Low Noise 150mA LDO Regulator for Automotive Applications

NO.EC-173-200129

OUTLINE

The RP130x is a CMOS-based positive voltage regulator IC with high ripple rejection, low dropout voltage, high output voltage accuracy and extremely low supply current. The RP130x consists of a voltage reference unit, an error amplifier, a resistor network for voltage setting, a short current limit circuit, and a chip enable circuit.

The RP130x has low supply current characteristics in the CMOS process. In addition, the RP130x can supply a low dropout voltage, which becomes the smallest difference between the input voltage and output voltage by having a low on-resistance and also can achieve the battery's long life by a chip enable function.

When compared with the conventional products of high-speed type, the RP130x achieves low consumption current of 38µA (Typ.) while improving the input transient response, the load transient response, and the ripple rejection.

The RP130x supports two package types: SOT-23-5 and DFN1212-4. By the adoption of the ultra-compact DFN1212-4, the RP130x can achieve a higher density mounting than ever.

FEATURES

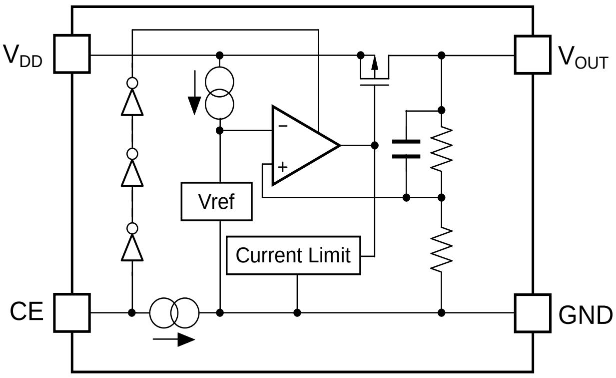
- Input Voltage Range (Max. Rating)··························1.7V to 6.5V (7.0V)
- Supply Current··Typ. 38µA
- Supply Current (Standby Mode)·······························Typ. 0.1µA
- Ripple Rejection··Typ. 80dB (f = 1kHz)
- Output Voltage Range ··1.2V, 1.5V, 1.8V, 2.5V, 2.7V, 2.8V, 2.9V, 3.0V, 3.3V, 3.4V, 4.5V, and 5.0V
  *Contact our sales representatives for other voltages.
- Output Voltage Accuracy···±1.0% (V_{SET} > 2.0V, Ta = 25°C)
- Temperature-Drift Coefficient of Output Voltage··········Typ. ±20 ppm/°C
- Dropout Voltage ··Typ. 0.32V (I_{OUT} = 150mA, V_{SET} = 2.8V)
- Line Regulation···Typ. 0.02%/V
- Packages ··DFN1212-4, SOT-23-5
- Built-in Fold Back Protection Circuit··························Typ. 40mA
- Recommended Ceramic Capacitors ·························0.47µF or more
- Output Noise Voltage ···Typ. $V_{SET} \times 20$ [µVrms]
  (BW = 10Hz to 100kHz, I_{OUT} = 30mA)

APPLICATIONS

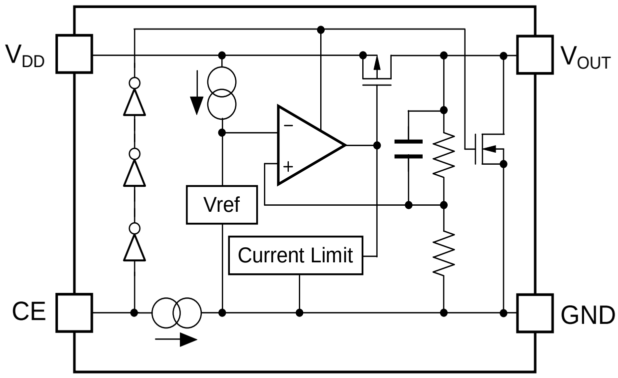
- Power source for car accessories including car audio equipment, car navigation system, and ETC system.

BLOCK DIAGRAMS

RP130xxx1B



RP130xxx1D



SELECTION GUIDE

The output voltage, chip-enable polarity, auto-discharge function, and package type for this device can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP130Lxx1∗-TR-#	DFN1212-4	3,000pcs	Yes	Yes
RP130Nxx1∗-TR-#E	SOT-23-5	3,000pcs	Yes	Yes

xx : Specify the set output voltage (V_{SET})
1.2 V (12) / 1.5 V (15) / 1.8 V (18) / 2.5 V (25) / 2.7 V (27) / 2.8 V (28) / 2.9 V (29)
3.0 V (30) / 3.3 V (33) / 3.4 V (34) / 4.5 V (45) / 5.0 V (50)
Note: Contact our sales representatives for other voltages.

∗ : Specify the desired functions for chip-enable polarity and auto-discharge
B: "H" active / No auto-discharge function
D: "H" active / Auto-discharge function

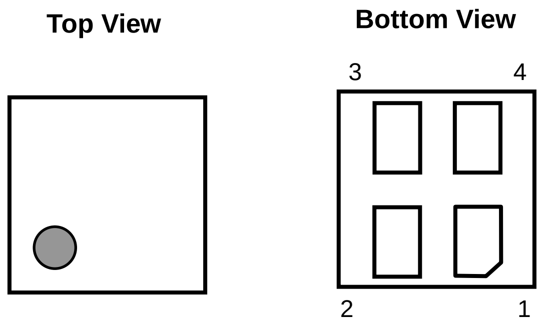
: Specify Automotive Class Code

	Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
A	- 40°C to 105°C	25°C	High temperature

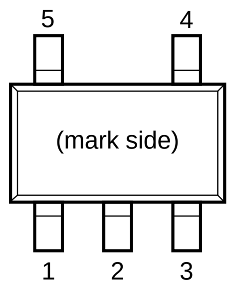
Auto-Discharge function quickly lowers the output voltage to 0V by releasing the electrical charge in the external capacitor when the chip enable signal is switched from the active mode to the standby mode.

PIN DESCRIPTION

- **DFN1212-4**



- **SOT-23-5**



DFN1212-4

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

SOT-23-5

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

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	- 0.3 to 7.0	V
V_{CE}	Input Voltage (CE Pin)	- 0.3 to 7.0	V
V_{OUT}	Output Voltage	- 0.3 to V_{IN}+0.3	V
I_{OUT}	Output Current	200	mA
P_D	Power Dissipation	Refer to "*PACKAGE INFORMATION*"	
Tj	Junction Temperature	- 40 to 150	°C
Tstg	Strong Temperature Range	- 55 to 150	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage 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 rating is not assured.

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	1.7 to 6.5	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 they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

V_{IN} = V_{SET}+1.0V (V_{SET} > 1.5V), V_{IN} = 2.5V (V_{SET} ≤ 1.5V), I_{OUT} = 1mA, C_{IN} = C_{OUT} = 0.47µF, unless otherwise noted.
The specifications surrounded by ▭ are guaranteed by design engineering at - 40ºC ≤ Ta ≤ 105ºC.

RP130xxx1B/D **(Ta = 25°C)**

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	Ta = 25°C	V_{SET} > 2.0V	×0.99		×1.01	V
			V_{SET} ≤ 2.0V	- 20		20	mV
		- 40°C ≤ Ta ≤ 105°C	V_{SET} > 2.0V	×0.985		×1.015	V
			V_{SET} ≤ 2.0V	- 30		30	mV
I_{OUT}	Output Current			150			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	1mA ≤ I_{OUT} ≤ 150mA			10	30	mV
V_{DIF}	Dropout Voltage	I_{OUT} = 150mA	1.2V ≤ V_{SET} < 1.5V		0.67	1.03	V
			1.5V ≤ V_{SET} < 1.7V		0.54	0.84	
			1.7V ≤ V_{SET} < 2.0V		0.46	0.75	
			2.0V ≤ V_{SET} < 2.5V		0.41	0.63	
			2.5V ≤ V_{SET} < 4.0V		0.32	0.51	
			V_{SET} = 4.5V		0.24	0.39	
			V_{SET} = 5V		0.24	0.31	
I_{SS}	Supply Current	I_{OUT} = 0mA			38	58	µA
Istandby	Supply Current (at Standby)	V_{CE} = 0			0.1	1.0	µA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{SET} + 0.5V ≤ V_{IN} ≤ 6.5V			0.02	0.10	%/V
I_{SC}	Short Current Limit	V_{OUT} = 0V			40		mA
I_{PD}	CE Pull-down Current				0.4		µA
V_{CEH}	CE Input Voltage "H"			1.0			V
V_{CEL}	CE Input Voltage "L"					0.36	V
R_{LOW}	Nch ON Resistance for Auto Discharge (D Version Only)	V_{IN} = 4.0V, V_{CE} = 0V			30		Ω

All test items listed under Electrical Characteristics are done under the pulse load condition (Tj ≈ Ta = 25°C)

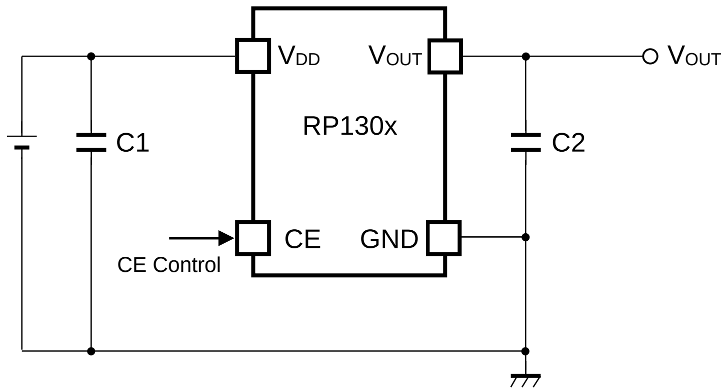
Product-specific Electrical Characteristics

The specifications surrounded by ☐ are guaranteed by design engineering at - 40ºC ≤ Ta ≤ 105ºC.

