AEC-Q100 Compliant

300 mA 10 V Input LDO Regulator for Automotive Applications

No. EC-205-190107

OUTLINE

The RP170x is an LDO regulator featuring 300 mA output current. Having the 10 V maximum input voltage, the RP170x can be used in 2 cell lithium-ion battery powered portable appliances and besides a portable equipment. The supply current is Typ. 23 μA though an excellent response characteristics. The output voltage range from 1.2 V is possible. The output voltage accuracy and temperature-drift coefficient of output voltage of the RP170x is excellent. RP170x has a fold-back protection circuit and a thermal shutdown circuit. Moreover, a standby mode with ultra low supply current can be realized with the chip enable function. SOT-23-5 and SOT-89-5 with high power dissipation packages are available.

FEATURES

- Input Voltage Range (Maximum Rating).....2.6 V to 10.0 V (12 V)
- Operating Temperature .....−40°C to 105°C (RP170xx1x-xx-AE)
  −40°C to 125°C (RP170xx1x-xx-KE)
- Supply Current .....Typ. 23 μA
- Standby Current.....Typ. 0.1 μA
- Dropout Voltage .....Typ. 0.20 V (I_{OUT} = 100 mA, V_{OUT} = 3.0 V)
  .....Typ. 0.77 V (I_{OUT} = 300 mA, V_{OUT} = 2.8 V)
- Ripple Rejection.....Typ. 70 dB (f = 1 kHz)
- Temperature-Drift Coefficient of Output Voltage ...Typ. ±80 ppm/°C
- Line Regulation .....Typ. 0.02%/V
- Output Voltage Accuracy.....±1.0%
- Packages SOT-23-5, SOT-89-5
- Output Voltage Range.....1.2 V/1.25 V/1.5 V/1.8 V/2.5 V/2.8 V/2.9 V/3.0 V/
  3.3 V/5.0 V/5.5 V/6.0 V
  *Contact our sales representatives for other voltages.
- Built-in Fold Back Protection Circuit .....Typ. 40 mA (Current at short mode)
- Built-in Thermal Shutdown Circuit.....Shutdown Temperature at 165°C
- Constant Slope Circuit (Soft-start Function)
- Ceramic capacitors are recommended to be used with this IC ..... 1.0 μF or more

APPLICATIONS

- Power source for accessories such as car audios, car navigation systems, and ETC systems
- Power source for ECUs such as EV inverter and battery charge control unit

SELECTION GUIDE

The output voltage, auto discharge function(1), and package for the ICs can be selected at the user's request.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP170Nxx1∗-TR-#E	SOT-23-5	3,000 pcs	Yes	Yes
RP170Hxx1∗-T1-#E	SOT-89-5	1,000 pcs	Yes	Yes

xx: Specify the set output voltage (V_{SET})
1.2 V (12) / 1.25 V (12) / 1.5 V (15) / 1.8 V (18) / 2.5 V (25) / 2.8 V (28) / 2.9 V (29) / 3.0 V (30) / 3.3 V (33) / 5.0 V (50) / 5.5 V (55) / 6.0 V (60)

If the output voltage includes the 3rd digit, indicate the digit of 0.01 as follows.
1.25 V → RP170x121∗5

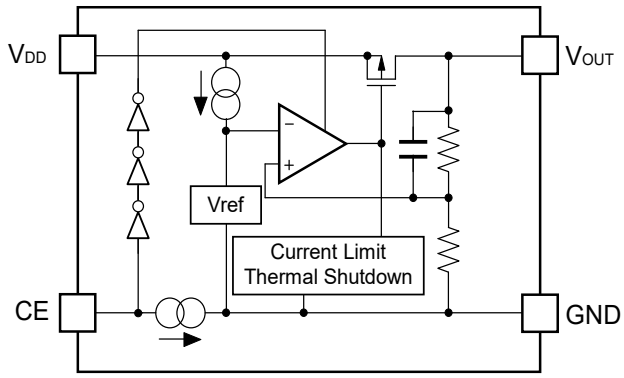
∗ : The auto discharge functions at off state are as follows.
(B) without auto discharge function at off state
(D) with auto discharge function at off state

#: Quality Class

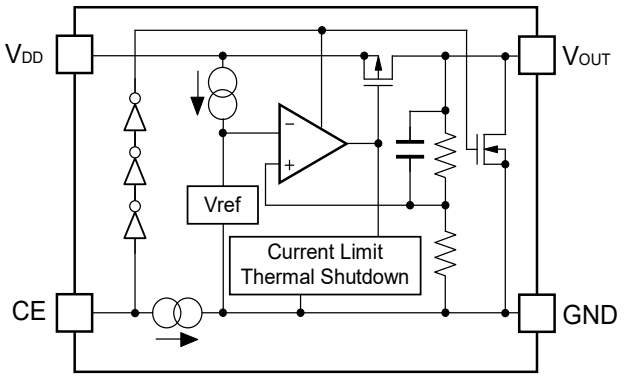
#	Operating Temperature Range	Test Temperature
A	−40°C to 105°C	25°C, High
K	−40°C to 125°C	Low, 25°C, High

(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.

BLOCK DIAGRAMS

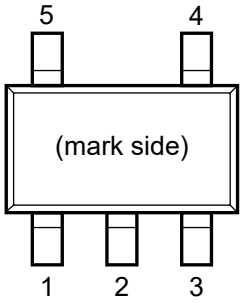


RP170xxxxB Block Diagram

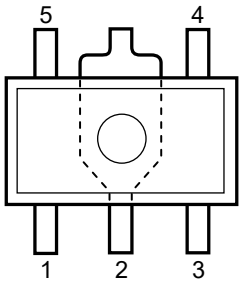


RP170xxxxD Block Diagram

PIN DESCRIPTIONS



SOT-23-5 Pin Configuration



SOT-89-5 Pin Configuration

SOT-23-5 Pin Description

Pin No	Symbol	Pin 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

SOT-89-5 Pin Description

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

ABSOLUTE MAXIMUM RATINGS

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(1)	SOT-23-5	JEDEC STD. 51-7 Test Land Pattern	830	mW
		SOT-89-5	JEDEC STD. 51-7 Test Land Pattern	3200	
Tj	Junction Temperature			−40 to 150	°C
Tstg	Storage Temperature Range			−55 to 150	°C

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

Recommended Operating Conditions

Symbol	Item		Rating	Unit
V_{IN}	Input Voltage		2.6 to 10	V
Ta	Operating Temperature Range	RP170xx1x-xx-AE	−40 to 105	°C
		RP170xx1x-xx-KE	−40 to 125	°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 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.

(1) Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

V_{IN} = V_{SET} + 1 V, I_{OUT} = 1 mA, unless otherwise noted.
The specifications surrounded by [ ] are guaranteed by design engineering at –40°C ≤ Ta ≤ 105°C.

RP170xxxxB/D (-AE) Electrical Characteristics (Ta = 25°)

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} ≤ 1.5V	Ta = 25°C	−15		15	mV
			−40°C ≤ Ta ≤ 105°C	[−53]		[45]	
I_{OUT}	Output Current			[300]			mA
ΔV_{OUT} /ΔI_{OUT}	Load Regulation	0.1 mA ≤ I_{OUT} ≤ 300 mA			10	[80]	mV
V_{DIF}	Dropout Voltage	I_{OUT} = 300 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
ΔV_{OUT} /ΔV_{IN}	Line Regulation	V_{SET} + 0.5 V ≤ V_{IN} ≤ 10.0 V (Incase that V_{SET} ≤ 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}	Nch On Resistance for Auto Discharge (RP170xxx1D only)	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).

ELECTRICAL CHARACTERISTICS (continued)

Product-specific Electrical Characteristics

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

RP170xxxxB/D (-AE) (Ta = 25°C)

Product Name	V_{OUT} [V] (Ta = 25°C)			V_{OUT} [V] (Ta = –40 to 105°C)			V_{DIF} [V]	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP170x121x	1.185	1.200	1.215	[1.147]	1.200	[1.245]	1.400	[1.925]
RP170x121x5	1.235	1.250	1.265	[1.197]	1.25	[1.295]		
RP170x151x	1.485	1.500	1.515	[1.447]	1.500	[1.545]	1.200	[1.655]
RP170x181x	1.782	1.800	1.818	[1.737]	1.800	[1.854]	0.980	[1.305]
RP170x251x	2.475	2.500	2.525	[2.413]	2.500	[2.575]	0.770	[1.185]
RP170x281x	2.772	2.800	2.828	[2.702]	2.800	[2.884]		
RP170x291x	2.871	2.900	2.929	[2.799]	2.900	[2.987]		
RP170x301x	2.970	3.000	3.030	[2.895]	3.000	[3.090]	0.600	[0.995]
RP170x331x	3.267	3.300	3.333	[3.185]	3.300	[3.399]		
RP170x501x	4.950	5.000	5.050	[4.825]	5.000	[5.150]	0.500	[0.875]
RP170x551x	5.445	5.500	5.555	[5.308]	5.500	[5.665]		
RP170x601x	5.940	6.000	6.060	[5.790]	6.000	[6.180]		

ELECTRICAL CHARACTERISTICS (continued)

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

RP170xxxxB/D (-KE) Electrical Characteristics (−40°C ≤ Ta ≤ 125°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 ≤ 125°C	V_{SET} x 0.960		V_{SET} x 1.035	
		V_{SET} ≤ 1.5 V	Ta = 25°C	−15		15	mV
			−40°C ≤ Ta ≤ 125°C	−60		50	
I_{OUT}	Output Current			300			mA
ΔV_{OUT} /ΔI_{OUT}	Load Regulation	0.1 mA ≤ I_{OUT} ≤ 300 mA			10	85	mV
V_{DIF}	Dropout Voltage	I_{OUT} = 300 mA		Refer to the *Product-specific Electrical Characteristics*			
I_{SS}	Supply Current	I_{OUT} = 0 mA			23	47	μA
Istandby	Standby Current	V_{IN} = 10.0 V V_{CE} = GND			0.1	1.25	μA
ΔV_{OUT} /ΔV_{IN}	Line Regulation	V_{SET} + 0.5 V ≤ V_{IN} ≤ 10.0 V (In case that V_{SET} ≤ 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}	Nch On Resistance for Auto Discharge (RP170xxx1D only)	V_{CE} = 0 V V_{IN} = 7.0 V			250		Ω

ELECTRICAL CHARACTERISTICS (continued)

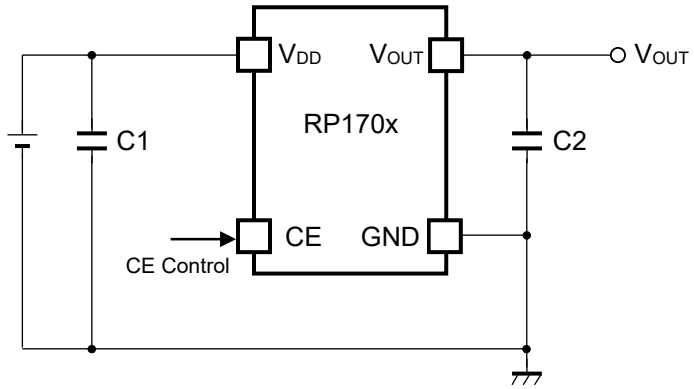
Product-specific Electrical Characteristics

