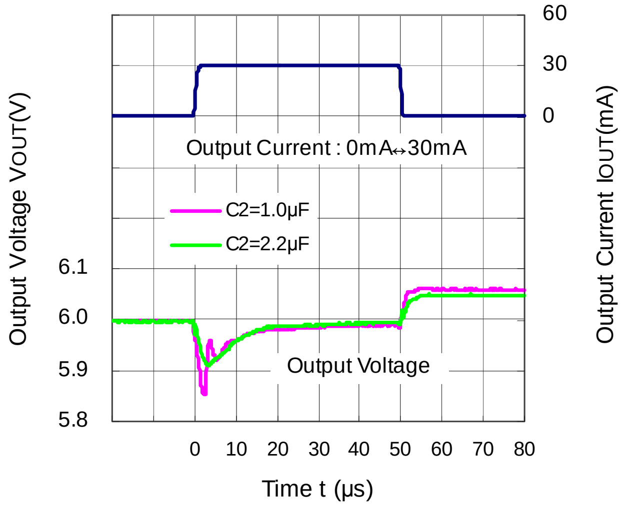

RP171x30xx
Output Voltage VOUT(V)
Output Current IOUT(mA)
300
150
0
3.4
3.0
2.6
2.2
Output Current : 1mA↔150mA
C2=1.0μF
C2=2.2μF
Output Voltage
0 20 40 60 80 100 120 140 160
Time t (μs)

