

RICOH**R1163x SERIES****3-MODE 150mA LDO REGULATOR with the Reverse Current Protection**

NO.EA-118-190320

OUTLINE

The R1163x Series consist of CMOS-based voltage regulator ICs with high output voltage accuracy and low supply current. These ICs perform with the chip enable function and realize a standby mode with ultra low supply current. To prevent the destruction by over current, the current limit circuit is included. The R1163x Series have 3-mode. One is standby mode with CE or standby control pin. Other two modes are realized with ECO pin. Fast Transient Mode (FT mode) and Low Power Mode (LP mode) are alternative with ECO pin. Consumption current is reduced at Low Power Mode compared with Fast Transient Mode. The output voltage is maintained between FT mode and LP mode.

Further, the reverse current protection circuit is built-in. Therefore, if a higher voltage than V_{DD} pin is forced to the output pin, the reverse current to V_{DD} pin is very small (Max. $0.1\mu\text{A}$), so it is suitable for backup circuit.

Since the packages for these ICs are SOT-23-5, SON-6, and DFN(PLP)1616-6 packages, high density mounting of the ICs on boards is possible.

FEATURES

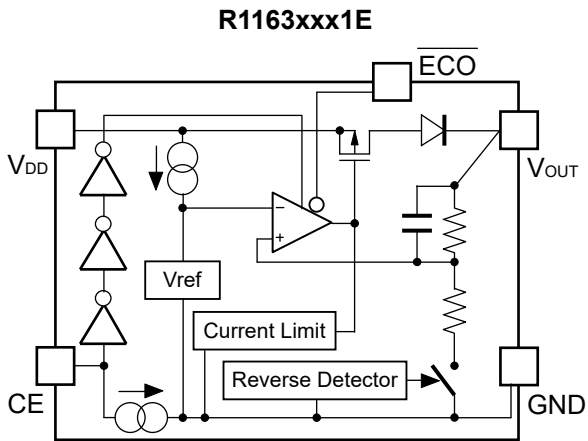
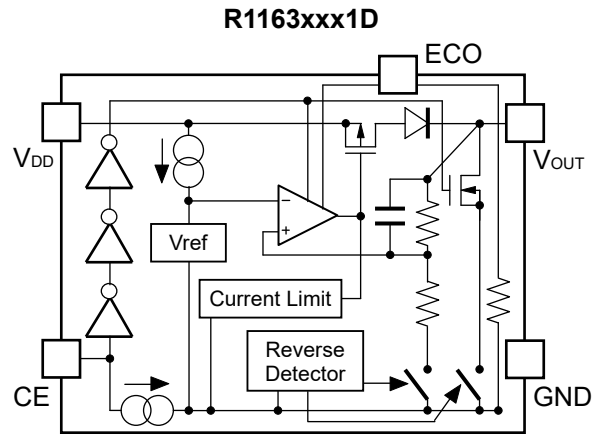
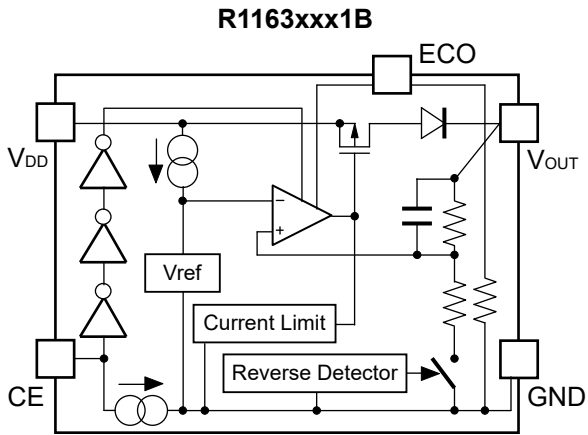
- Supply Current Typ. $6.0\mu\text{A}$ (Low Power Mode),
Typ. $70\mu\text{A}$ (Fast Transient Mode)
- Standby Mode Typ. $0.6\mu\text{A}$
- Reverse Current..... Max. $0.1\mu\text{A}$
- Input Voltage Range 2.0V to 6.0V
- Output Voltage Range..... 1.5V to 5.0V (0.1V steps)
(For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy..... $\pm 1.5\%$ ($\pm 2.5\%$ at Low Power Mode)
- Temperature-Drift Coefficient of Output Voltage .. Typ. $\pm 100\text{ppm}/^\circ\text{C}$
- Dropout Voltage Typ. 0.25V ($I_{\text{OUT}}=150\text{mA}$, $V_{\text{OUT}}=2.8\text{V}$)
- Ripple Rejection Typ. 70dB ($f=1\text{kHz}$, Fast Transient Mode)
- Line Regulation Typ. 0.02%/V (Fast Transient Mode)
- Packages DFN(PLP)1616-6, SOT-23-5, SON-6
- Built-in fold-back protection circuit Typ. 40mA (Current at short mode)
- Performs with Ceramic Capacitors $C_{\text{IN}}=\text{Ceramic } 1.0\mu\text{F}$, $C_{\text{OUT}}=\text{Ceramic } 0.47\mu\text{F}$

APPLICATIONS

- Precision Voltage References.
- Power source for electrical appliances such as cameras, VCRs and hand-held communication equipment.
- Power source for battery-powered equipment.

R1163x

BLOCK DIAGRAM



SELECTION GUIDE

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

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1163Kxx1*-TR	DFN(PLP)1616-6	5,000 pcs	Yes	Yes
R1163Nxx1*-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes
R1163Dxx1*-TR-FE	SON-6	3,000 pcs	Yes	Yes

xx: The output voltage can be designated in the range from 1.5V(15) to 5.0V(50) in 0.1V steps.
(For other voltages, please refer to MARK INFORMATIONS.)

* : The auto discharge function at off state are options as follows.

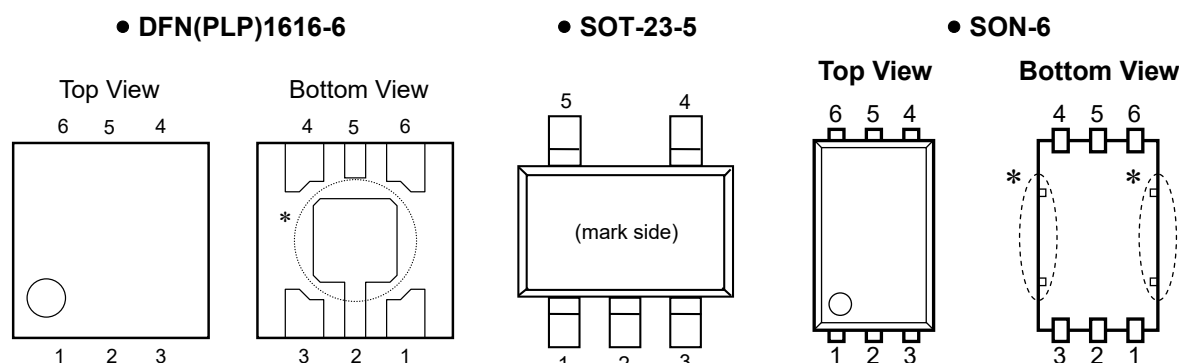
(B) without auto discharge function at off state

(D) with auto discharge function at off state

(E) without auto discharge function at off state, ECO logic reverse type (Low Power mode at ECO="H")

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PIN CONFIGURATIONS



PIN DISCRIPTIONS

• **DFN(PLP)1616-6**

Pin No	Symbol	Pin Description
1	V_{OUT}	Output pin
2	GND	Ground Pin
3	ECO	R1163xxx1B/D: FT/LP Mode Alternative Pin ("L" LP)
	\overline{ECO}	R1163xxx1E: FT/LP Mode Alternative Pin ("H" LP)
4	CE	Chip Enable pin ("H" Active)
5	NC	No Connection
6	V_{DD}	Input Pin

*) Tab is GND level. (They are connected to the reverse side of this IC.)

The tab is better to be connected to the GND, but leaving it open is also acceptable.

• **SOT-23-5**

Pin No	Symbol	Pin Description
1	V_{DD}	Input Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin ("H" Active)
4	ECO	R1163xxx1B/D: FT/LP Mode Alternative Pin ("L" LP)
	\overline{ECO}	R1163xxx1E: FT/LP Mode Alternative Pin ("H" LP)
5	V_{OUT}	Output pin

• **SON-6**

Pin No	Symbol	Pin Description
1	V_{DD}	Input Pin
2	NC	No Connection
3	V_{OUT}	Output pin
4	ECO	R1163xxx1B/D: FT/LP Mode Alternative Pin ("L" LP)
	\overline{ECO}	R1163xxx1E: FT/LP Mode Alternative Pin ("H" LP)
5	GND	Ground Pin
6	CE	Chip Enable Pin ("H" Active)

*) Tab suspension leads are GND level. (They are connected to the reverse side of this IC.)

The tab suspension leads should be open and do not connect to other wires or land patterns.

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	6.5	V
V_{ECO}	Input Voltage (ECO/ \overline{ECO} Pin)	-0.3 ~ 6.5	V
V_{CE}	Input Voltage (CE Pin)	-0.3 ~ 6.5	V
V_{OUT}	Output Voltage	-0.3 ~ 6.5	V
I_{OUT}	Output Current	180	mA
P_D	Power Dissipation (DFN(PLP)1616-6)*	640	mW
	Power Dissipation (SOT-23-5) *	420	
	Power Dissipation (SON-6) *	500	
T_{opt}	Operating Temperature Range	-40 ~ 85	°C
T_{stg}	Storage Temperature Range	-55 ~ 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.

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.

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ELECTRICAL CHARACTERISTICS

R1163xxx1B/D

T_{opt}=25°C

Symbol	Item		Conditions	Min.	Typ.	Max.	Unit	
V _{OUT}	Output Voltage	FT Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =V _{IN} 1mA ≤ I _{OUT} ≤ 30mA	×0.985		×1.015	V	
		LP Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =GND 1mA ≤ I _{OUT} ≤ 30mA	×0.975		×1.025		
ΔV _{OUT}	Output Voltage Deviation between FT Mode and LP Mode		V _{IN} =Set V _{OUT} +1V, I _{OUT} =30mA	V _{OUT} > 2.0V	-1.2	0	1.2	%
				V _{OUT} ≤ 2.0V	-24	0	24	mV
I _{OUT}	Output Current		V _{IN} -V _{OUT} =1.0V	150			mA	
ΔV _{OUT} / ΔI _{OUT}	Load Regulation	FT Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =V _{IN} 1mA ≤ I _{OUT} ≤ 150mA		20	40	mV	
		LP Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =GND 1mA ≤ I _{OUT} ≤ 150mA		20	45		
V _{DIF}	Dropout Voltage		Refer to the following table					
I _{SS1}	Supply Current (FT Mode)		V _{IN} =Set V _{OUT} +1V V _{ECO} =V _{IN}		70	100	μA	
I _{SS2}	Supply Current (LP Mode)		V _{IN} =Set V _{OUT} +1V V _{ECO} =GND		6.0	10.0	μA	
I _{standby}	Supply Current (Standby)		V _{IN} =Set V _{OUT} +1V, V _{CE} =GND V _{ECO} =GND or V _{IN}		0.6	1.0	μA	
ΔV _{OUT} / ΔV _{IN}	Line Regulation	FT Mode	Set V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V I _{OUT} =30mA, V _{ECO} =V _{IN} If V _{OUT} ≤ 1.6V, then 2.2V ≤ V _{IN} ≤ 6.0V		0.02	0.10	%V	
		LP Mode	Set V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V I _{OUT} =30mA, V _{ECO} =GND If V _{OUT} ≤ 1.6V, then 2.2V ≤ V _{IN} ≤ 6.0V		0.05	0.20		
RR	Ripple Rejection (FT Mode)		Ripple 0.2V _{p-p} , V _{IN} =Set V _{OUT} +1V, I _{OUT} =30mA, V _{ECO} =V _{IN} If V _{OUT} ≤ 1.7V, then V _{IN} =Set V _{OUT} +1.2V	f=1kHz		70	dB	
				f=10kHz		60		
V _{IN}	Input Voltage			2.0		6.0	V	
ΔV _{OUT} / ΔT _{opt}	Output Voltage Temperature Coefficient		I _{OUT} =30mA -40°C ≤ T _{opt} ≤ 85°C		±100		ppm/°C	
I _{SC}	Short Current Limit		V _{OUT} =0V		40		mA	
I _{PD}	CE Pull-down Current				0.3	0.6	μA	
R _{PDE}	ECO Pull-down Resistance			2	5	30	MΩ	
V _{CEH}	CE, ECO Input Voltage "H"			1.0		6.0	V	
V _{CEL}	CE, ECO Input Voltage "L"			0		0.35	V	
en	Output Noise "H" (FT Mode)		BW=10Hz to 100kHz		30		μV _{rms}	
	Output Noise "L" (LP Mode)		BW=10Hz to 100kHz		40			
R _{LOW}	Low Output Nch Tr. ON Resistance (of D version)		V _{CE} =0V		60		Ω	
I _{REV}	Reverse Current		V _{OUT} >0.5V, 0V ≤ V _{IN} ≤ 6V		0	0.1	μA	

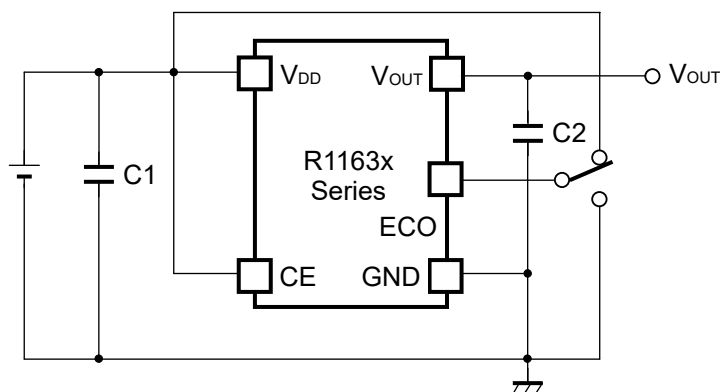
R1163xxx1E

T_{opt}=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V _{OUT}	Output Voltage	FT Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =GND 1mA ≤ I _{OUT} ≤ 30mA	×0.985		×1.015	V
		LP Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =V _{IN} 1mA ≤ I _{OUT} ≤ 30mA	×0.975		×1.025	
ΔV _{OUT}	Output Voltage Deviation between FT Mode and LP Mode	V _{IN} =Set V _{OUT} +1V, I _{OUT} =30mA	V _{OUT} > 2.0V	-1.2	0	1.2	%
			V _{OUT} ≤ 2.0V	-24	0	24	mV
I _{OUT}	Output Current	V _{IN} -V _{OUT} =1.0V	150			mA	
ΔV _{OUT} / ΔI _{OUT}	Load Regulation	FT Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =GND 1mA ≤ I _{OUT} ≤ 150mA		20	40	mV
		LP Mode	V _{IN} =Set V _{OUT} +1V, V _{ECO} =V _{IN} 1mA ≤ I _{OUT} ≤ 150mA		20	45	
V _{DIF}	Dropout Voltage	Refer to the following table					
I _{SS1}	Supply Current (FT Mode)	V _{IN} =Set V _{OUT} +1V V _{ECO} =GND		70	100	μA	
I _{SS2}	Supply Current (LP Mode)	V _{IN} =Set V _{OUT} +1V V _{ECO} =V _{IN}		6.0	10.0	μA	
I _{standby}	Supply Current (Standby)	V _{IN} =Set V _{OUT} +1V, V _{CE} =GND V _{ECO} =GND or V _{IN}		0.6	1.0	μA	
ΔV _{OUT} / ΔV _{IN}	Line Regulation	FT Mode	Set V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V I _{OUT} =30mA, V _{ECO} =GND If V _{OUT} ≤ 1.6V, then 2.2V ≤ V _{IN} ≤ 6.0V		0.02	0.10	%V
		LP Mode	Set V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V I _{OUT} =30mA, V _{ECO} =V _{IN} If V _{OUT} ≤ 1.6V, then 2.2V ≤ V _{IN} ≤ 6.0V		0.05	0.20	
RR	Ripple Rejection (FT Mode)	Ripple 0.2V _{p-p} V _{IN} =Set V _{OUT} +1V, I _{OUT} =30mA, V _{ECO} =GND If V _{OUT} ≤ 1.7V, then V _{IN} =Set V _{OUT} +1.2V	f = 1kHz		70		dB
			f = 10kHz		60		
V _{IN}	Input Voltage		2.0		6.0	V	
ΔV _{OUT} / ΔT _{opt}	Output Voltage Temperature Coefficient	I _{OUT} = 30mA -40°C ≤ T _{opt} ≤ 85°C		±100		ppm/°C	
I _{SC}	Short Current Limit	V _{OUT} = 0V		40		mA	
I _{PD}	CE Pull-down Current			0.3	0.6	μA	
V _{CEH}	CE, $\overline{\text{ECO}}$ Input Voltage "H"		1.0		6.0	V	
V _{CEL}	CE, $\overline{\text{ECO}}$ Input Voltage "L"		0		0.4	V	
en	Output Noise "H" (FT Mode)	BW = 10Hz to 100kHz		30		μVrms	
	Output Noise "L" (LP Mode)	BW = 10Hz to 100kHz		40			
I _{REV}	Reverse Current	V _{OUT} >0.5V, 0V ≤ V _{IN} ≤ 6V		0	0.1	μA	

