

300mA LDO REGULATOR with the Reverse Current Protection

NO.EA-229-111026

OUTLINE

R1191x Series are a low supply current voltage regulator with high output voltage accuracy. The maximum operating voltage is 16V. These ICs can switch to the fast mode and the low power mode by the low power / fast mode changer pin (ECO pin) without changing the output voltage value.

Each of these ICs consists of a voltage reference unit, an error amplifier, a resistor-net for voltage setting, a short current limit circuit, a thermal shutdown circuit and a chip enable circuit.

Moreover, the R1191x Series has the reverse current protection function, which protects the reverse current flow into V_{DD} pin when the output pin voltage becomes higher than the V_{DD} pin voltage. Thus it is suitable for the back-up circuit.

Since the packages for these ICs are SOT-89-5, SOT-23-5 and DFN1616-6, therefore high density mounting of the ICs on boards is possible.

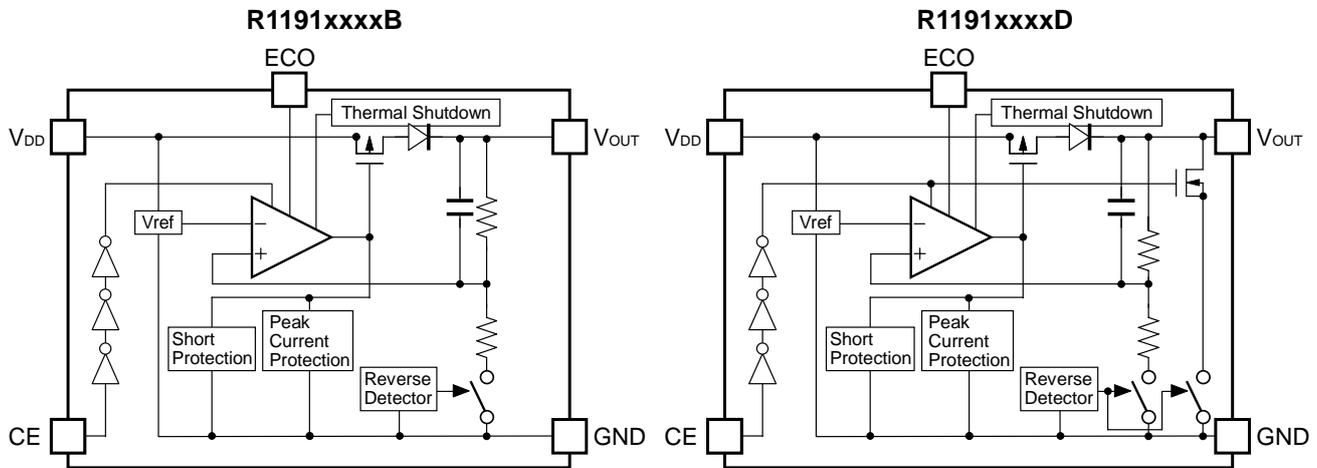
FEATURES

- Supply Current Typ. 50 μ A (Fast Mode),
Typ. 6.0 μ A (Low Power Mode)
- Standby Mode Typ. 0.3 μ A
- Reverse Current..... Max. 0.1 μ A
- Output Current Min. 300mA
- Input Voltage Range 3.5V to 16.0V
- Output Voltage Range..... 2.0V to 15.0V (0.1V steps)
(For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy..... \pm 1.5% (Fast Mode)
 \pm 2.5% (Low Power Mode)
- Temperature-Drift Coefficient of Output Voltage .. Typ. \pm 80ppm/ $^{\circ}$ C
- Dropout Voltage Typ. 0.55V (Fast Mode, I_{OUT} =300mA, V_{OUT} =5.0V)
Typ. 0.70V (Low Power Mode, I_{OUT} =300mA, V_{OUT} =5.0V)
- Ripple Rejection Typ. 60dB (f =1kHz, V_{OUT} =5.0V, Fast Mode)
- Line Regulation Typ. 0.02%/V (Fast Mode)
- Packages DFN1616-6, SOT-23-5, SOT-89-5
- Built-in fold-back protection circuit Typ. 50mA (Current at short mode)
- Built-in Thermal Shutdown Circuit..... Shutdown Temperature at 150 $^{\circ}$ C
- Ceramic capacitors are recommended to be used with this IC C_{IN} =2.2 μ F or more, C_{OUT} =4.7 μ F or more

APPLICATIONS

- Power source for digital home appliances
- Power source for audio visual equipment

BLOCK DIAGRAM



SELECTION GUIDE

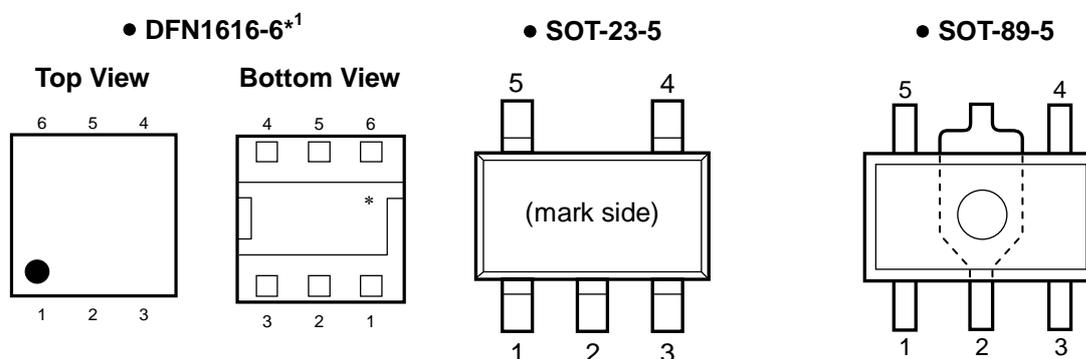
The output voltage, auto-discharge function, and package, for the ICs can be selected at the user's request.

| Product Name | Package | Quantity per Reel | Pb Free | Halogen Free |
|------------------|-----------|-------------------|---------|--------------|
| R1191Lxxx*-TR | DFN1616-6 | 5,000 pcs | Yes | Yes |
| R1191Nxxx*-TR-FE | SOT-23-5 | 3,000 pcs | Yes | Yes |
| R1191Hxxx*-T1-FE | SOT-89-5 | 1,000 pcs | Yes | Yes |

xxx : The output voltage can be designated in the range from 2.0V(020) to 15.0V(150) 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.