RICOH

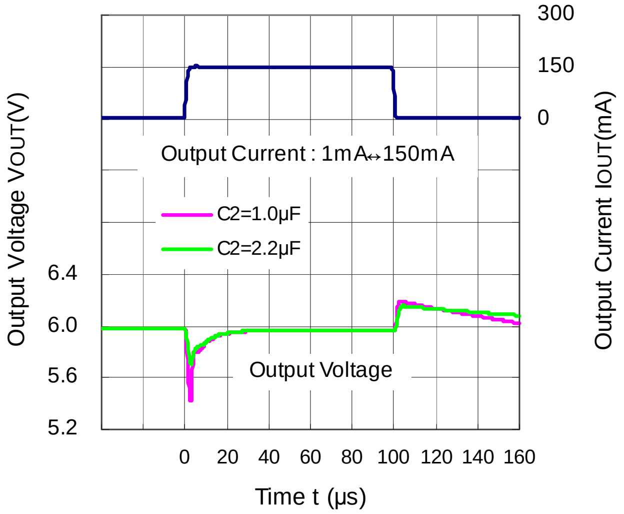
RP171x60xx



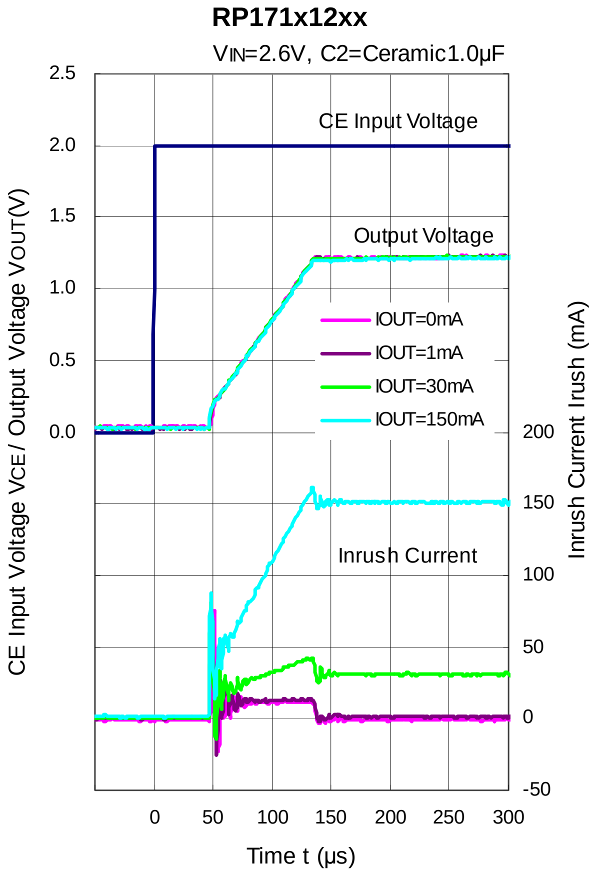
RP171x60xx

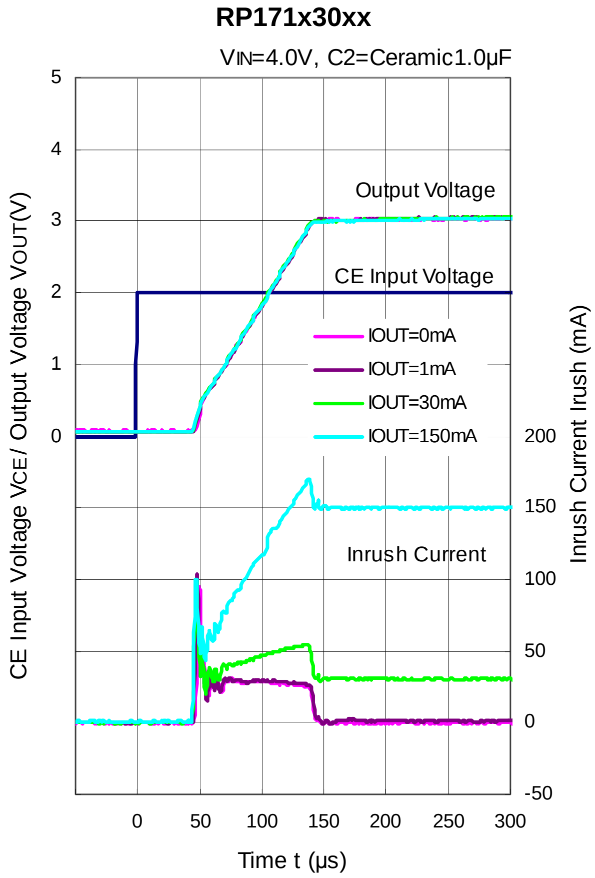


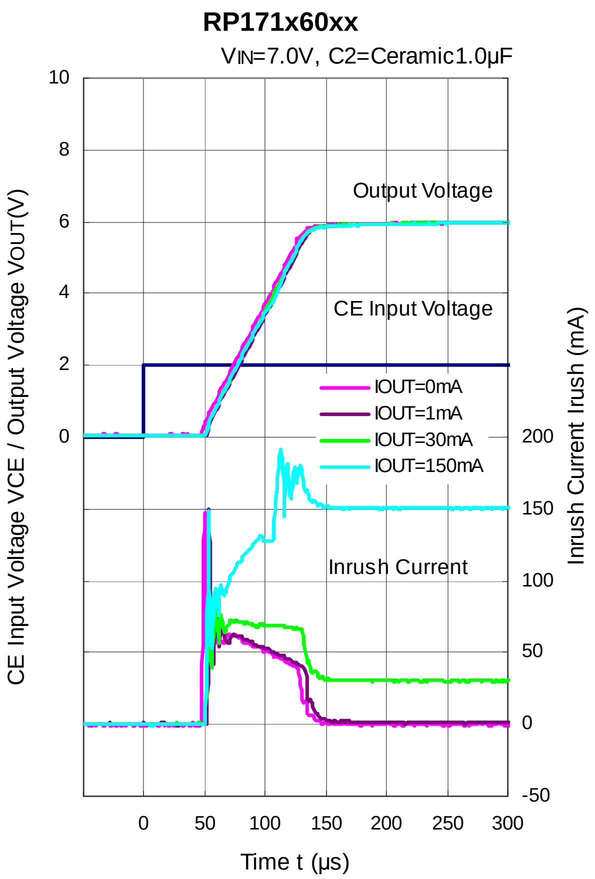