R1163x**ELECTRICAL CHARACTERISTICS by OUTPUT VOLTAGE**T_{opt}=25°C

Output Voltage V _{OUT} (V)	Dropout Voltage (mV)				
	Condition	V _{DIF} (FT Mode)		V _{DIF} (LP Mode)	
		Typ.	Max.	Typ.	Max.
1.5 ≤ V _{OUT} < 1.6	I _{OUT} =150mA	400	680	420	680
1.6 ≤ V _{OUT} < 1.7		380	550	390	550
1.7 ≤ V _{OUT} < 1.8		350	520	370	520
1.8 ≤ V _{OUT} < 2.0		340	490	350	490
2.0 ≤ V _{OUT} < 2.8		290	425	300	430
2.8 ≤ V _{OUT} ≤ 5.0		250	350	250	350

TYPICAL APPLICATION

(External Components)

Ex. C1: Ceramic Capacitor 1.0μF

C2: Ceramic Capacitor 0.47μF Murata GRM40B474K
Kyocera CM105B474K**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, be sure to use a 0.47μF or more ceramic capacitor C2.

(Test these ICs with as same external components as ones to be used on the PCB.)

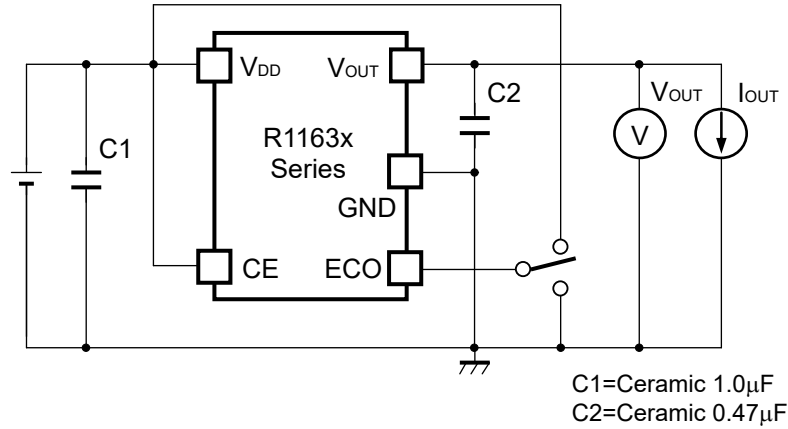
When a tantalum capacitor is used with this IC, if the equivalent series resistor (ESR) of the capacitor is large, output voltage may be unstable.

PCB Layout

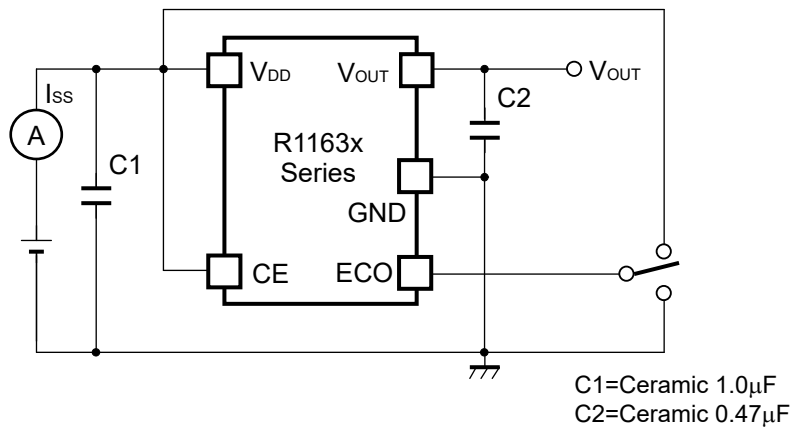
Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with as much as 1.0μF capacitor between V_{DD} and GND pin as close as possible.

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

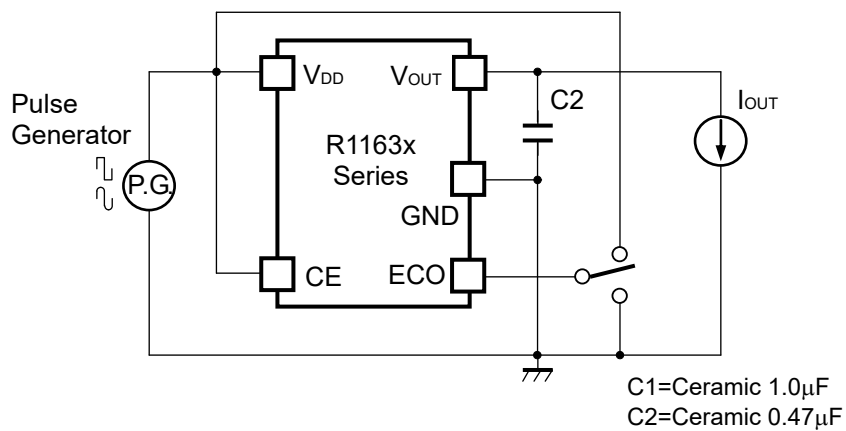
TEST CIRCUITS



Basic Test Circuit

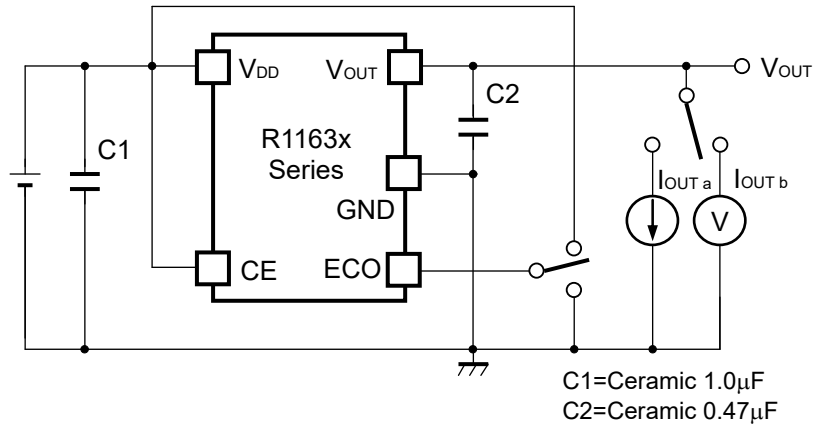


Test Circuit for Supply Current

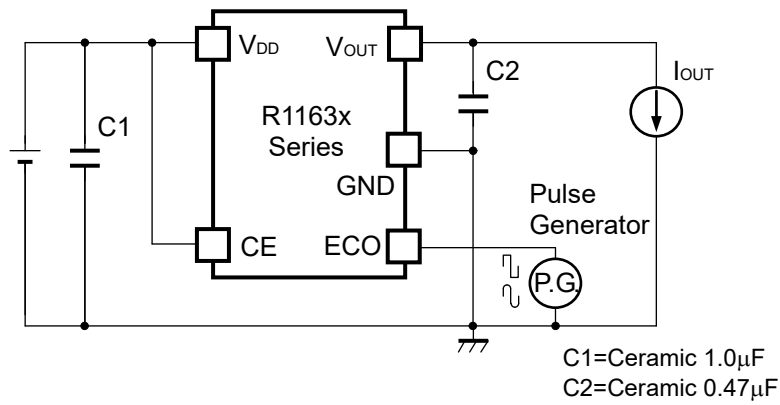


Test Circuit for Ripple Rejection, Line Transient Response

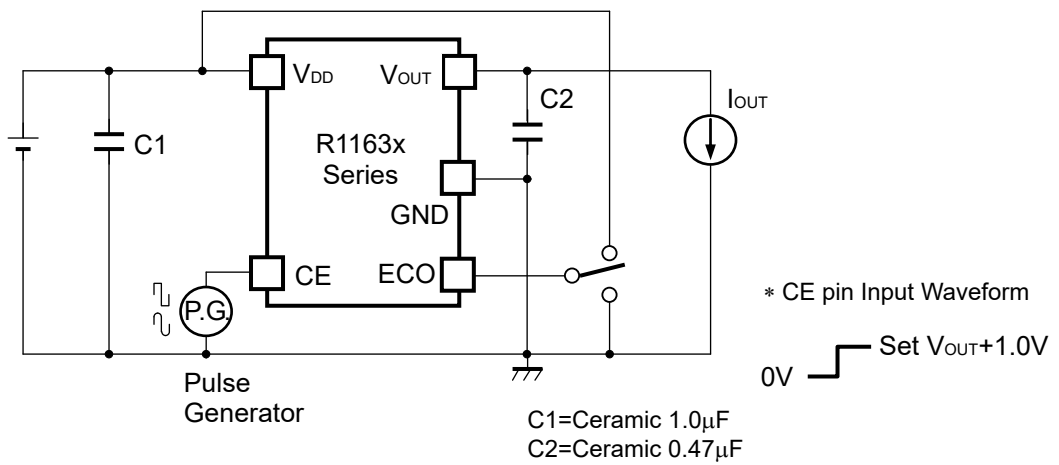
R1163x



Test Circuit for Load Transient Response



Test Circuit for Output Voltage at Mode alternative point



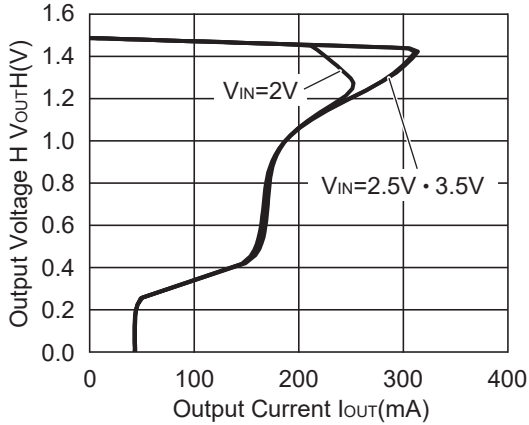
Test Circuit for Turn On Speed with CE pin

TYPICAL CHARACTERISTICS

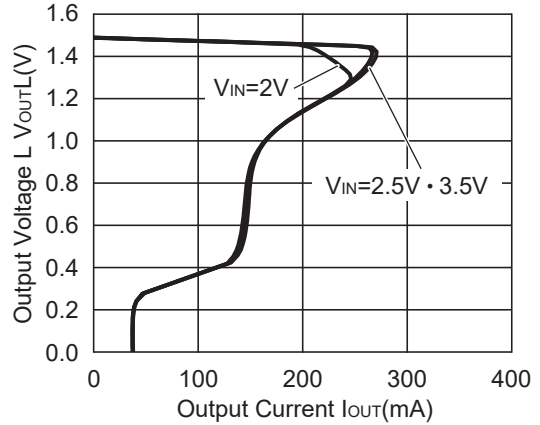
Unless otherwise provided, capacitors are ceramic type.