(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.
RP130x121x	1.180	1.200	1.220	1.170	1.200	1.230	0.67	1.03
RP130x151x	1.480	1.500	1.520	1.470	1.500	1.530	0.54	0.84
RP130x181x	1.780	1.800	1.820	1.770	1.800	1.830	0.46	0.75
RP130x251x	2.475	2.500	2.525	2.463	2.500	2.538	0.32	0.51
RP130x271x	2.673	2.700	2.727	2.660	2.700	2.741		
RP130x281x	2.772	2.800	2.828	2.758	2.800	2.842		
RP130x291x	2.871	2.900	2.929	2.857	2.900	2.944		
RP130x301x	2.970	3.000	3.030	2.955	3.000	3.045		
RP130x331x	3.267	3.300	3.333	3.251	3.300	3.350		
RP130x341x	3.366	3.400	3.434	3.349	3.400	3.451		
RP130x451x	4.455	4.500	4.545	4.433	4.500	4.567	0.24	0.39
RP130x501x	4.950	5.000	5.050	4.925	5.000	5.075	0.24	0.31

TYPICAL APPLICATION



External Part Example :

Symbol	Description
C2	0.47µF (Ceramic)

TECHNICAL NOTES

Phase Compensation

In the ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, use a capacitor C2 with 0.47µF or more.

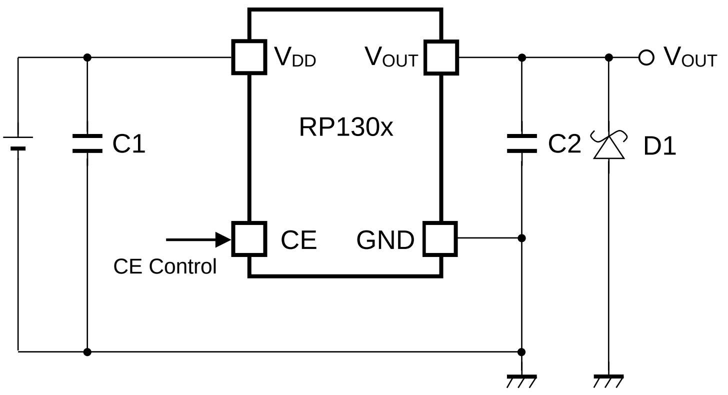
If a tantalum capacitor is used, and its ESR (Equivalent Series Resistance) of C2 is large, the loop oscillation may result. Because of this, select C2 carefully considering its frequency characteristics.

PCB Layout

Make V_{DD} and GND lines sufficient. If their impedance is too high, noise pickup or unstable operation may result. Connect 0.47µF or more of the capacitor C1 between the V_{DD} and GND, and as close as possible to the pins.

In addition, connect the capacitor C2 between V_{OUT} and GND, 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 (DFN1212-4)

PD-DFN1212-4-(105150)-JE-B

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.

Measurement Conditions

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2mm × 114.3mm × 1.6mm
Copper Ratio	Outer Layers (First and Forth Layers): Less than 10% of 60mm Square Inner Layers (Second and Third Layers): Approx. 100% of 74.2mm Square

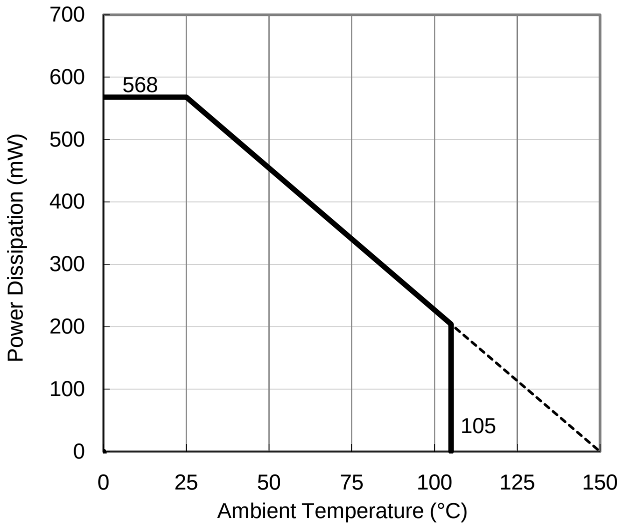
Measurement Result

(Ta = 25°C, Tjmax = 150°C)

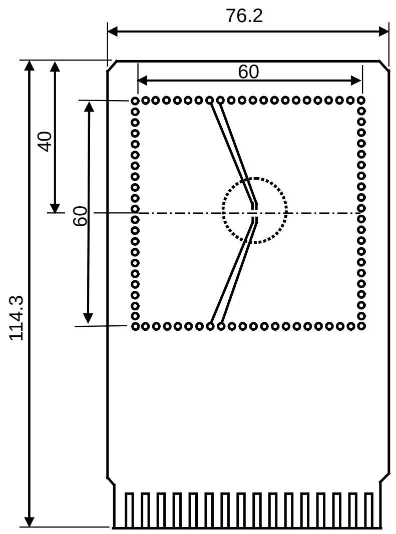
Item	Measurement Result
Power Dissipation	568mW
Thermal Resistance (θja)	θja = 220°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 68°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter

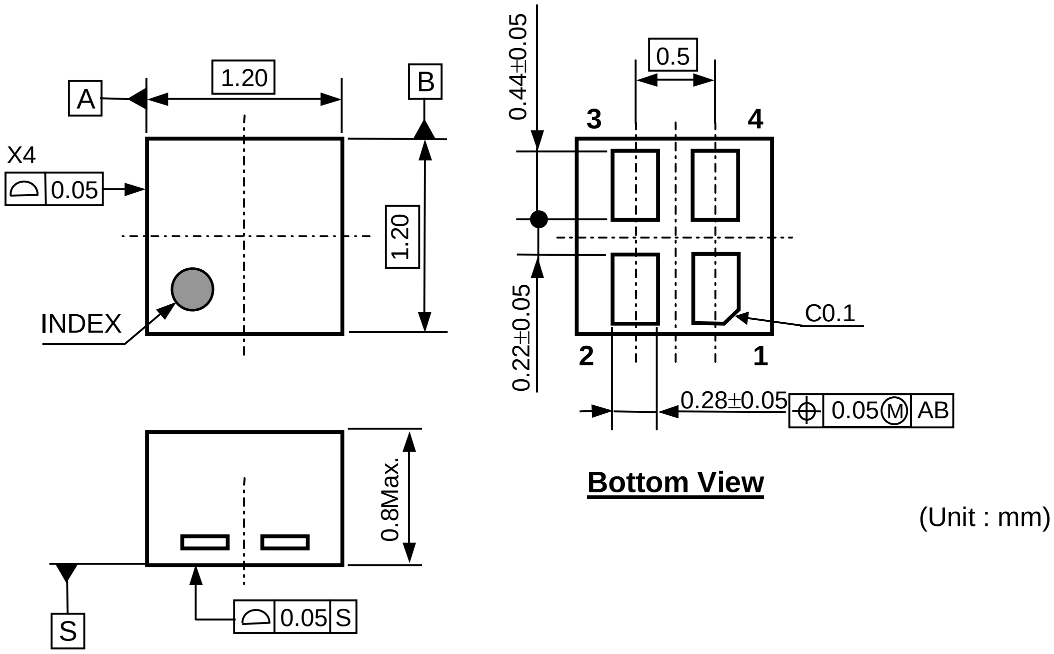


Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

Package Dimensions (DFN1212-4) DM-DFN1212-4-JE-A



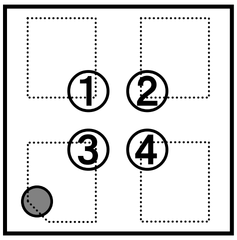
DFN1212-4 Package Dimensions

Mark Specifications (DFN1212-4)

MK-RP130L-JCEC-B

①②: Product Code … **Refer to "*RP130L Mark Specification Table*"**

③④: Lot Number …Alphanumeric Serial Number



DFN1212-4 Mark Specifications

RP130L Mark Specification Table (DFN1212-4)

RP130Lxx1B

Product Name	①②	V_{SET}
RP130L121B	J A	1.2 V
RP130L151B	J D	1.5 V
RP130L181B	J G	1.8 V
RP130L251B	J Q	2.5 V
RP130L271B	J S	2.7 V
RP130L281B	J T	2.8 V
RP130L291B	J V	2.9 V
RP130L301B	J W	3.0 V
RP130L331B	J Z	3.3 V
RP130L341B	K A	3.4 V
RP130L451B	K M	4.5 V
RP130L501B	K S	5.0 V

RP130Lxx1D

Product Name	①②	V_{SET}
RP130L121D	L A	1.2 V
RP130L151D	L D	1.5 V
RP130L181D	L G	1.8 V
RP130L251D	L Q	2.5 V
RP130L271D	L S	2.7 V
RP130L281D	L T	2.8 V
RP130L291D	L V	2.9 V
RP130L301D	L W	3.0 V
RP130L331D	L Z	3.3 V
RP130L341D	M A	3.4 V
RP130L451D	M M	4.5 V
RP130L501D	M S	5.0 V

Power Dissipation (SOT-23-5)

PD-SOT-23-5-(105150)-JE-B

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

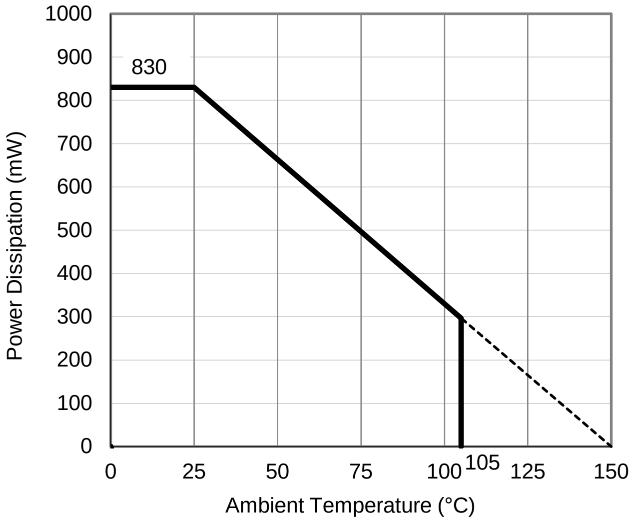
Measurement Result

(Ta = 25°C, Tjmax = 150°C)

