
0.8%ACCURACY 0.7V OUTPUT 400mA LDO REGULATOR

NO.EA-281-111020

OUTLINE

The RP116Z Series are low voltage 400mA voltage regulator. These ICs had been further improved of low-voltage capability compared with previous low-voltage product.

The input voltage is as low as Min. 1.0V and the output voltage can be set from 0.7V. The output voltage accuracy has been improved to $\pm 0.8\%$ and due to a built-in transistor with low on-resistance of 0.55Ω (at $V_{OUT}=1.5V$).

Each of these ICs consists of a voltage reference unit, an error amplifier, a resistor-net for voltage setting, and a current limit circuits for over-current for the destruction prevention by the over-current.

The CE pin can switch the regulator to standby mode.

The RP116Z is available in the small and thin WLCSP-4-P7 package (0.69mm square, 0.36mm thickness and 0.4mm pitch), consequently providing a high density mounting.

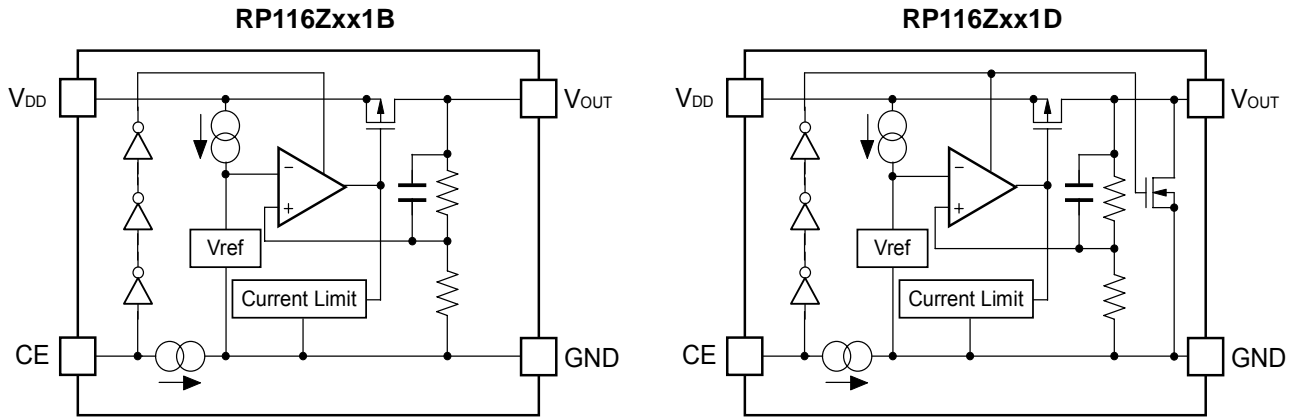
FEATURES

- Supply Current Typ. $48\mu A$
- Standby Current Typ. $0.1\mu A$
- Ripple Rejection Typ. 60dB ($f=10kHz$)
- Input Voltage Range 1.0V to 3.6V
- Output Voltage Range 0.7V to 1.8V (0.1V steps)
(For other voltages, please refer to MARK INFORMATION.)
- Output Voltage Accuracy $\pm 0.8\%$ ($V_{OUT}\geq 1.0V$, $T_{opt}=25^{\circ}C$)
- Temperature-Drift Coefficient of Output Voltage ... Typ. $\pm 60ppm/^{\circ}C$
- Dropout Voltage Typ. 0.22V ($V_{OUT}=1.5V$)
- Line Regulation Typ. 0.10%/V
- Package WLCSP-4-P7
- Built-in Fold Back Protection Circuit Typ. 110mA (Current at short mode)
- Built-in Constant Slope Circuit
- Ceramic capacitors are recommended to be used with this IC $1.0\mu F$ or more

APPLICATIONS

- Power source for portable communication equipment.
- Power source for electrical appliances such as cameras, VCRs and camcorders.
- Power source for battery-powered equipment.

BLOCK DIAGRAMS



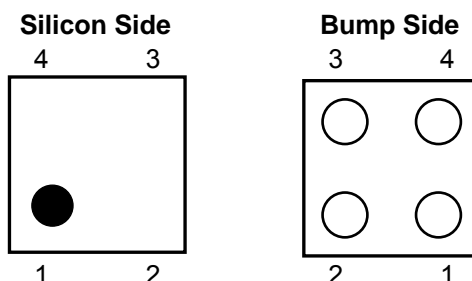
SELECTION GUIDE

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

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP116Zxx1*-TR-F	WLCSP-4-P7	5,000 pcs	Yes	Yes
xx: The output voltage can be designated in the range from 0.7V(07) to 1.8V(18) in 0.1V steps. (For other voltages, please refer to MARK INFORMATIONS.)				
* : CE pin polarity and auto discharge function at off state are options as follows. (B) without auto discharge function at off state (D) with auto discharge function at off state				

PIN CONFIGURATIONS

• WLCSP-4-P7



PIN DESCRIPTIONS

• WLCSP-4-P7

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

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	4.0	V
V_{CE}	Input Voltage (CE Pin)	-0.3 to 4.0	V
V_{OUT}	Output Voltage	-0.3 to $V_{IN}+0.3$	V
I_{OUT}	Output Current	500	mA
P_D	Power Dissipation (WLCSP-4-P7)*	278	mW
T_{opt}	Operating Temperature Range	-40 to 85	°C
T_{stg}	Storage Temperature Range	-55 to 125	°C

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

ABSOLUTE MAXIMUM RATINGS

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

ELECTRICAL CHARACTERISTICS

• RP116Z

$V_{IN} = \text{Set } V_{OUT} + 1V$, $I_{OUT} = 1mA$, $C_{IN} = C_{OUT} = 1\mu F$, unless otherwise noted.

The specification in is checked and guaranteed by design engineering at $-40^{\circ}C \leq T_{opt} \leq 85^{\circ}C$.

$T_{opt} = 25^{\circ}C$

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V_{OUT}	Output Voltage	$T_{opt} = 25^{\circ}C$	$V_{OUT} \geq 1.0V$	$\times 0.992$	$\times 1.008$	V	
			$V_{OUT} < 1.0V$	-8	8	mV	
		$-40^{\circ}C \leq T_{opt} \leq 85^{\circ}C$	$V_{OUT} \geq 1.0V$	×0.983		×1.017	V
			$V_{OUT} < 1.0V$	-17		17	mV
I_{OUT}	Output Current		400			mA	
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$1mA \leq I_{OUT} \leq 400mA$		25	45	mV	
V_{DIF}	Dropout Voltage	Refer to the following table					
I_{SS}	Supply Current	$I_{OUT} = 0mA$		48	75	μA	
$I_{standby}$	Standby Current	$V_{CE} = 0V$		0.1	8.0	μA	
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	Set $V_{OUT} + 0.5V \leq V_{IN} \leq 3.6V$ In case that Set $V_{OUT} < 0.8V$, $1.3V \leq V_{IN} \leq 3.6V$		0.10	0.25	%/V	
RR	Ripple Rejection	$f = 10kHz$, Ripple 0.2Vp-p $V_{IN} = \text{Set } V_{OUT} + 1V$, $I_{OUT} = 30mA$		60		dB	
V_{IN}	Input Voltage*		1.0		3.6	V	
$\Delta V_{OUT}/\Delta T_{opt}$	Output Voltage Temperature Coefficient	$-40^{\circ}C \leq T_{opt} \leq 85^{\circ}C$		± 60		ppm/ $^{\circ}C$	
I_{SC}	Short Current Limit	$V_{OUT} = 0V$		110		mA	
V_{CEH}	CE Input Voltage "H"		0.9			V	
V_{CEL}	CE Input Voltage "L"				0.4	V	
en	Output Noise	BW=10Hz to 100kHz $I_{OUT} = 30mA$, $V_{OUT} = 0.7V$		30		μV_{rms}	
R_{LOW}	Low Output Nch Tr. ON Resistance (of D version)	$V_{IN} = 2.0V$, $V_{CE} = 0V$		43		Ω	

All of units are tested and specified under load conditions such that $T_j \approx T_{opt} = 25^{\circ}C$ except for Output Noise, Ripple Rejection, Output Voltage Temperature Coefficient.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