1) Output Voltage vs. Output Current

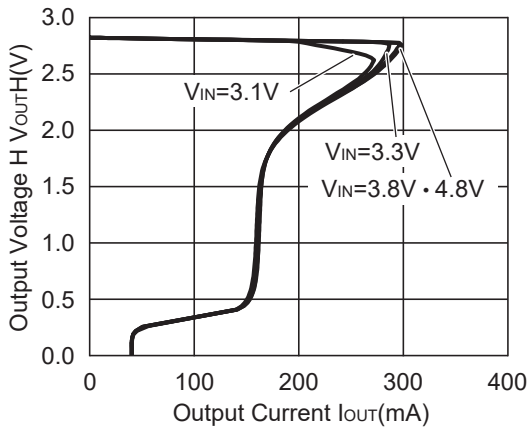
R1163x151x FT Mode



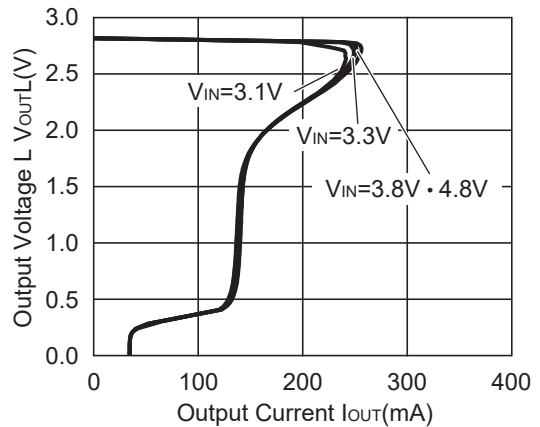
R1163x151x LP Mode



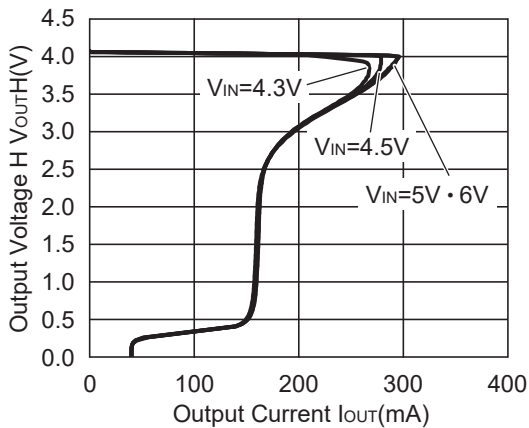
R1163x281x FT Mode



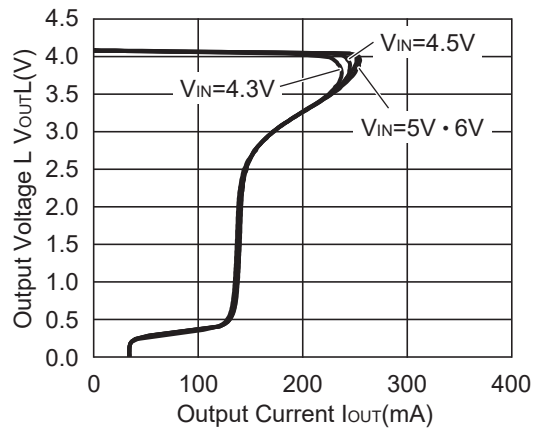
R1163x281x LP Mode



R1163x40x FT Mode



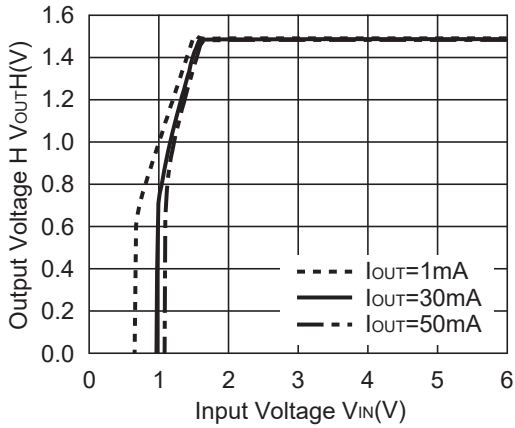
R1163x40x LP Mode



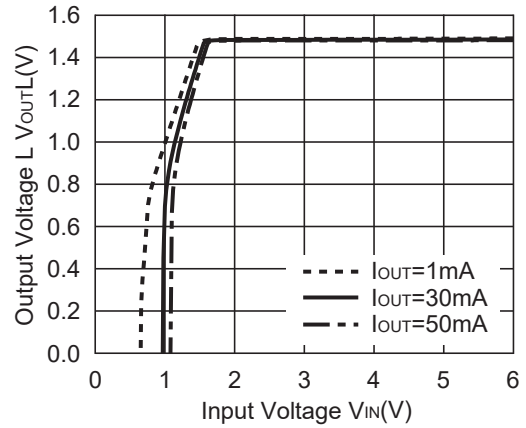
R1163x

2) Output Voltage vs. Input Voltage

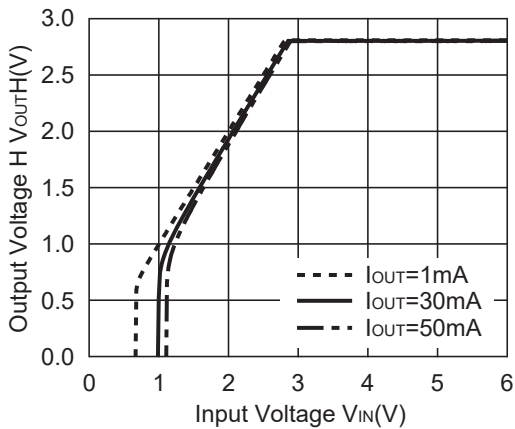
R1163x151x FT Mode



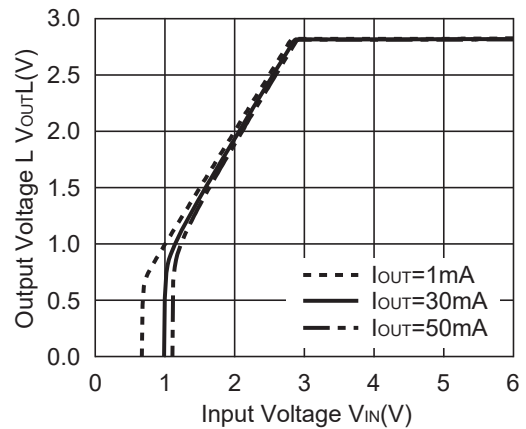
R1163x15x LP Mode



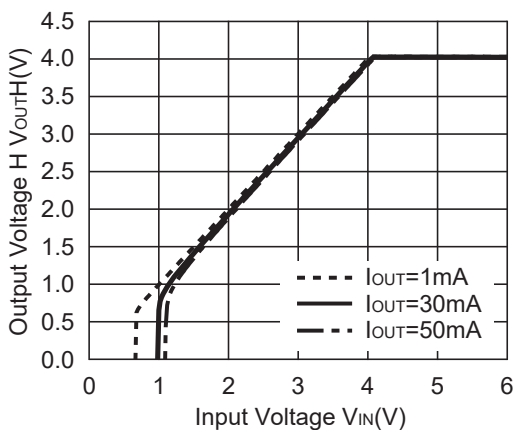
R1163x28x FT Mode



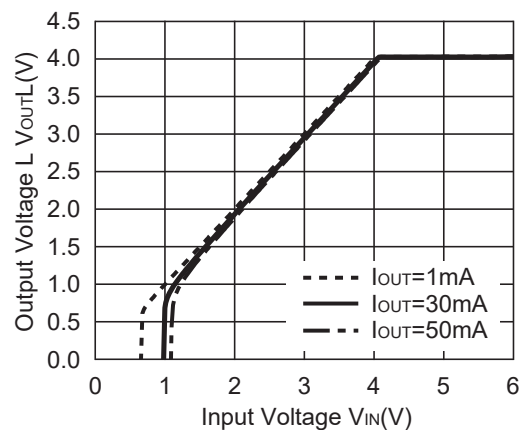
R1163x28x LP Mode



R1163x40x FT Mode

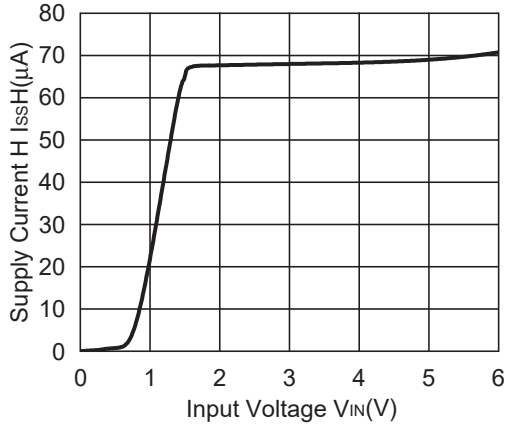


R1163x40x LP Mode

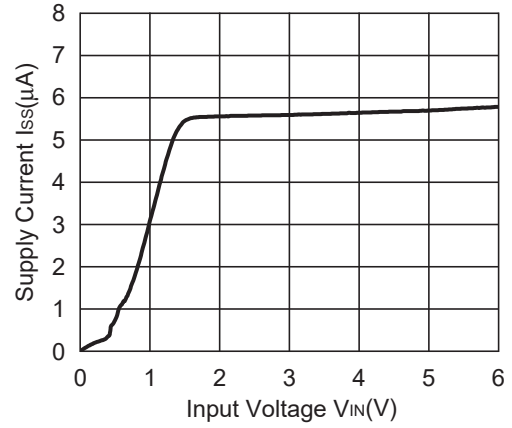


3) Supply Current vs. Input Voltage

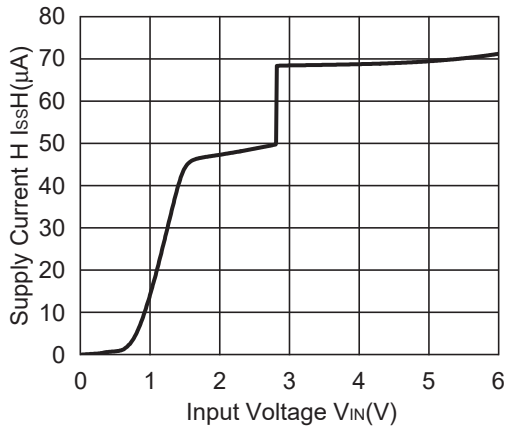
R1163x151x FT Mode



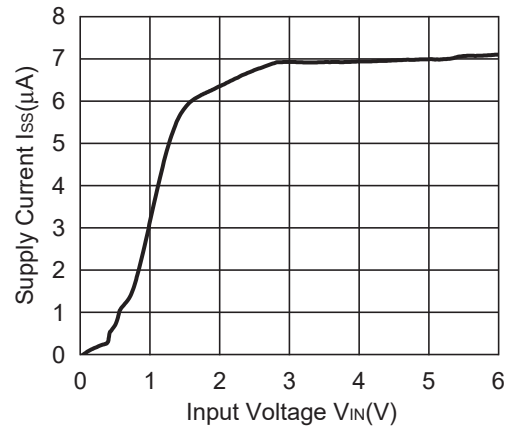
R1163x151x LP Mode



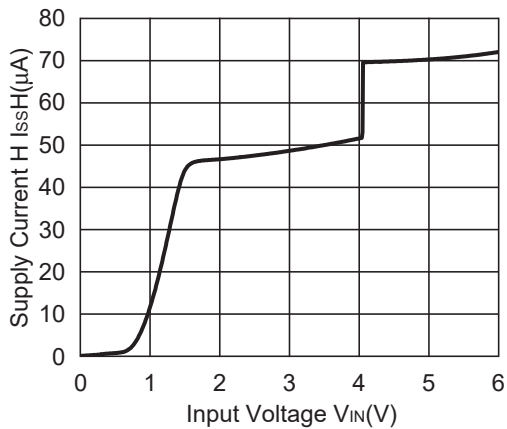
R1163x281x FT Mode



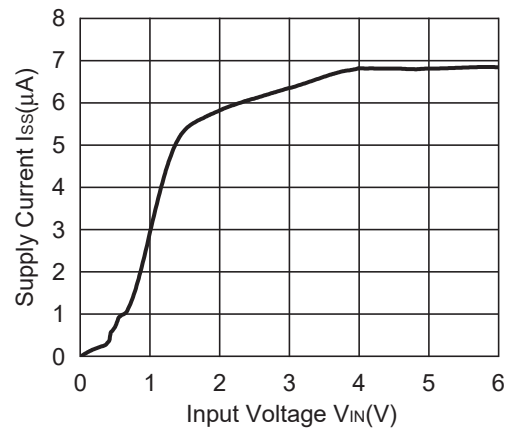
R1163x281x LP Mode



R1163x401x FT Mode



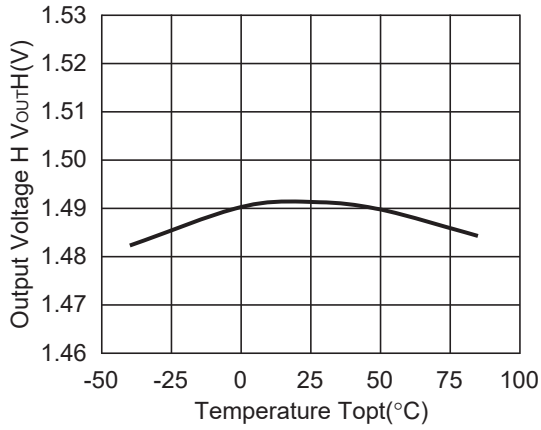
R1163x401x LP Mode



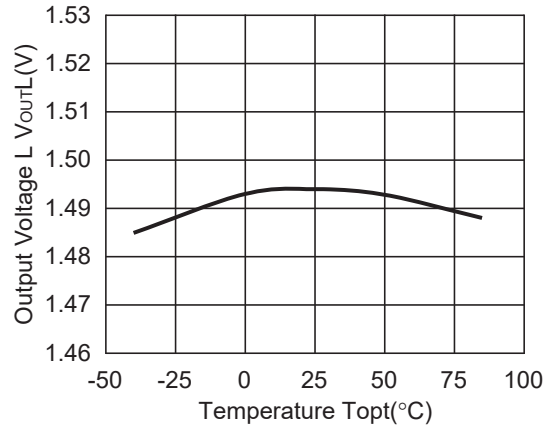
R1163x

4) Output Voltage vs. Temperature

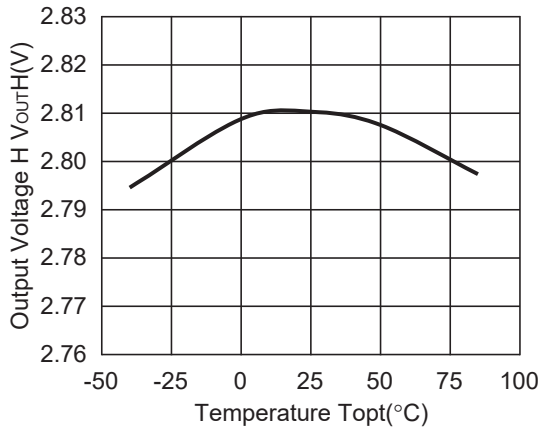
R1163x151x FT Mode



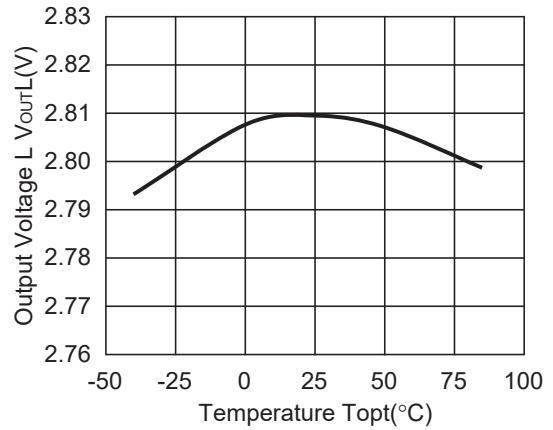