RP171x60xx

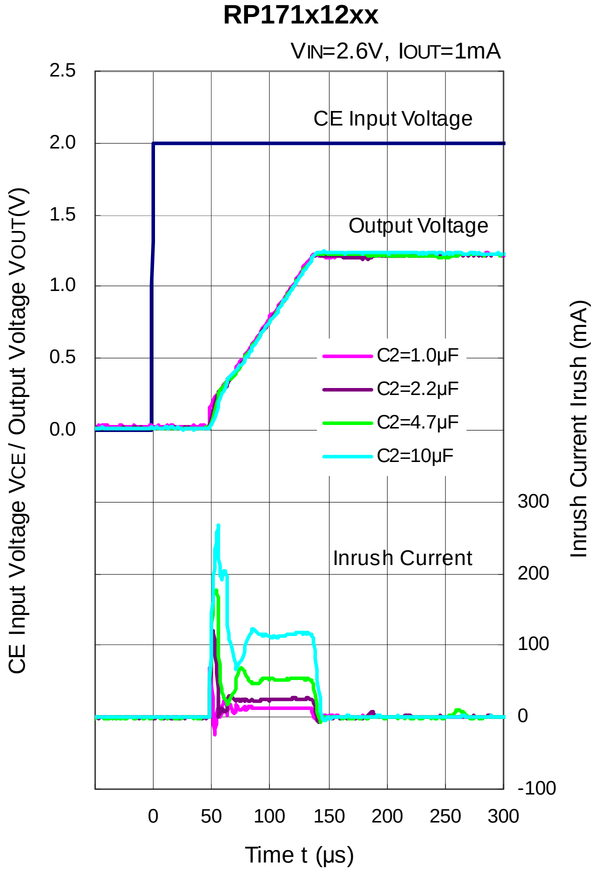


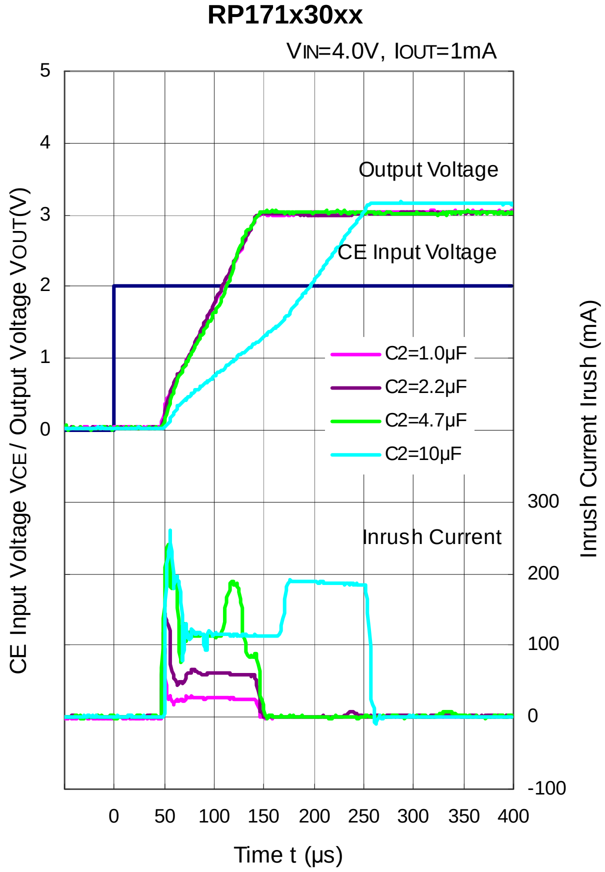
14) Turn On Speed with CE pin (C1 = Ceramic 1.0 μF, Ta = 25°C)