RP170xxxxB/D (-KE) (−40°C ≤ Ta ≤ 125°C)

Product Name	V_{OUT} [V] (Ta = 25°C)			V_{OUT} [V] (Ta = –40 to 125°C)			V_{DIF} [V]	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP170x121x	1.185	1.200	1.215	1.140	1.200	1.250	1.400	1.925
RP170x121x5	1.235	1.250	1.265	1.190	1.250	1.300		
RP170x151x	1.485	1.500	1.515	1.440	1.500	1.550	1.200	1.655
RP170x181x	1.782	1.800	1.818	1.728	1.800	1.863	0.980	1.305
RP170x251x	2.475	2.500	2.525	2.400	2.500	2.587	0.770	1.185
RP170x281x	2.772	2.800	2.828	2.688	2.800	2.898		
RP170x291x	2.871	2.900	2.929	2.784	2.900	3.001		
RP170x301x	2.970	3.000	3.030	2.880	3.000	3.105	0.600	0.995
RP170x331x	3.267	3.300	3.333	3.168	3.300	3.415		
RP170x501x	4.950	5.000	5.050	4.800	5.000	5.175	0.500	0.875
RP170x551x	5.445	5.500	5.555	5.280	5.500	5.692		
RP170x601x	5.940	6.000	6.060	5.760	6.000	6.210		

APPLICATION INFORMATION

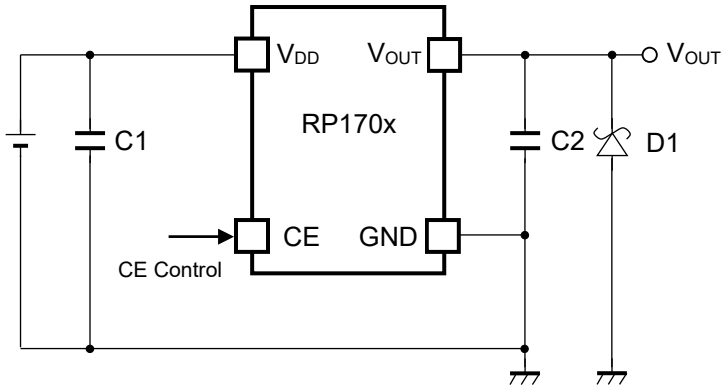
TYPICAL APPLICATION



External Components

Symbol	Descriptions
C1	1.0 µF, Ceramic Capacitor, MURATA, GRM155B31A105KE15
C2	1.0 µF, Ceramic Capacitor, MURATA, GRM155B31A105KE15

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION



When a sudden surge of electrical current travels along the VOUT 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 VOUT pin and GND has the effect of preventing damage to them.

TECHNICAL NOTES

PHASE COMPENSATION

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

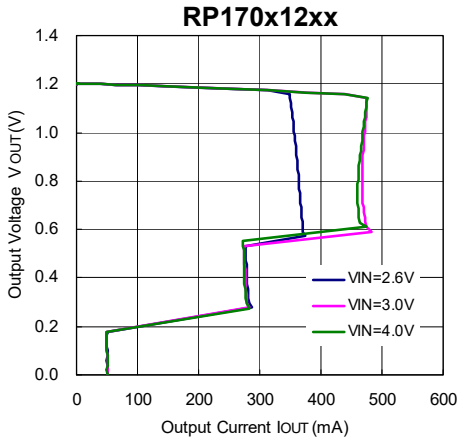
PCB LAYOUT

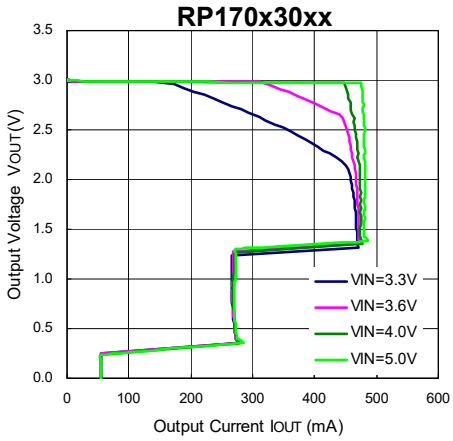
Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as 1.0 μF or more between V_{DD} and GND, and as close as possible to the pins.
Set external components, especially the output capacitor C2, as close as possible to the ICs, and make wiring as short as possible.

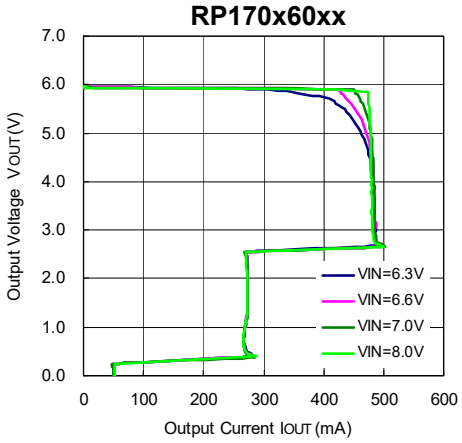
TYPICAL CHARACTERISTICS

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

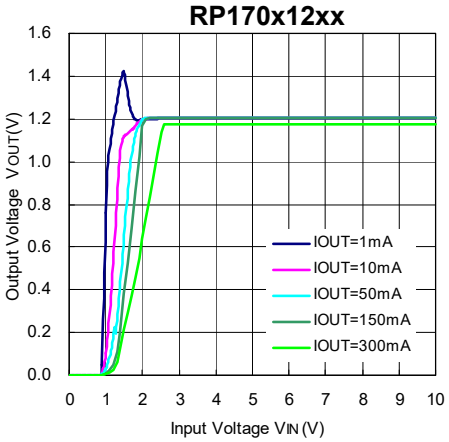
1) Output Voltage vs. Output Current (Ta = 25°C)

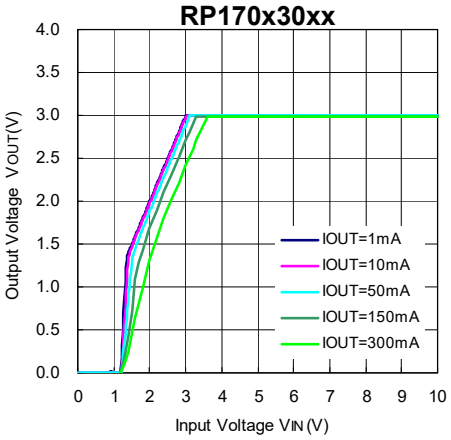




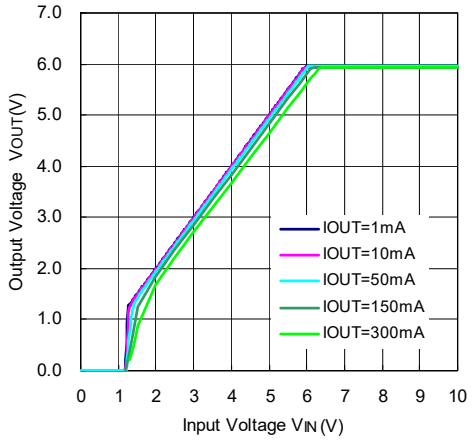


2) Output Voltage vs. Input Voltage (Ta = 25°C)



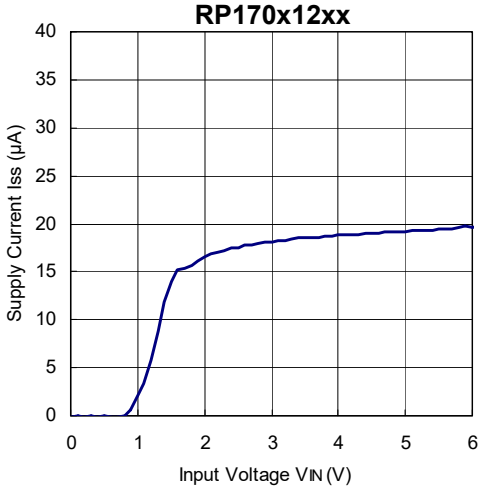


RP170x60xx

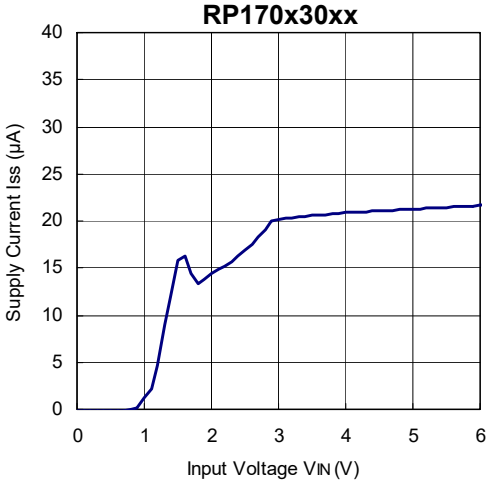


3) Supply Current vs. Input Voltage (Ta = 25°C)