R1163x151x LP Mode



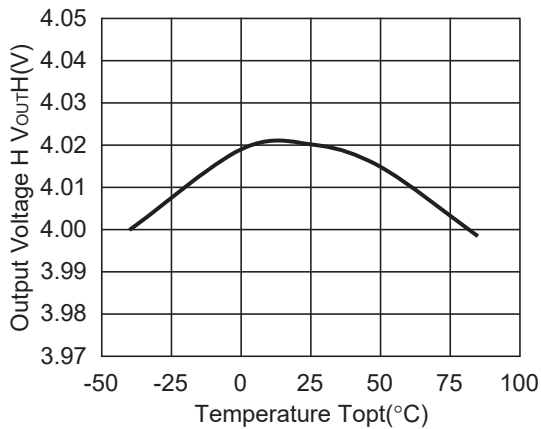
R1163x281x FT Mode



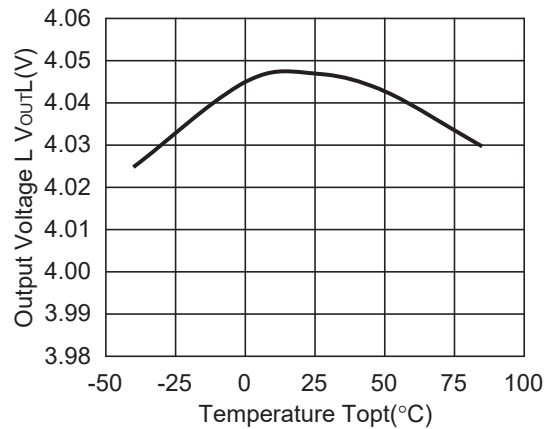
R1163x281x LP Mode



R1163x401x FT Mode

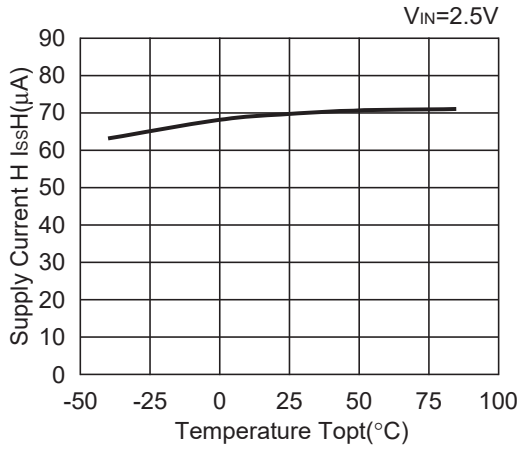


R1163x401x LP Mode

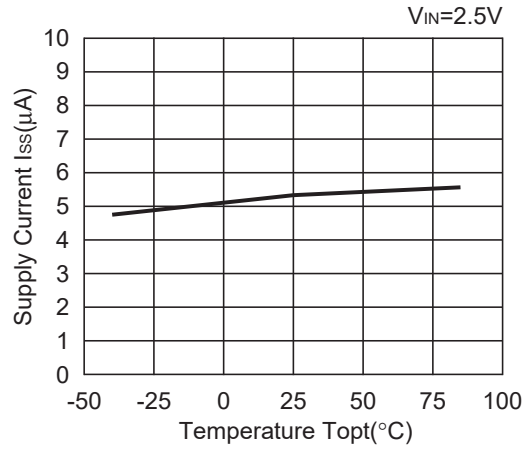


5) Supply Current vs. Temperature

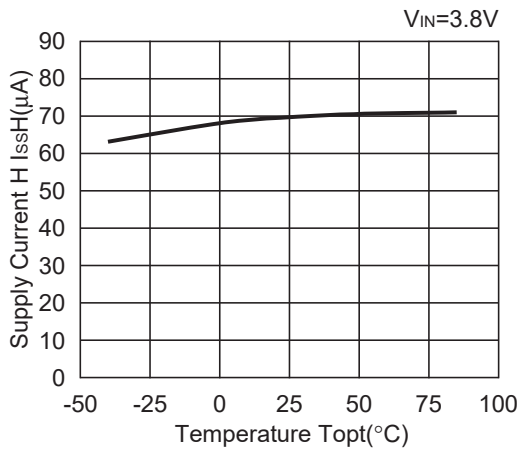
R1163x151x FT Mode



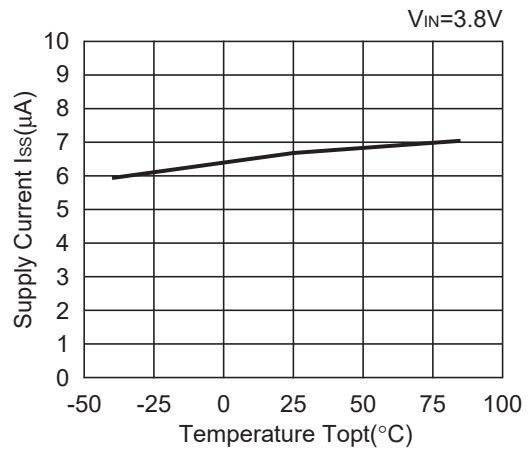
R1163x151x LP Mode



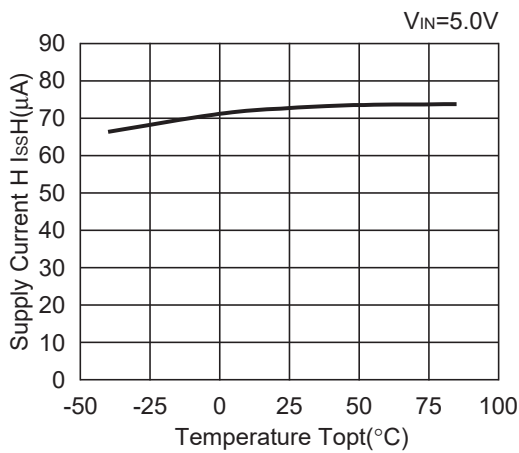
R1163x281x FT Mode



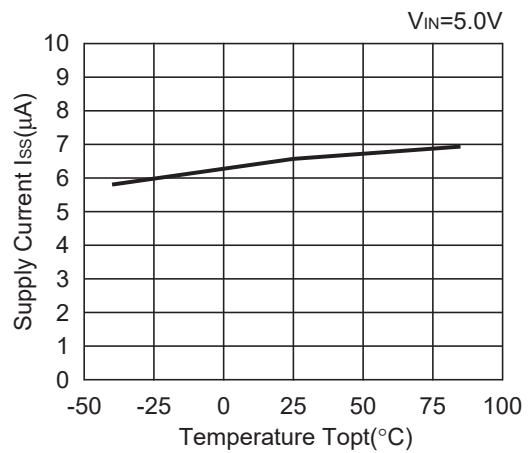
R1163x281x LP Mode



R1163x401x FT Mode

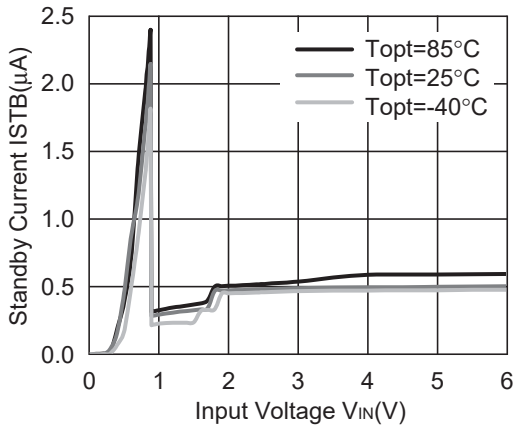


R1163x401x LP Mode

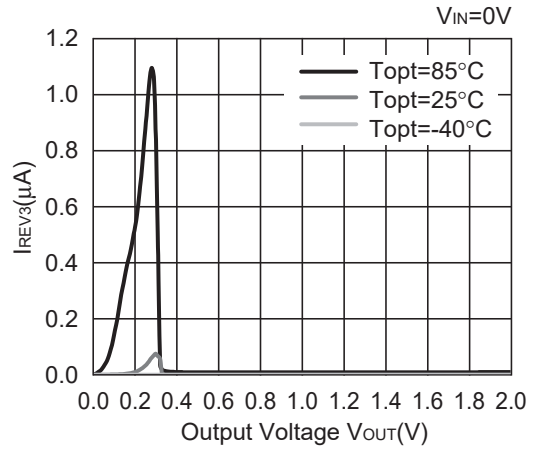
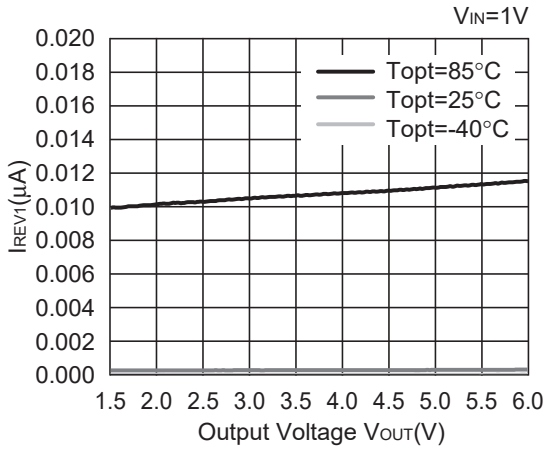


R1163x

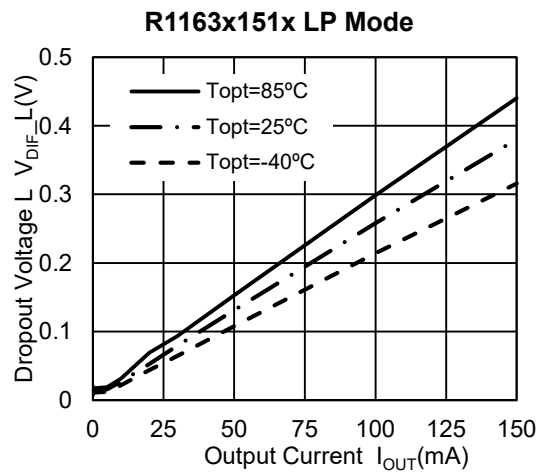
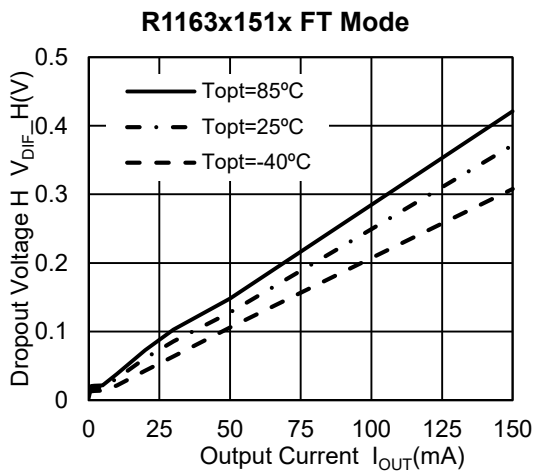
6) Standby Current vs. Input Voltage

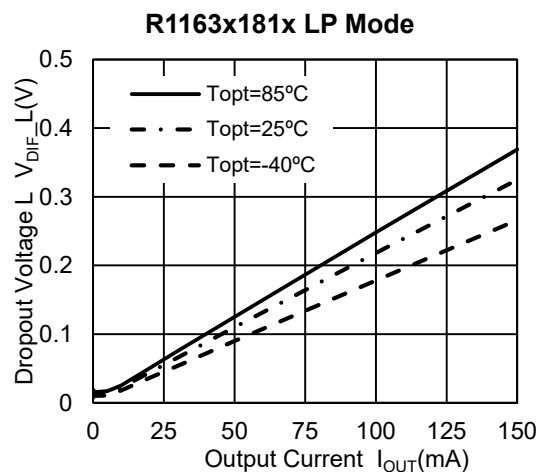
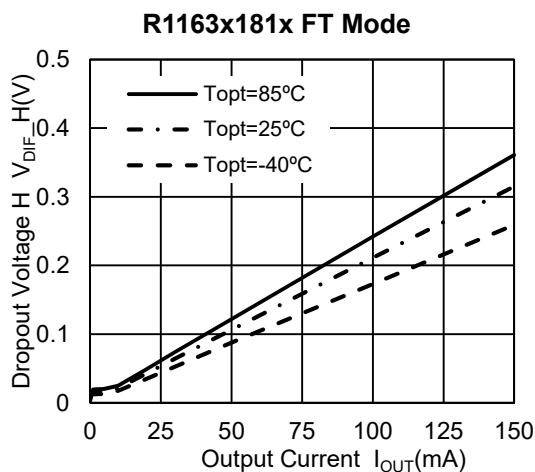
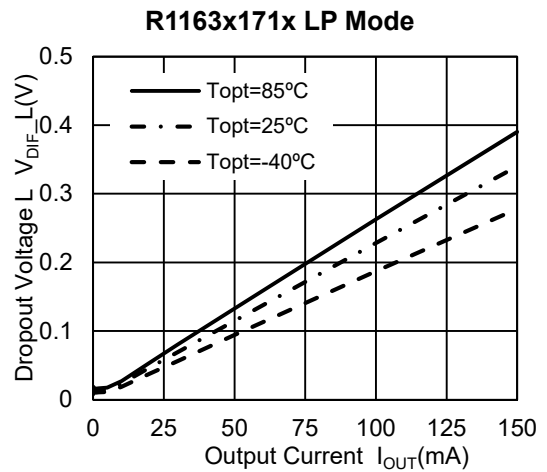
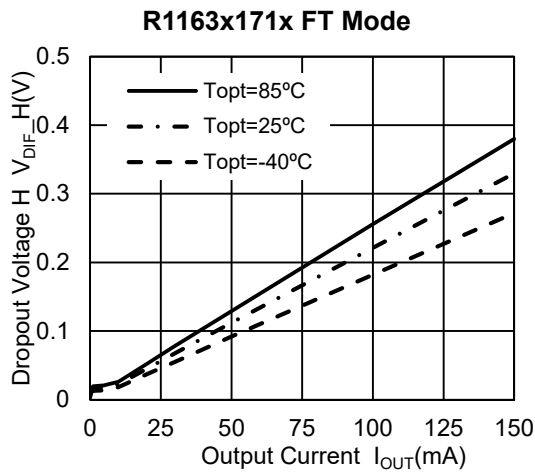
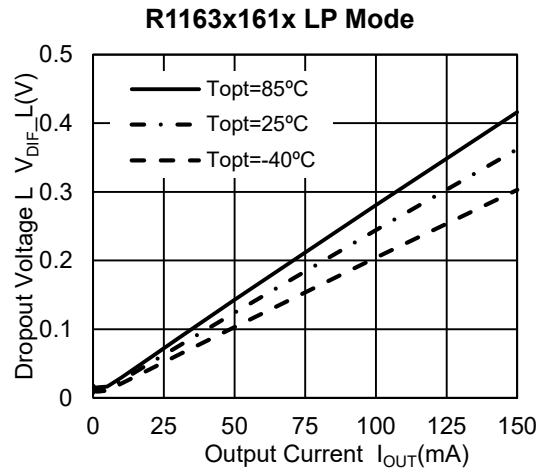
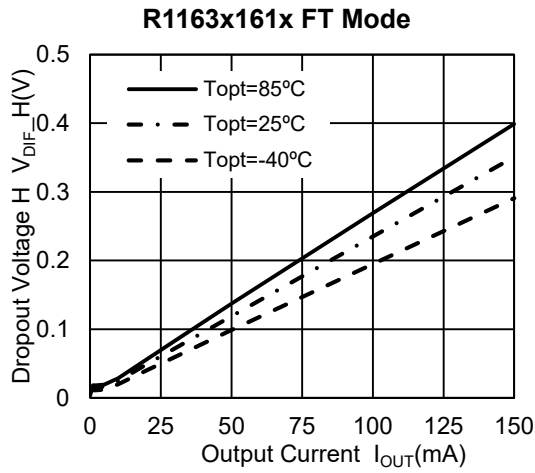


7) Reverse Current vs. Output Voltage

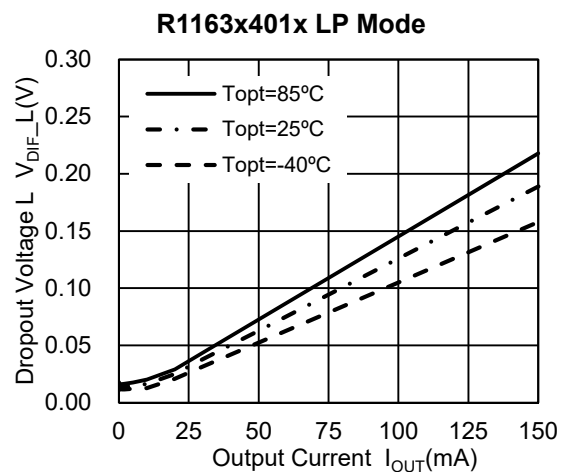
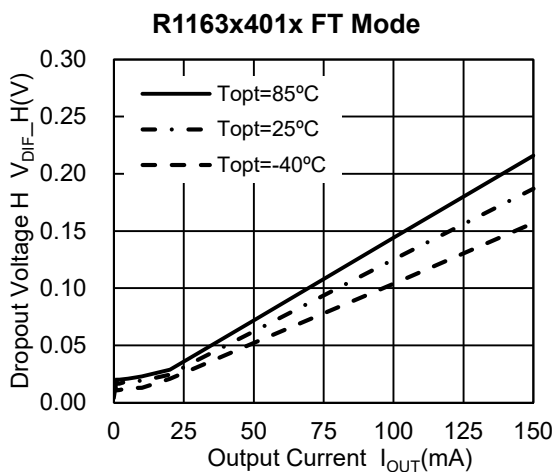
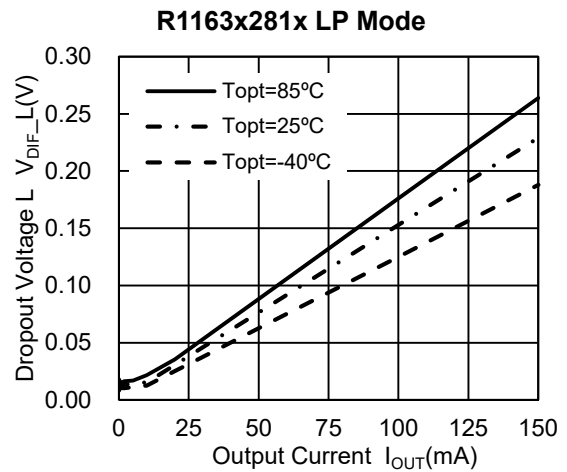
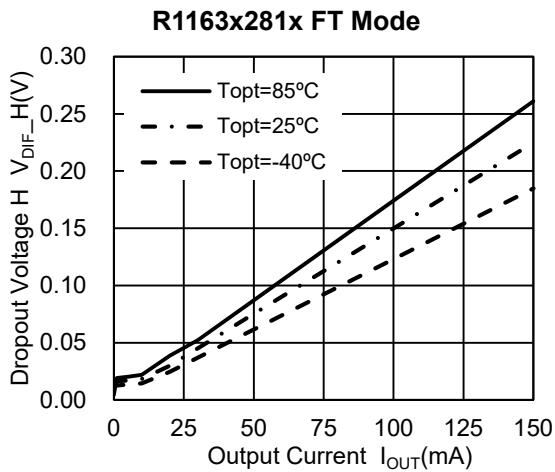
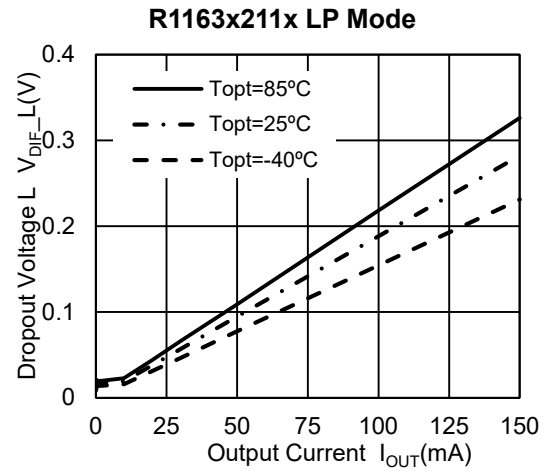
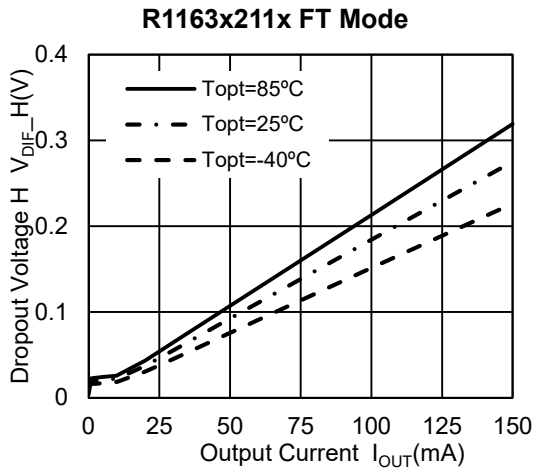