PIN CONFIGURATIONS



PIN DISCRIPTIONS

• DFN1616-6*¹

| Pin No | Symbol | Pin Description |
|--------|------------------|--|
| 1 | ECO | Low Power / Fast Mode Changer Pin ("H": Fast Mode) |
| 2 | NC | No Connection |
| 3 | V _{DD} | Input Pin |
| 4 | V _{OUT} | Output pin |
| 5 | GND | Ground Pin |
| 6 | CE | Chip Enable Pin ("H" Active) |

*1) 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 | ECO | Low Power / Fast Mode Changer Pin ("H": Fast Mode) |
| 2 | GND | Ground Pin |
| 3 | CE | Chip Enable Pin ("H" Active) |
| 4 | V _{OUT} | Output pin |
| 5 | V _{DD} | Input Pin |

• SOT-89-5

| Pin No | Symbol | Pin Description |
|--------|------------------|--|
| 1 | V _{OUT} | Output pin |
| 2 | GND | Ground Pin |
| 3 | CE | Chip Enable Pin ("H" Active) |
| 4 | ECO | Low Power / Fast Mode Changer Pin ("H": Fast Mode) |
| 5 | V _{DD} | Input Pin |

ABSOLUTE MAXIMUM RATINGS

| Symbol | Item | Rating | Unit |
|------------------|--------------------------------|--------------------------------------|------|
| V _{IN} | Input Voltage | -0.3 to 18.0 | V |
| V _{CE} | Input Voltage (CE Pin) | -0.3 to 18.0 | V |
| V _{ECO} | Input Voltage (ECO Pin) | -0.3 to V _{IN} + 0.3 ≤ 18.0 | V |
| V _{OUT} | Output Voltage | -0.3 to 18.0 | V |
| I _{OUT} | Output Current | 400 | mA |
| P _D | Power Dissipation (DFN1616-6)* | 640 | mW |
| | Power Dissipation (SOT-23-5)* | 420 | |
| | Power Dissipation (SOT-89-5)* | 900 | |
| 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.

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.

ELECTRICAL CHARACTERISTICS

$V_{IN}=V_{CE}=\text{Set } V_{OUT}+3.0\text{V}$ (Max.16V), $C_{IN}=2.2\mu\text{F}$, $C_{OUT}=4.7\mu\text{F}$ $I_{OUT}=1\text{mA}$, unless otherwise noted.
The values in are applicable under the condition of $-40^{\circ}\text{C} \leq T_{opt} \leq 85^{\circ}\text{C}$.

R1191xxxxB/D

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

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit | | |
|---------------------------------|---|---|--|---|---|---|---|---|
| V_{OUT} | Output Voltage | Fast Mode | $V_{ECO}=V_{IN}$ | $T_{opt}=25^{\circ}\text{C}$ | $\times 0.985$ | $\times 1.015$ | V | |
| | | | $-40^{\circ}\text{C} \leq T_{opt} \leq 85^{\circ}\text{C}$ | | | | | |
| | | Low Power Mode | $V_{ECO}=0\text{V}$ | $T_{opt}=25^{\circ}\text{C}$ | $\times 0.975$ | $\times 1.025$ | | |
| | | | | $-40^{\circ}\text{C} \leq T_{opt} \leq 85^{\circ}\text{C}$ | | | | |
| ΔV_{OUT} | Output Voltage Deviation between Fast Mode and Low Power Mode | | | 0 | | % | | |
| I_{OUT} | Output Current | | | | | mA | | |
| $\Delta V_{OUT}/\Delta I_{OUT}$ | Load Regulation | Fast Mode | $V_{ECO}=V_{IN}$, $1\text{mA} \leq I_{OUT} \leq 300\text{mA}$ | | 50 | | mV | |
| | | Low Power Mode | $V_{ECO}=\text{GND}$, $1\text{mA} \leq I_{OUT} \leq 300\text{mA}$ | | 60 | | | |
| V_{DIF} | Dropout Voltage | | Refer to the following table | | | | | |
| I_{SS1} | Supply Current (Fast Mode) | | $V_{ECO}=V_{IN}$, $I_{OUT}=0\text{mA}$ | | 50 | | μA | |
| I_{SS2} | Supply Current (Low Power Mode) | | $V_{ECO}=\text{GND}$, $I_{OUT}=0\text{mA}$ | | 6 | | μA | |
| $I_{standby}$ | Supply Current (Standby) | | $V_{IN}=16\text{V}$, $V_{CE}=0\text{V}$ (If $V_{OUT} < 3.0\text{V}$, $V_{IN}=14\text{V}$) | | 0.3 | 1.0 | μA | |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | | Set $V_{OUT}+0.5\text{V} \leq V_{IN} \leq 16\text{V}$ (If Set $V_{OUT} < 3.0\text{V}$, $3.5\text{V} \leq V_{IN} \leq 14\text{V}$) | | 0.02 | | %/V | |
| RR | Ripple Rejection | $f=1\text{kHz}$, $I_{OUT}=30\text{mA}$ Ripple 0.2V_{p-p} , $V_{IN}=V_{ECO}=\text{Set } V_{OUT}+1\text{V}$ | $2.0\text{V} \leq V_{OUT} < 5.0\text{V}$ | | 70 | | dB | |
| | | | $5.0\text{V} \leq V_{OUT} < 12\text{V}$ | | 60 | | | |
| | | | $12\text{V} \leq V_{OUT}$ | | 60 | | | |
| V_{IN} | Input Voltage | $2.0\text{V} \leq V_{OUT} < 3.0\text{V}$ | | | | V | | |
| | | $3.0\text{V} \leq V_{OUT}$ | | | | | | |
| $\Delta V_{OUT}/\Delta T_{opt}$ | Output Voltage Temperature Coefficient | | $-40^{\circ}\text{C} \leq T_{opt} \leq 85^{\circ}\text{C}$ | | ± 80 | | ppm/ $^{\circ}\text{C}$ | |
| I_{SC} | Short Current Limit | | $V_{OUT}=0\text{V}$ | | 50 | | mA | |
| V_{CEH} | CE, ECO Input Voltage "H" | | | | | V_{IN} | V | |
| V_{CEL} | CE, ECO Input Voltage "L" | | | 0 | | | V | |
| T_{TSD} | Thermal Shutdown Temperature | | Junction Temperature | | | 150 | $^{\circ}\text{C}$ | |
| T_{TSR} | Thermal Shutdown Released Temperature | | Junction Temperature | | | 130 | $^{\circ}\text{C}$ | |
| R_{LOW} | Low Output Nch Tr. ON Resistance (of D Version) | | $V_{IN}=5\text{V}$, $V_{CE}=0\text{V}$, $V_{OUT}=0.3\text{V}$ | | | 150 | Ω | |
| I_{REV} | Reverse Current | | $V_{OUT} > 0.6\text{V}$, $0\text{V} \leq V_{IN} \leq 16\text{V}$ | | | 0 | | μA |

*) The values in have been tested and guaranteed by Design Engineering.