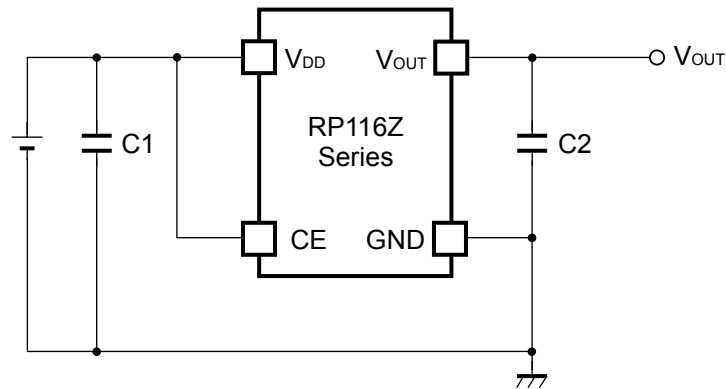
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic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

• Dropout Voltage by Output Voltage
 $T_{opt}=25^{\circ}\text{C}$

Output Voltage V_{OUT} (V)	Dropout Voltage V_{DIF} (V)		
	Condition	Typ.	Max.
$0.7 \leq V_{OUT} < 0.8$	$I_{OUT}=400\text{mA}$	0.48	0.62
$0.8 \leq V_{OUT} < 0.9$		0.40	0.54
$0.9 \leq V_{OUT} < 1.0$		0.36	0.47
$1.0 \leq V_{OUT} < 1.2$		0.32	0.45
$1.2 \leq V_{OUT} < 1.5$		0.28	0.38
$1.5 \leq V_{OUT}$		0.22	0.31

The specification in is checked and guaranteed by design engineering at $-40^{\circ}\text{C} \leq T_{opt} \leq 85^{\circ}\text{C}$.

TYPICAL APPLICATION



(External Components)

C1, C2 Ceramic 1.0 μ F MURATA: GRM155B31A105KE15

TECHNICAL NOTES

When using these ICs, consider the following points:

Phase Compensation

In these ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, use a capacitor C2 with 1.0 μ F 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 high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as 1.0 μ F or more between V_{DD} and GND pin, and as close as possible to the pins.

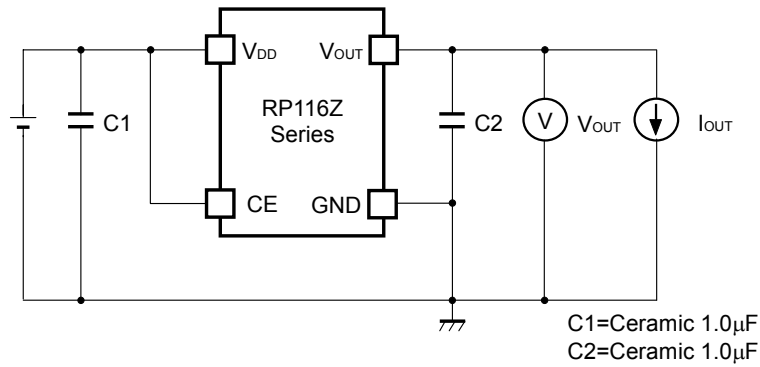
Set external components, especially the output capacitor C2, as close as possible to the ICs, and make wiring as short as possible.

Impedance of Input pin

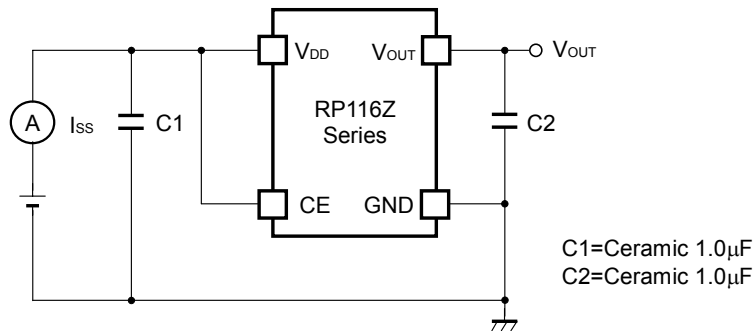
CE pull-down constant current circuit is built in the RP116Z.

However, if the CE pin is floating and the wiring is long, the malfunction may occur by noise. Therefore, fully evaluation on the actual PCB is necessary.