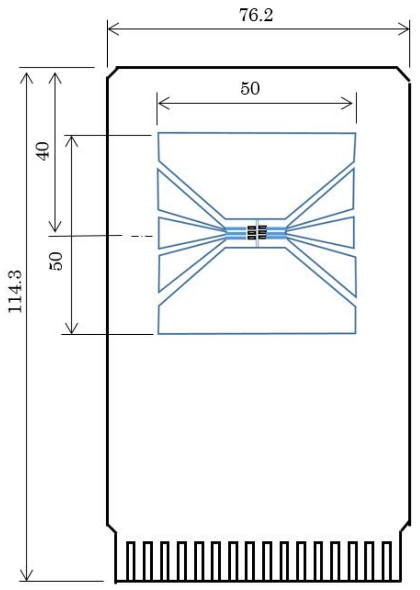
Item	Measurement Result
Power Dissipation	830 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter

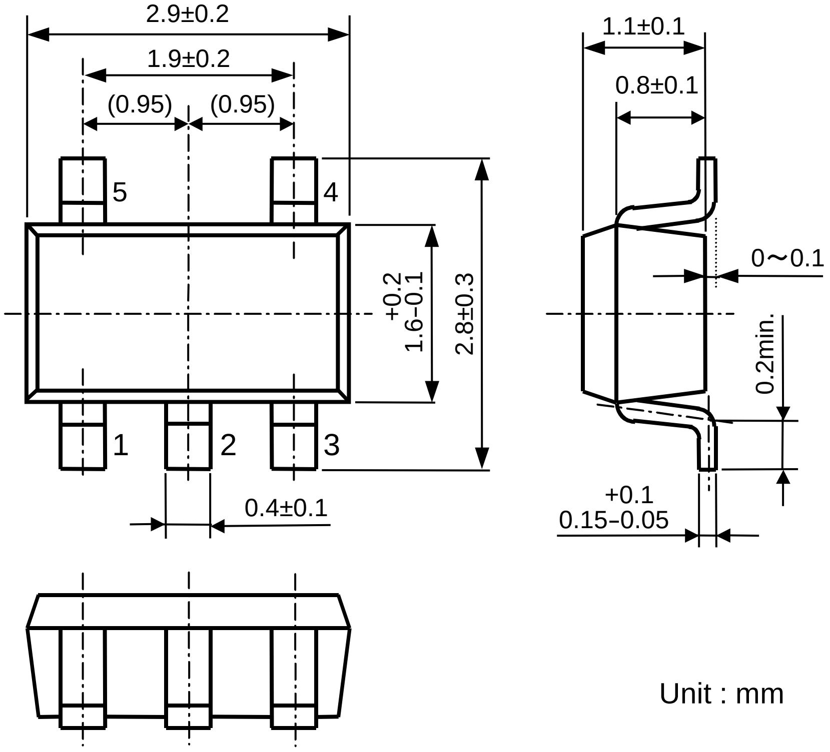


Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

Package Dimensions (SOT-23-5) DM-SOT-23-5-JE-A



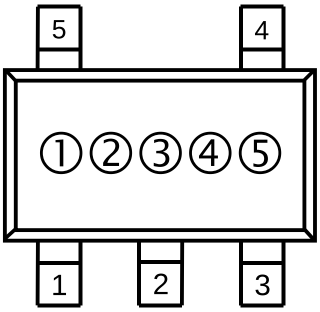
SOT-23-5 Package Dimensions

Mark Specifications (SOT-23-5)

MK-RP130N-JCEC-B

①②③: Product Code … **Refer to *"RP130N Mark Specification Table"***

④⑤: Lot Number … Alphanumeric Serial Number



SOT-23-5 Mark Specifications

RP130N Mark Specification Table (SOT-23-5)

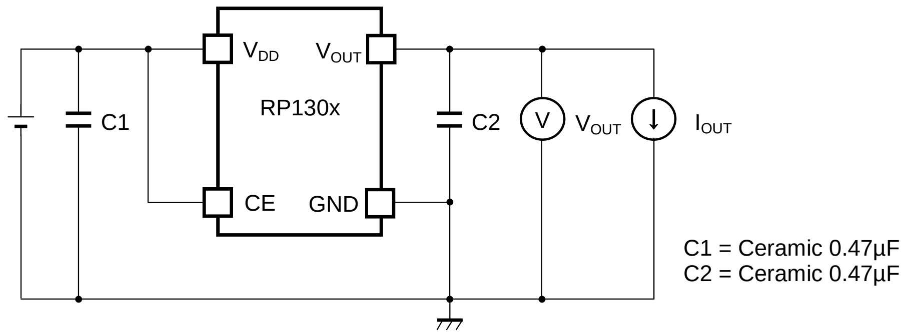
RP130Nxx1B

Product Name	①②③	V_{SET}
RP130N121B	H 1 A	1.2 V
RP130N151B	H 1 D	1.5 V
RP130N181B	H 1 G	1.8 V
RP130N251B	H 1 Q	2.5 V
RP130N271B	H 1 S	2.7 V
RP130N281B	H 1 T	2.8 V
RP130N291B	H 1 V	2.9 V
RP130N301B	H 1 W	3.0 V
RP130N331B	H 1 Z	3.3 V
RP130N341B	J 1 A	3.4 V
RP130N451B	J 1 M	4.5 V
RP130N501B	J 1 S	5.0 V

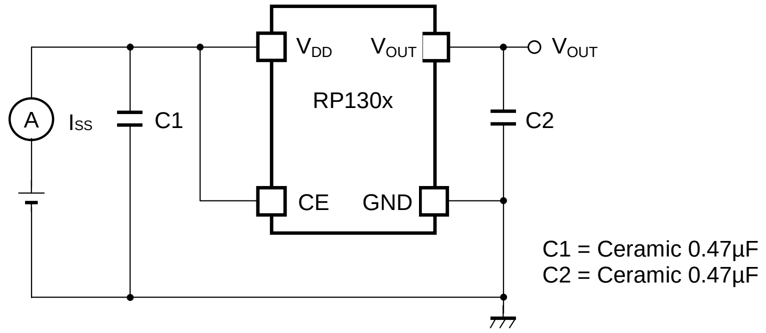
RP130Nxx1D

Product Name	①②③	V_{SET}
RP130N121D	H 2 A	1.2 V
RP130N151D	H 2 D	1.5 V
RP130N181D	H 2 G	1.8 V
RP130N251D	H 2 Q	2.5 V
RP130N271D	H 2 S	2.7 V
RP130N281D	H 2 T	2.8 V
RP130N291D	H 2 V	2.9 V
RP130N301D	H 2 W	3.0 V
RP130N331D	H 2 Z	3.3 V
RP130N341D	J 2 A	3.4 V
RP130N451D	J 2 M	4.5 V
RP130N501D	J 2 S	5.0 V