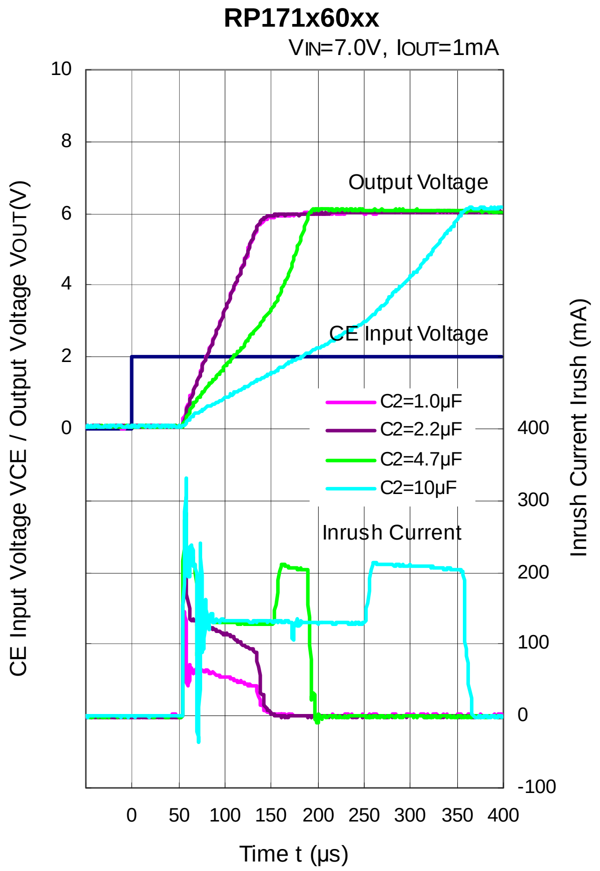




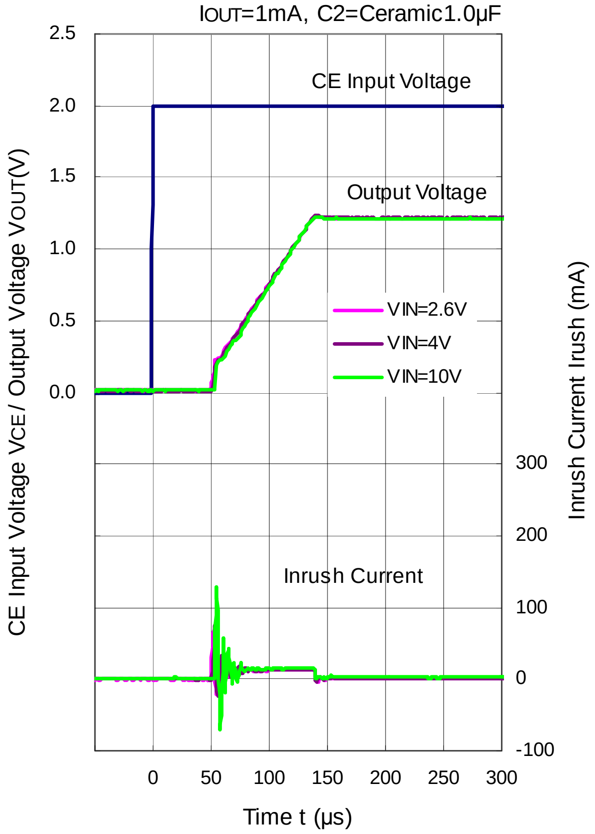



RP171x12xx
VIN=2.6V, IOUT=1mA
CE Input Voltage
Output Voltage
C2=1.0µF
C2=2.2µF
C2=4.7µF
C2=10µF
Inrush Current
CE Input Voltage VCE / Output Voltage VOUT(V)
Inrush Current Irush (mA)
Time t (µs)