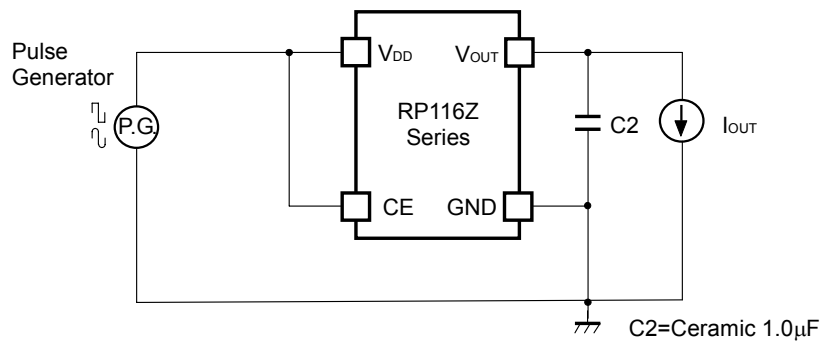
TEST CIRCUITS



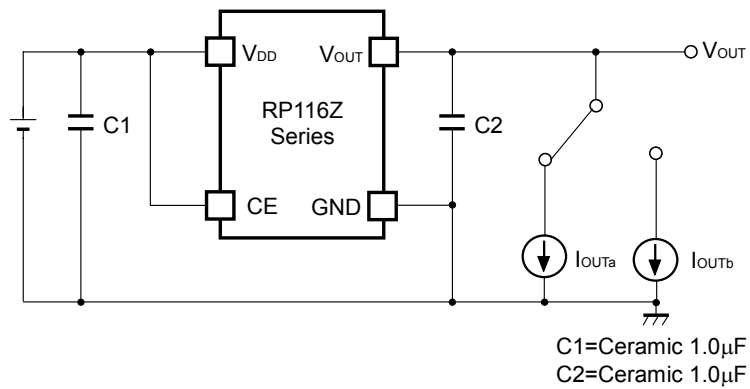
Basic Test Circuit



Supply Current Test Circuit



Ripple Rejection Test Circuit



Load Transient Response Test Circuit

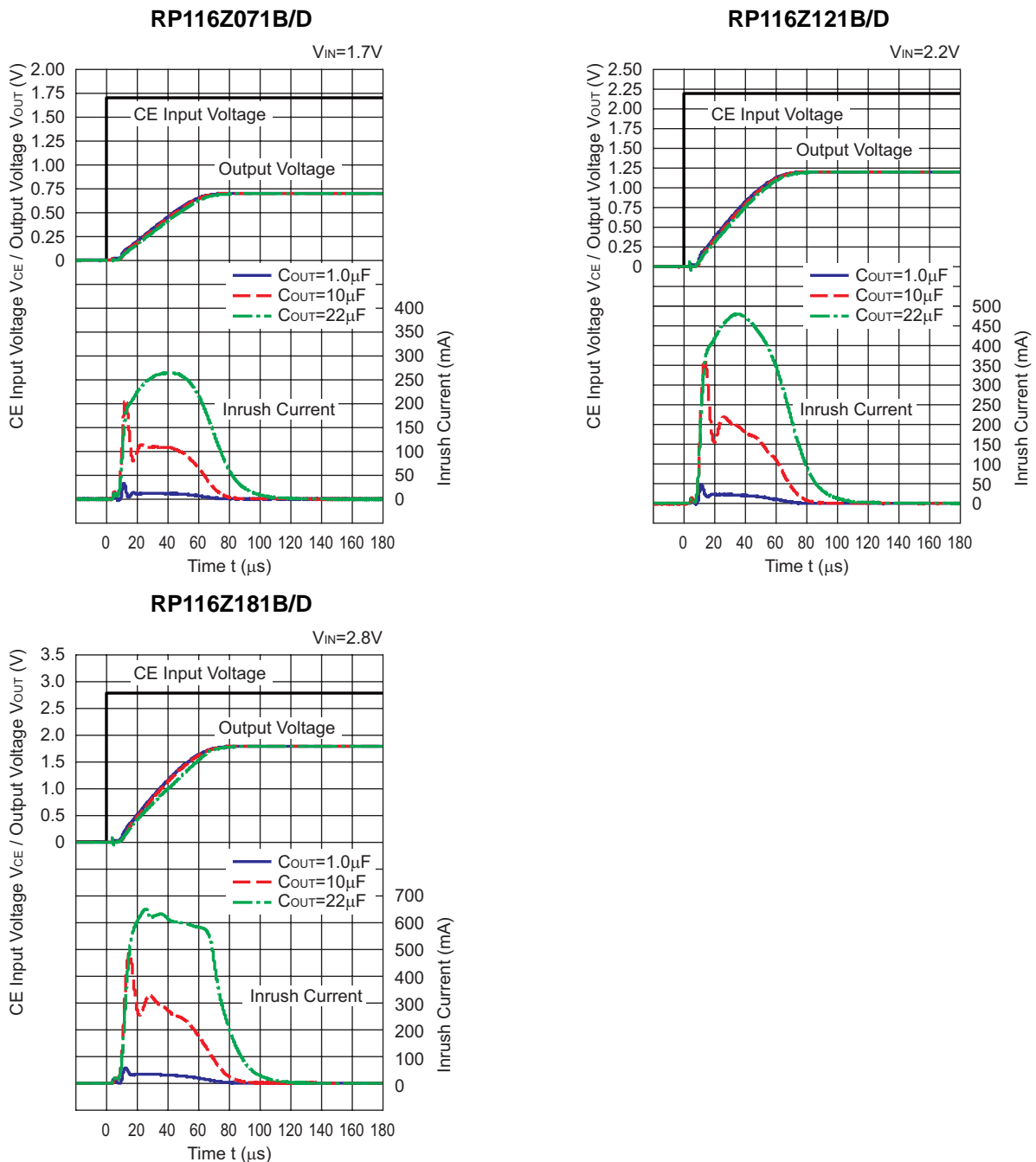
■ Constant Slope Circuits

The RP116Z Series is equipped with a constant slope circuit as a soft-start circuit, which allows the output voltage to start up gradually when the CE is turned on.

The constant slope circuit minimizes the inrush current at the start-up and also prevents the overshoot of the output voltage.

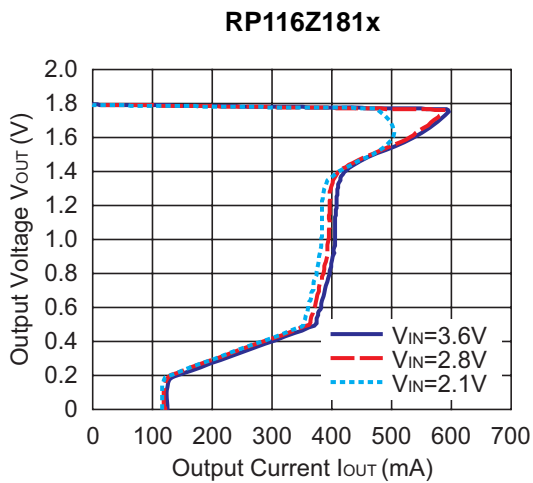
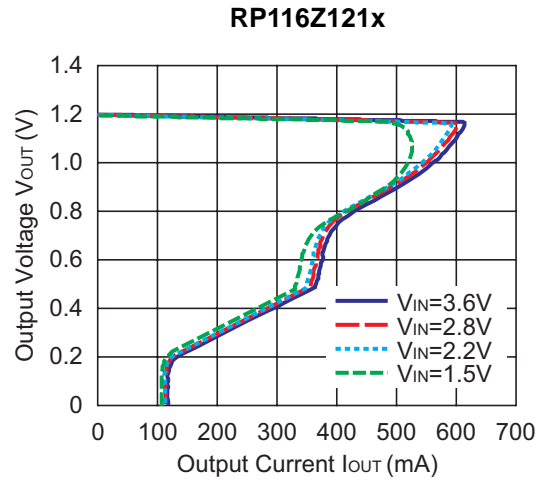
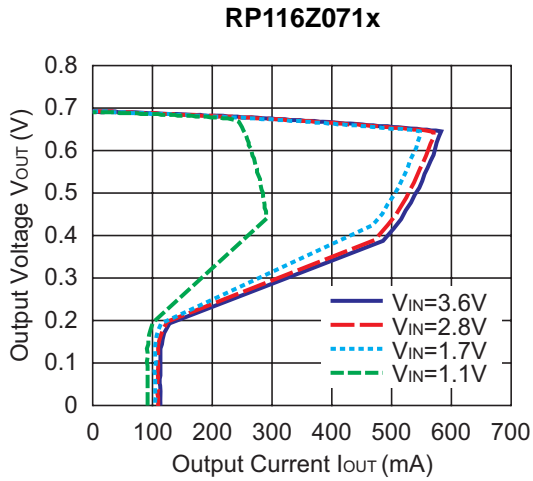
The capacitor to create the start-up slope is built in the IC that does not require any external components. The start-up time and the start-up slope angle are fixed inside the IC. For more details, please refer to the graph 15 of “Inrush Current Characteristics Example”.

Inrush Current Characteristics Example (C₁=1.0μF, T_{opt}=25°C)

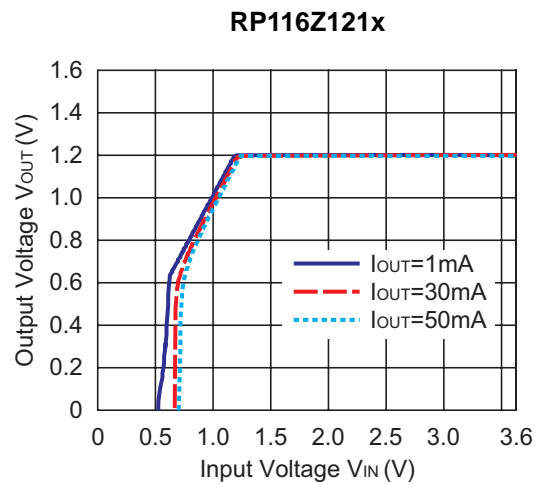
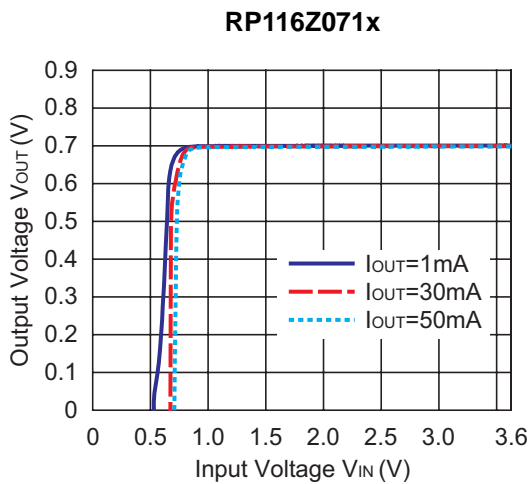


TYPICAL CHARACTERISTICS

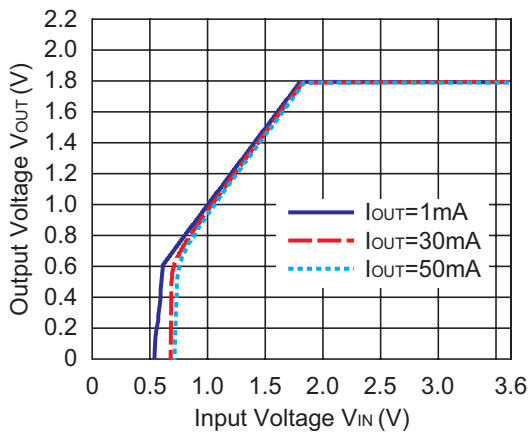
1) Output Voltage vs. Output Current ($T_{opt}=25^{\circ}C$)



2) Output Voltage vs. Input Voltage ($T_{opt}=25^{\circ}C$)

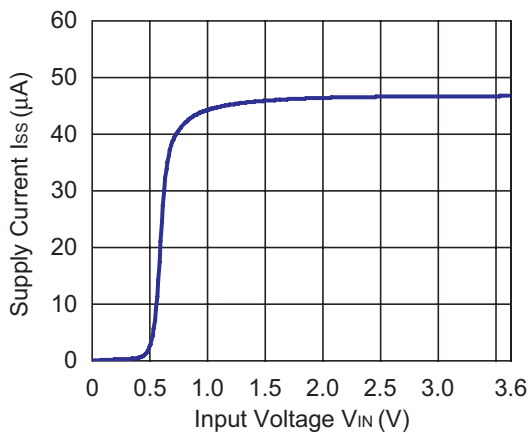


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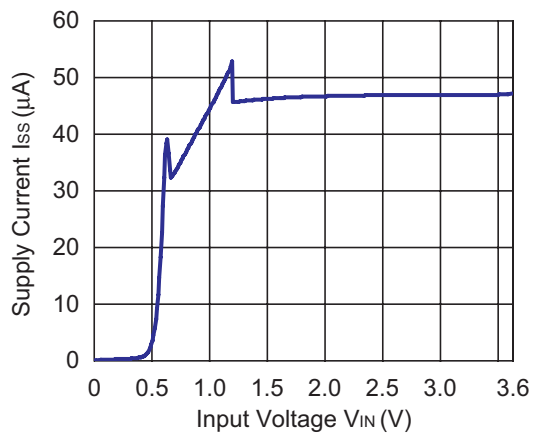