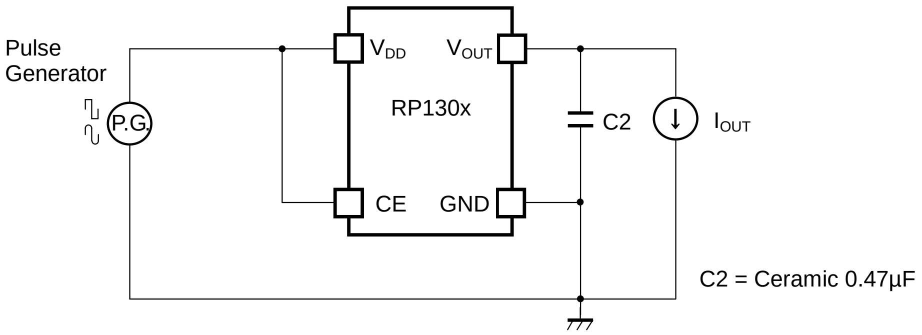
TEST CIRCUITS



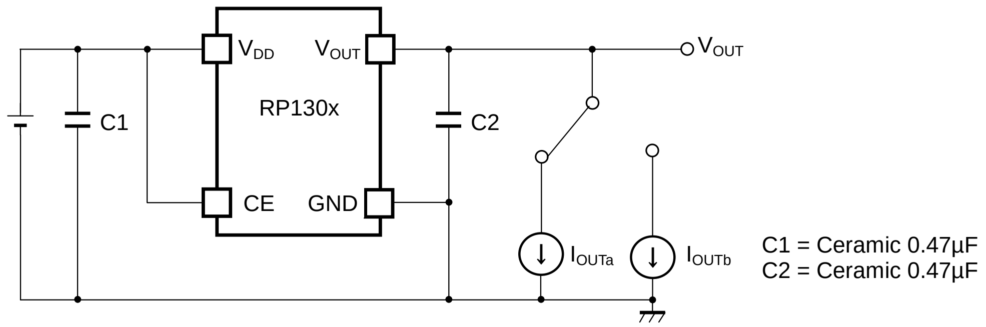
Standard Test Circuit



Supply Current Test Circuit



Ripple Rejection, Line Transient Response Test Circuit

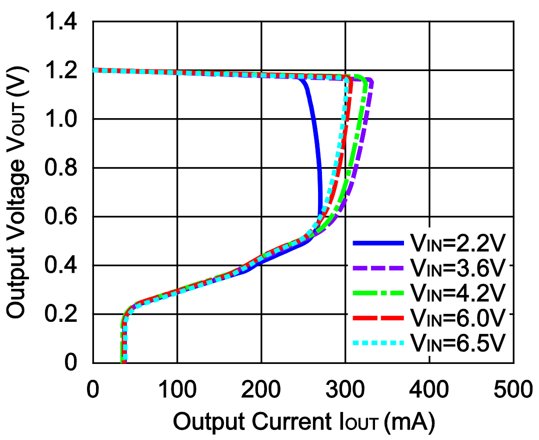


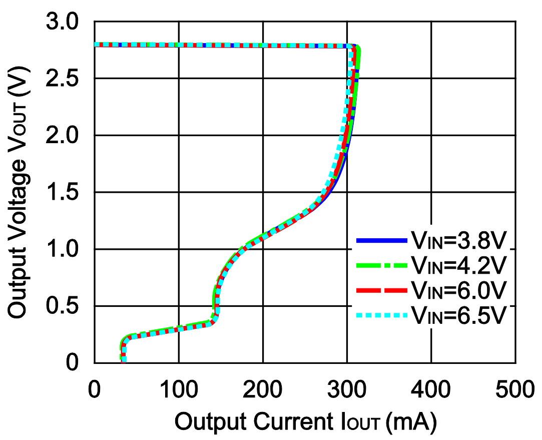
Load Transient Response Test Circuit

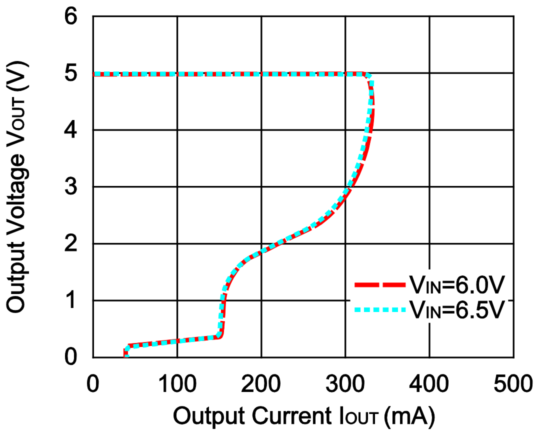
TYPICAL CHARACTERISTICS

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

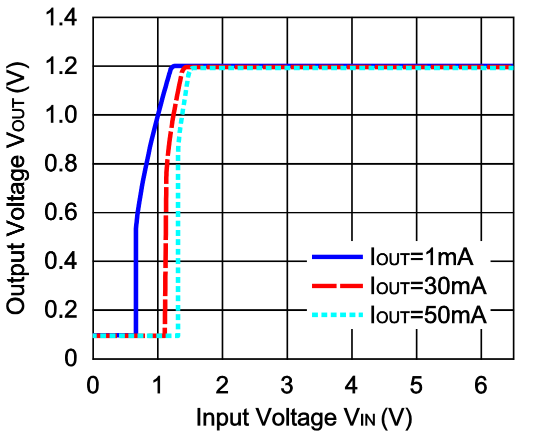
1) Output Voltage vs. Output Current (C1 = C2 = 0.47μF, Ta = 25°C)

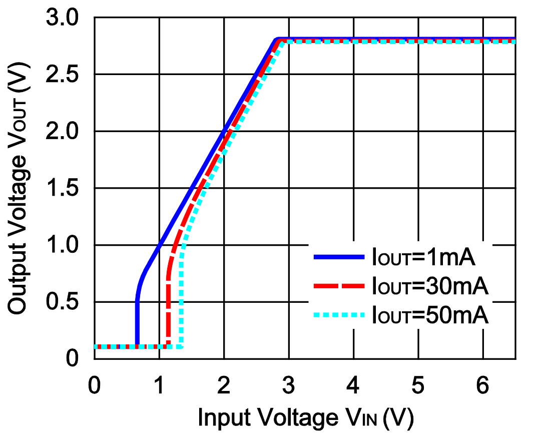


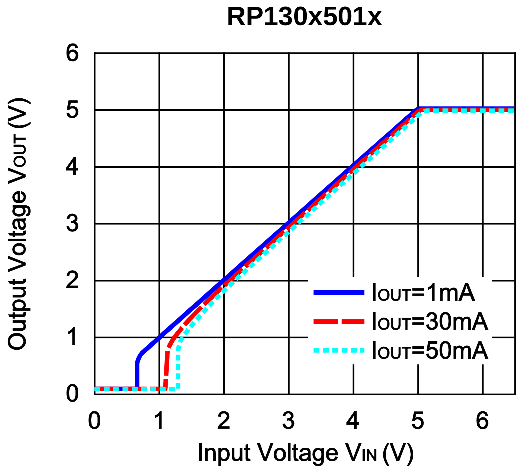




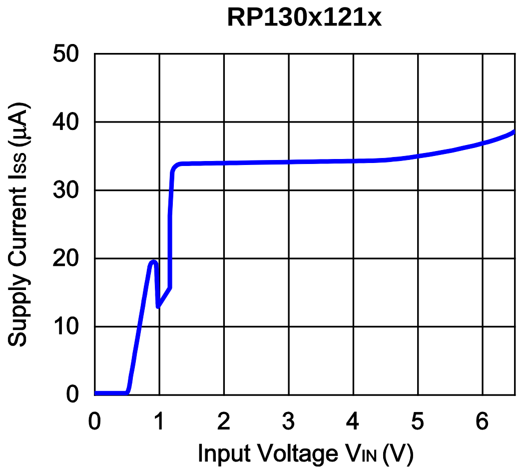
2) Output Voltage vs. Input Voltage (C1 = C2 = 0.47μF, Ta = 25°C)

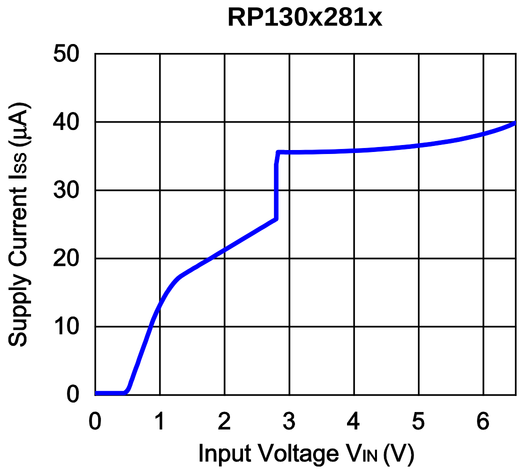


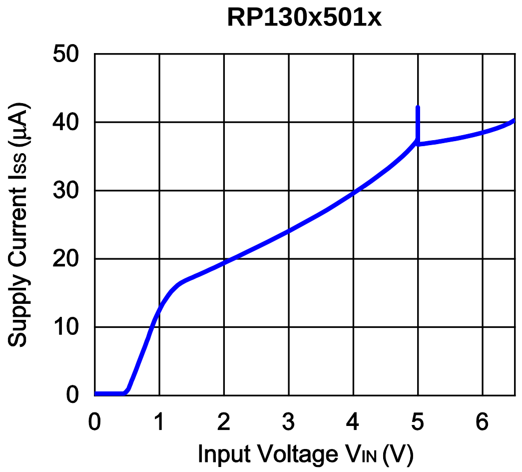




3) Supply Current vs. Input Voltage (C1 = C2 = 0.47μF, Ta = 25°C)

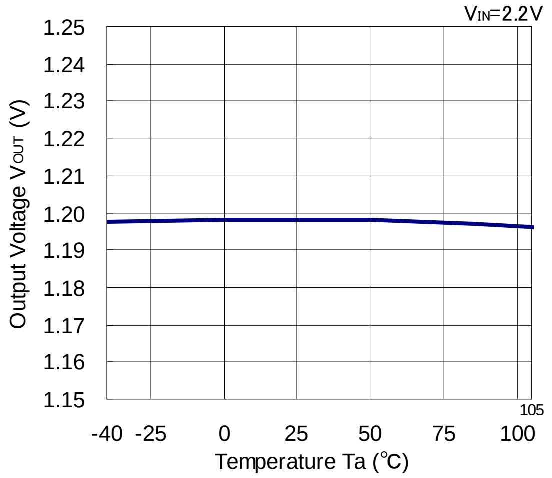




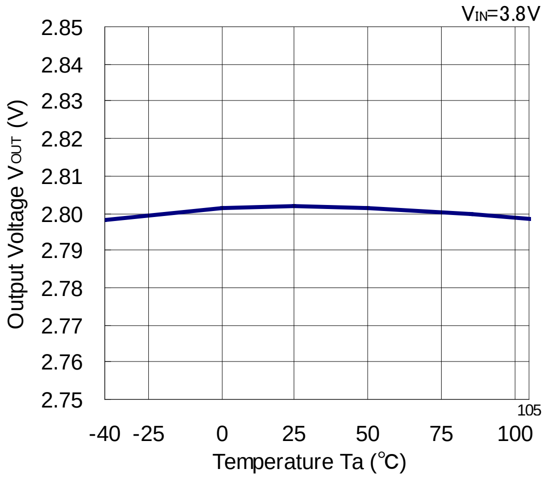


4) Output Voltage vs. Temperature (I_{OUT} = 1mA, C1 = C2 = 0.47μF)

RP130x121x



RP130x281x



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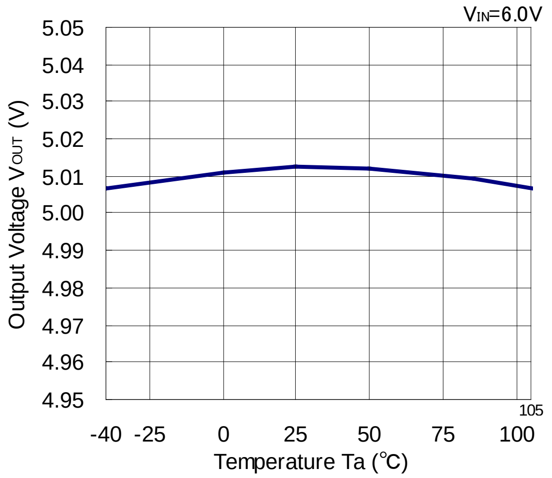
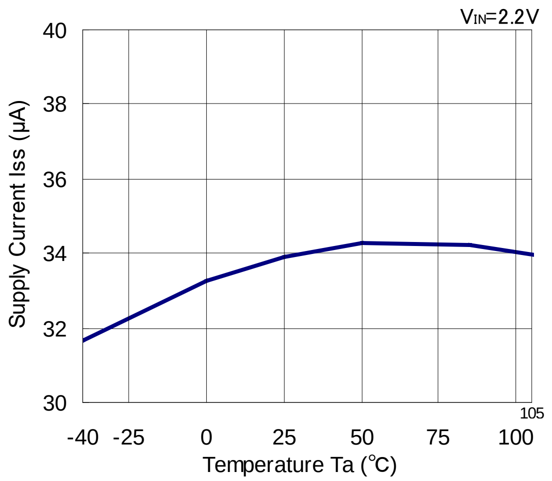