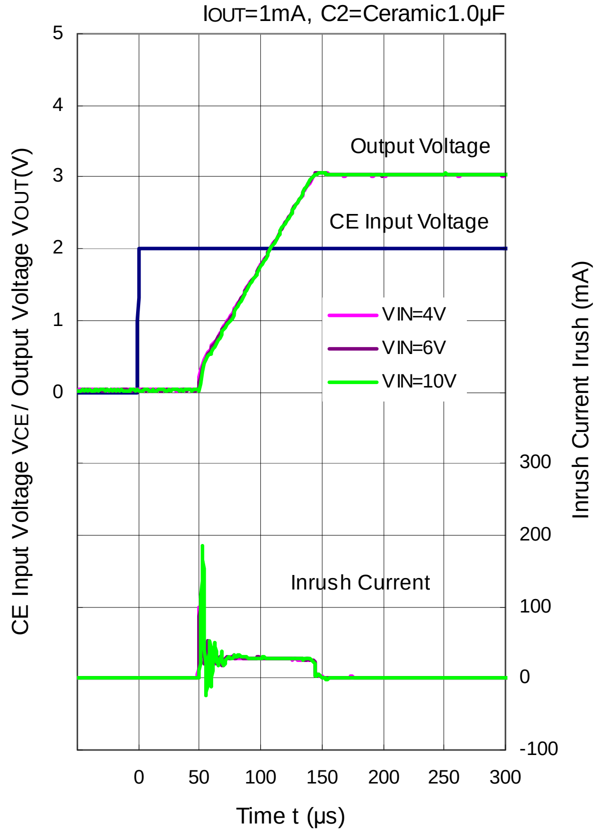

RP171x30xx
VIN=4.0V, IOUT=1mA
Output Voltage
CE Input Voltage
C2=1.0µF
C2=2.2µF
C2=4.7µF
C2=10µF
Inrush Current
CE Input Voltage VCE / Output Voltage VOUT(V)
Inrush Current Irush (mA)
Time t (µs)


RP171x60xx
VIN=7.0V, IOUT=1mA
Output Voltage
CE Input Voltage
C2=1.0µF
C2=2.2µF
C2=4.7µF
C2=10µF
Inrush Current
CE Input Voltage VCE / Output Voltage VOUT(V)
Inrush Current Irush (mA)
Time t (µs)