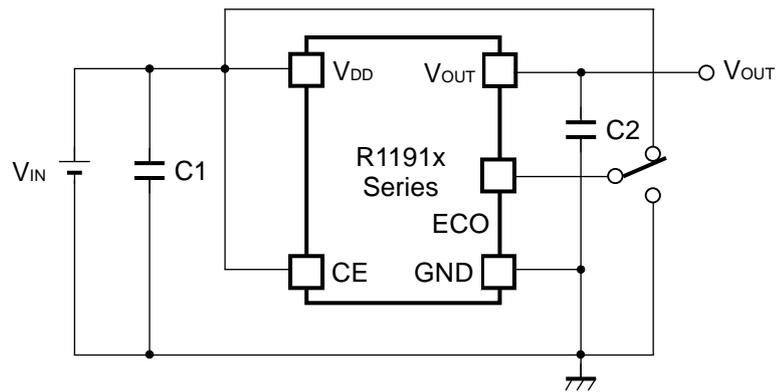
All test categories were tested on the products under the pulse load condition ($T_j \approx T_a = 25^{\circ}\text{C}$) except the following test categories: ripple rejection, output voltage temperature coefficient, and thermal shutdown.

ELECTRICAL CHARACTERISTICS by OUTPUT VOLTAGE

T_{opt}=25°C

| Output Voltage V _{OUT} (V) | Dropout Voltage V _{DIF} (V) | | | | |
|--|--------------------------------------|---------|------|---------|------|
| | Condition | ECO="H" | | ECO="L" | |
| | | Typ. | Max. | Typ. | Max. |
| 2.0 ≤ V _{OUT} < 2.5 | I _{OUT} =300mA | 1.20 | 1.80 | 2.5 | 3.0 |
| 2.5 ≤ V _{OUT} < 3.3 | | 1.00 | 1.50 | 2.0 | 2.5 |
| 3.3 ≤ V _{OUT} < 5.0 | | 0.75 | 1.00 | 1.5 | 1.8 |
| 5.0 ≤ V _{OUT} < 12.0 | | 0.55 | 0.75 | 0.7 | 1.0 |
| 12.0 ≤ V _{OUT} | | 0.40 | 0.60 | 0.4 | 0.6 |

TYPICAL APPLICATION



(External Components)

- Ex. C1: Ceramic Capacitor 2.2μF Murata GRM32RB11E225KC01B
 C2: Ceramic Capacitor 4.7μF Murata GCM31CR71E475KA40

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 good frequency characteristics and ESR (Equivalent Series Resistance).

(Note: If additional ceramic capacitors are connected with parallel to the output pin with an output capacitor for phase compensation, the operation might be unstable. Because of this, test these ICs with as same external components as ones to be used on the PCB.)

- **PCB Layout**

Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as $2.2\mu\text{F}$ or more between V_{DD} and GND pin, and as close as possible to the pins.

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

- **Thermal Shutdown Function**

There is the built-in thermal-shutdown function in R1191x series. It discontinues operation of the IC when the junction temperature becomes over 150°C (Typ.) and IC re-operates when the junction temperature under 130°C (Typ.). If the temperature increasing keeps the IC repeats ON and OFF operating. The output becomes the pulse condition.

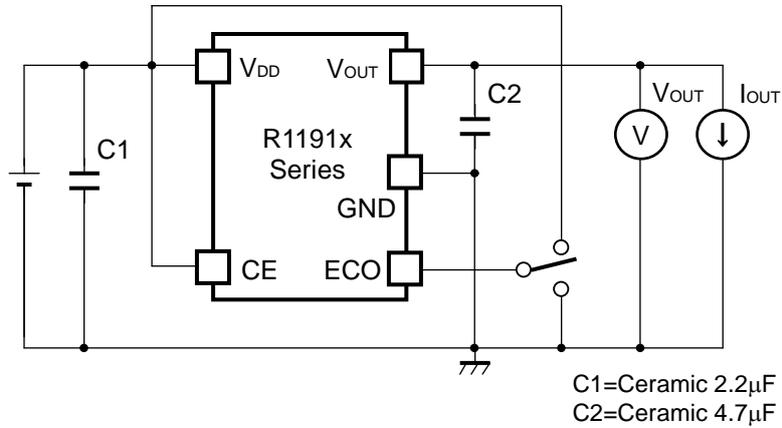
- **Chip Enable (CE) Circuit and High-speed/ Low Supply Current Switching (ECO) Circuit**

To maintain the stability of the output voltage, please do not use the intermediate electric potentials (the voltage values between V_{CEH} and V_{CEL}) for the CE pin and the ECO pin. The use of the intermediate electric potentials increases the supply current and causes the unstable output voltage.

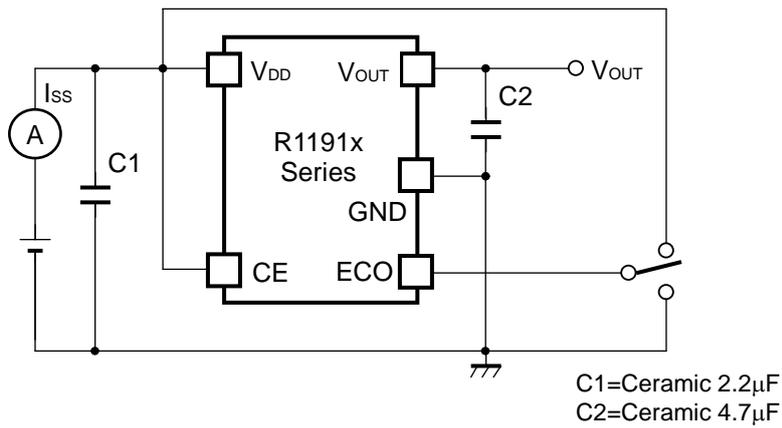
- **Auto-discharge Function**

R1191xxxxD has adopted Auto-discharge function, which decreases the output voltage quickly to 0V by turning on the transistor between V_{OUT} pin and GND pin when switching "Active" to "Standby" and releases the electrical charges accumulated in the external capacitor.