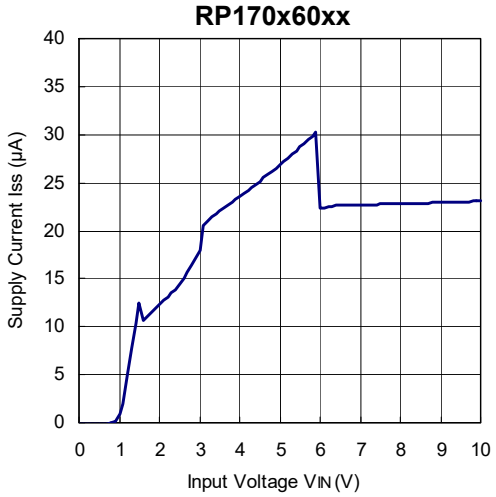
RP170x12xx



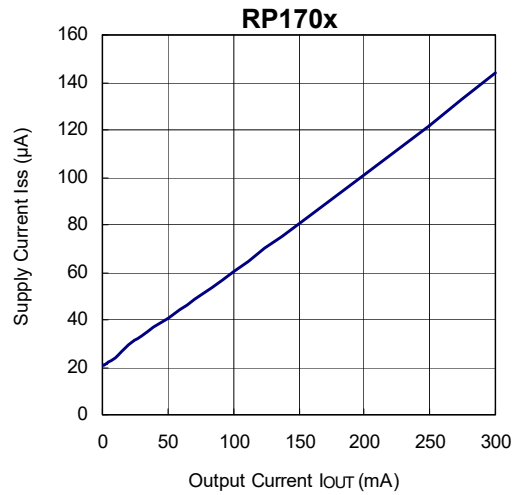
RP170x30xx



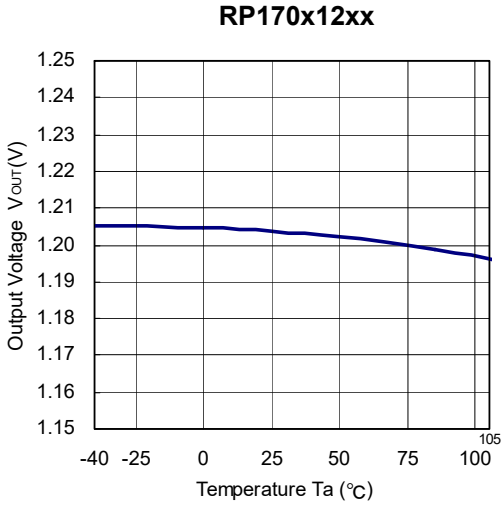
RP170x60xx

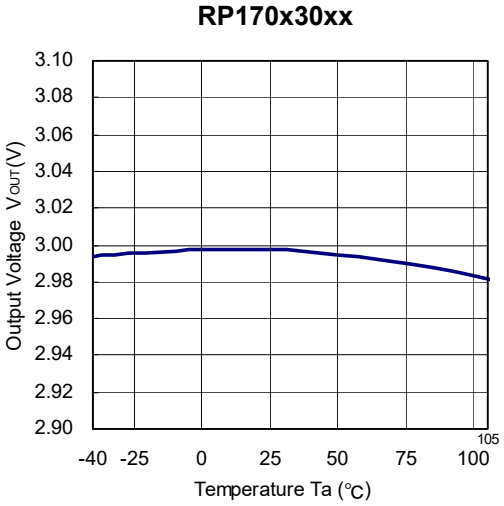


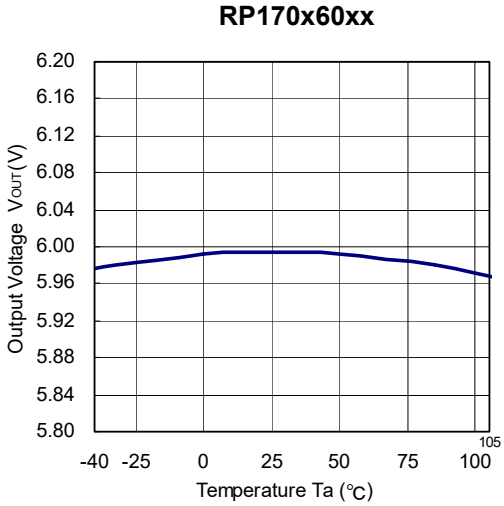
4) Supply Current vs. Output Current (Ta = 25°C)



5) Output Voltage vs. Temperature

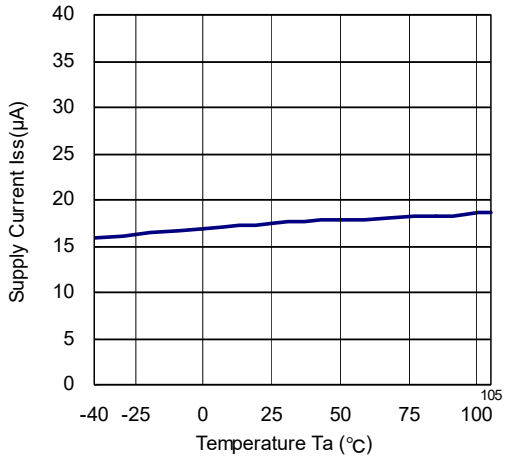




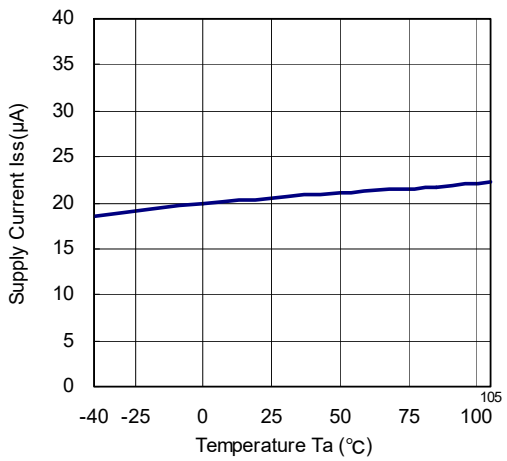


6) Supply Current vs. Temperature

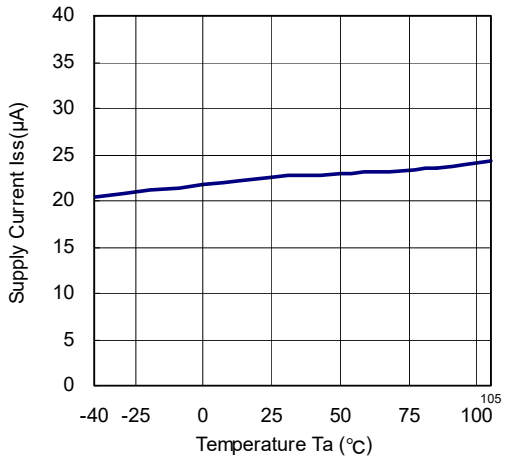
RP170x12xx



RP170x30xx

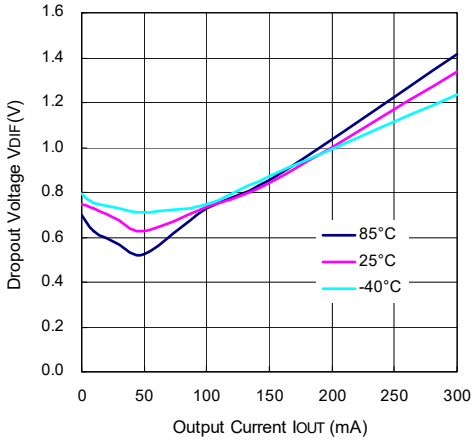


RP170x60xx

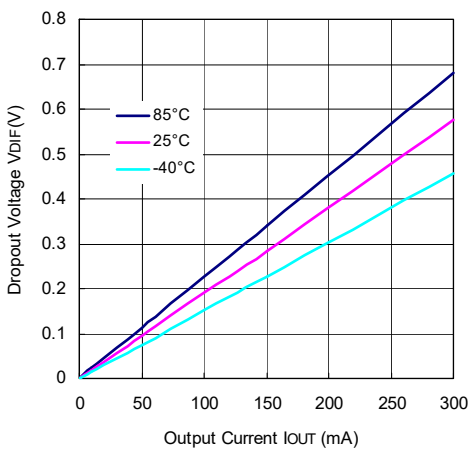


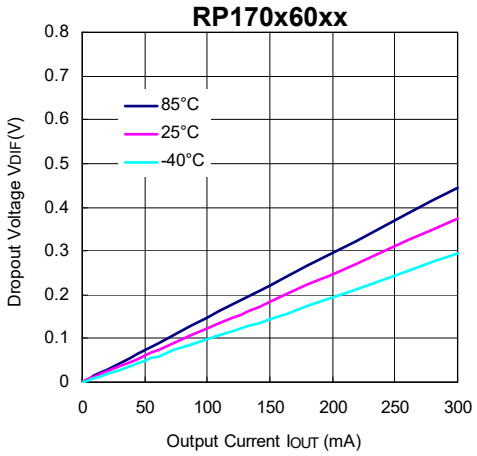
7) Dropout Voltage vs. Output Current

RP170x12xx

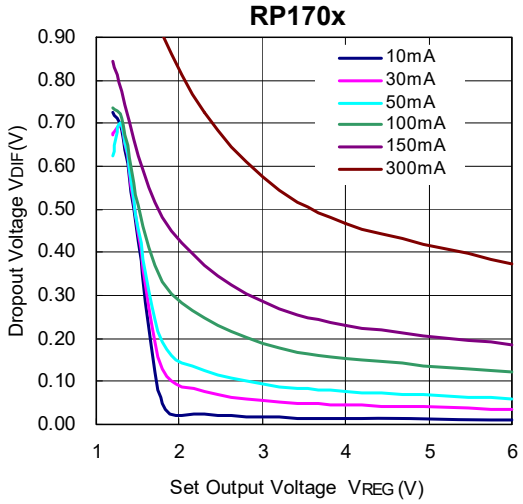


RP170x30xx

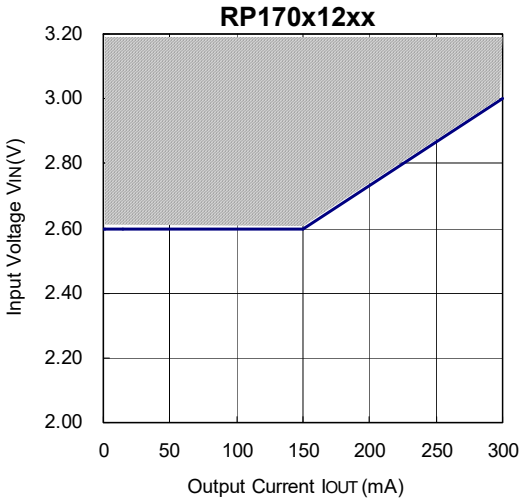




8) Dropout Voltage vs. Set Output Voltage (Ta = 25°C)