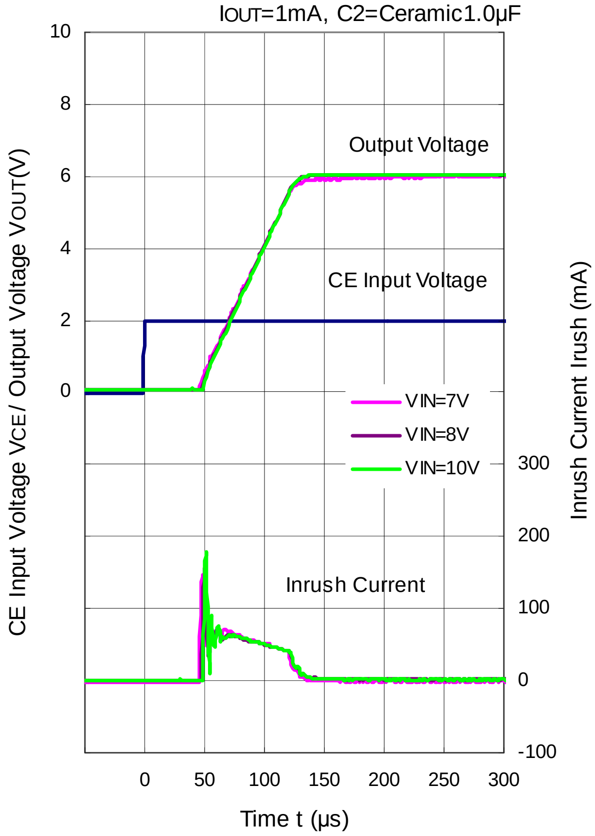
RP171x12xx
IOUT=1mA, C2=Ceramic1.0µF



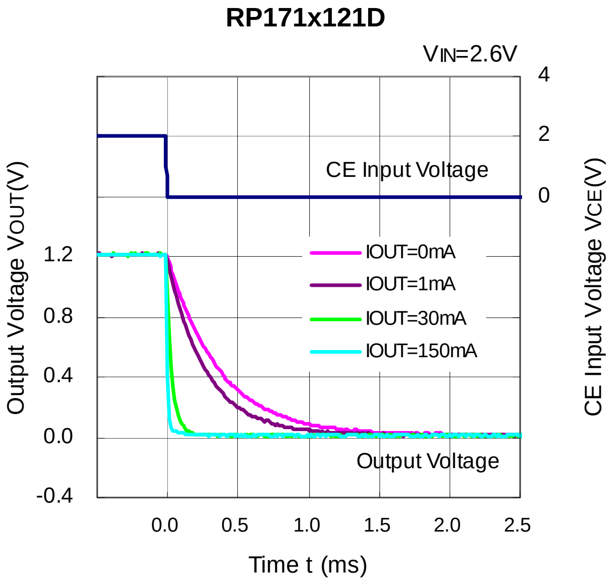
RP171x30xx
IOUT=1mA, C2=Ceramic1.0µF

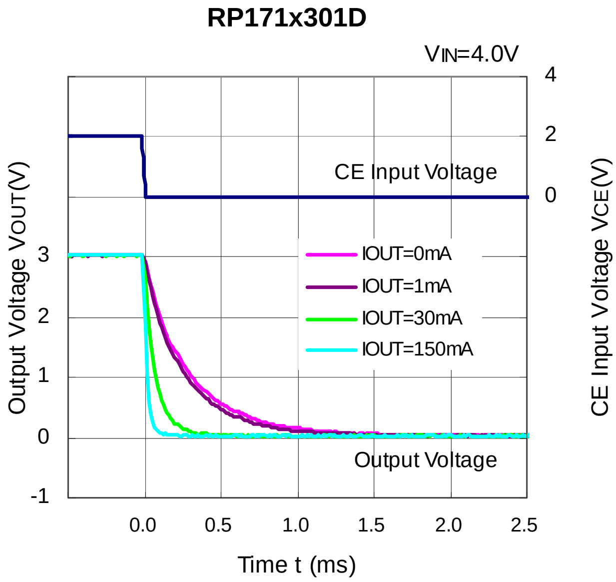


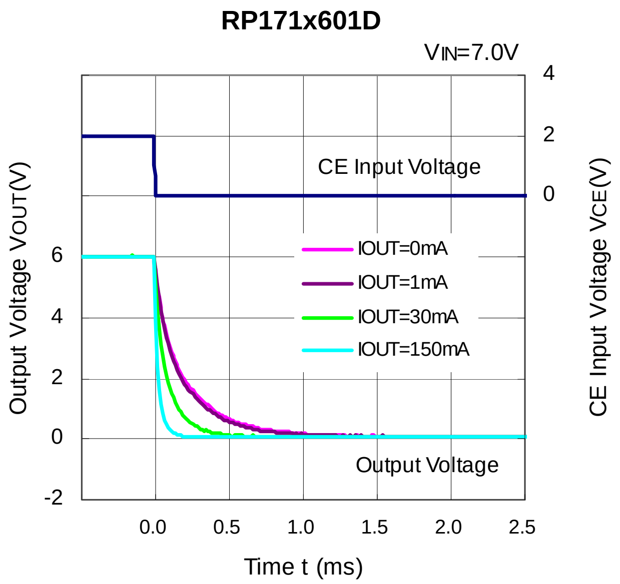
RP171x60xx
IOUT=1mA, C2=Ceramic1.0µF



15) Turn Off Speed with CE pin (RP171xxxxD) (C1 = C2 = Ceramic 1.0 μF, Ta = 25°C)