5) Supply Current vs. Temperature (I_{OUT} = 0mA, C1 = C2 = 0.47μF)

RP130x121x



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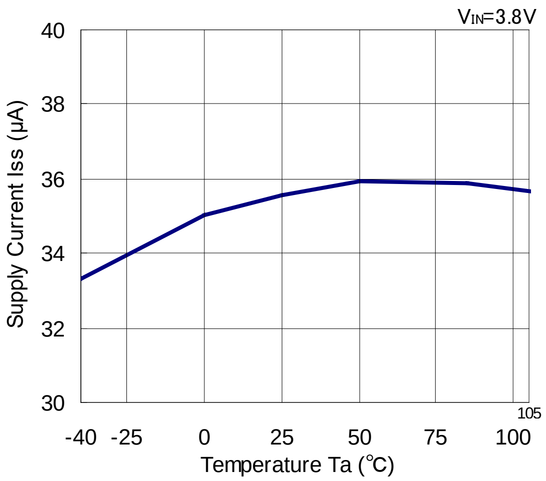
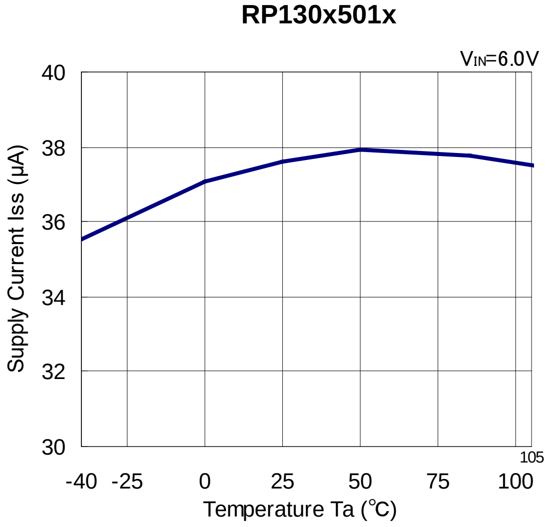
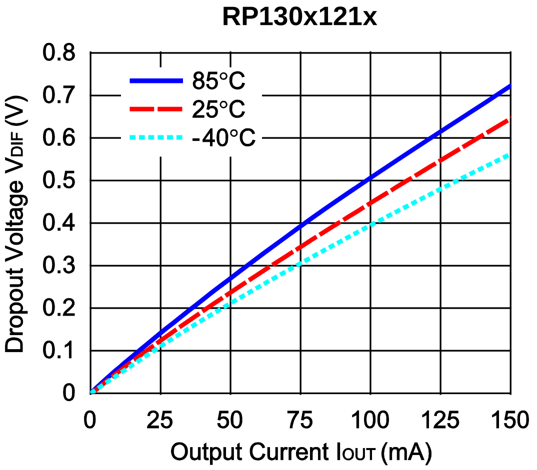
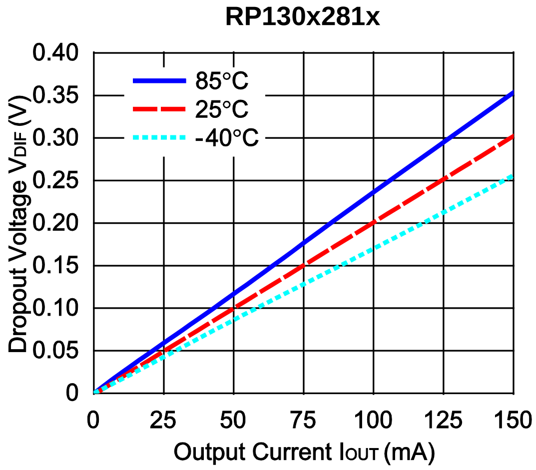
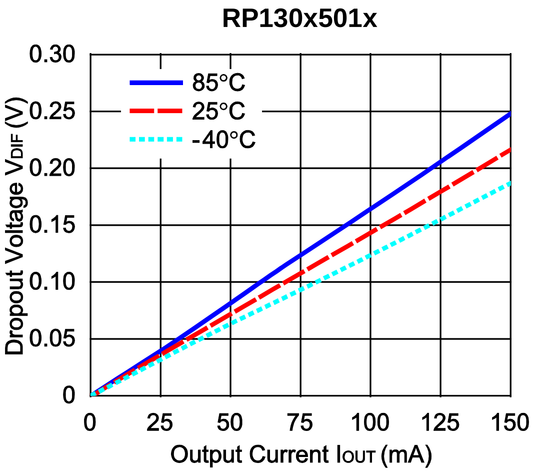




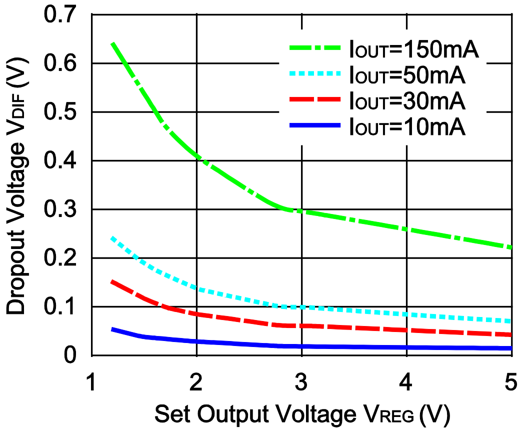
6) Dropout Voltage vs. Output Current (C1 = C2 = 0.47μF)





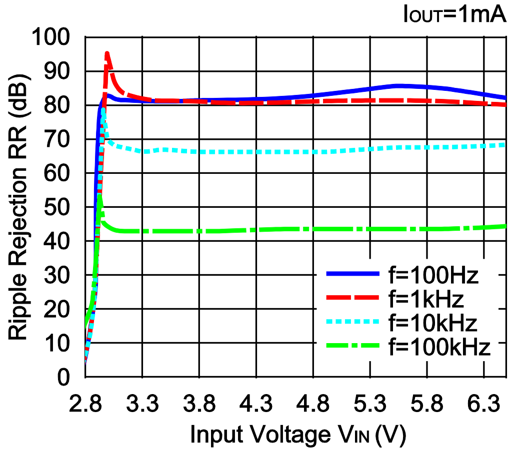


7) Dropout Voltage vs. Set Output Voltage (C1 = C2 = 0.47μF)

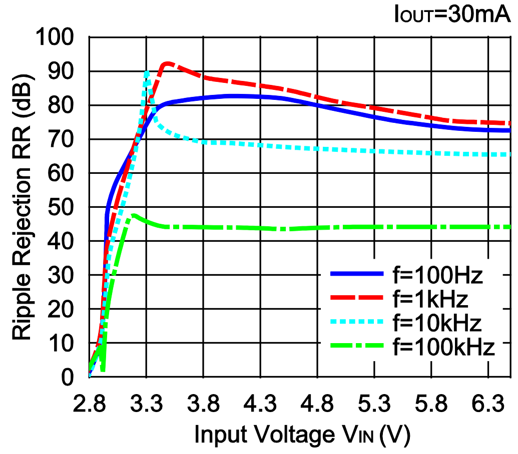


8) Ripple Rejection vs. Input Bias Voltage (C1 = none, C2 = 0.47μF, Ripple = 0.2Vp-p, Ta = 25°C)

RP130x281x

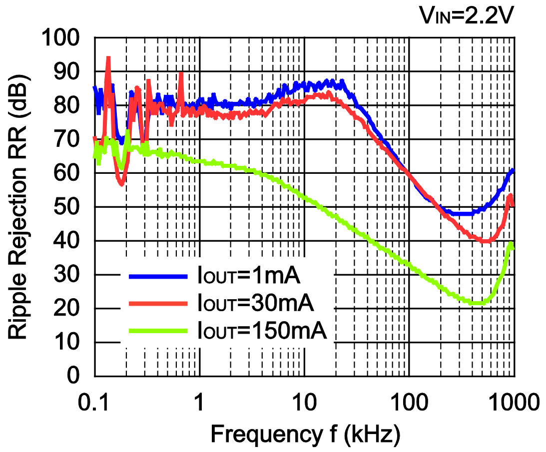


RP130x281x

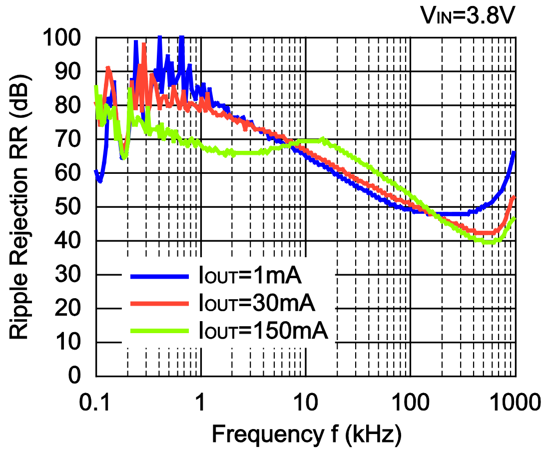


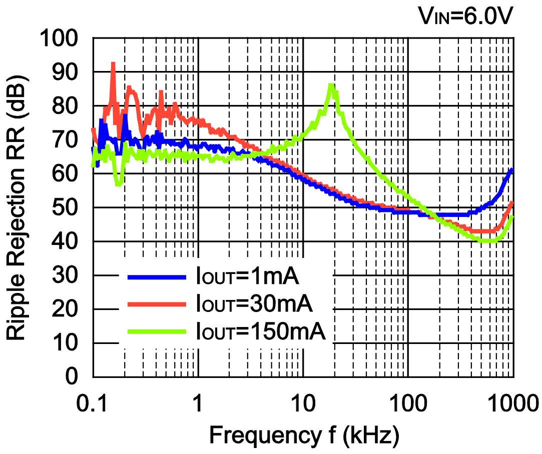
9) Ripple Rejection vs. Frequency (C1 = none, C2 = 0.47μF, Ripple = 0.2Vp-p, Ta = 25°C)