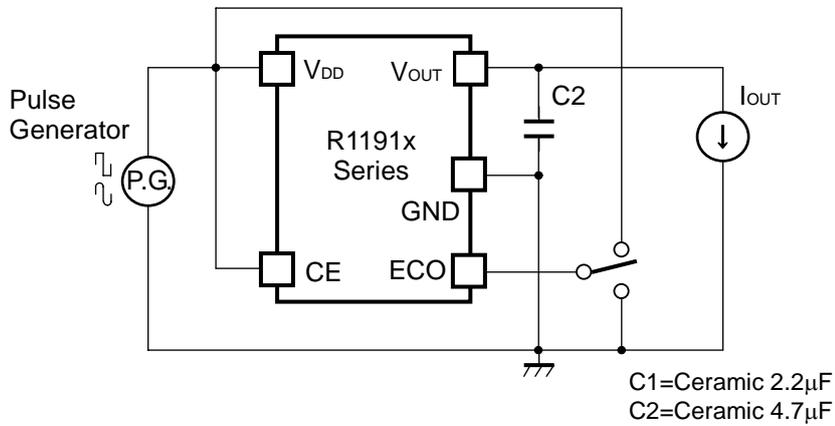
TEST CIRCUITS



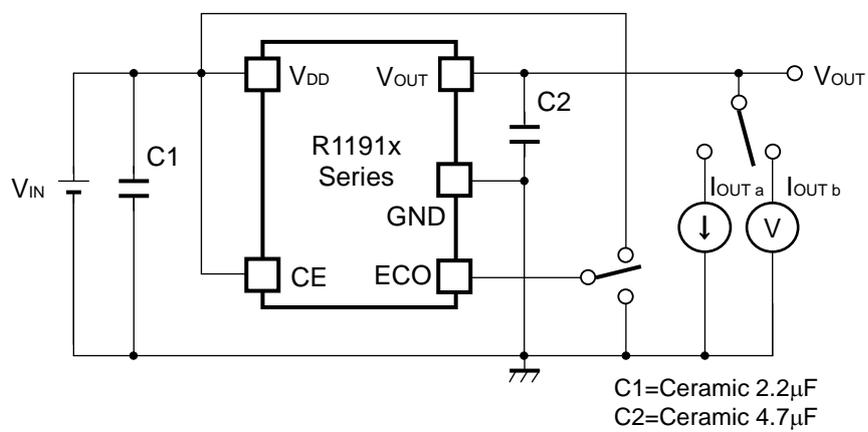
Basic Test Circuit



Test Circuit for Supply Current

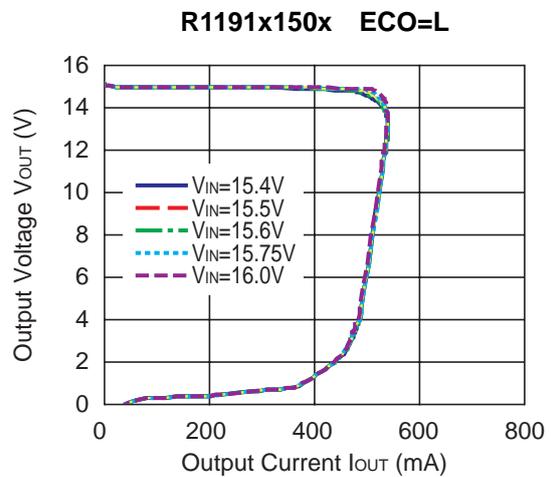
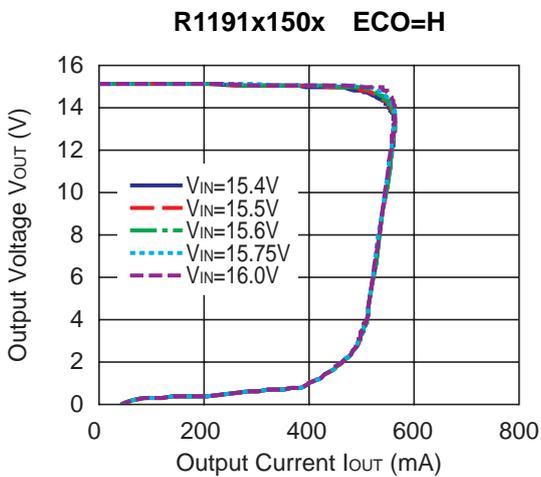
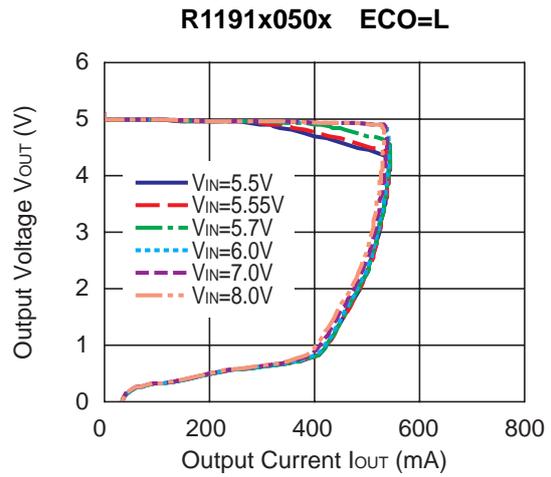
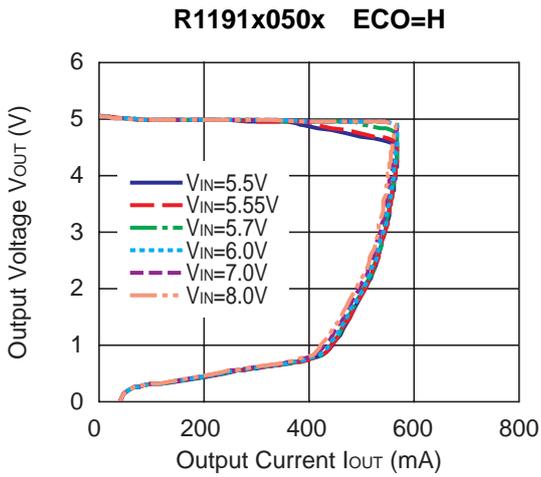
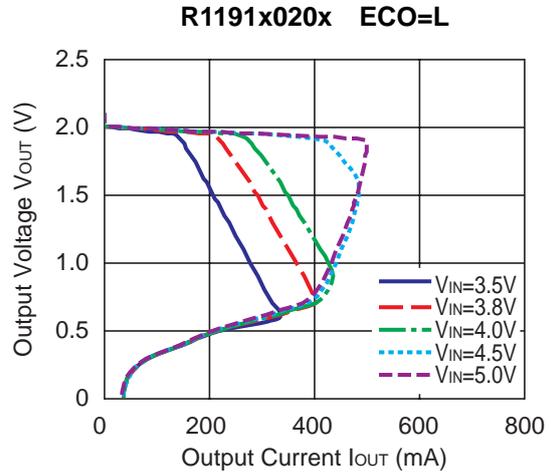
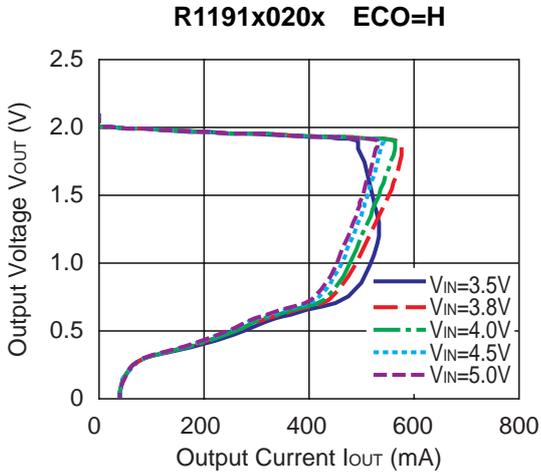