8) Dropout Voltage vs. Output Current

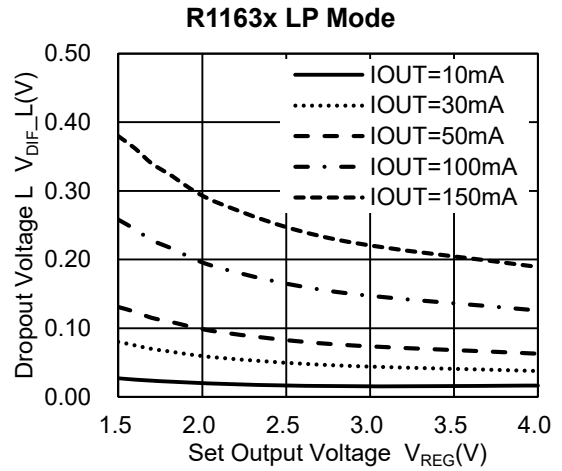
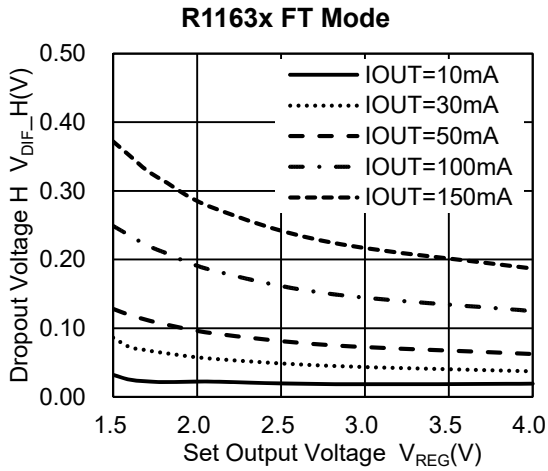




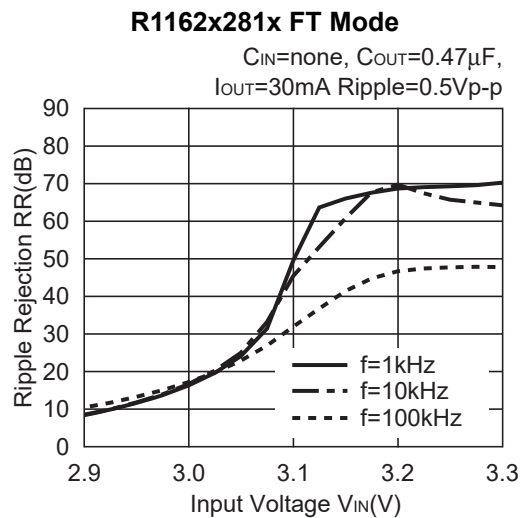
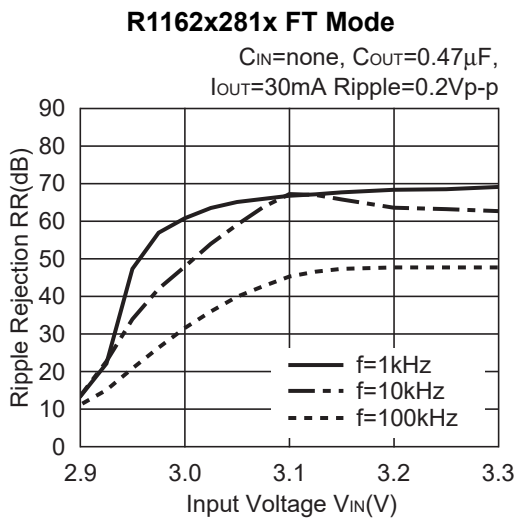
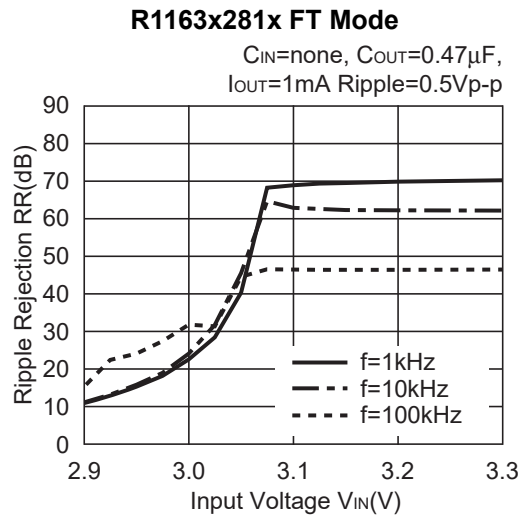
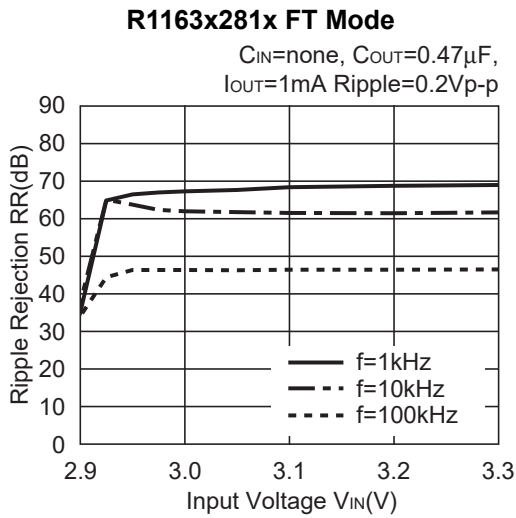
R1163x



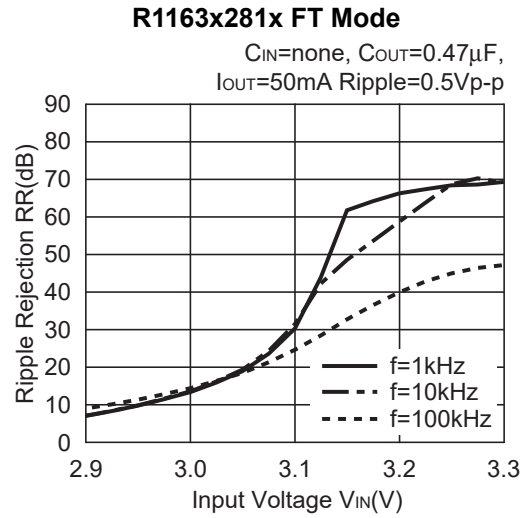
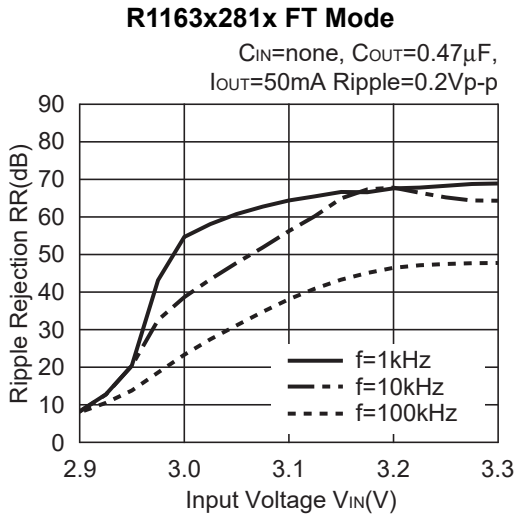
9) Dropout Voltage vs. Set Output Voltage



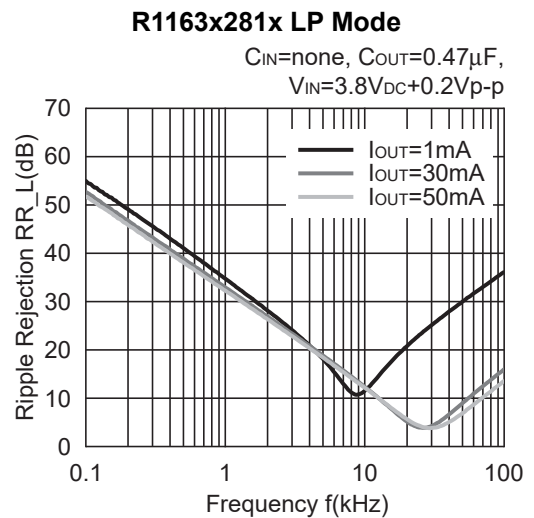
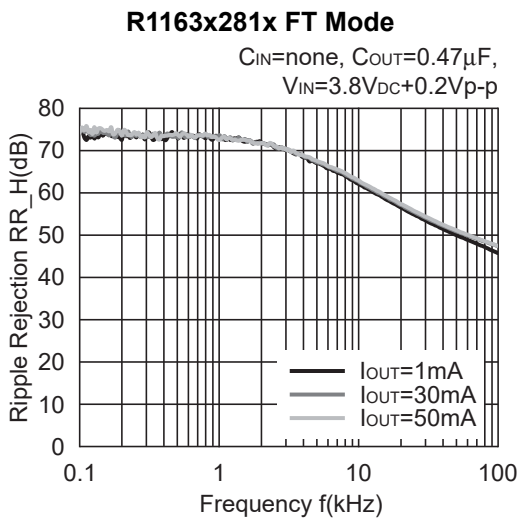
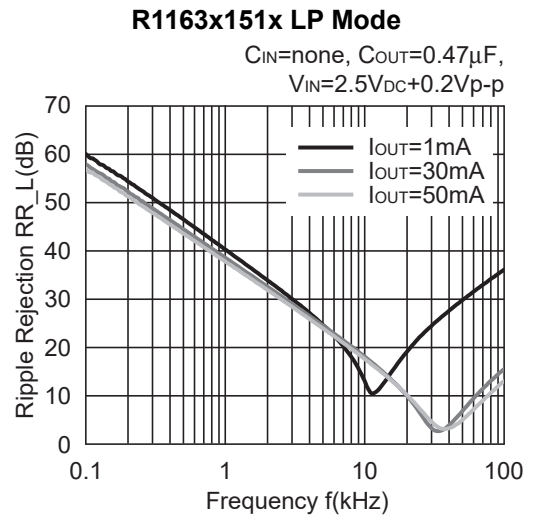
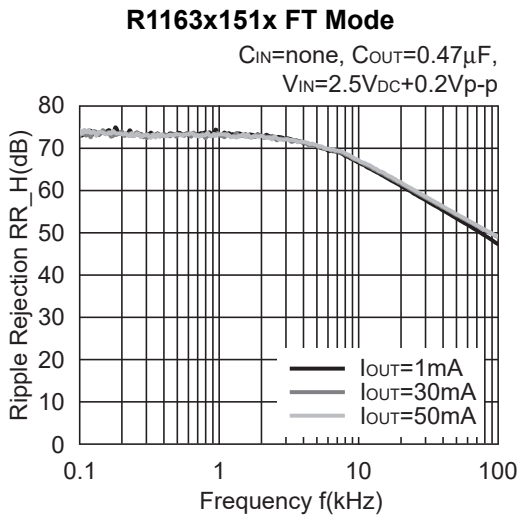
10) Ripple Rejection vs. Input Bias Voltage