3) Supply Current vs. Input Voltage ($T_{opt}=25^{\circ}C$)

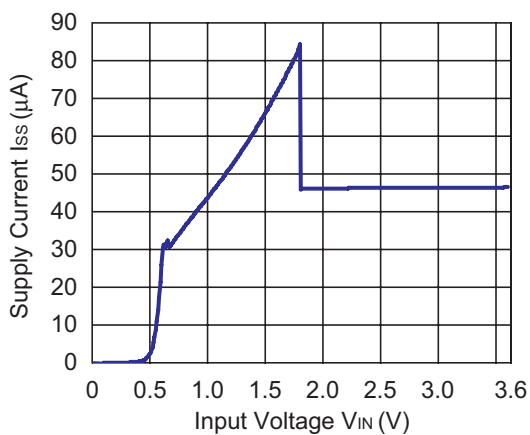
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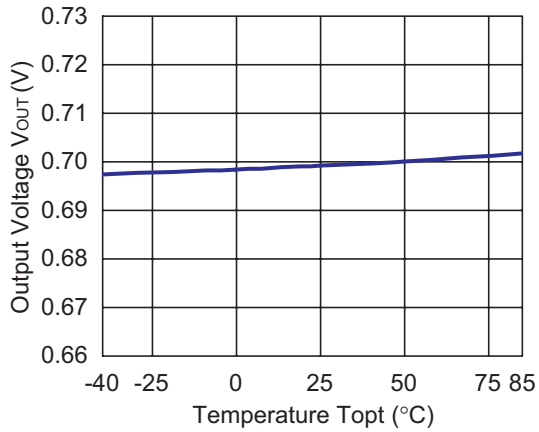


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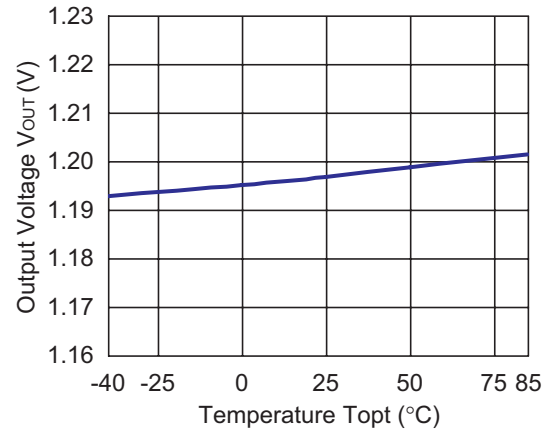


4) Output Voltage vs. Temperature

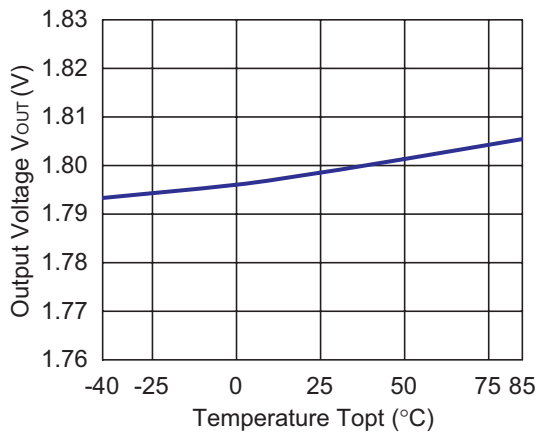
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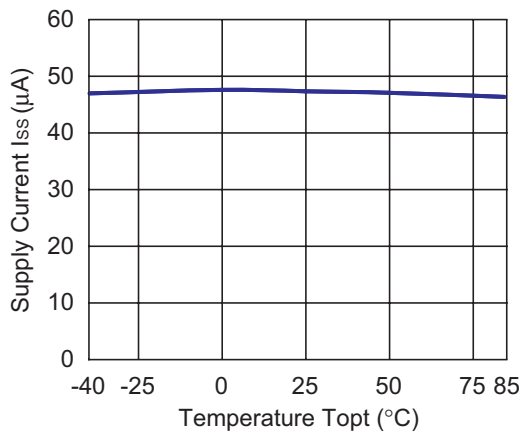


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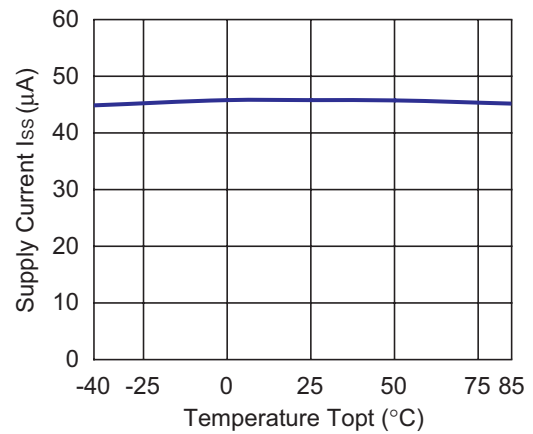


5) Supply Current vs. Temperature

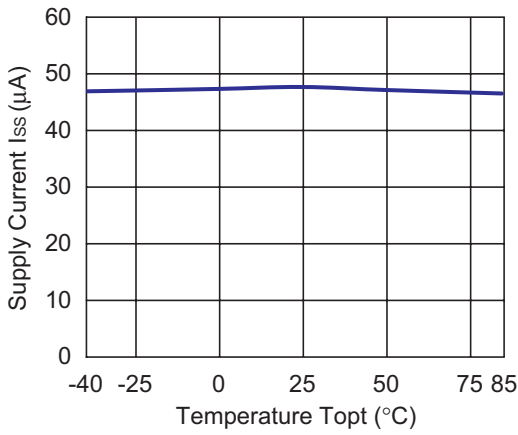
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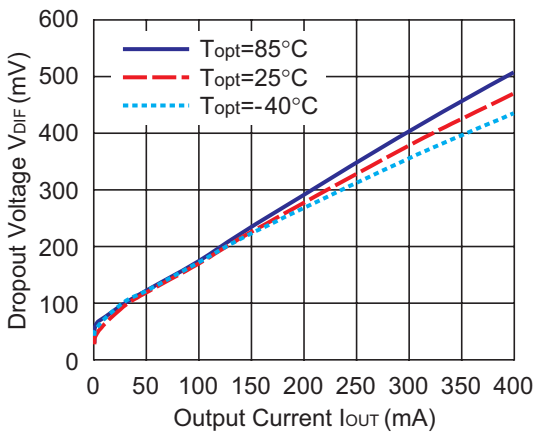


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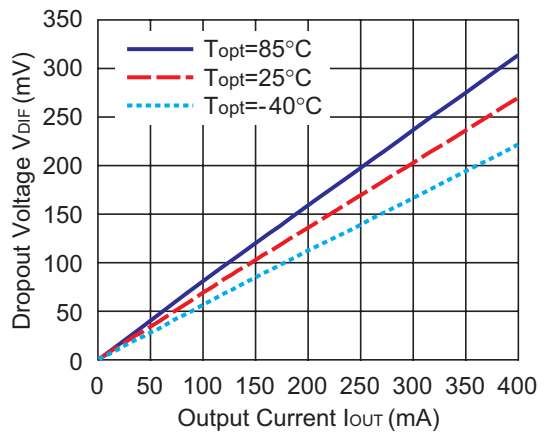