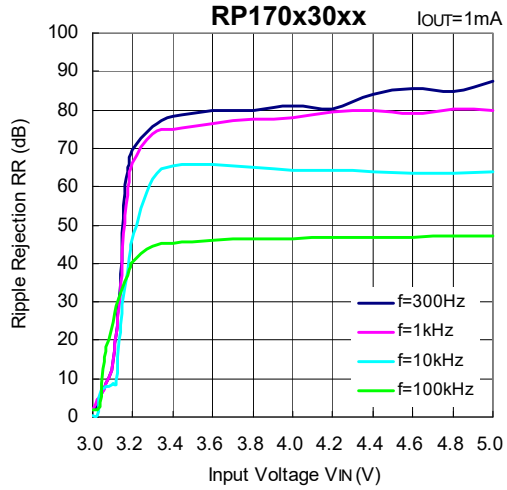


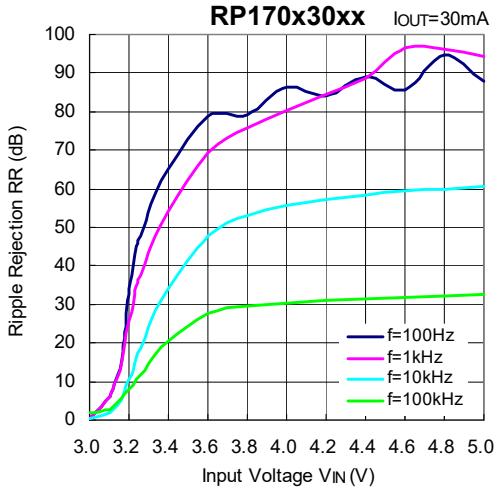
9) Minimum Operating Voltage

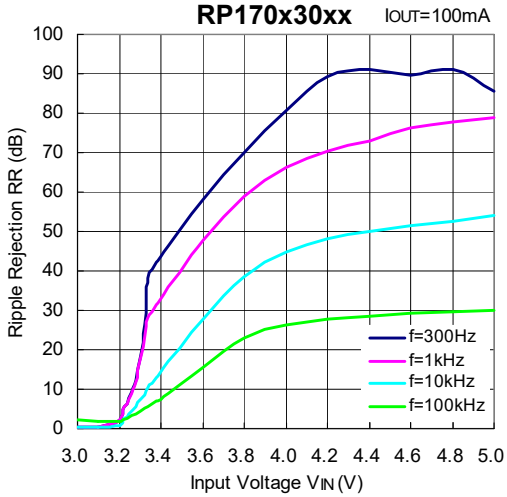


Hatched area is available
for 1.2 V output

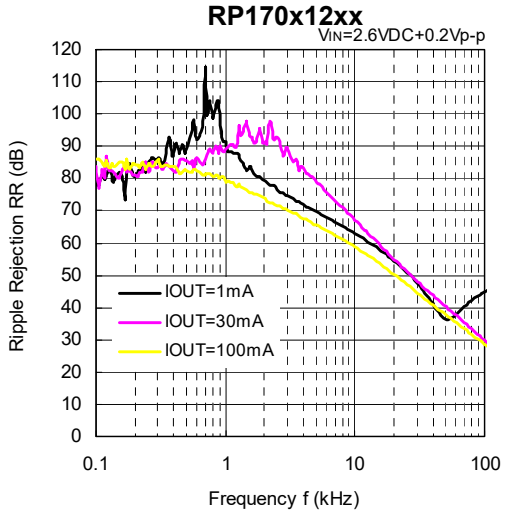
10) Ripple Rejection vs. Input Bias Voltage (C1 = none, C2 = Ceramic 1.0 µF, Ripple = 0.2 Vp-p, Ta = 25°C)

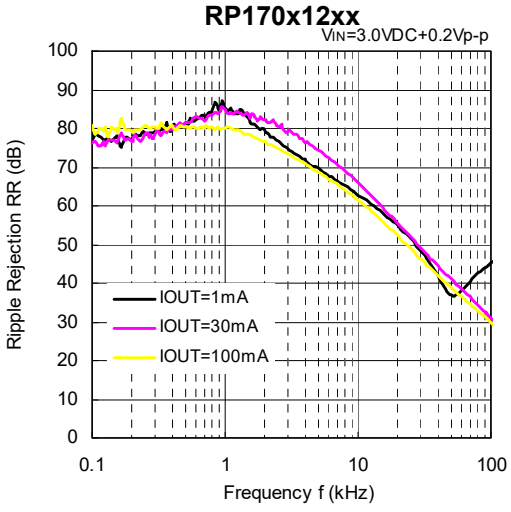


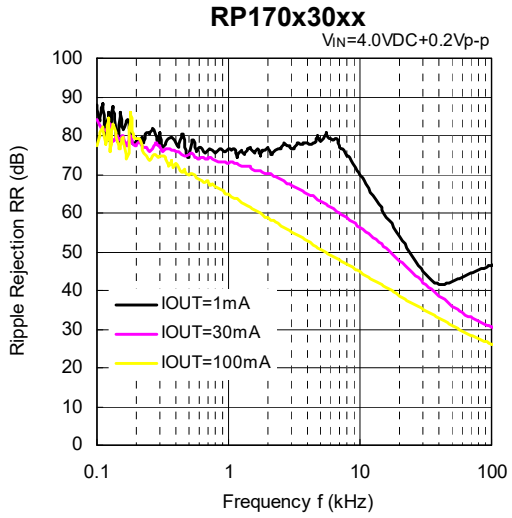


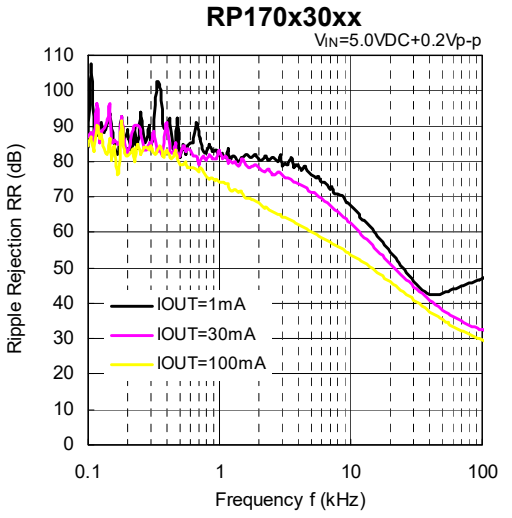


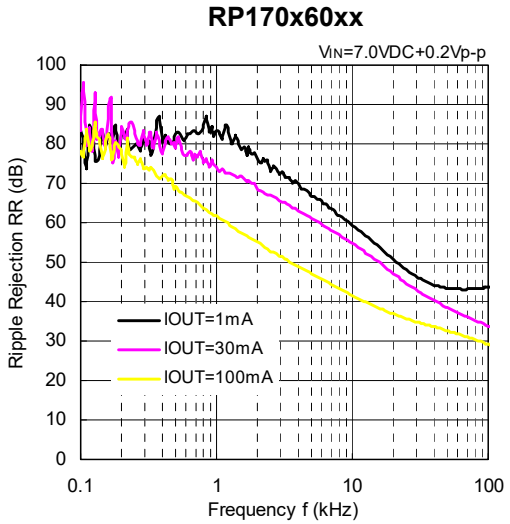
11) Ripple Rejection vs. Frequency (C1 = none, C2 = Ceramic 1.0 µF, Ta = 25°C)

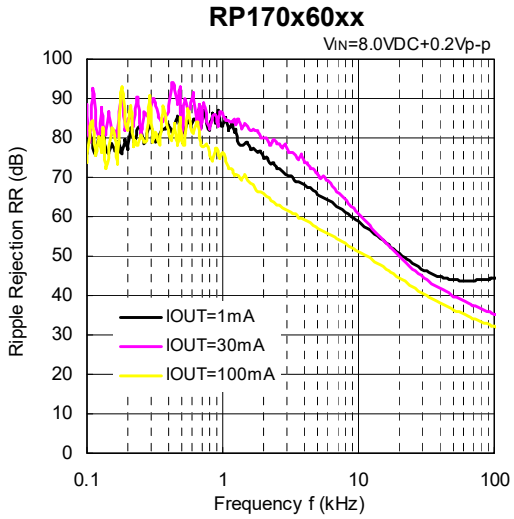




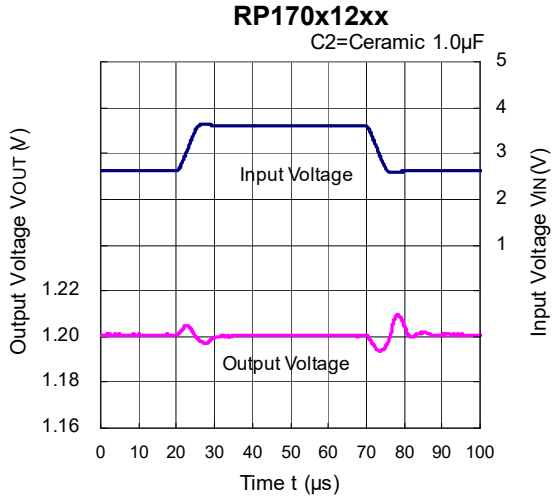


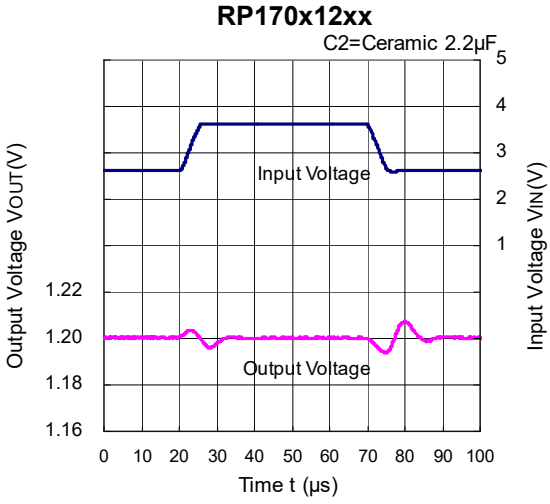


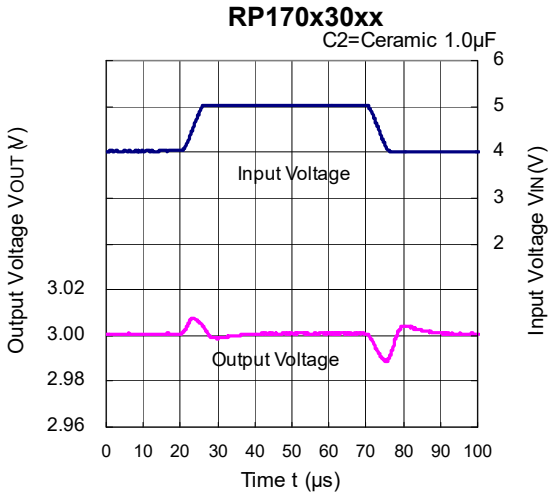


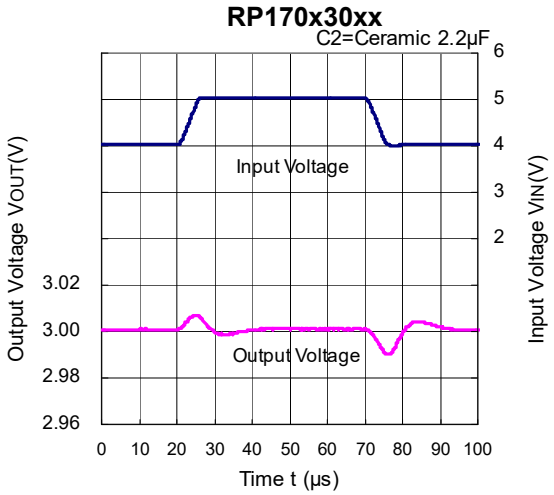


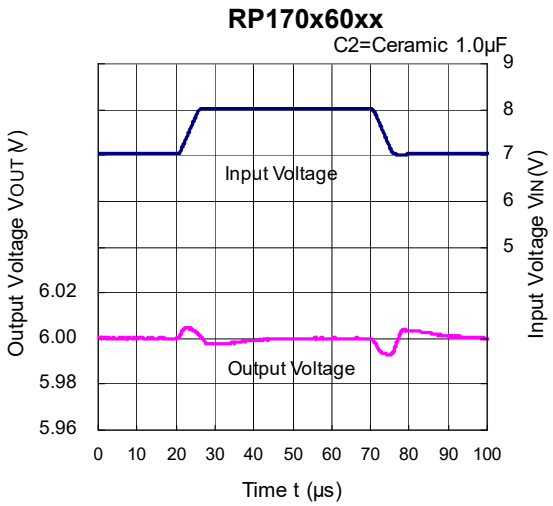
12) Input Transient Response (C1 = none, I_{OUT} = 30 mA, tr = tf = 5 µs, Ta = 25°C)