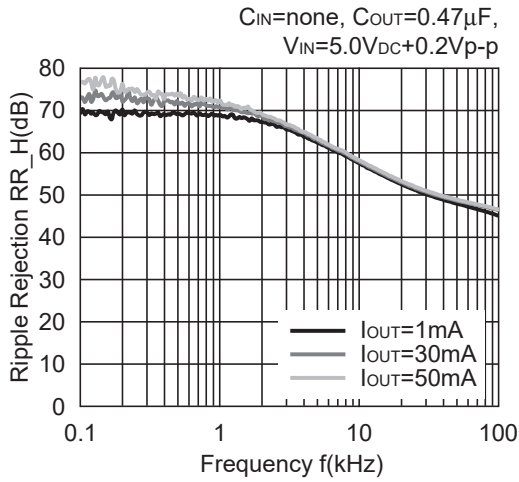
R1163x



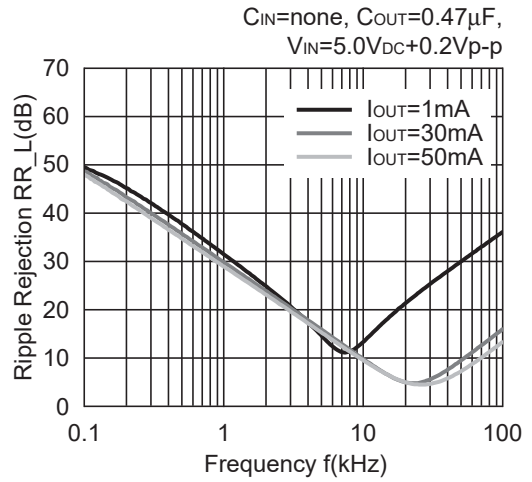
11) Ripple Rejection vs. Frequency



R1163x401x FT Mode

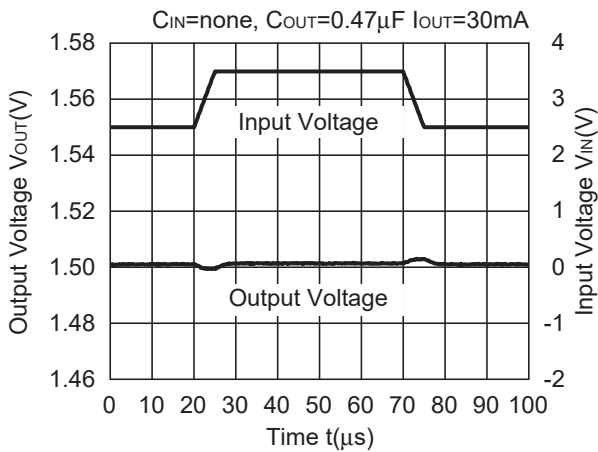


R1163x401x LP Mode

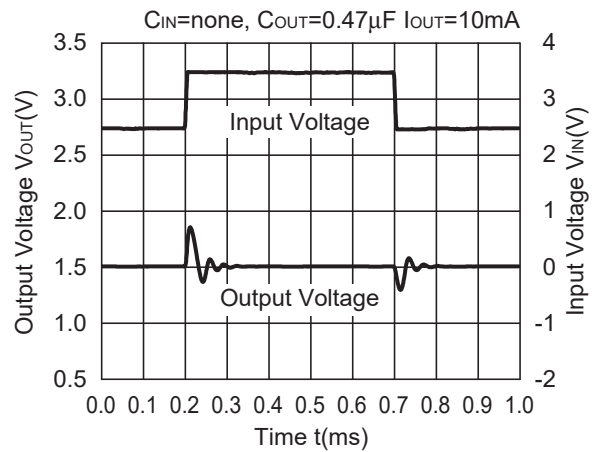


12) Input Transient Response

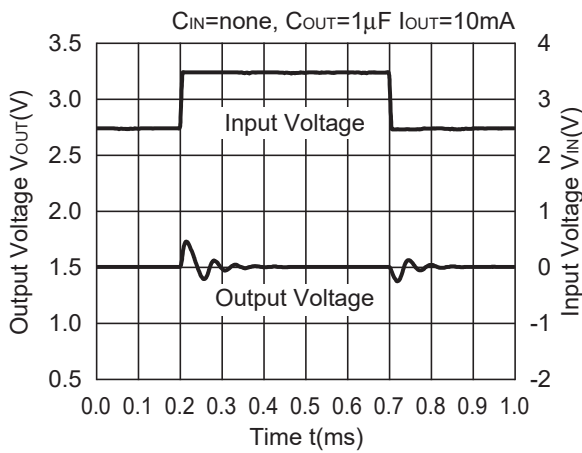
R1163x151x FT Mode



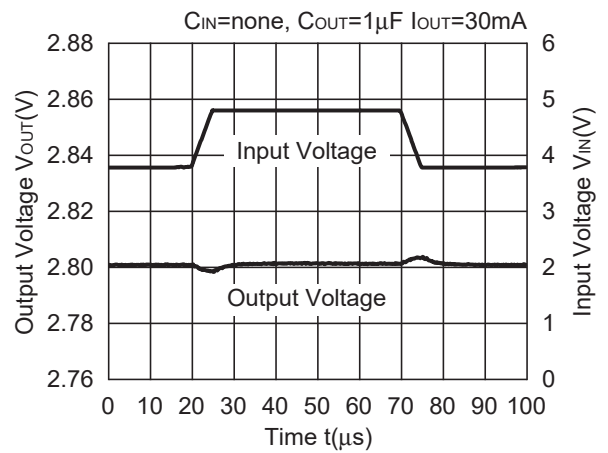
R1163x151x LP Mode



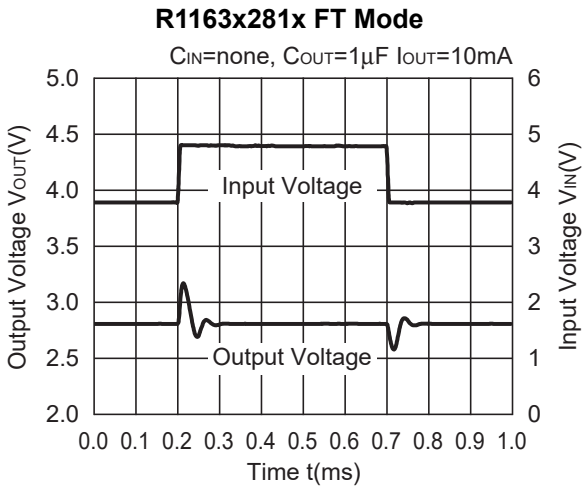
R1163x151x LP Mode



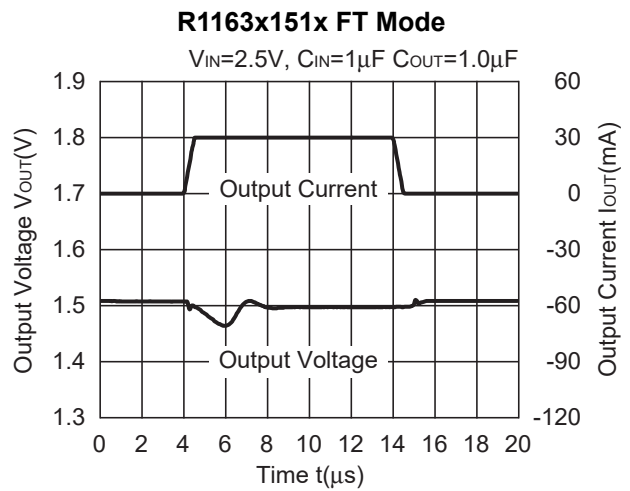
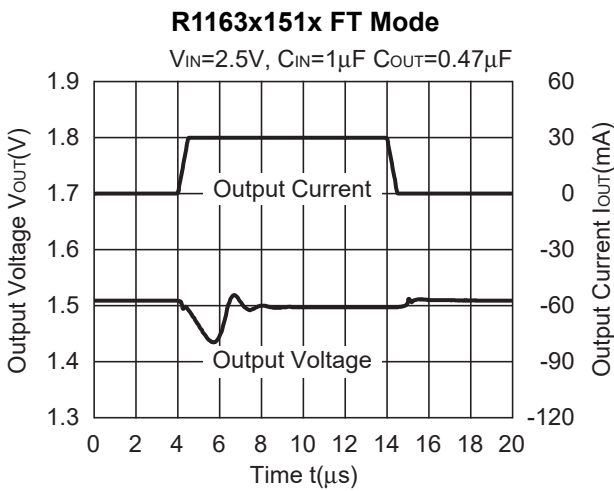
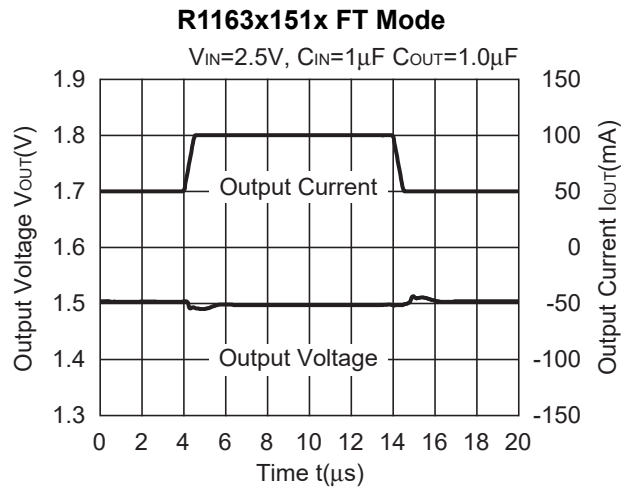
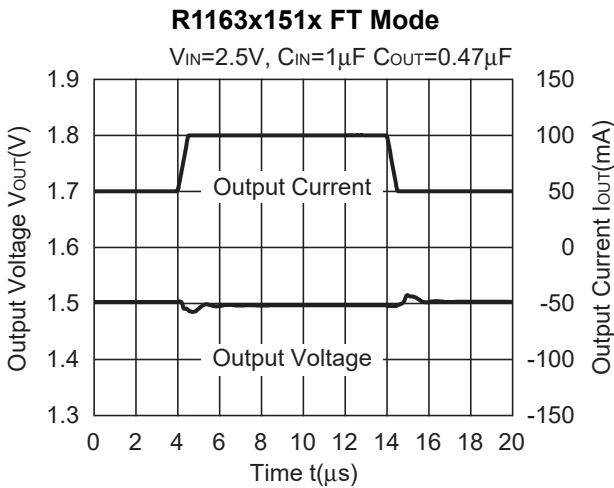
R1163x281x FT Mode

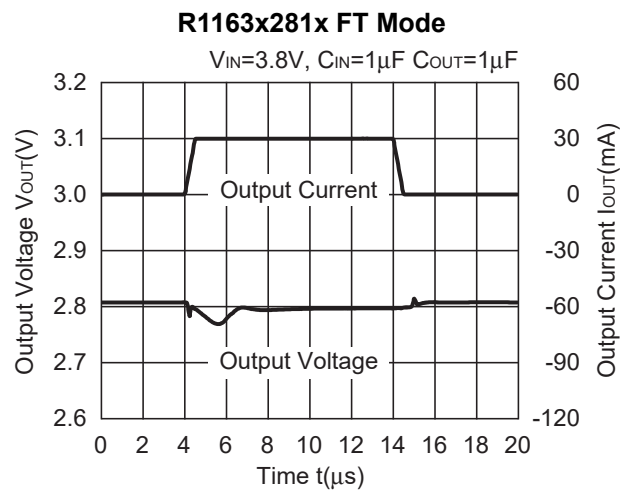
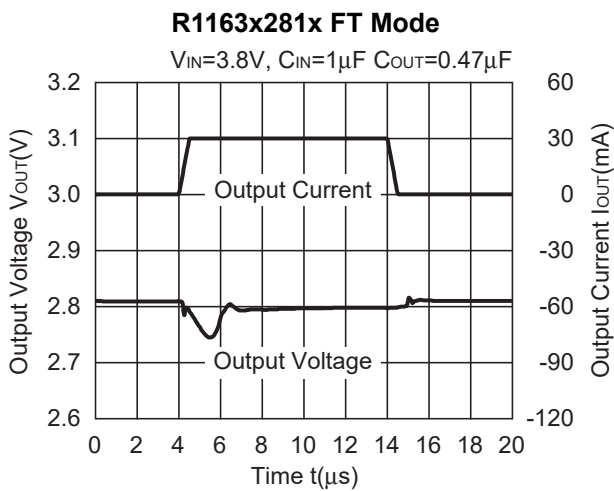
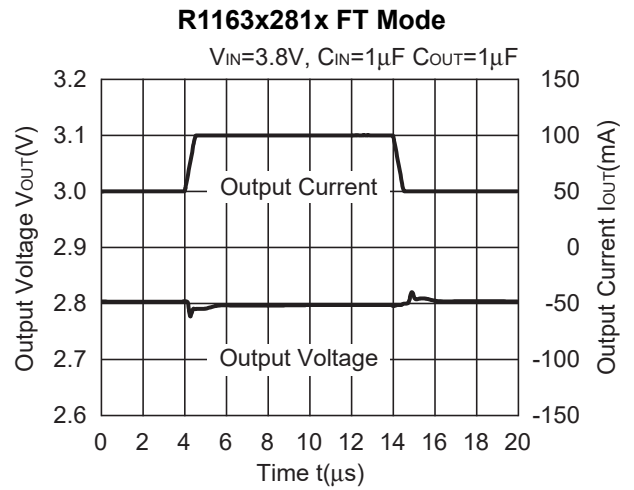
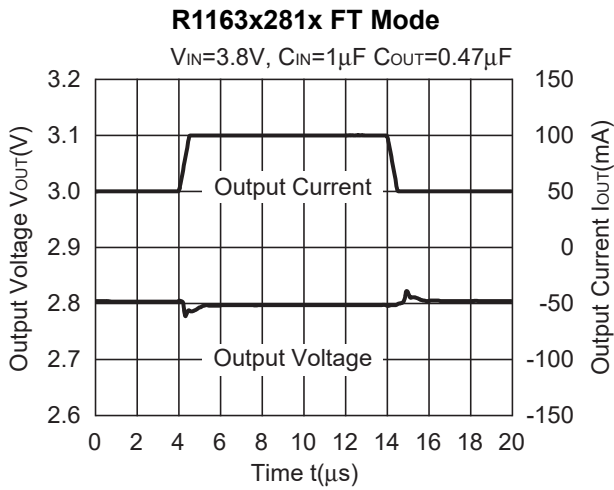
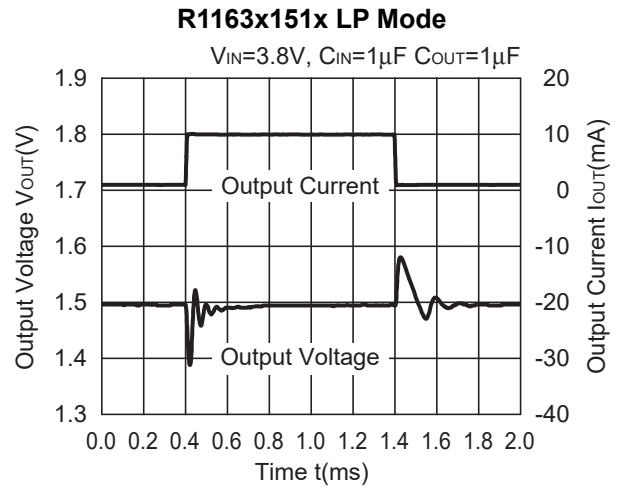
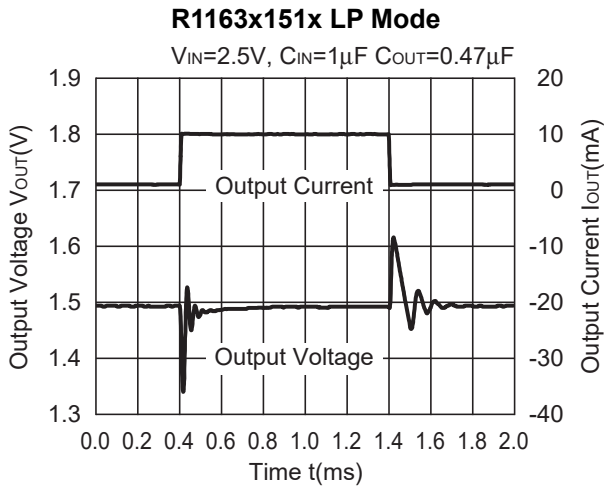


R1163x

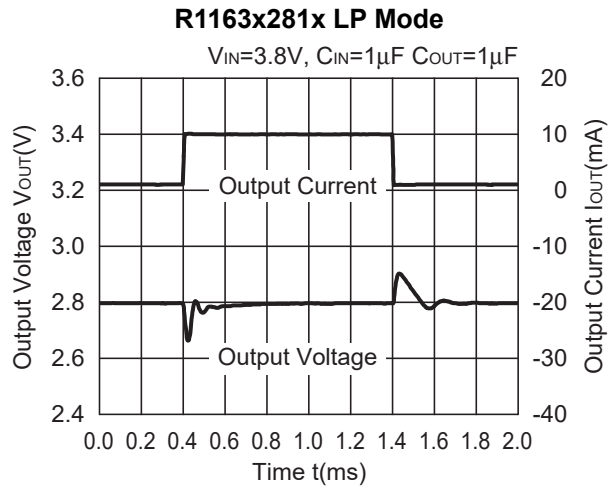
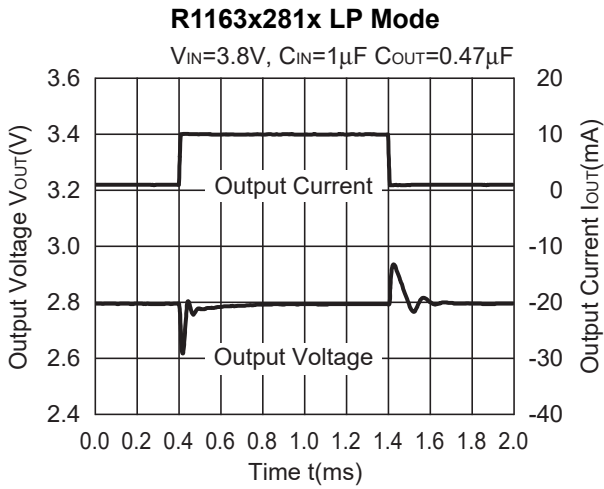