Test Circuit for Ripple Rejection

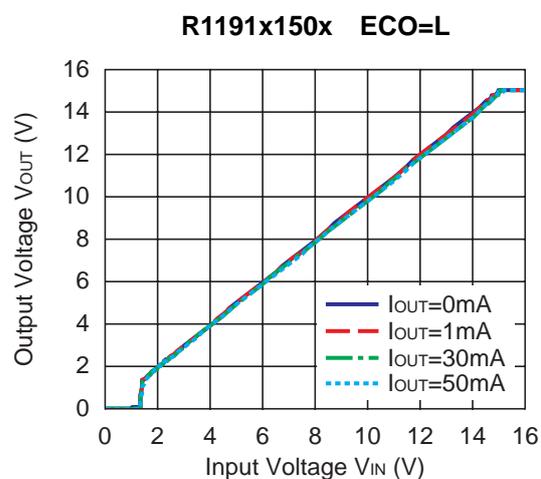
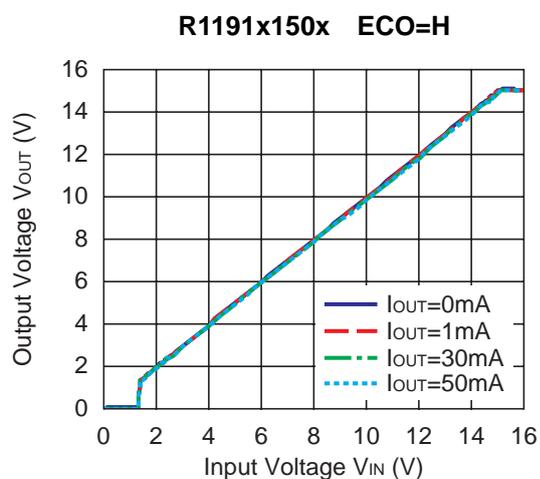
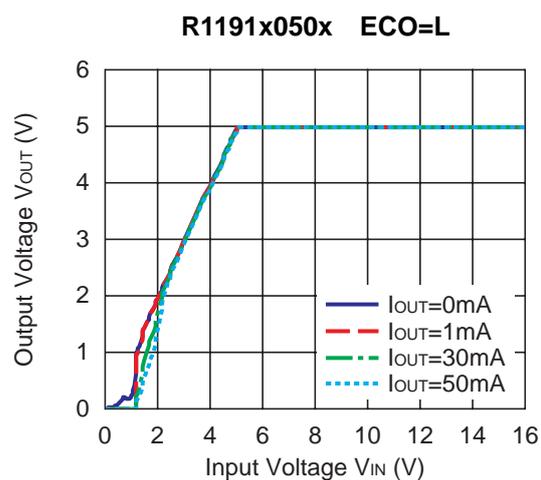
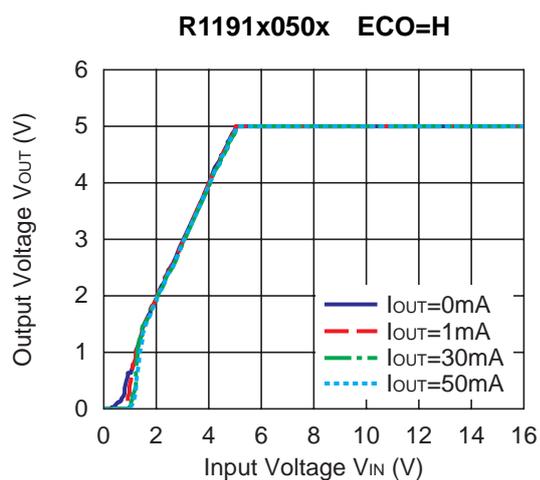
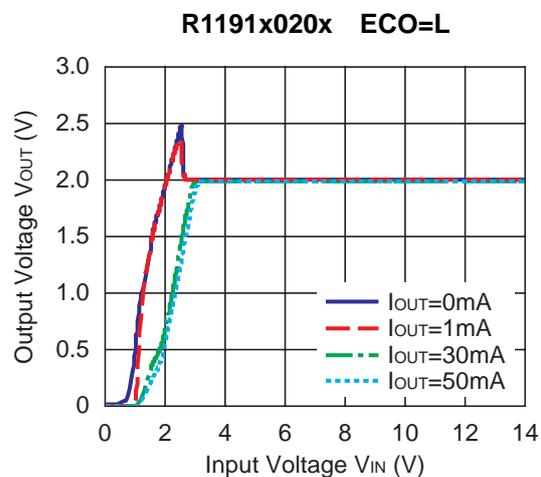
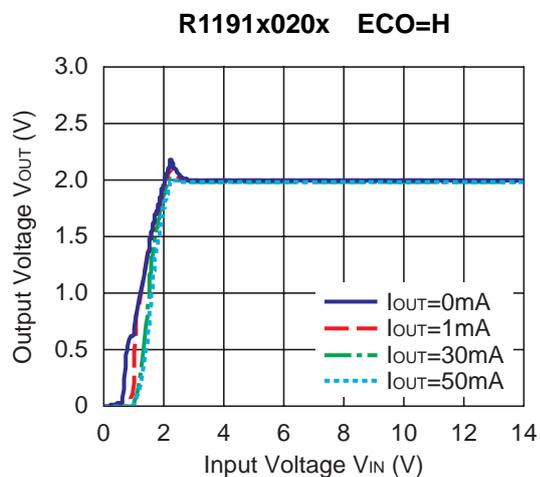
**Test Circuit for Load Transient Response**

TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current (C1=2.2μF, C2=4.7μF, T_{opt}=25°C)

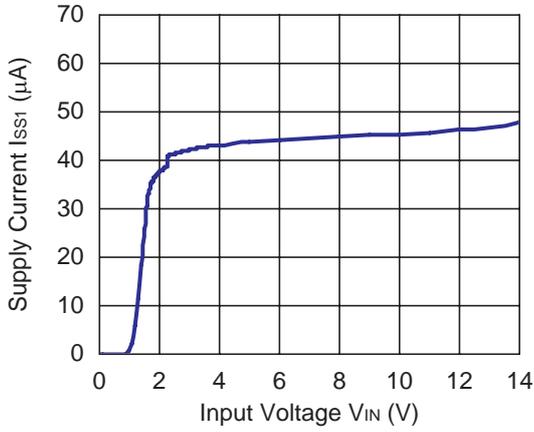


2) Output Voltage vs. Input Voltage ($C_1=2.2\mu\text{F}$, $C_2=4.7\mu\text{F}$, $T_{\text{opt}}=25^\circ\text{C}$)

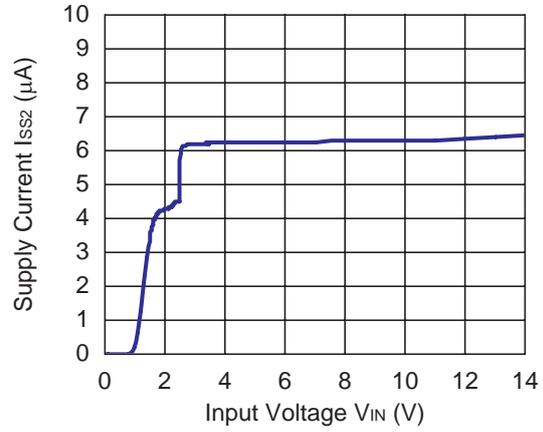


3) Supply Current vs. Input Voltage (C1=2.2μF, C2=4.7μF, T_{opt}=25°C)