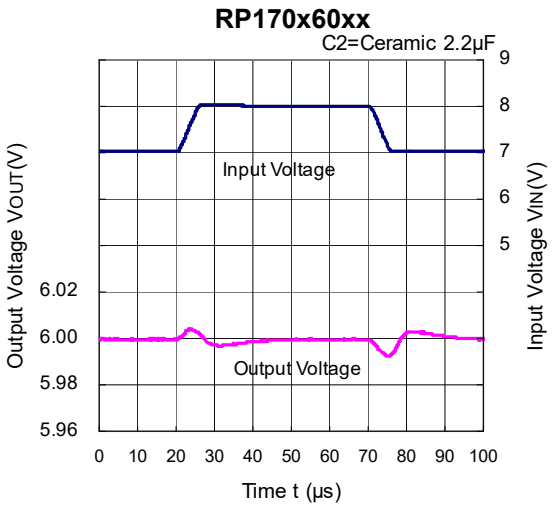




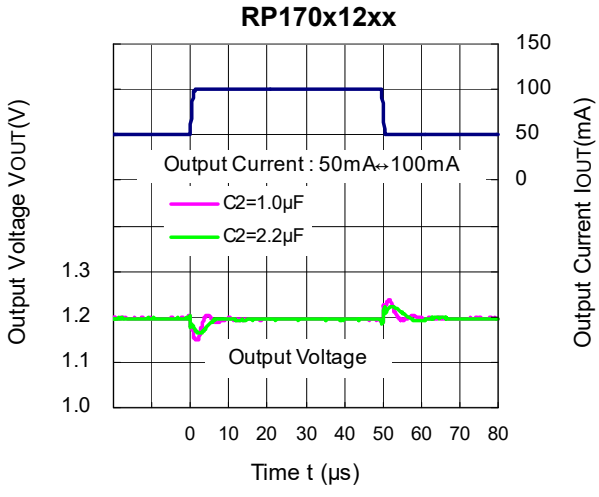


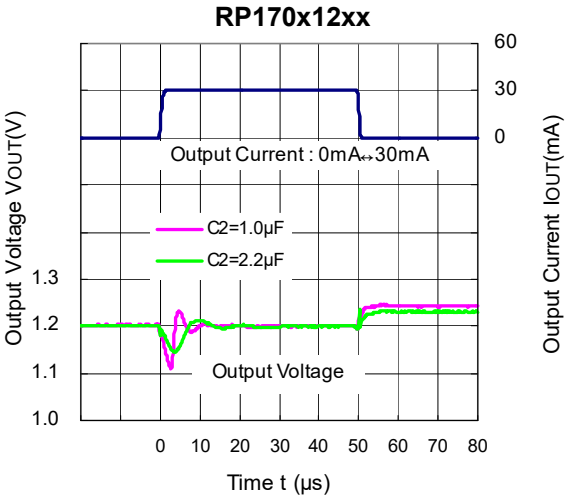




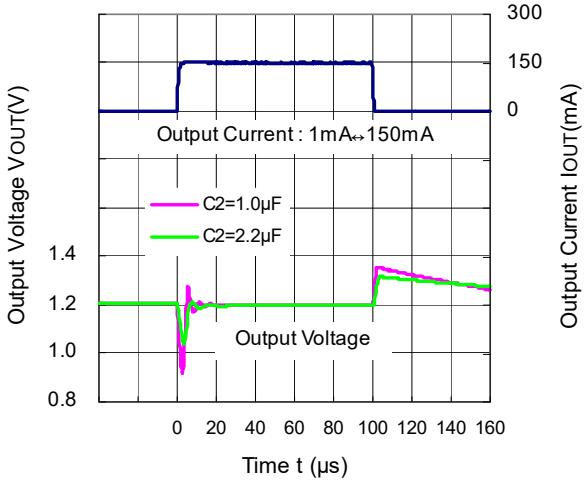


13) Load Transient Response (C1 = Ceramic 1.0 µF, tr = tf = 500 ns, Ta = 25°C)