13) Load Transient Response

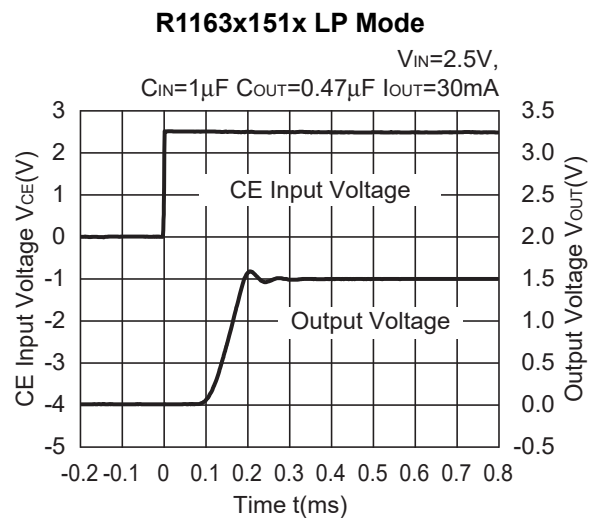
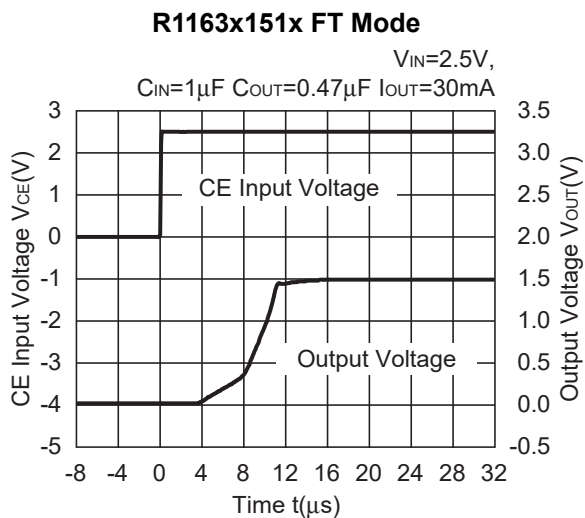
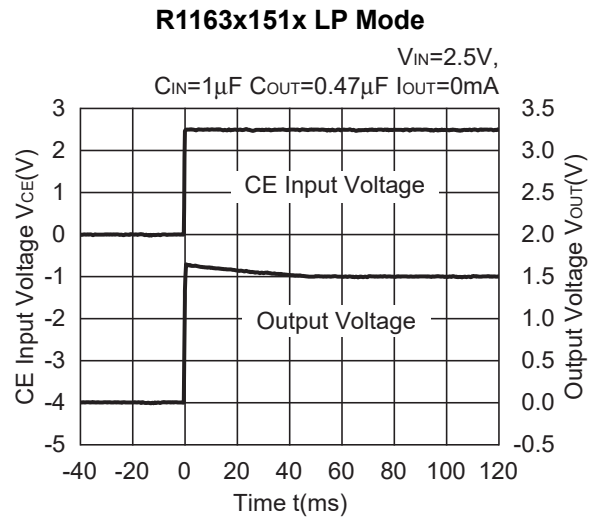
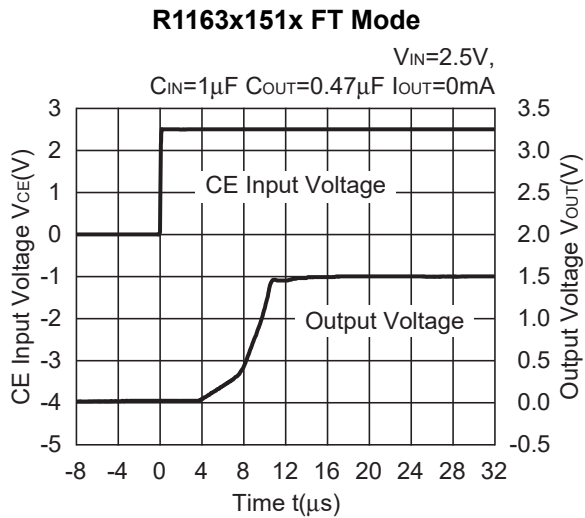