6) Dropout Voltage vs. Output Current

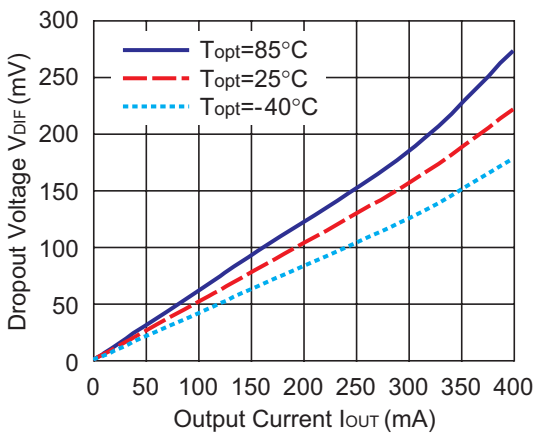
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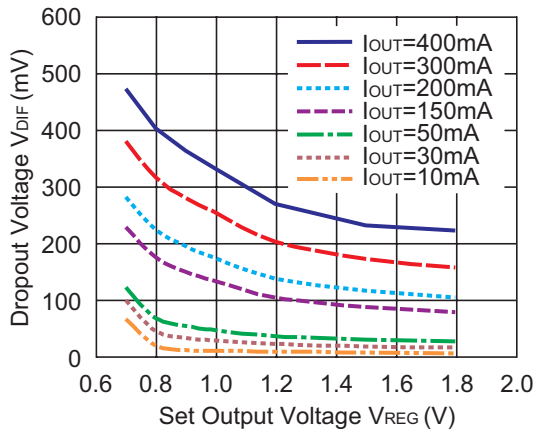
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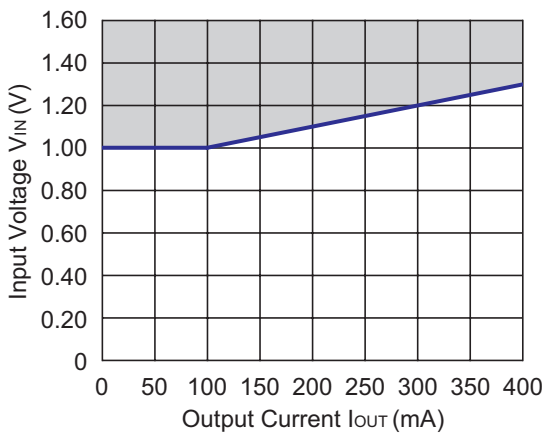


7) Dropout Voltage vs Set Output Voltage ($T_{opt}=25^{\circ}C$)



8) Minimum Operating Voltage

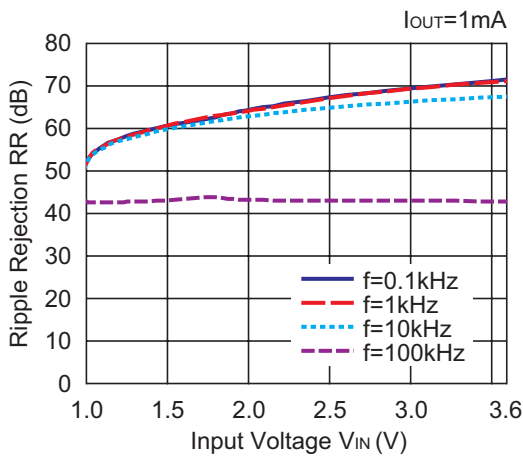
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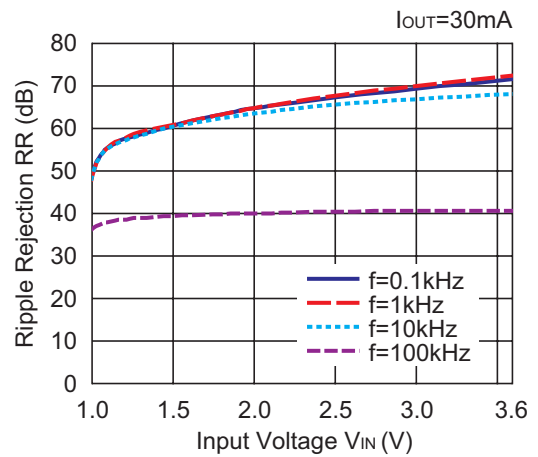
Hatched area is available for 0.7V output

9) Ripple Rejection vs. Input Bias Voltage ($C_1=none, C_2=1.0\mu F, Ripple=0.2Vp-p, T_{opt}=25^{\circ}C$)

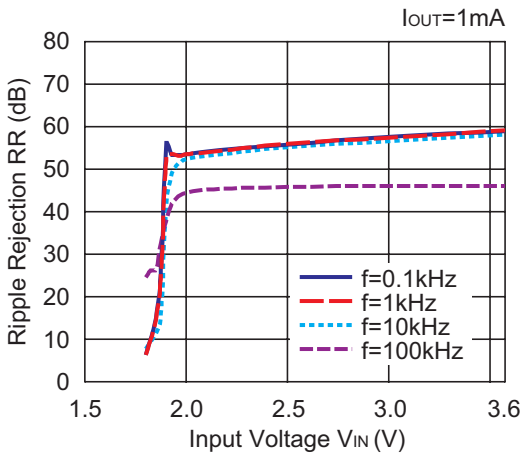
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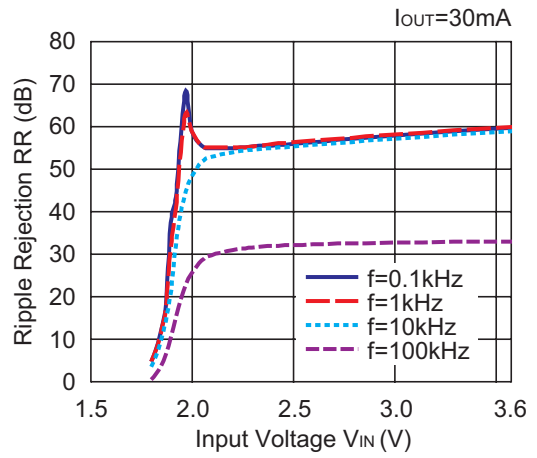
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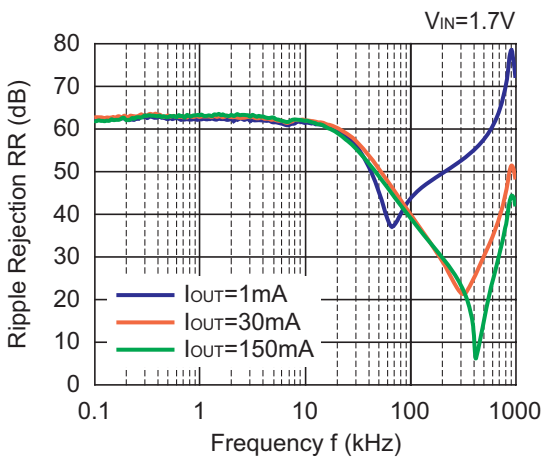


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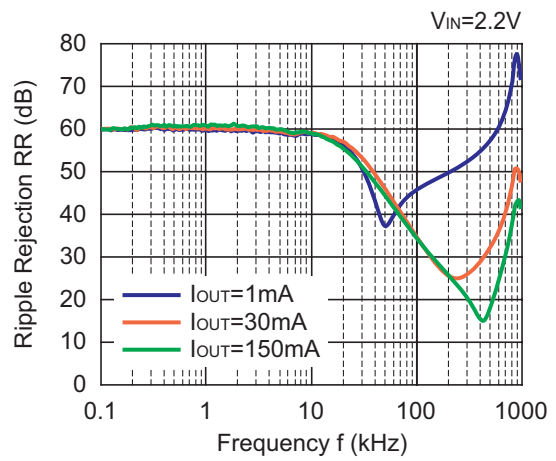


10) Ripple Rejection vs. Frequency (C1=none, C2=1.0μF, Ripple=0.1Vp-p, T_{opt}=25°C)