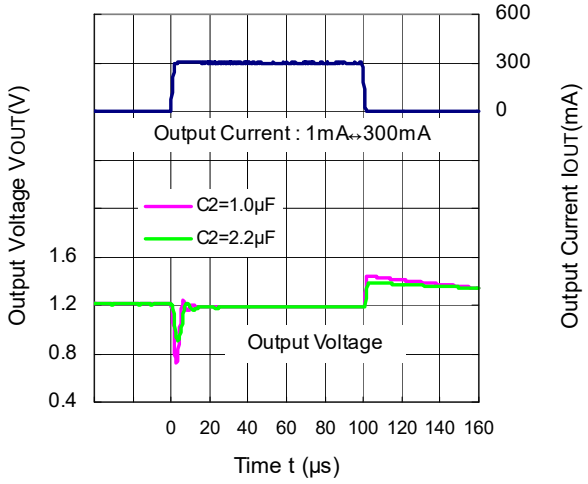




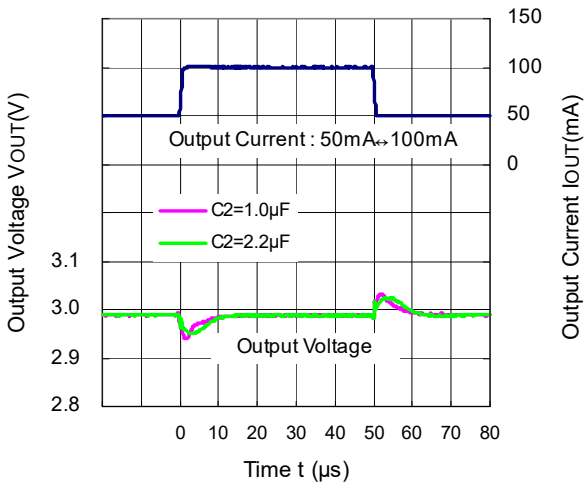
RP170x12xx



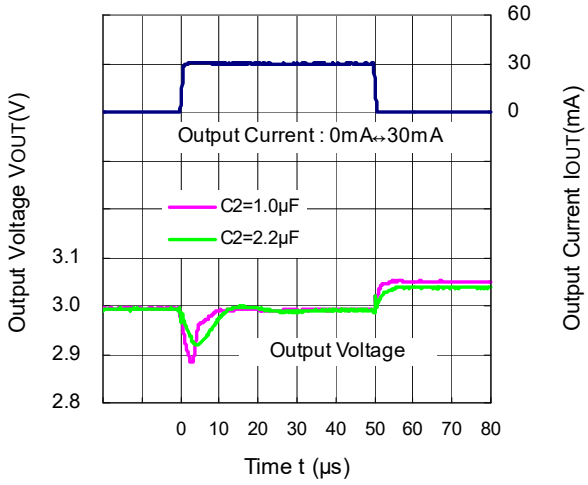
RP170x12xx



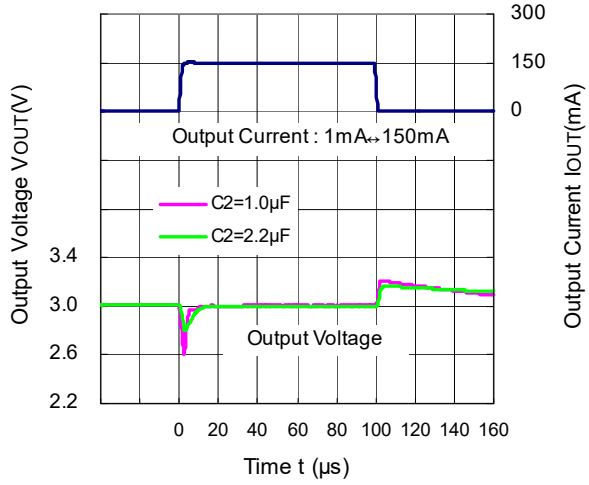
RP170x30xx



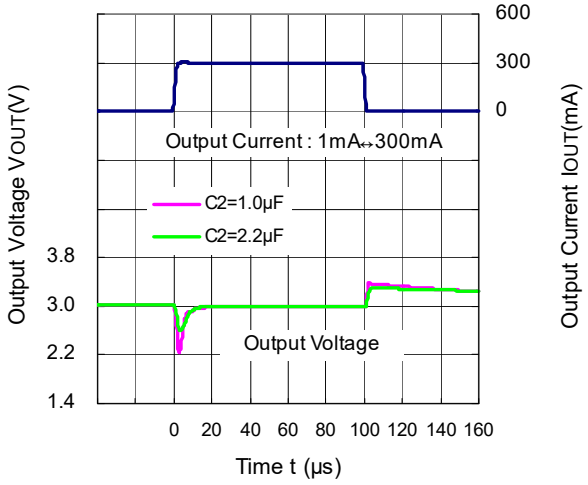
RP170x30xx



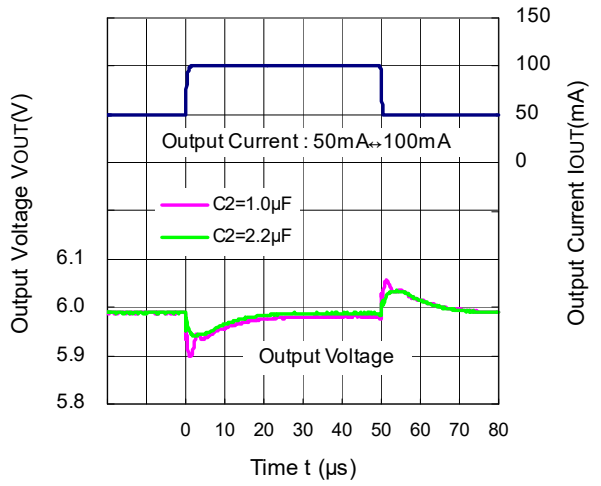
RP170x30xx



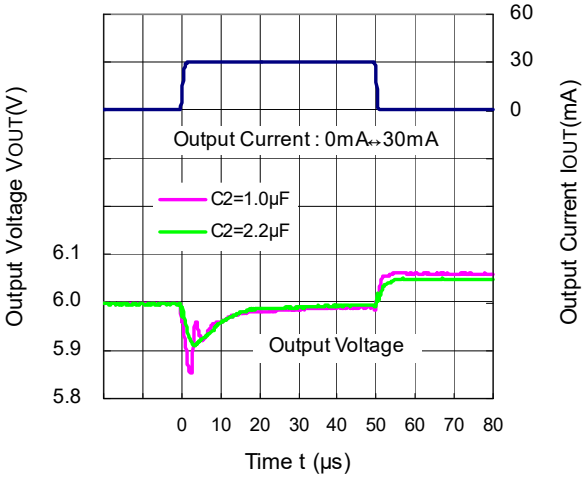
RP170x30xx



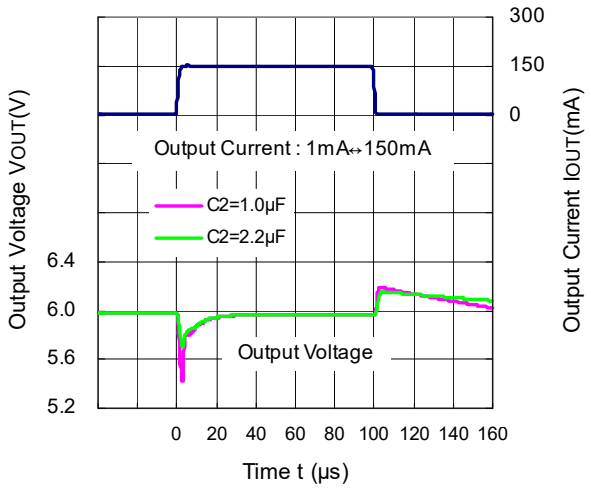
RP170x60xx



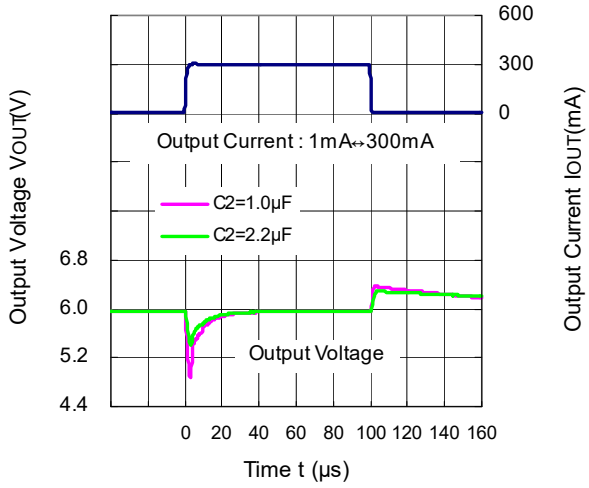
RP170x60xx



RP170x60xx

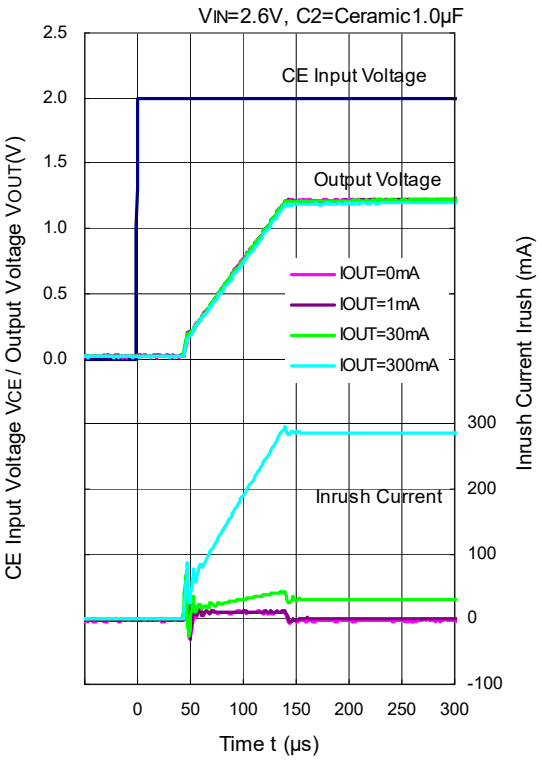


RP170x60xx

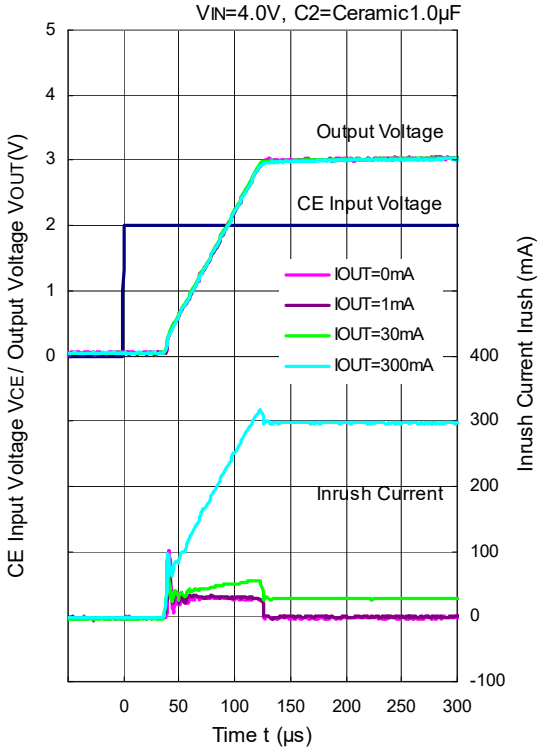


14) Turn On Speed with CE pin (C1 = Ceramic 1.0 μF, Ta = 25°C)