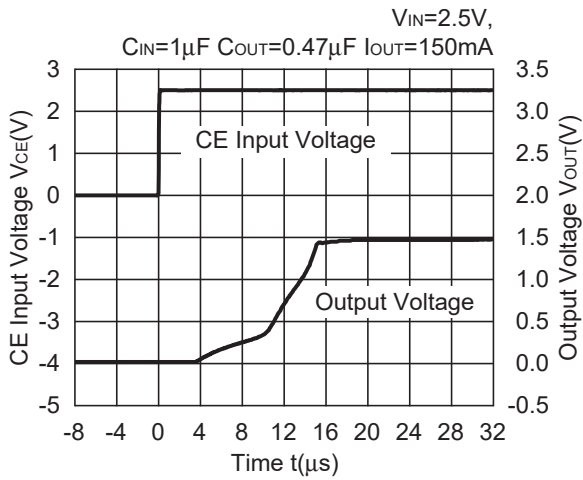
R1163x



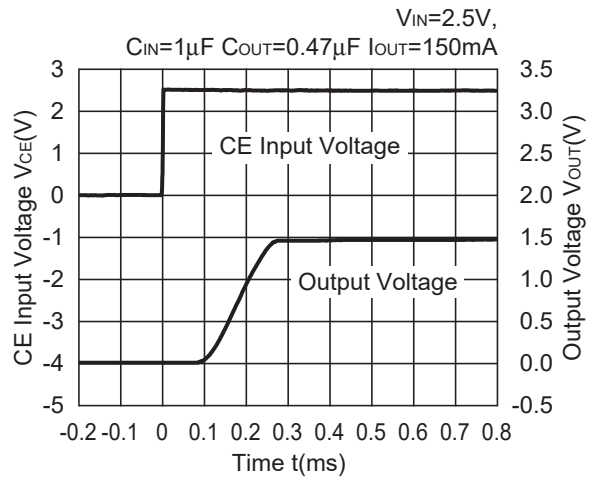
14) Turn on speed with CE pin



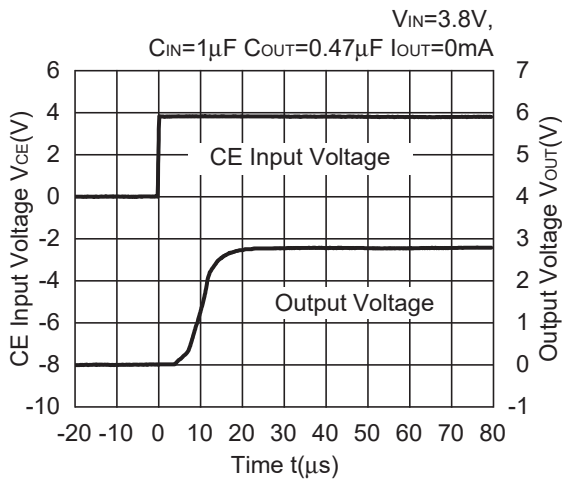
R1163x151x FT Mode



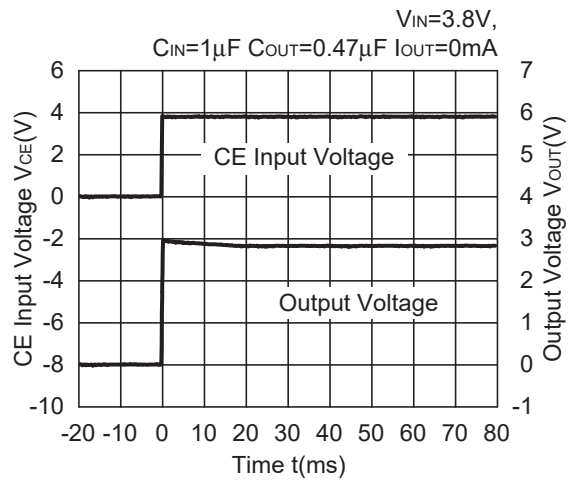
R1163x151x LP Mode



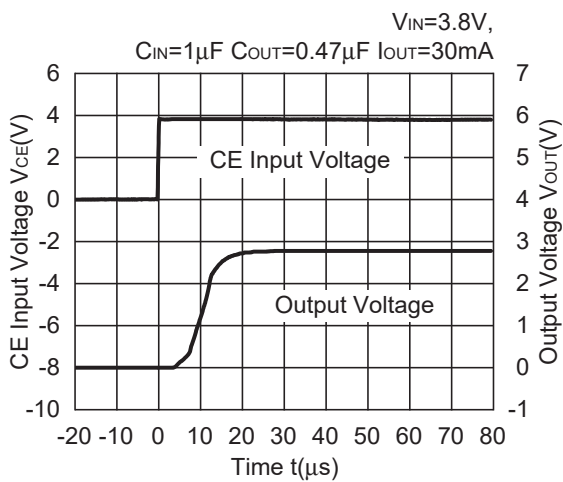
R1163x281x FT Mode



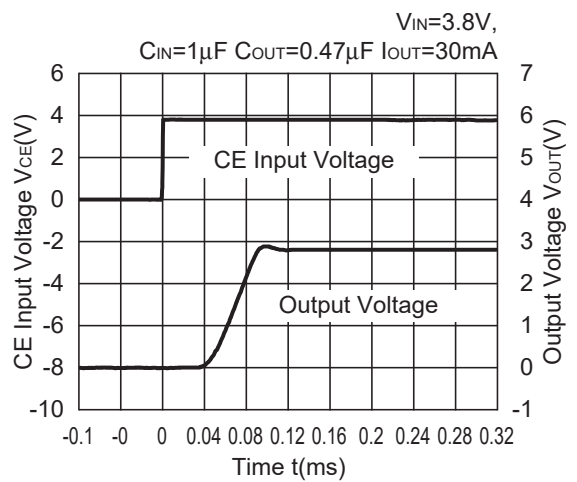
R1163x281x LP Mode



R1163x281x FT Mode

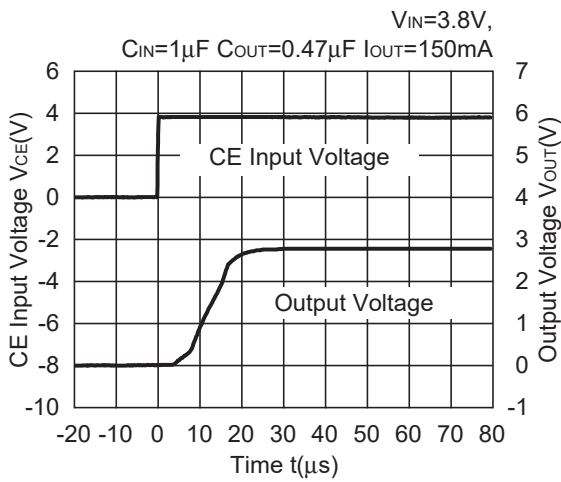


R1163x281x LP Mode

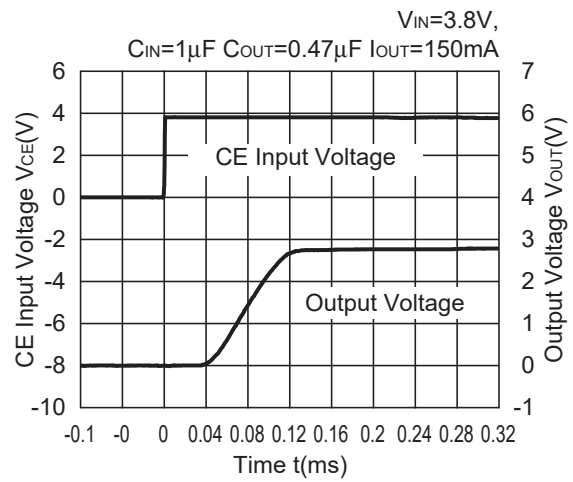


R1163x

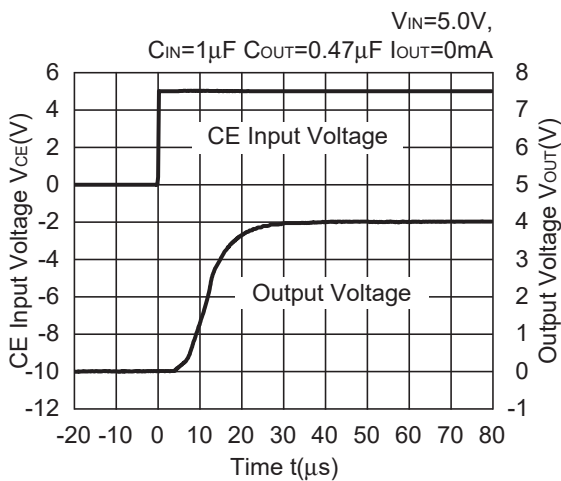
R1163x281x FT Mode



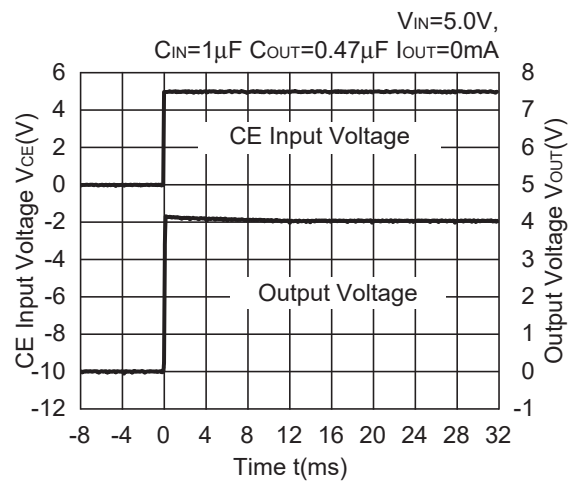
R1163x281x LP Mode



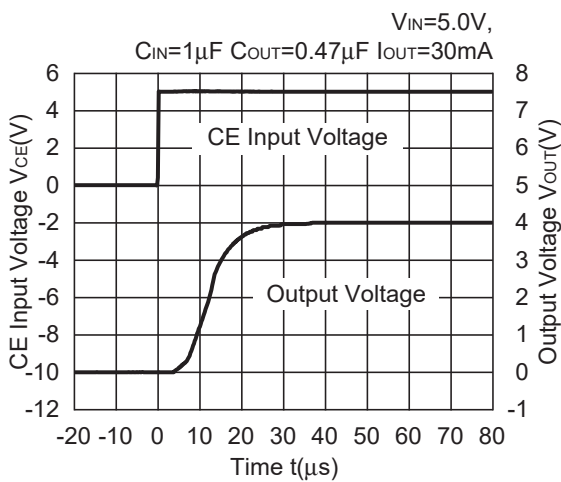
R1163x401x FT Mode



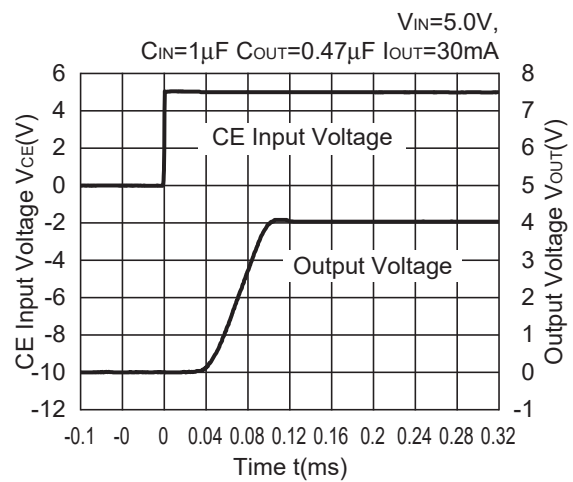
R1163x401x LP Mode



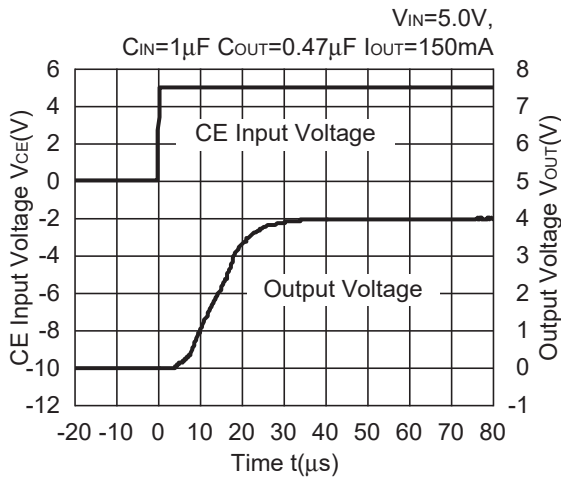
R1163x401x FT Mode



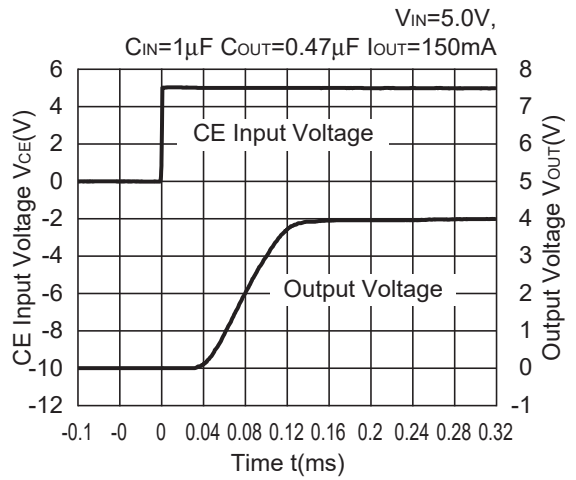
R1163x401x LP Mode



R1163x401x FT Mode

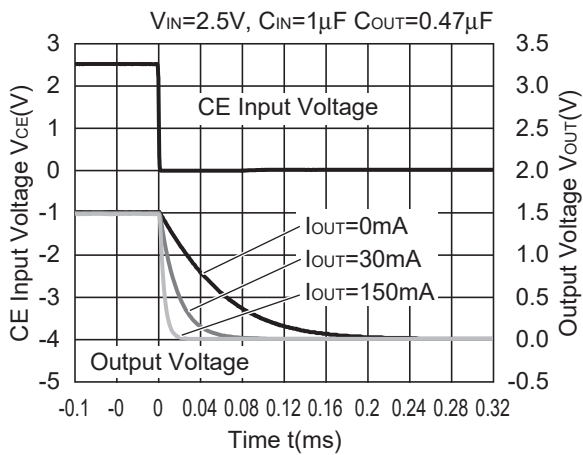


R1163x401x LP Mode

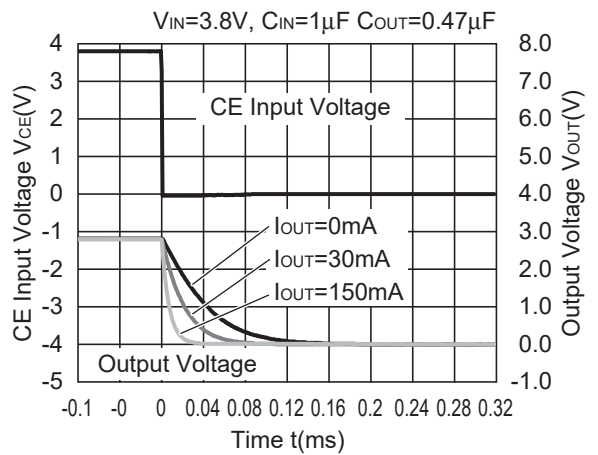


15) Turn off speed with CE pin

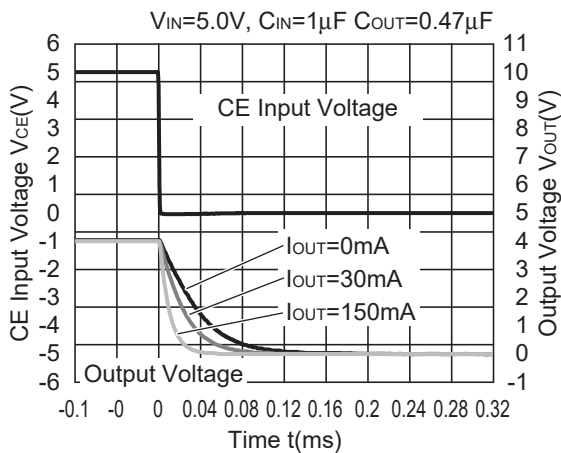
R1163x151xD



R1163x281xD



R1163x401xD

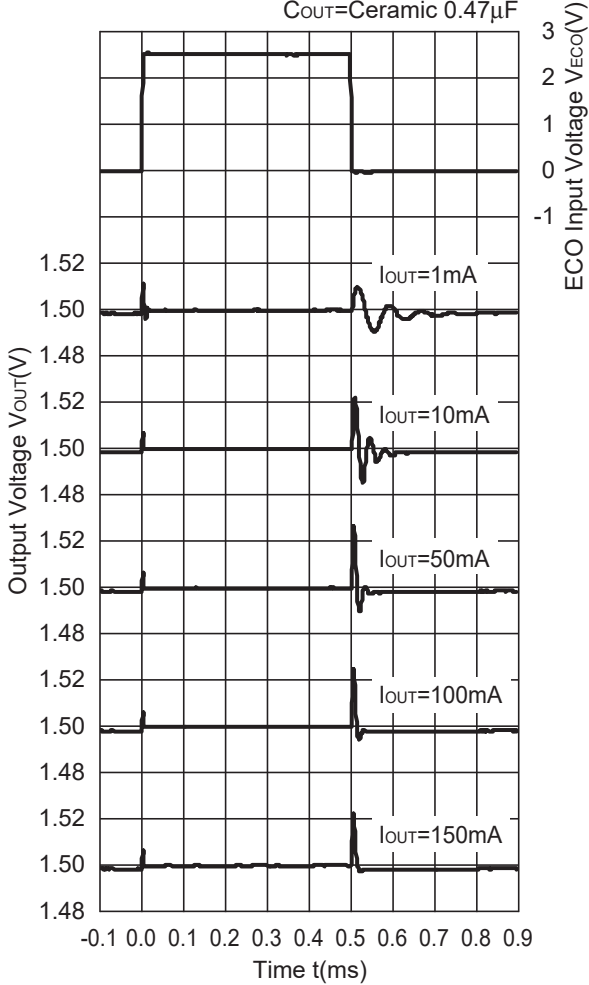


R1163x

16) Output Voltage at Mode alternative point

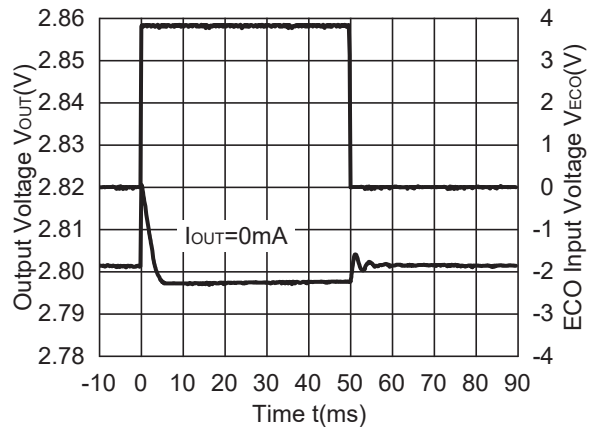
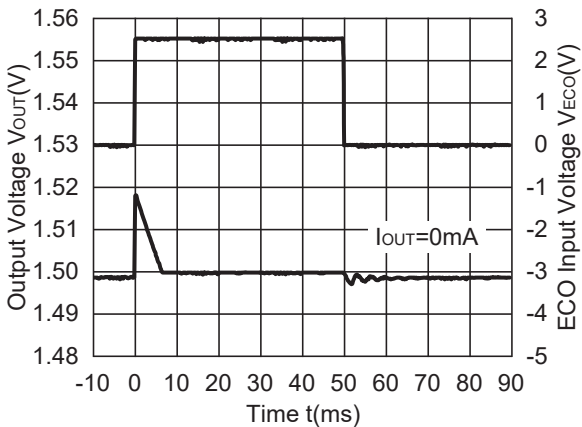
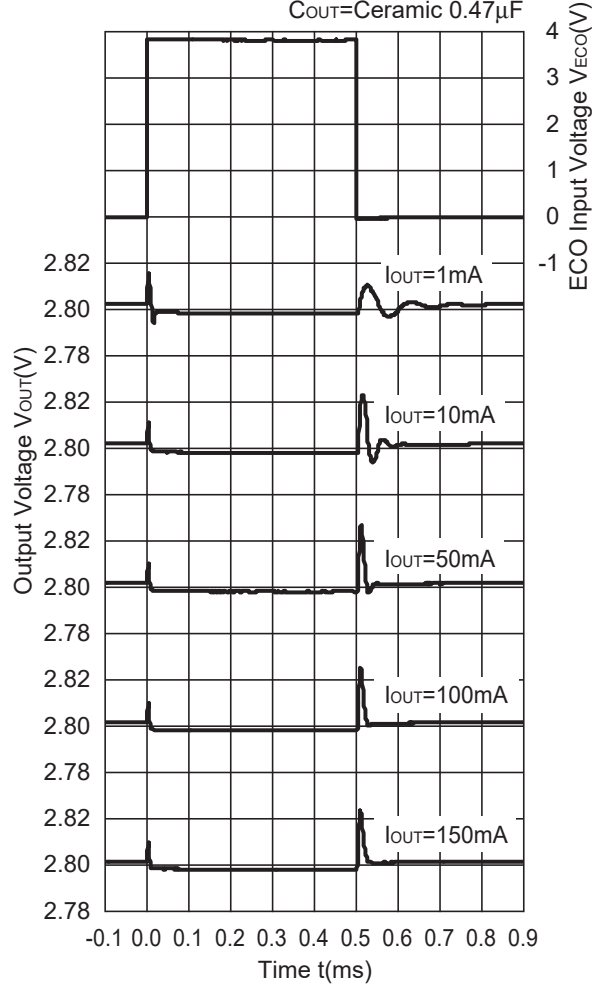
R1163x151B/D

$V_{IN}=2.5V$, C_{IN} =Ceramic $1.0\mu F$,
 C_{OUT} =Ceramic $0.47\mu F$



R1163x281B/D

$V_{IN}=3.8V$, C_{IN} =Ceramic $1.0\mu F$,
 C_{OUT} =Ceramic $0.47\mu F$



TECHNICAL NOTES

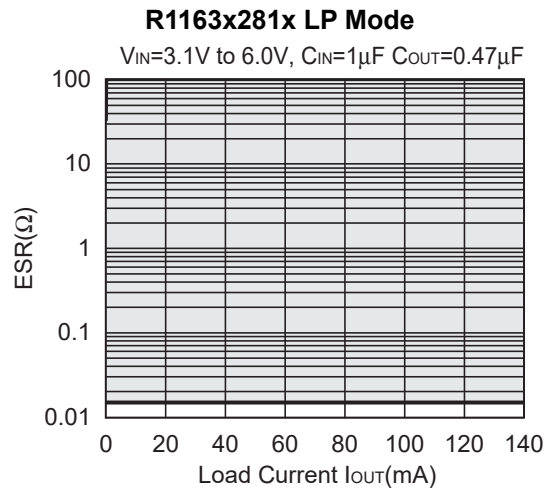
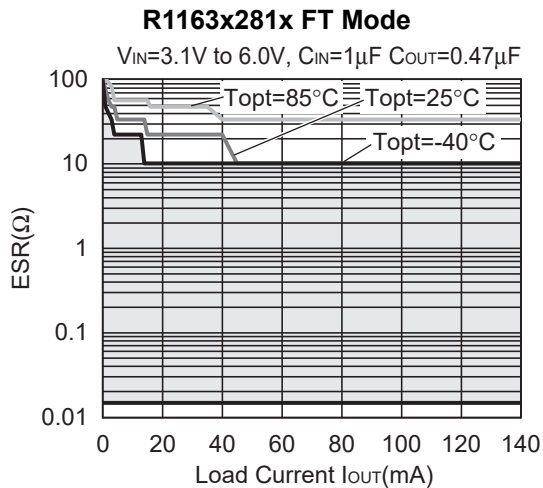
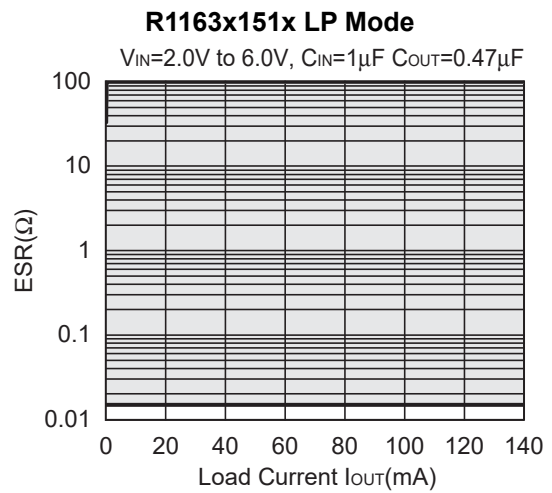
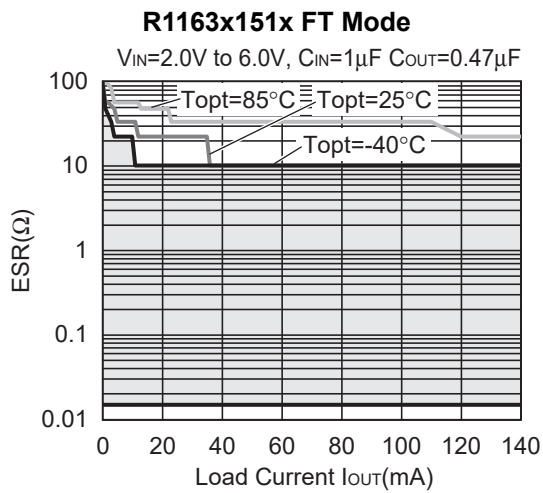
When using these ICs, consider the following points:

In these ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, be sure to use a capacitor C_{OUT} with good frequency characteristics and ESR (Equivalent Series Resistance) in the range described as follows:

The relations between I_{OUT} (Output Current) and ESR of Output Capacitor are shown below. The conditions when the white noise level is under $40\mu V$ (Avg.) are marked as the hatched area in the graph.

<Test conditions>

(1) Frequency band: 10Hz to 2MHz





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Sales & Support Offices

Ricoh Electronic Devices Co., Ltd.

Shin-Yokohama Office (International Sales)

2-3, Shin-Yokohama 3-chome, Kohoku-ku, Yokohama-shi, Kanagawa, 222-8530, Japan
Phone: +81-50-3814-7687 Fax: +81-45-474-0074

Ricoh Americas Holdings, Inc.

675 Campbell Technology Parkway, Suite 200 Campbell, CA 95008, U.S.A.
Phone: +1-408-610-3105

Ricoh Europe (Netherlands) B.V.

Semiconductor Support Centre

Prof. W.H. Keesomlaan 1, 1183 DJ Amstelveen, The Netherlands
Phone: +31-20-5474-309

Ricoh International B.V. - German Branch

Semiconductor Sales and Support Centre

Oberrather Strasse 6, 40472 Düsseldorf, Germany
Phone: +49-211-6546-0

Ricoh Electronic Devices Korea Co., Ltd.

3F, Haesung Bldg, 504, Teheran-ro, Gangnam-gu, Seoul, 135-725, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2051-5713

Ricoh Electronic Devices Shanghai Co., Ltd.

Room 403, No.2 Building, No.690 Bibo Road, Pu Dong New District, Shanghai 201203,
People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

Ricoh Electronic Devices Shanghai Co., Ltd.

Shenzhen Branch

1205, Block D (Jinlong Building), Kingkey 100, Hongbao Road, Luohu District,
Shenzhen, China
Phone: +86-755-8348-7600 Ext 225

Ricoh Electronic Devices Co., Ltd.

Taipei office

Room 109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623

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