RP130x121x

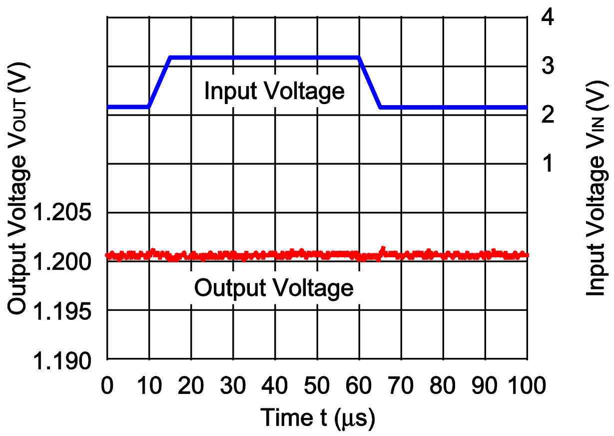


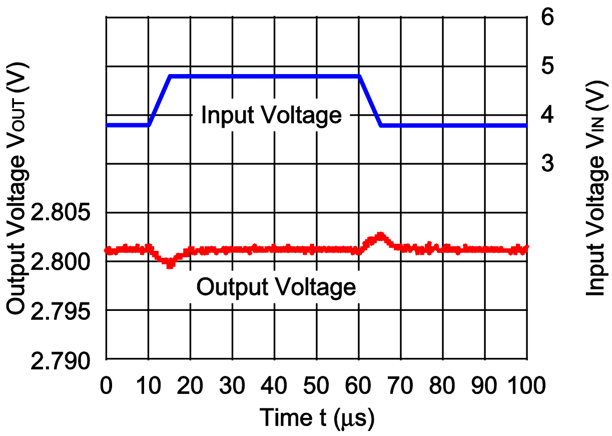
RP130x281x

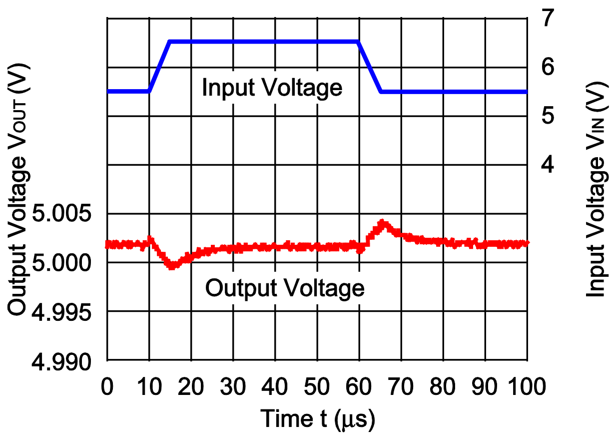




10) Input Transient Response (I_{OUT} = 30mA, tr = tf = 5μs, C1 = none, C2 = 0.47μF, Ta = 25°C)

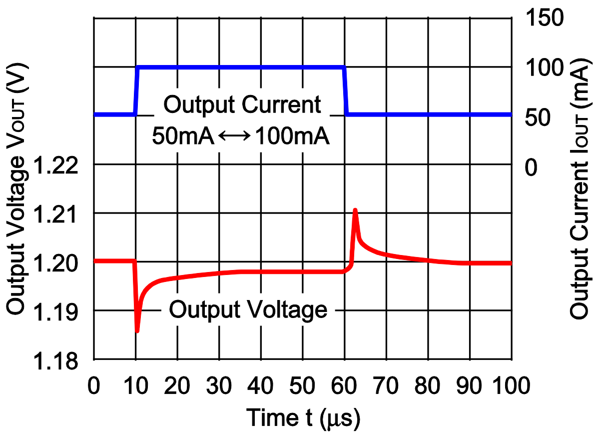




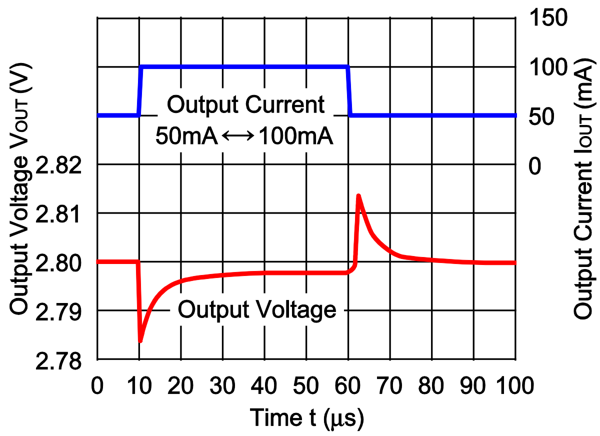


11) Load Transient Response (tr = tf = 0.5μs, C1 = C2 = 0.47μF, I_{OUT} = 50mA ⇔100mA, Ta = 25°C)

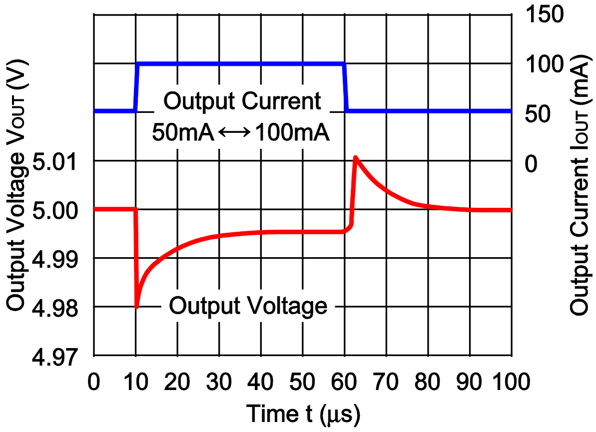
RP130x121x



RP130x281x

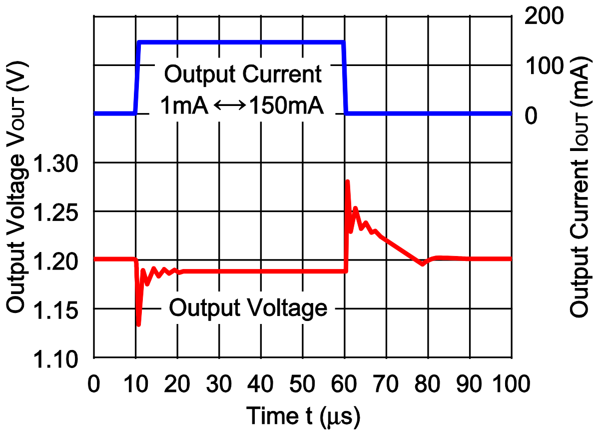


RP130x501x



12) Load Transient Response (tr = tf = 0.5μs, C1 = C2 = 0.47μF, I_{OUT} = 1mA ⇔ 150mA, Ta = 25°C)

RP130x121x



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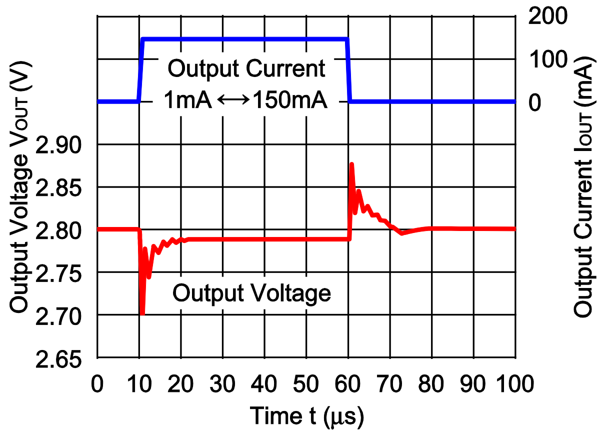

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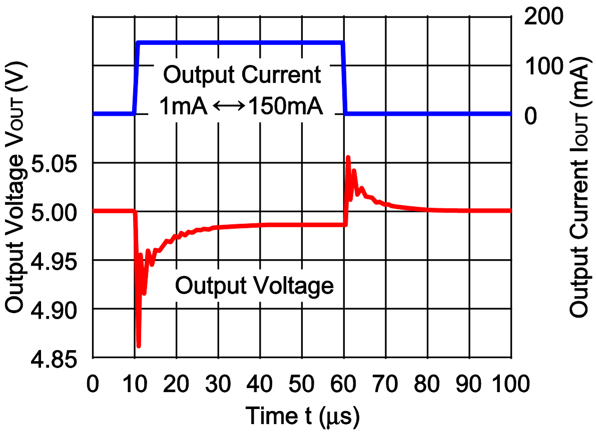
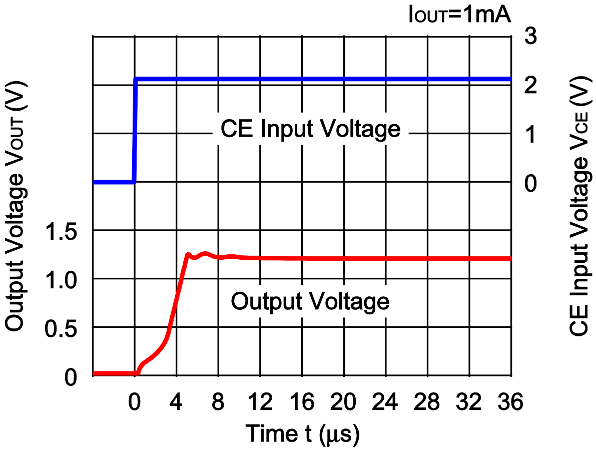
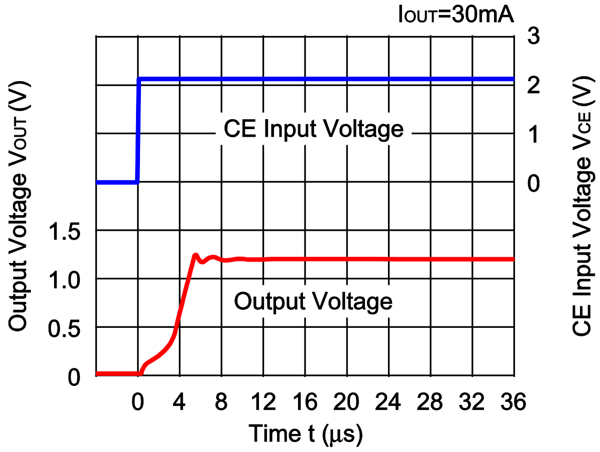