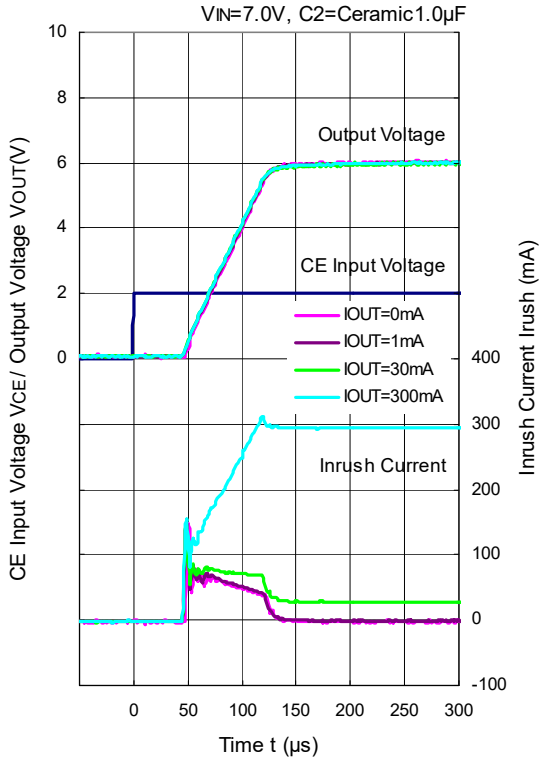
RP170x12xx



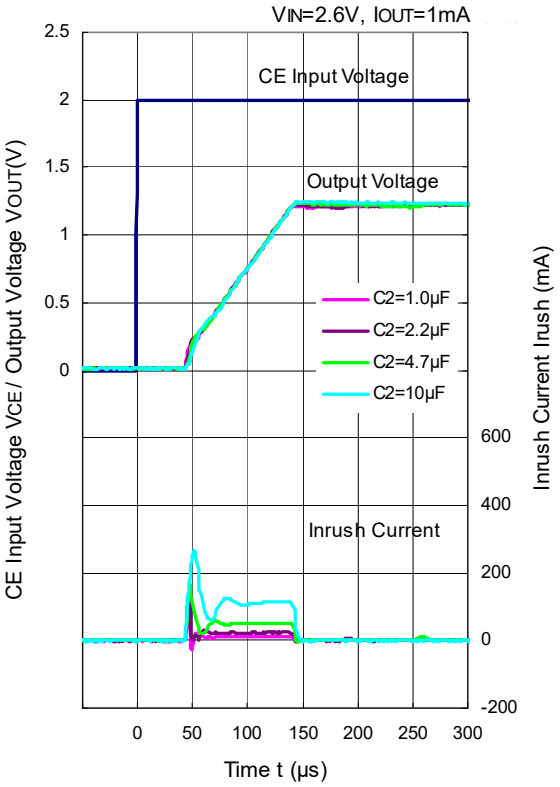
RP170x30xx



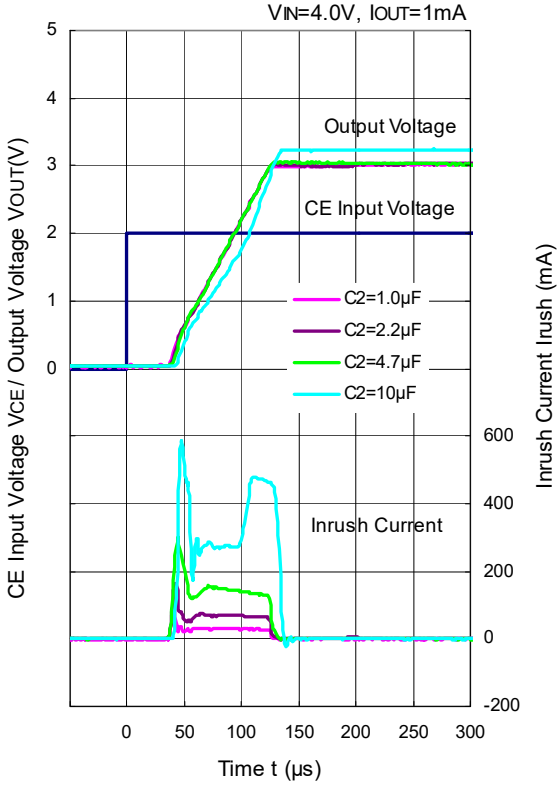
RP170x60xx



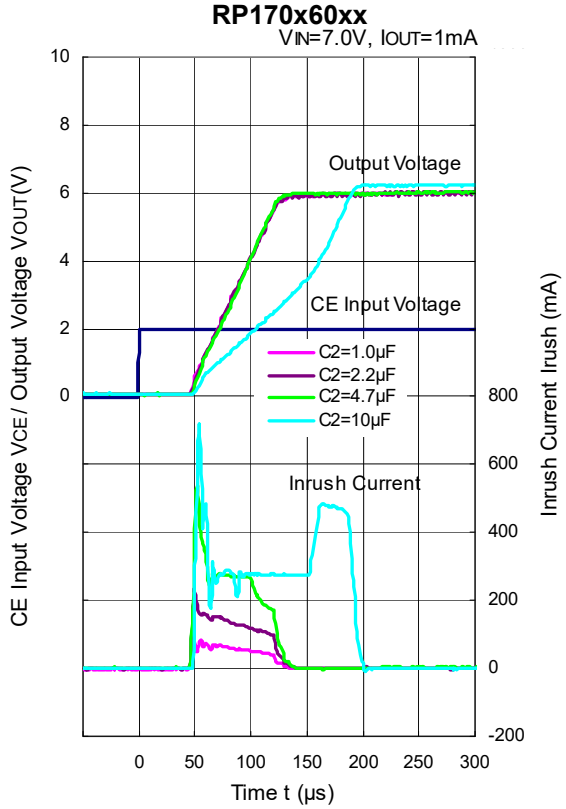
RP170x12xx



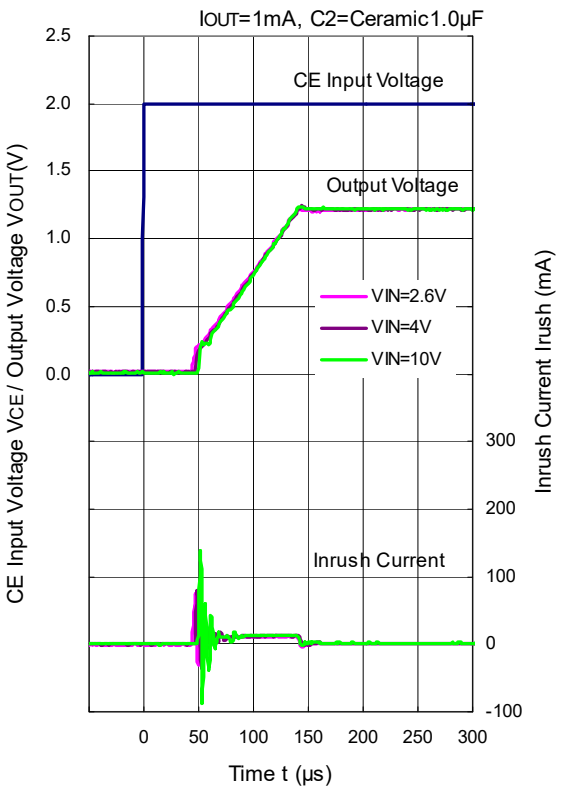
RP170x30xx



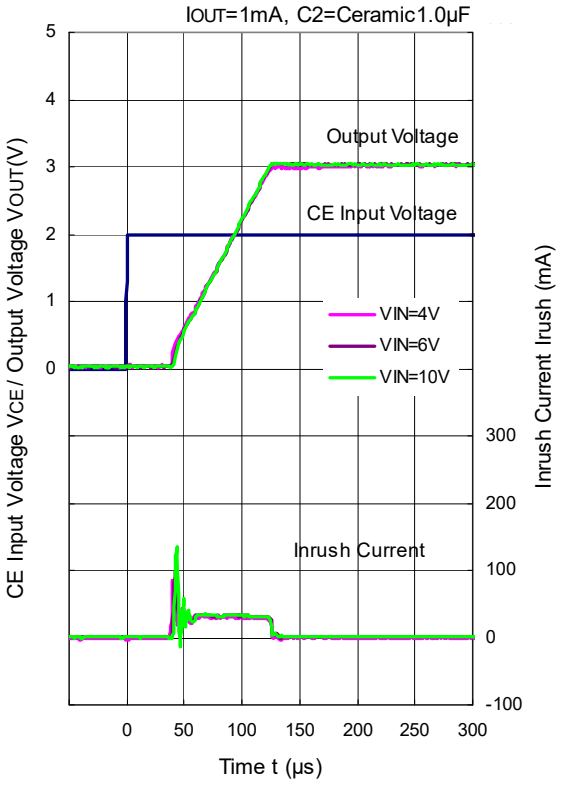
RP170x60xx



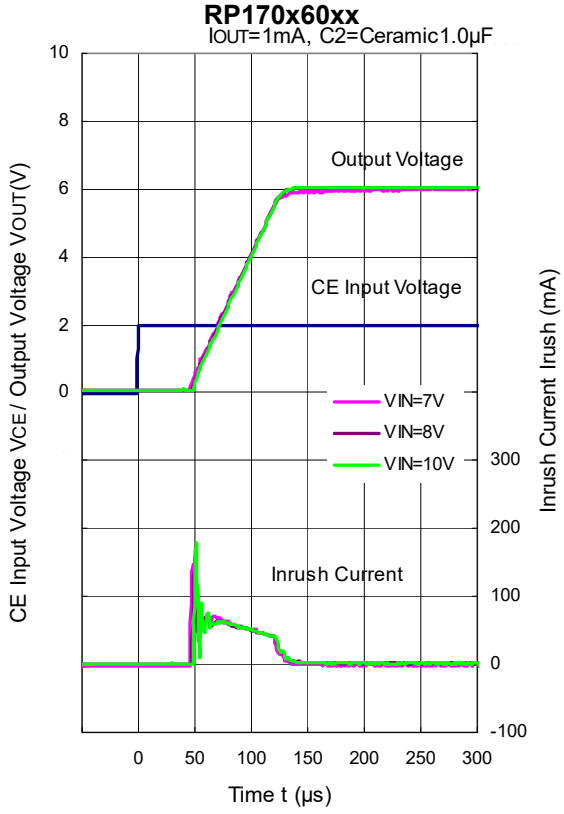
RP170x12xx



RP170x30xx

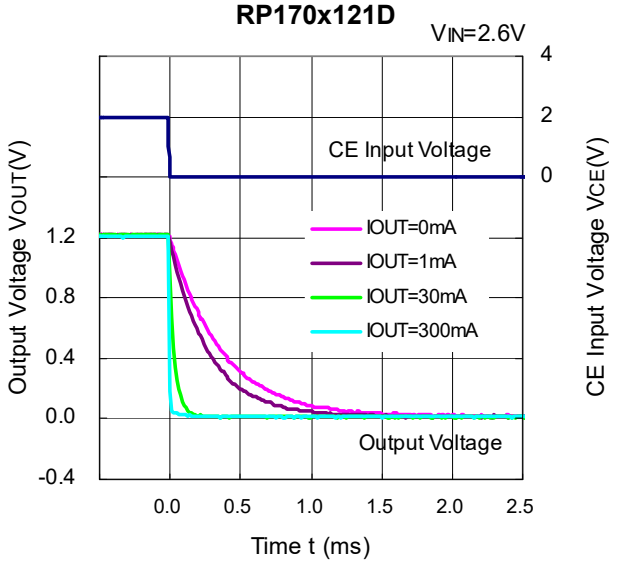


RP170x60xx

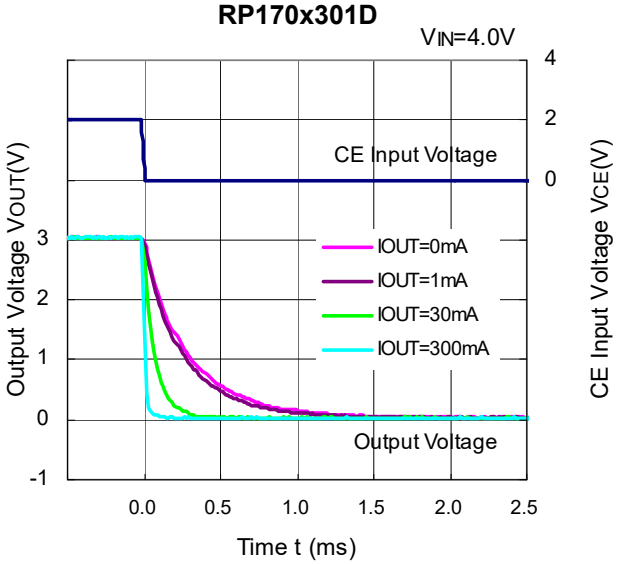


15) Turn Off Speed with CE pin (RP170xxx1D) (C1 = Ceramic 1.0 μF, Ta = 25°C)

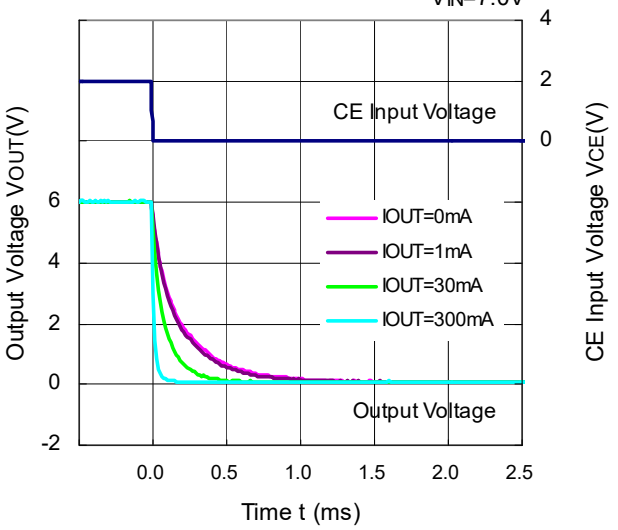
RP170x121D



RP170x301D



RP170x601D



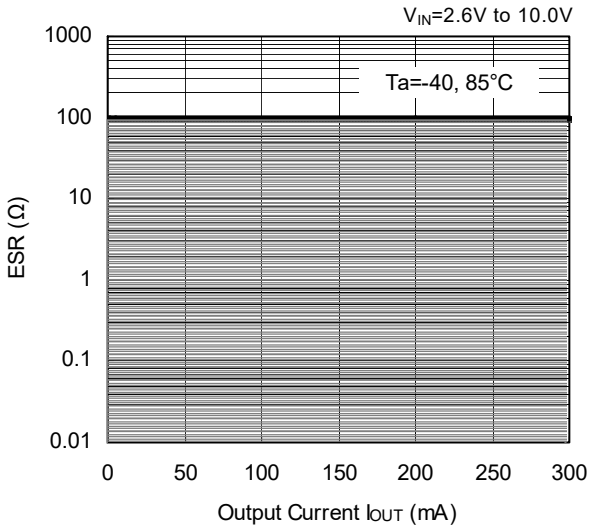
ESR vs. Output Current

Ceramic type output capacitor is recommended for this IC; 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.