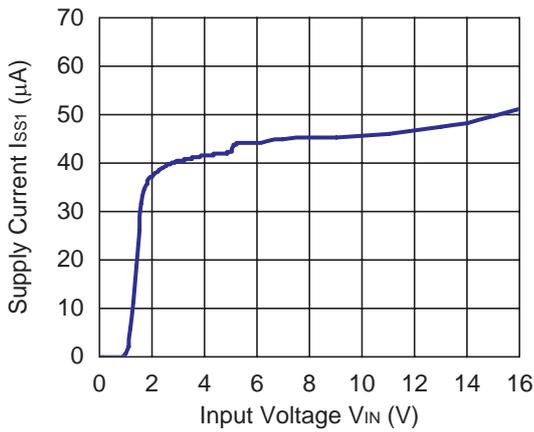
R1191x020x ECO=H



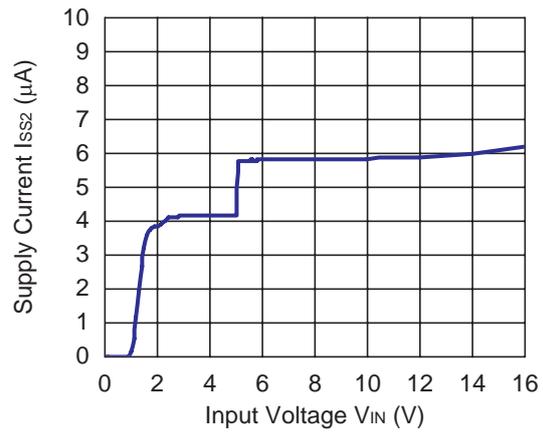
R1191x020x ECO=L



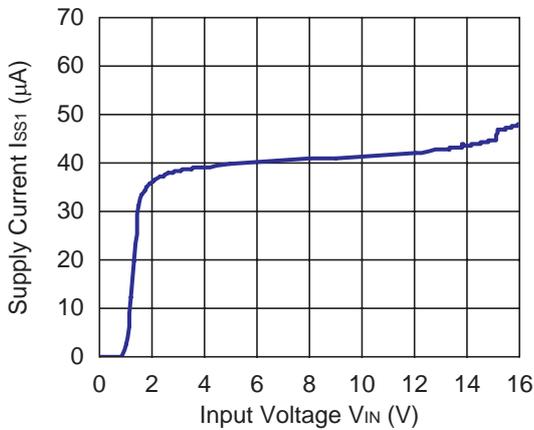
R1191x050x ECO=H



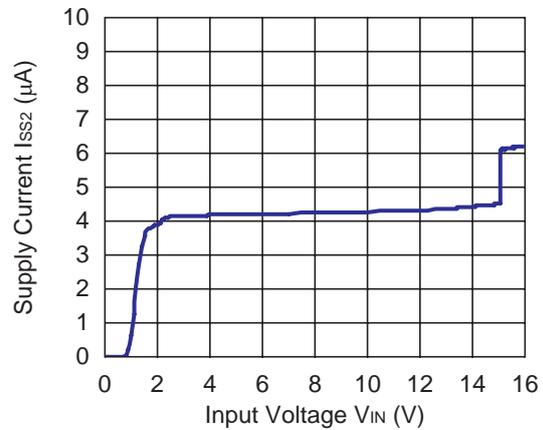
R1191x050x ECO=L



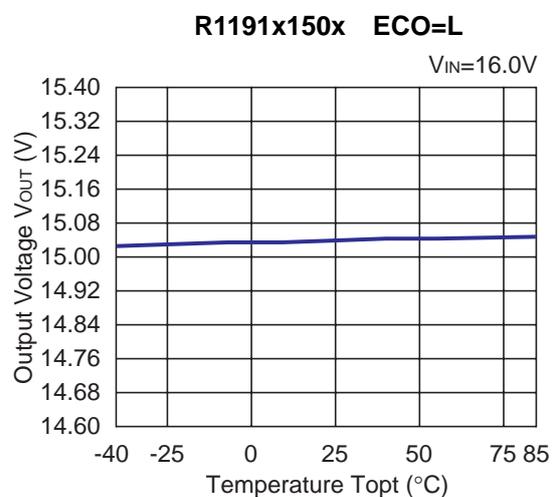
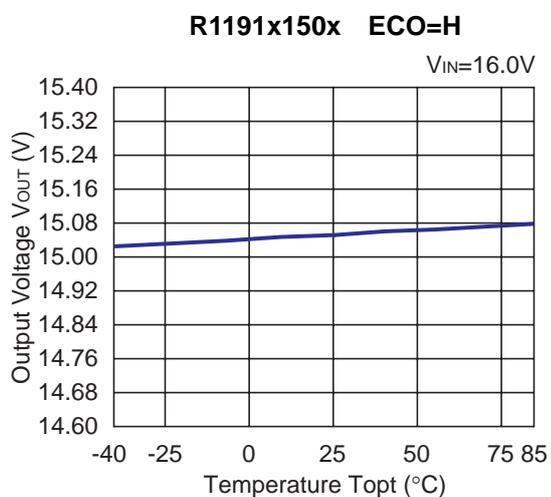
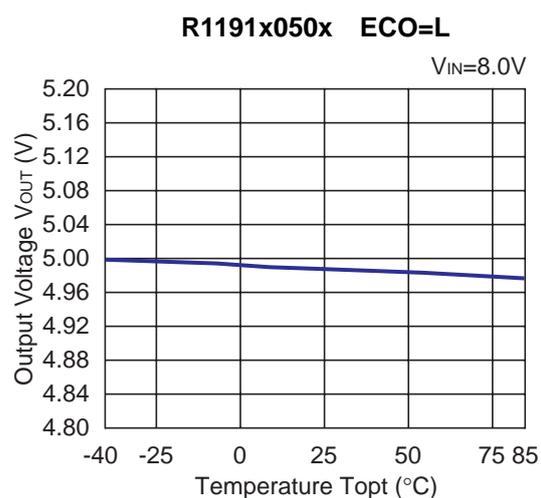
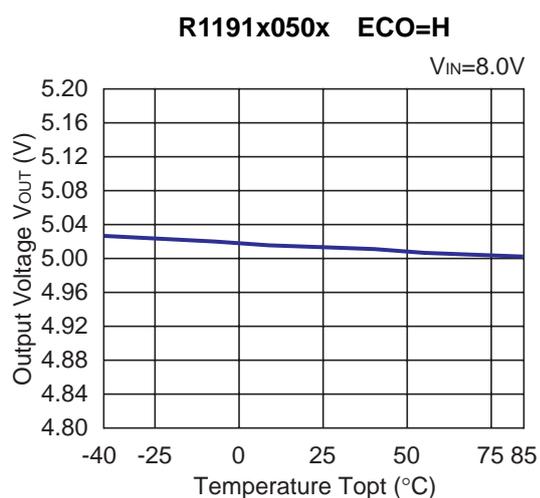
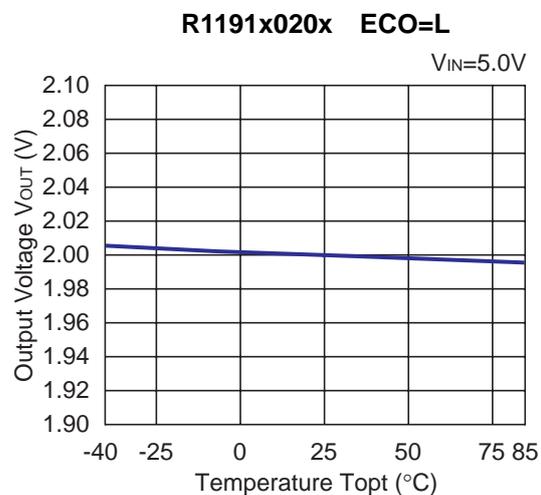
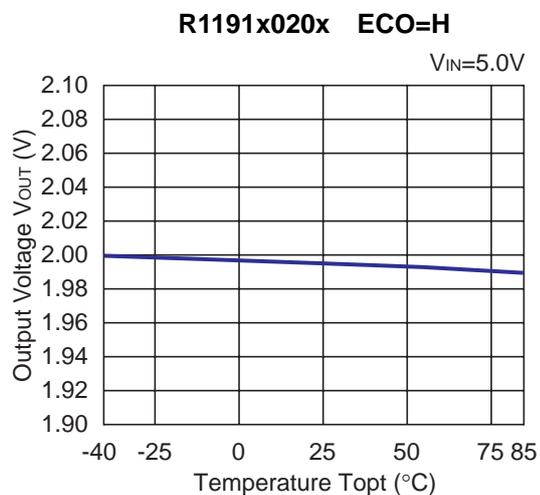
R1191x150x ECO=H