13) Rise Time with CE Pin (C1 = C2 = 0.47μF, Ta = 25°C)

RP130x121x



RP130x121x



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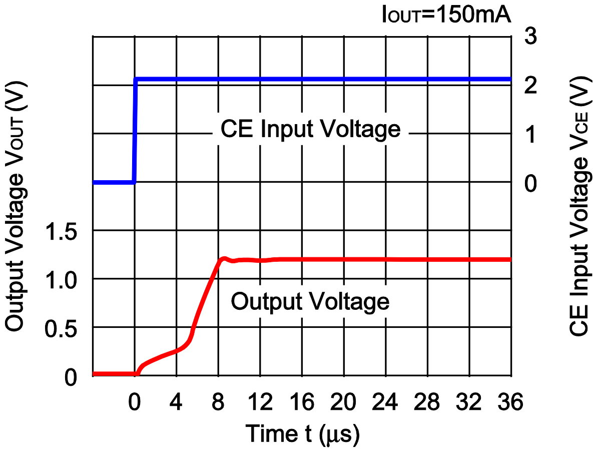

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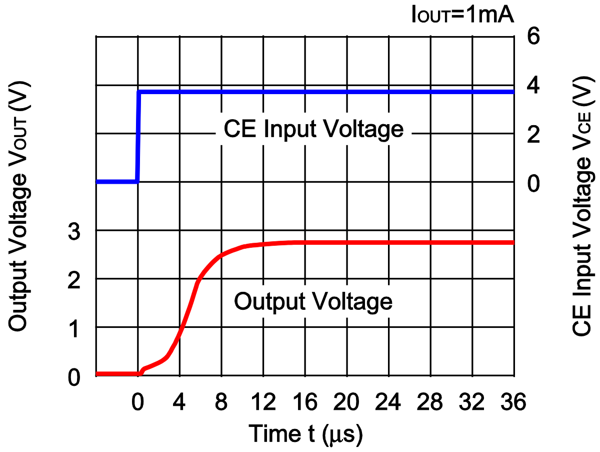

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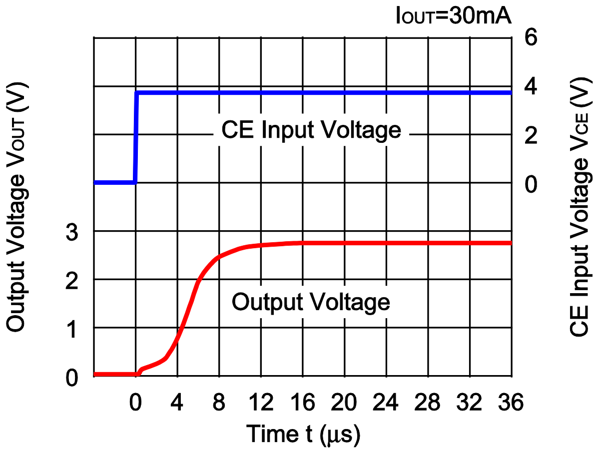

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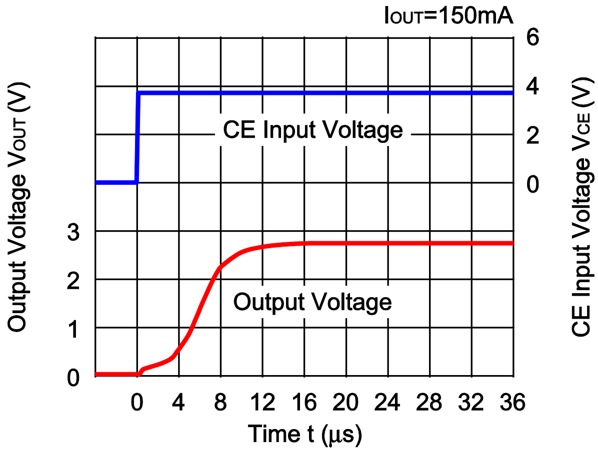

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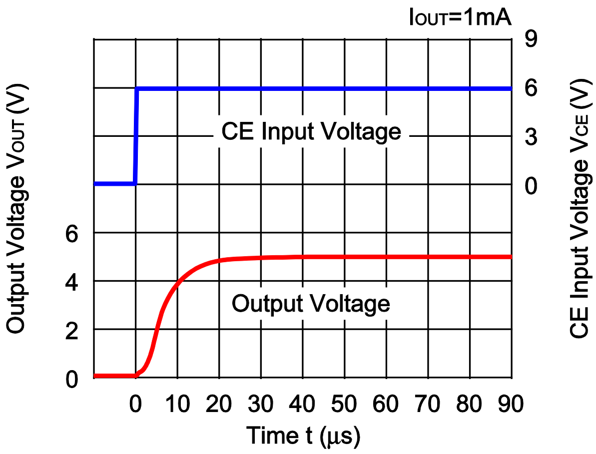

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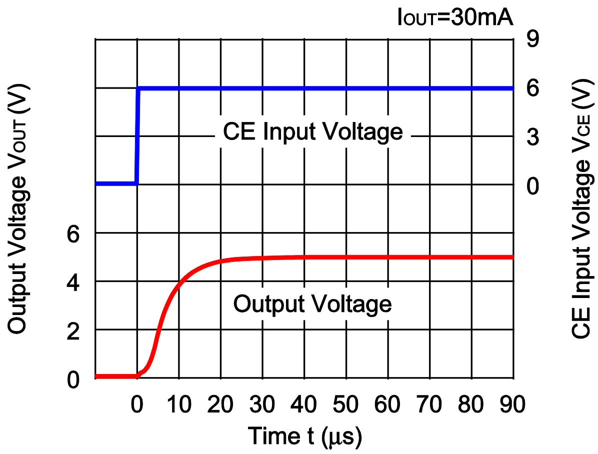
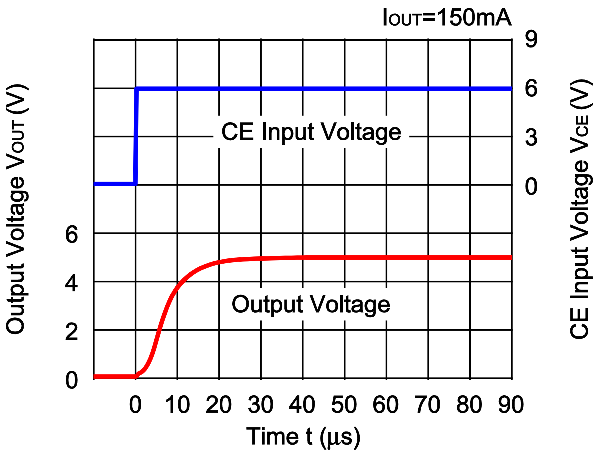
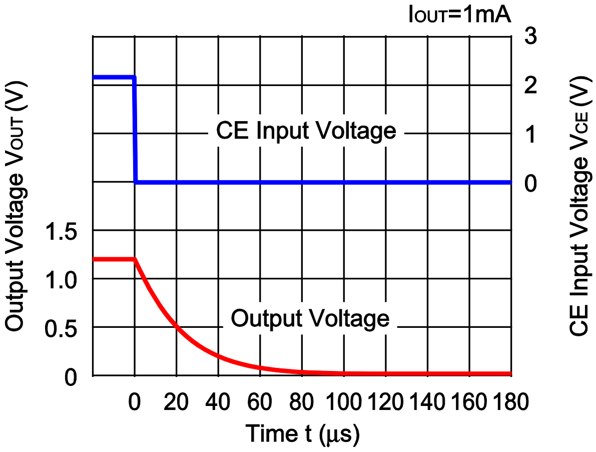


RP130x501x

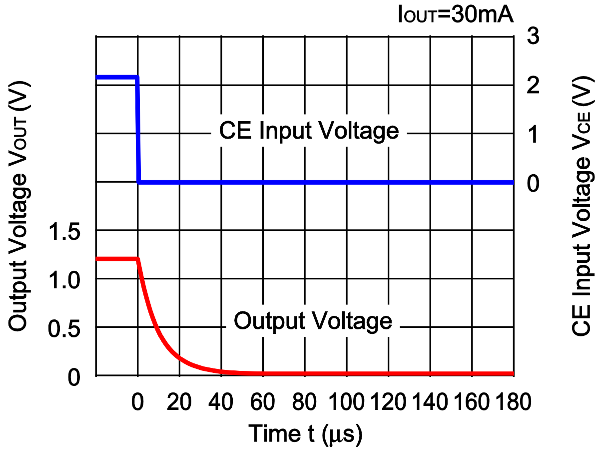


14) Fall Time with CE Pin in D-Version (C1 = C2 = 0.47μF, Ta = 25°C)

RP130x121D



RP130x121D



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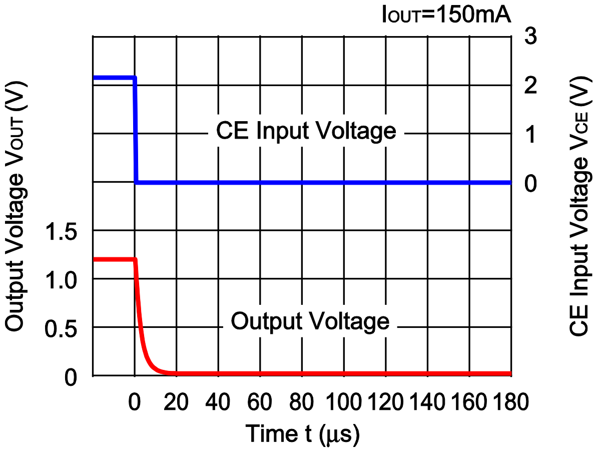