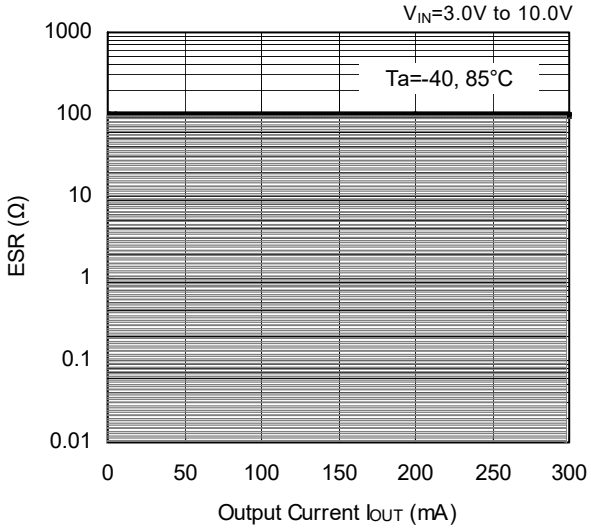
Measurement conditions

Frequency Band : 10 Hz to 2 MHz
Temperature : −40°C to 85°C
C1, C2 : Ceramic 1.0 μF (Murata GRM155B31A105KE)

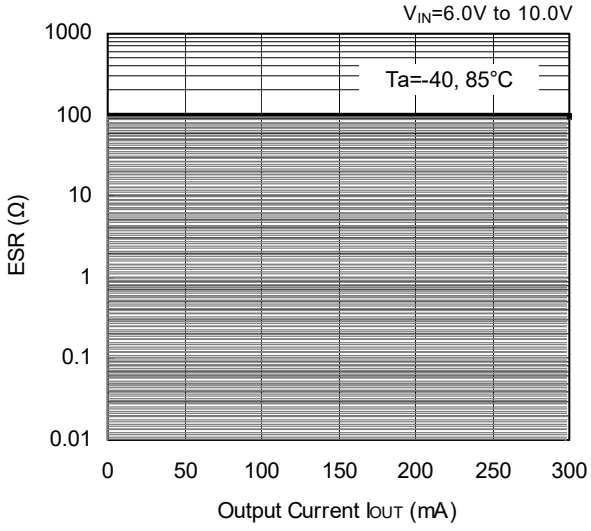
RP170x12xx



RP170x30xx



RP170x60xx



Ver. A

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

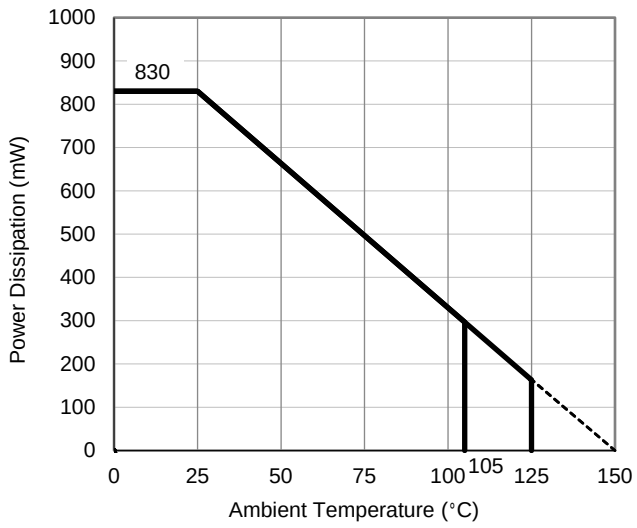
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 7 pcs

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

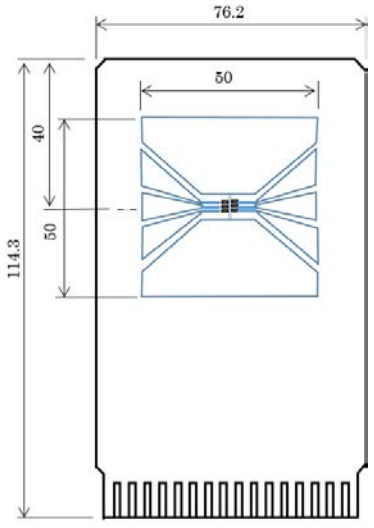
Item	Measurement Result
Power Dissipation	830 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

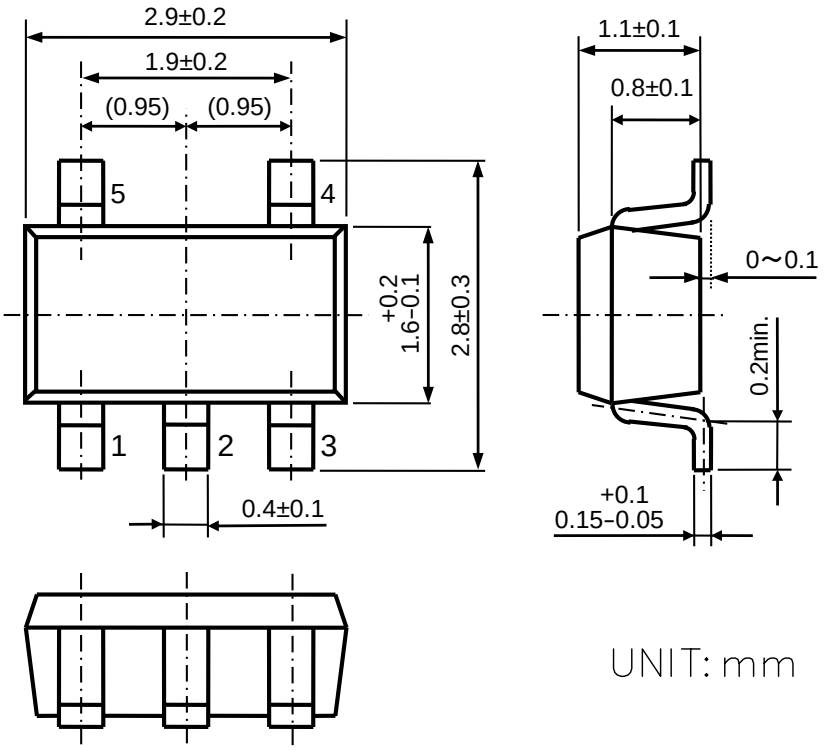
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-23-5 Package Dimensions

Ver. A

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

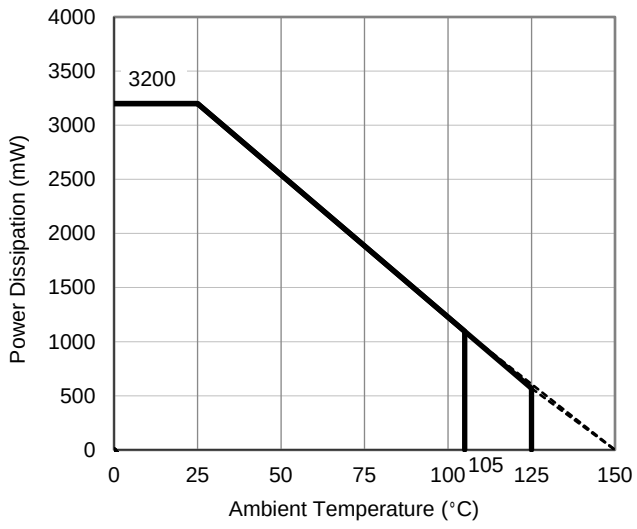
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 13 pcs

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

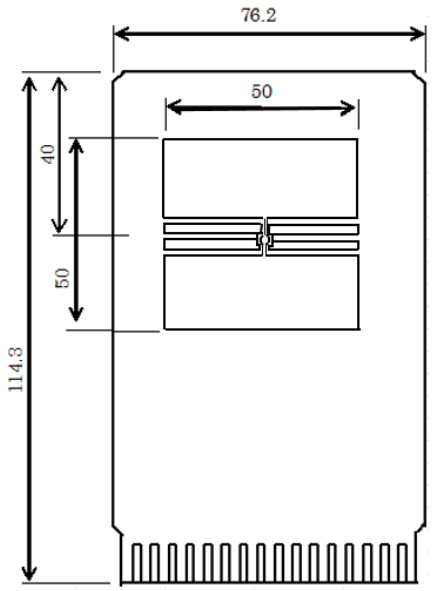
Item	Measurement Result
Power Dissipation	3200 mW
Thermal Resistance (θja)	θja = 38°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 13°C/W

θja: Junction-to-Ambient Thermal Resistance

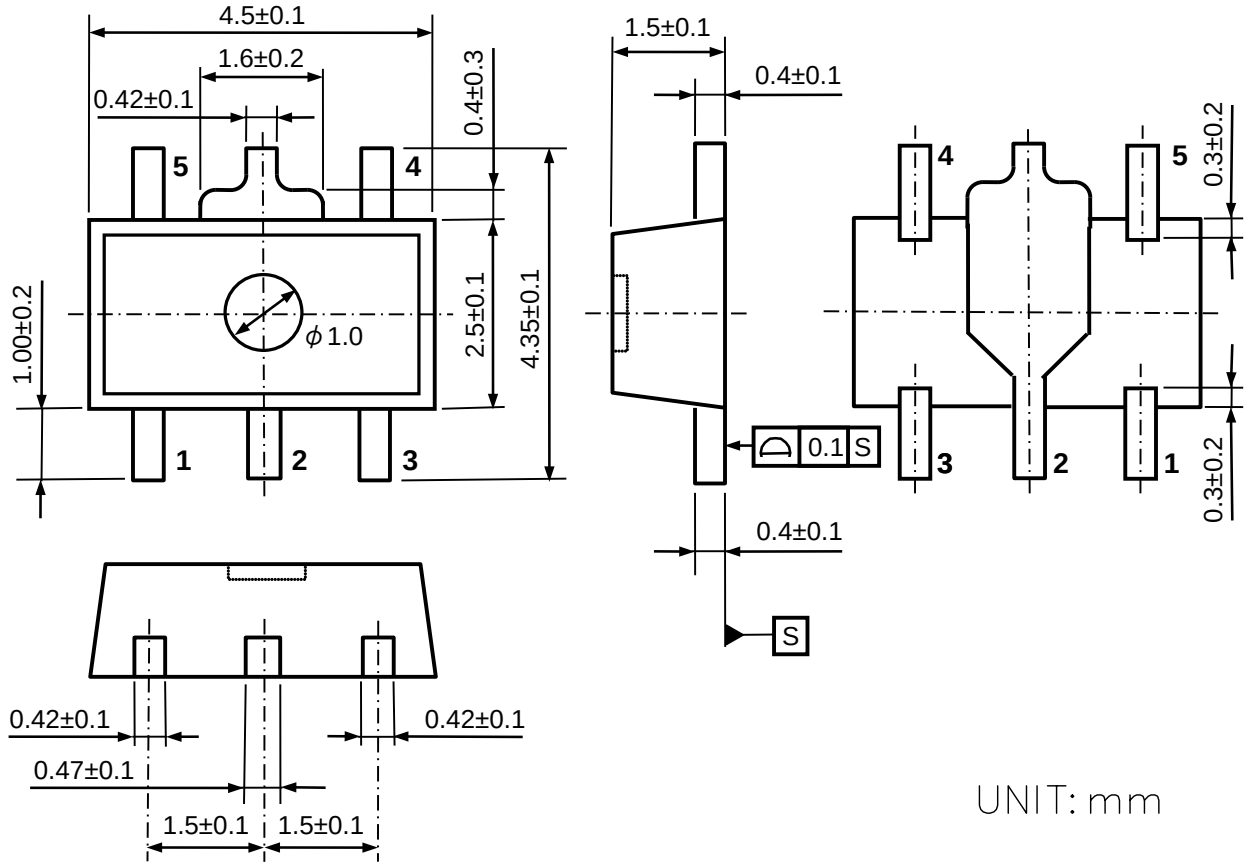
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-89-5 Package Dimensions

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6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. Anti-radiation design is not implemented in the products described in this document.
8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or our distributor before attempting to use AOI.
11. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

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