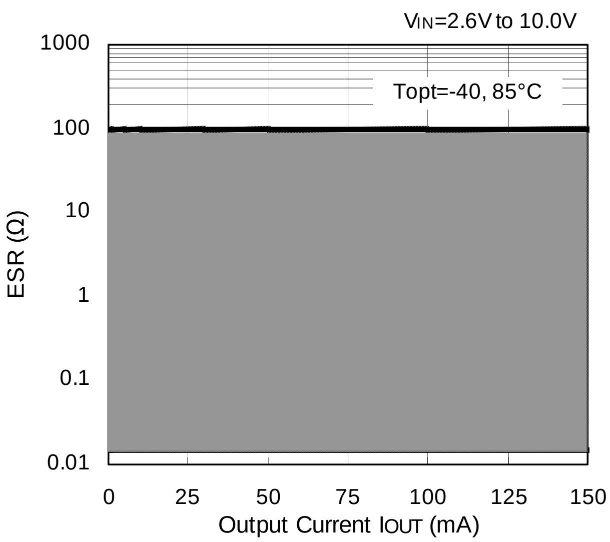
EQUIVALENT SERIES RESISTANCE (ESR) vs. OUTPUT CURRENT (I_{OUT})

Ceramic type output capacitor is recommended for the RP171x; however, the other output capacitors with low ESR also can be used. 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 40 µV (Avg.) are marked as the hatched area in the graph.

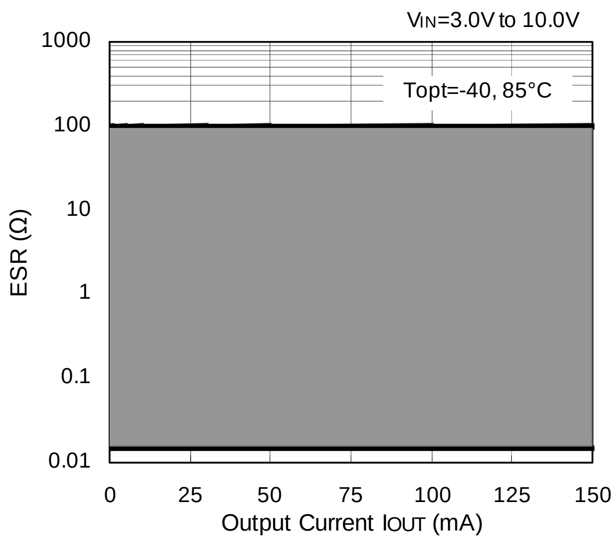
Measurement Conditions

Noise Frequency Band: 10 Hz to 2 MHz
Measurement Temperature: –40°C to 85°C
Hatched area: Noise level below 40 µV (Avg.).
C1, C2: Ceramic 1.0 µF (Murata, GRM155B31A105KE)

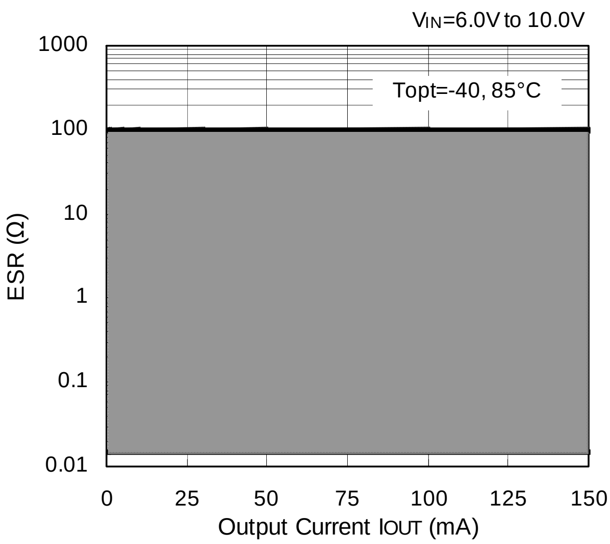
RP171x12xx



RP171x30xx



RP171x60xx



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