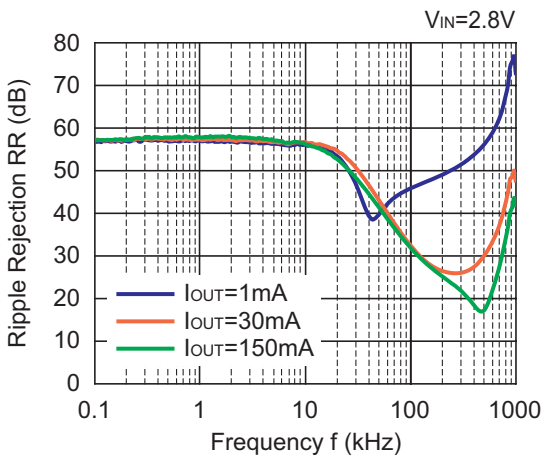
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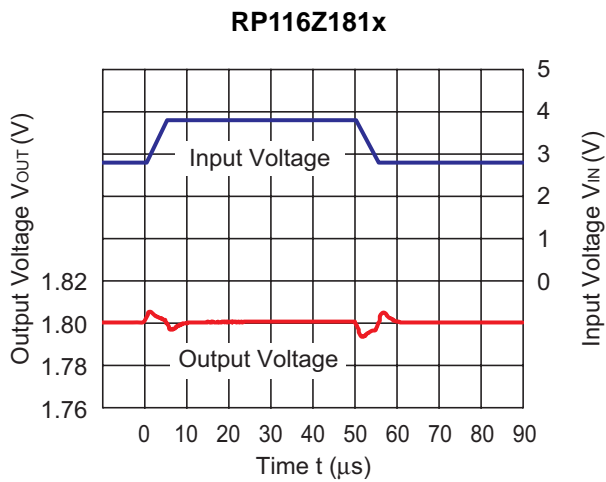
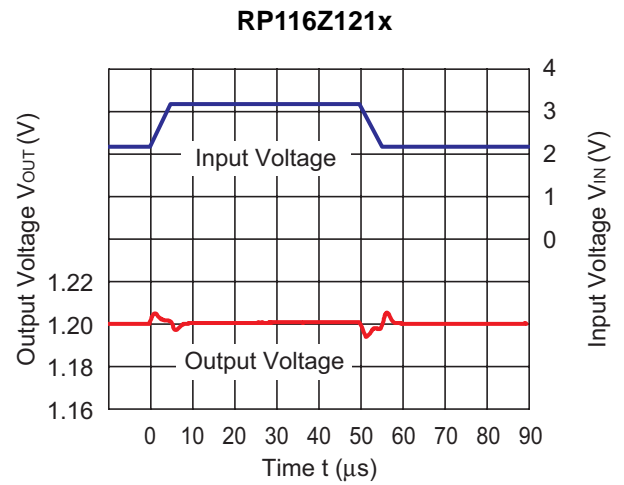
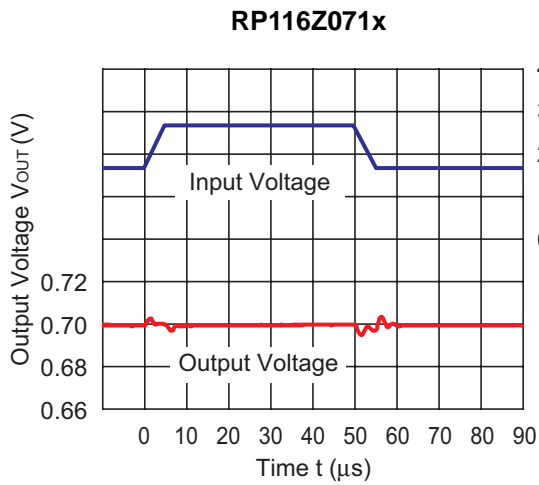
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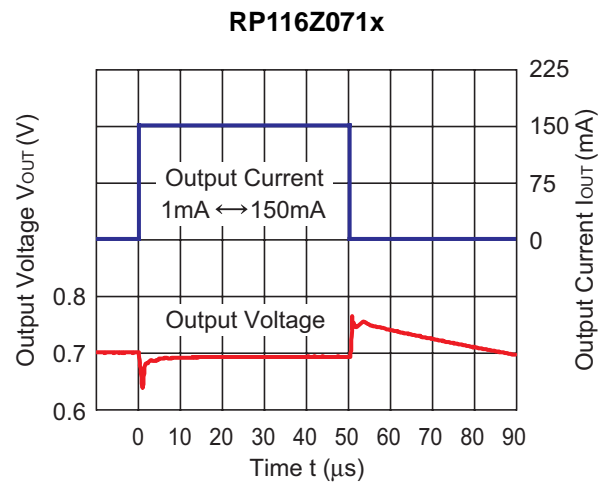
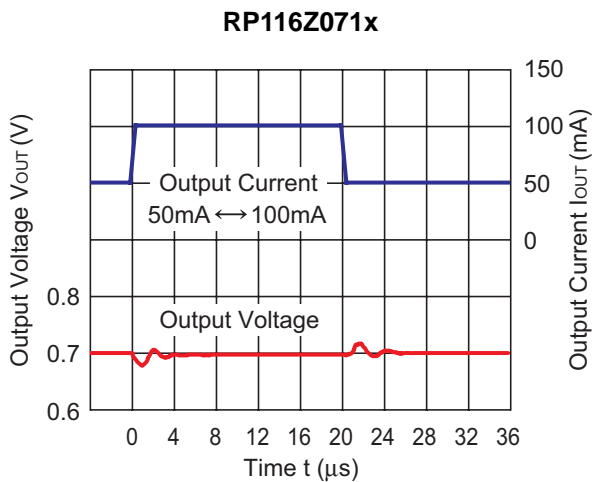
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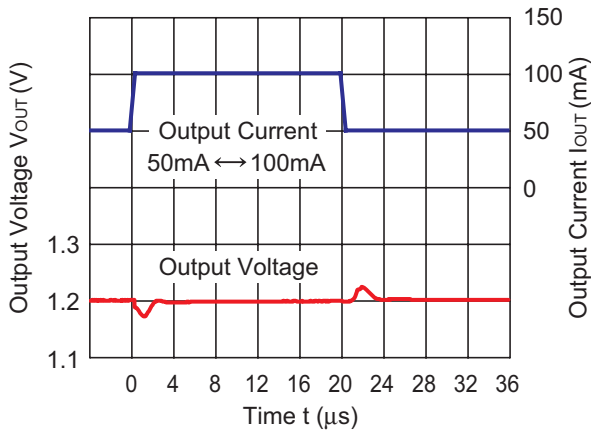
11) Input Transient Response (C1=none, C2=1.0μF, I_{OUT}=30mA, tr=tf=5μs, T_{opt}=25°C)



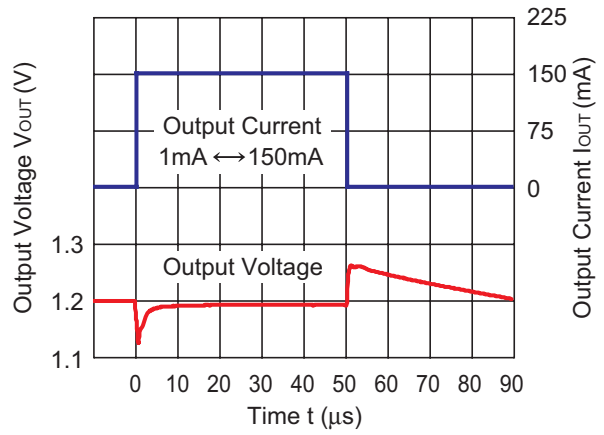
12) Load Transient Response (C1=C2=1.0μF, tr=tf=5μs, T_{opt}=25°C)



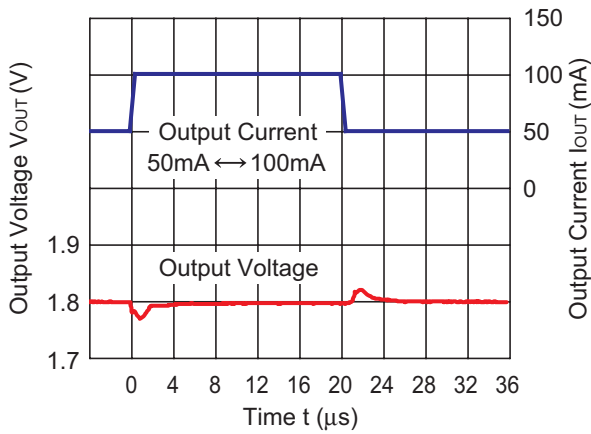
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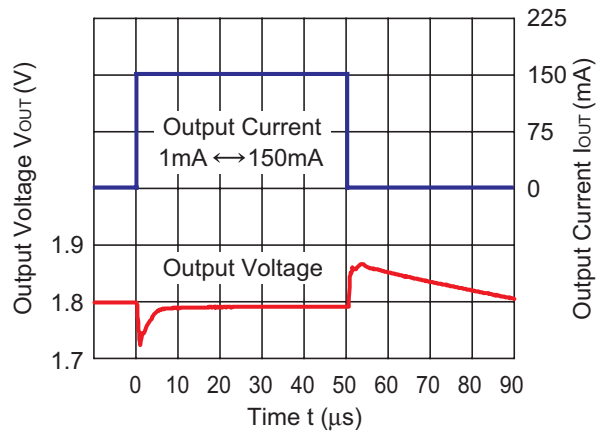
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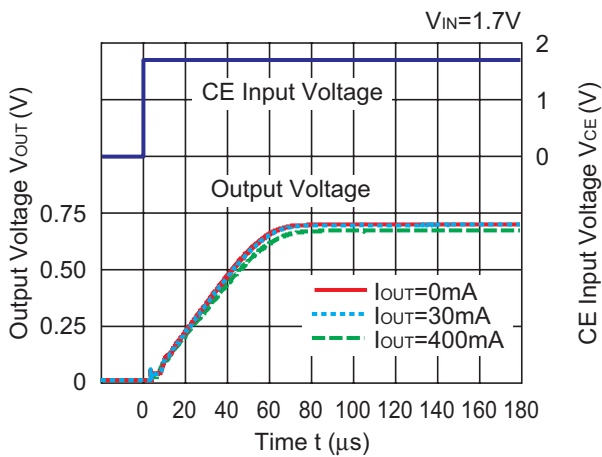