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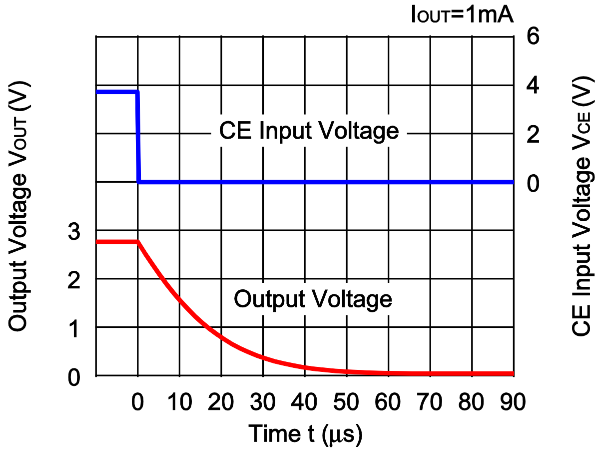
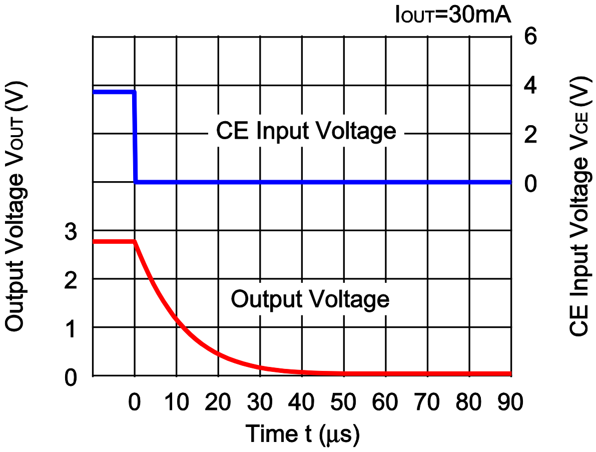


RP130x281D



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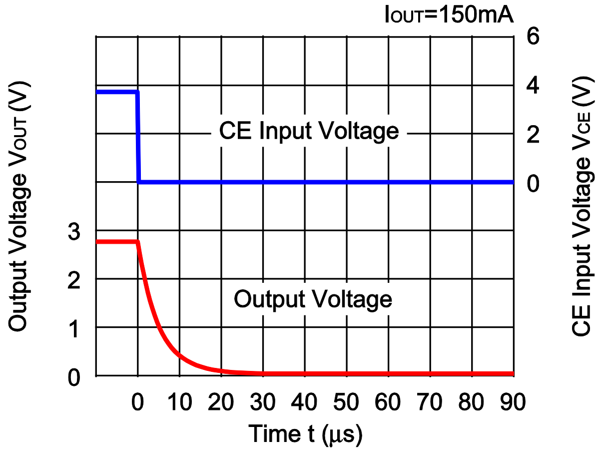
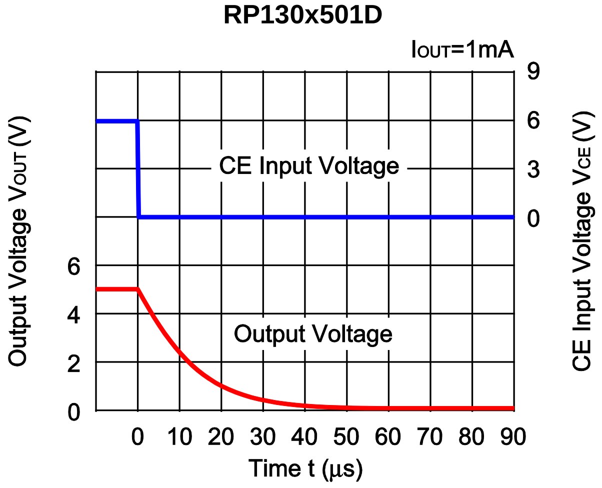
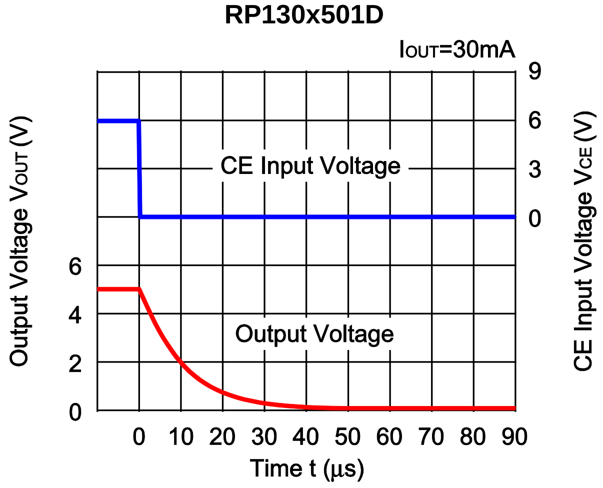
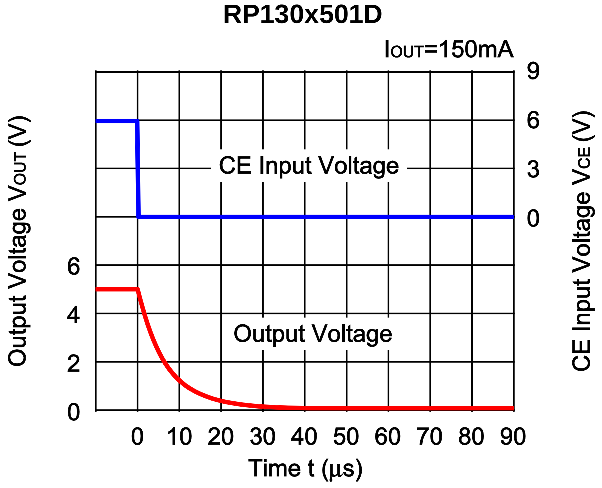
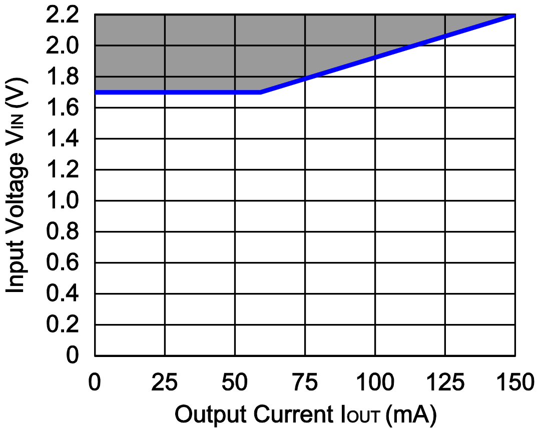








15) Minimum Operating Voltage (C1 = C2 = 0.47μF)



Hatched area is available for 1.2V output.

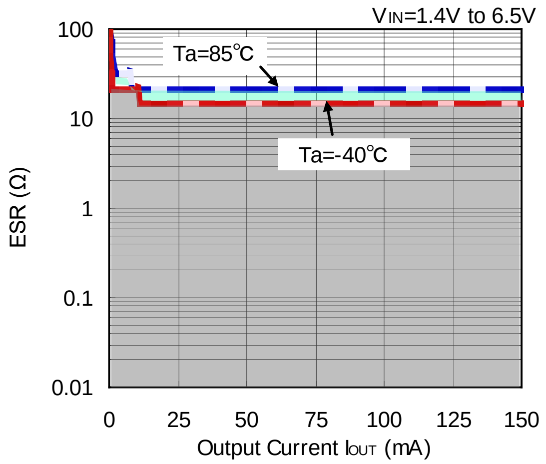
ESR vs. Output Current

The RP130x is recommended to use a ceramic type capacitor, but the RP130x can be used other capacitors of the lower ESR type. The relation between the output current (I_{OUT}) and the ESR of output capacitor is shown below.

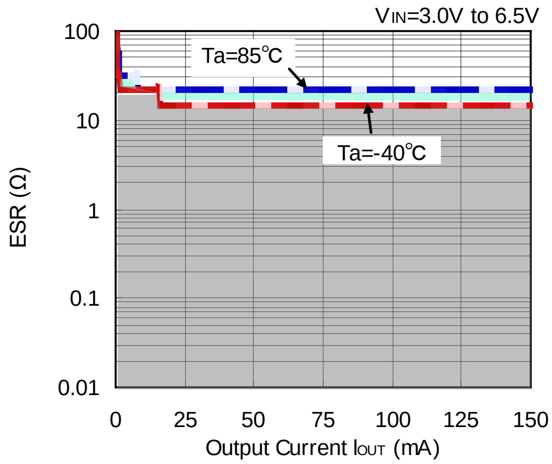
Measurement conditions

Frequency Band: 10Hz to 3MHz
Measurement Temperature: − 40°C to 85°C
Hatched area: Noise level is 40μV (average) or below
Ceramic Capacitor: C1 = Ceramic 0.47μF, C2 = 0.47μF

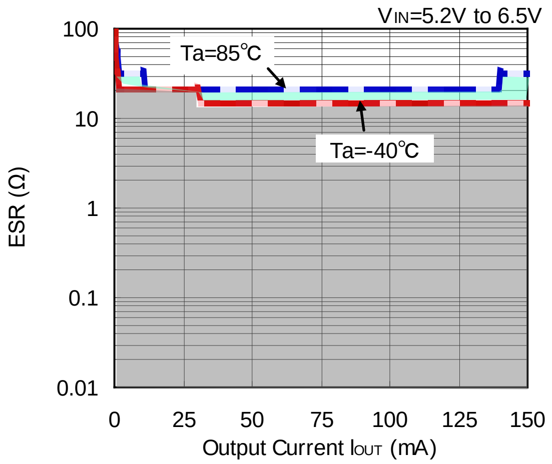
RP130x121x



RP130x281x



RP130x501x



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