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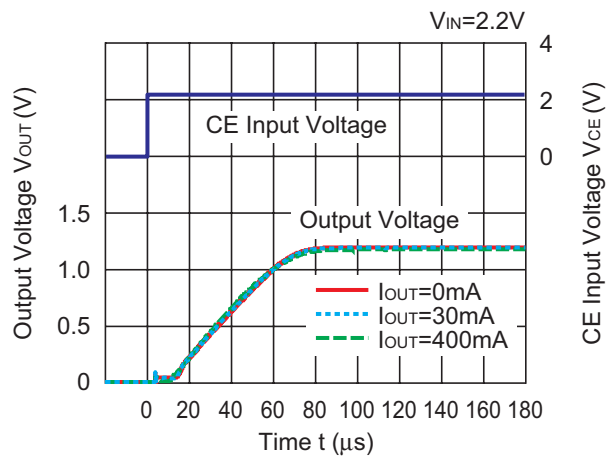


13) Turn On Speed with CE pin ($C1=C2=1.0\mu$ F, $T_{opt}=25^{\circ}$ C)

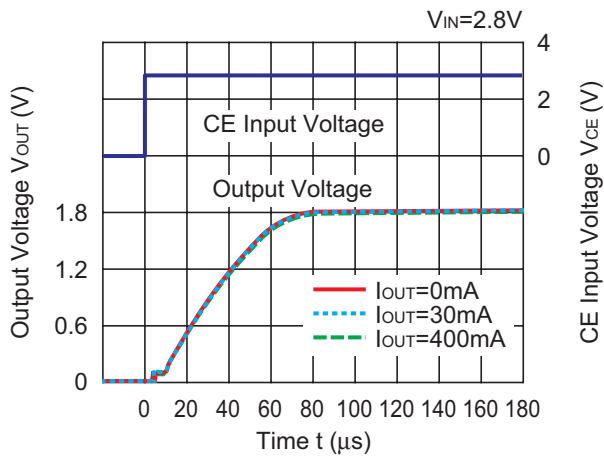
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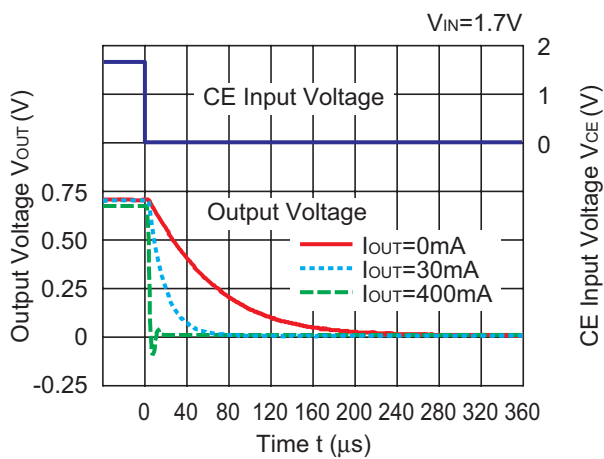


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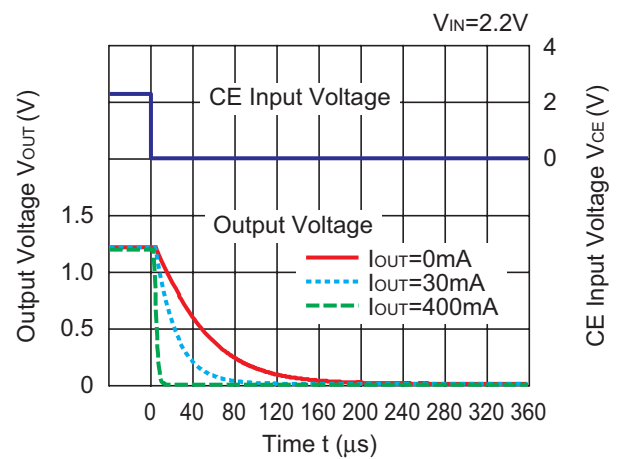


14) Turn Off Speed with CE pin ($C1=C2=1.0\mu F$, $T_{opt}=25^{\circ}C$)

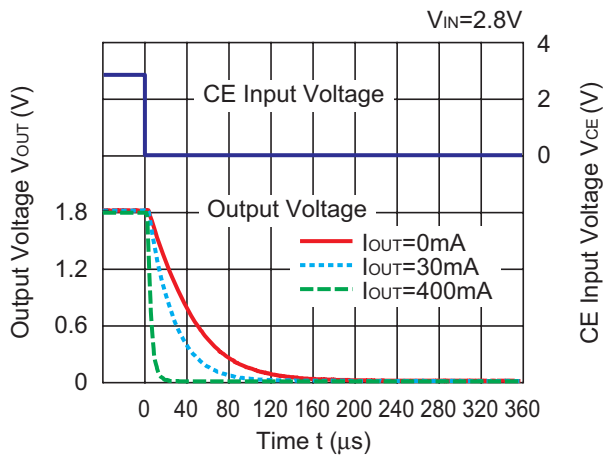
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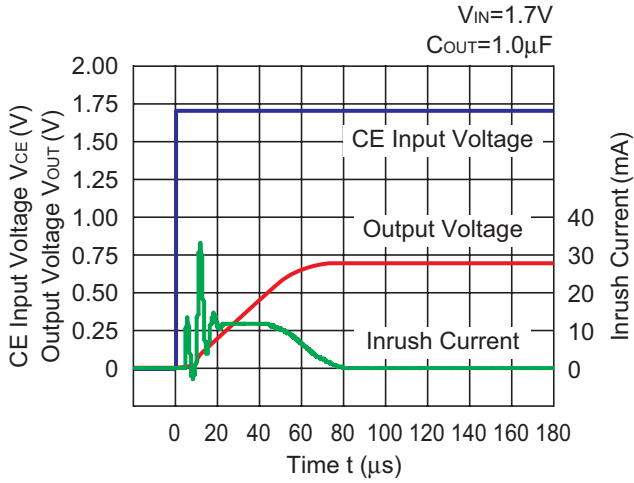


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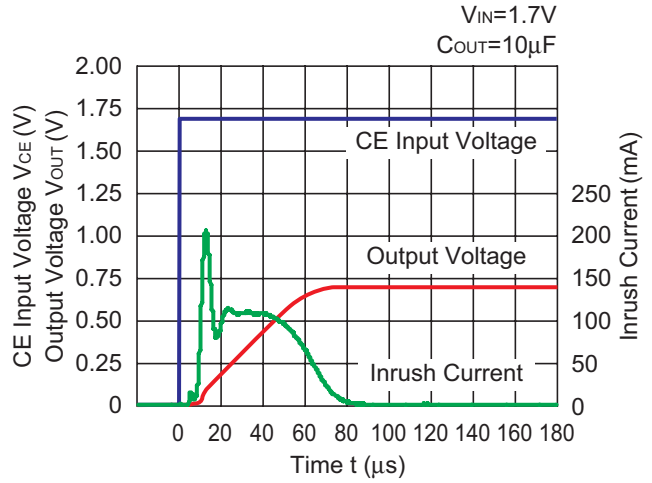


15) Inrush Current at Start up ($C_1=1.0\mu\text{F}$, $T_{\text{opt}}=25^\circ\text{C}$)

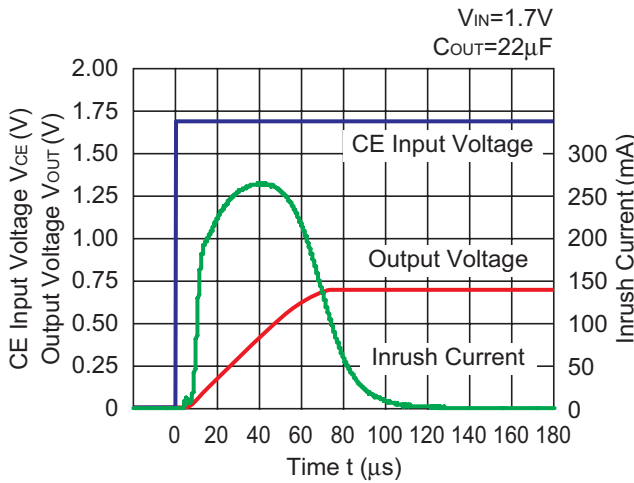
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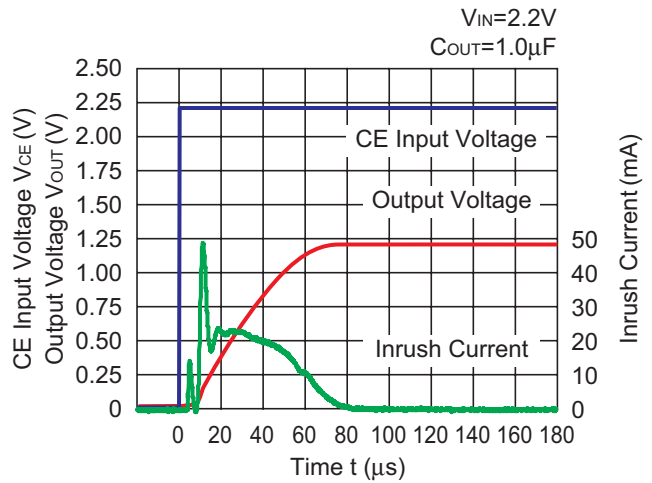
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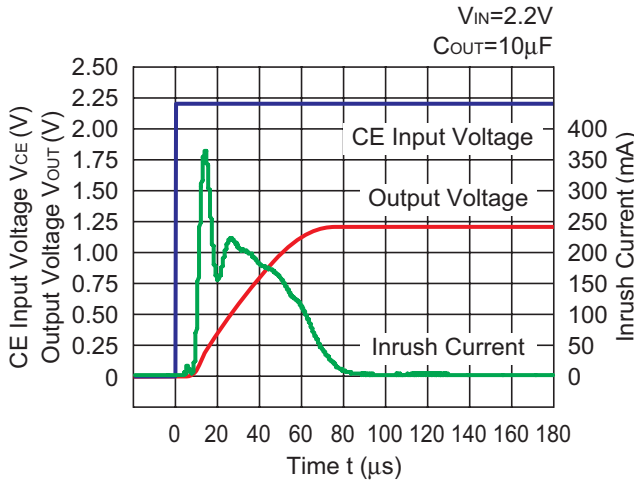
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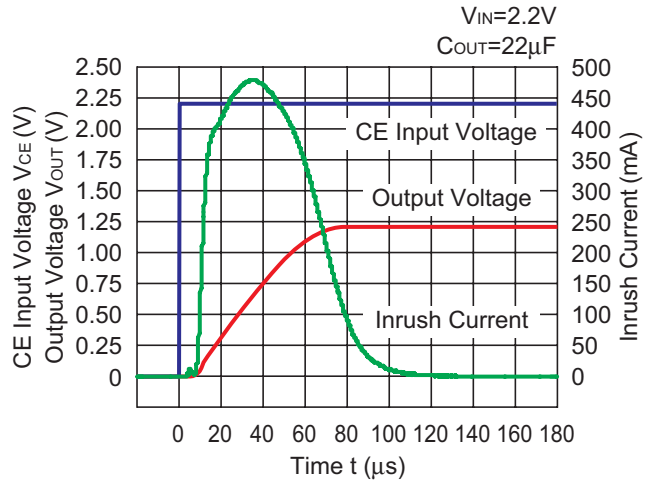
RP116Z121x



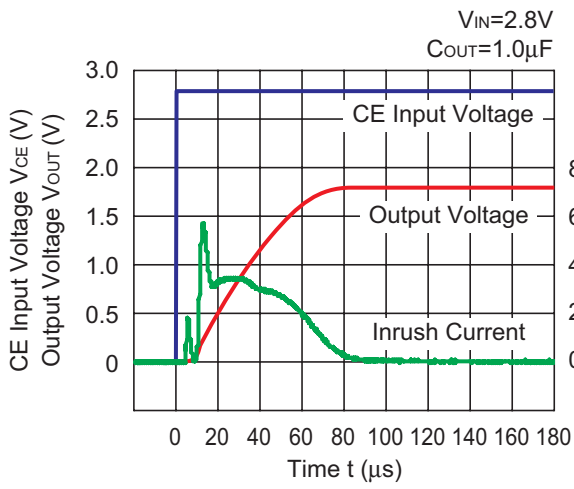
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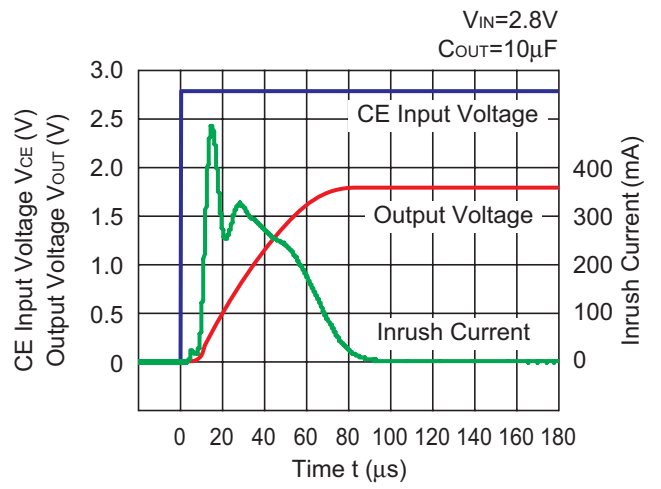
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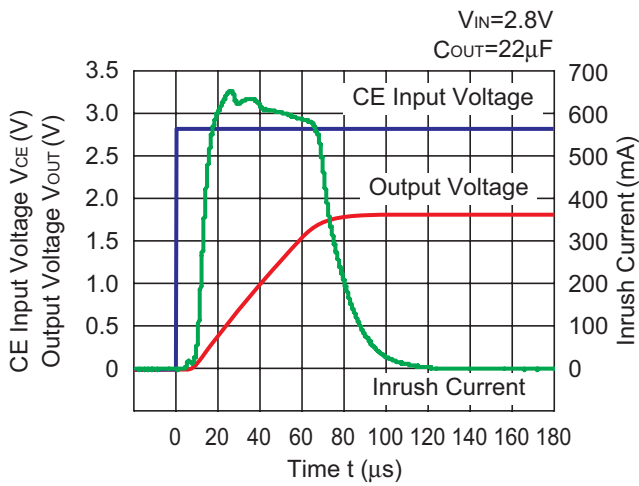
RP116Z181x



RP116Z181x



RP116Z181x



ESR vs. Output Current

When using these ICs, consider the following points:

The relations between I_{OUT} (Output Current) and ESR of an output capacitor are shown below.

The conditions when the white noise level is under $40\mu\text{V}$ (Avg.) are marked as the hatched area in the graph.

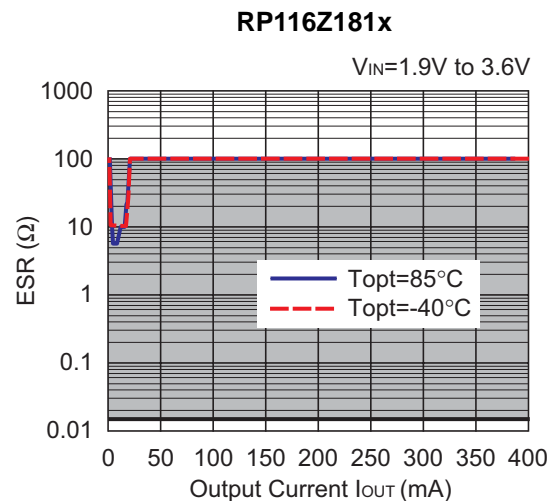
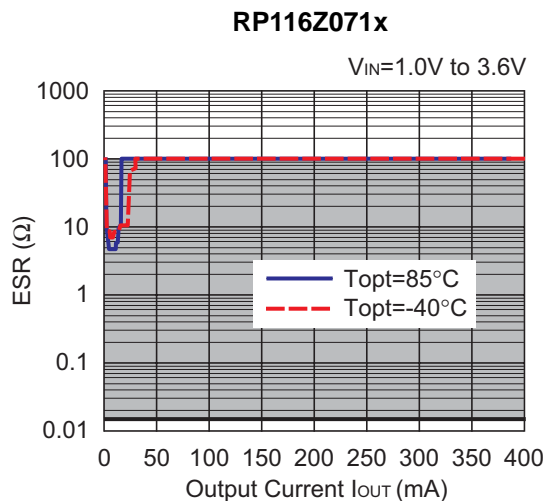
Measurement conditions

Frequency Band: 10Hz to 3MHz

Temperature : -40°C to 85°C

C1, C2 : $1.0\mu\text{F}$ MURATA GRM155B31A105KE15

If other than ceramic capacitors such as tantalum, the ESR of the capacitor might be higher than expected. This graph shows the stable area with ESR limit. In the actual evaluation, we used Murata GRM155B31A105KE15, therefore, bias characteristics of the same kind of ceramic capacitors are considered.





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