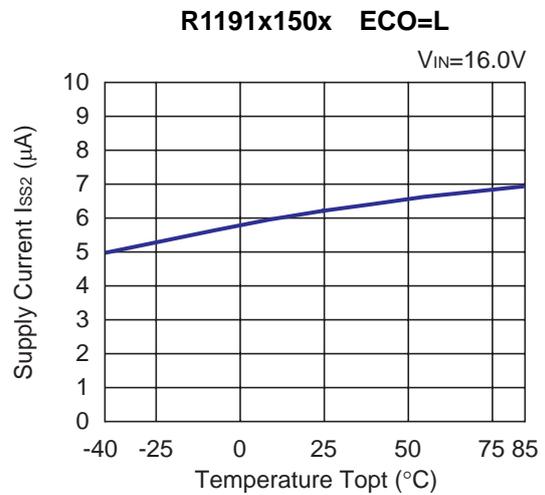
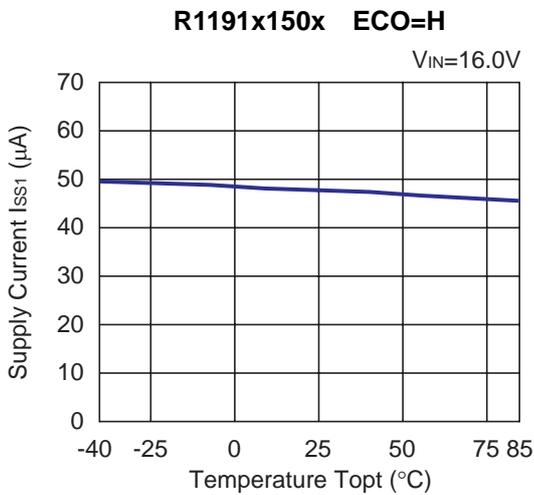
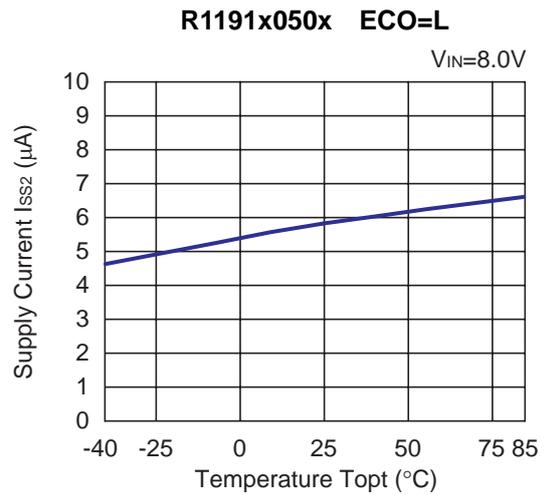
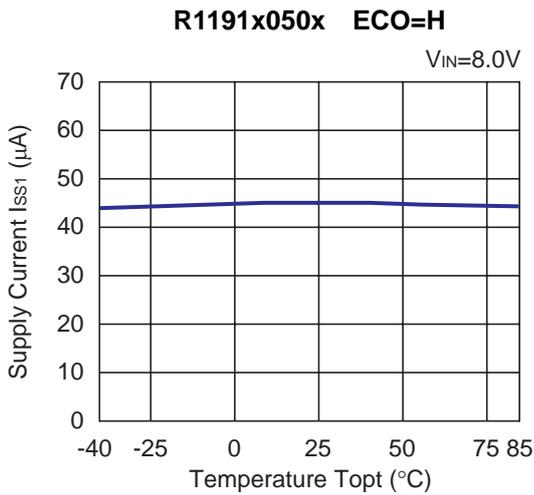
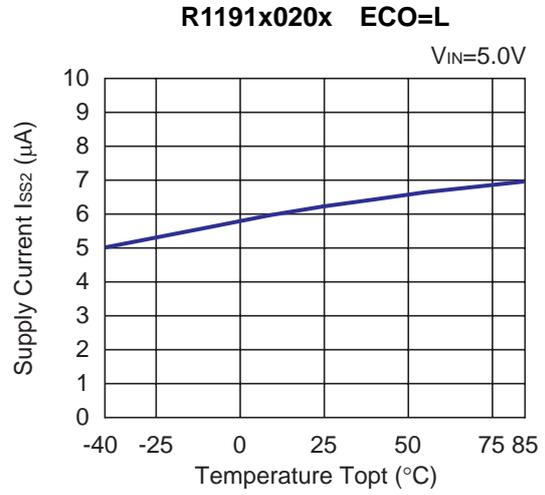
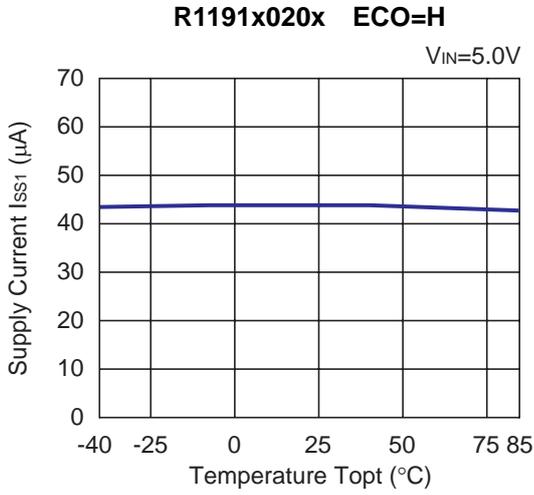
R1191x150x ECO=L



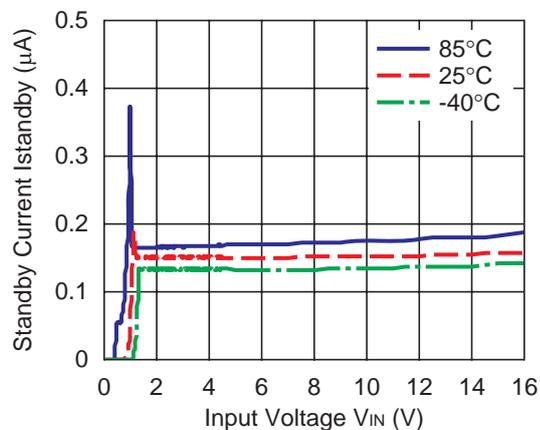
4) Output Voltage vs. Temperature ($C_1=2.2\mu\text{F}$, $C_2=4.7\mu\text{F}$, $I_{\text{OUT}}=1\text{mA}$)



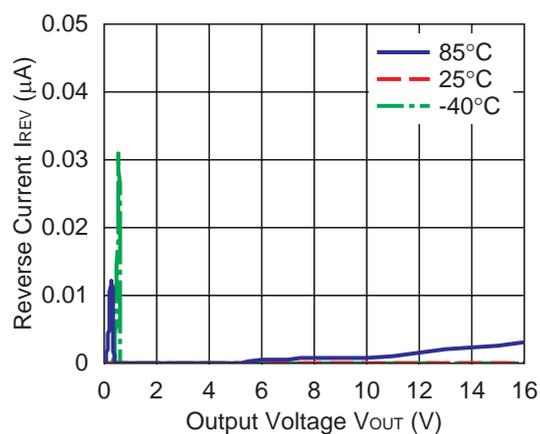
5) Supply Current vs. Temperature (C1=2.2μF, C2=4.7μF)



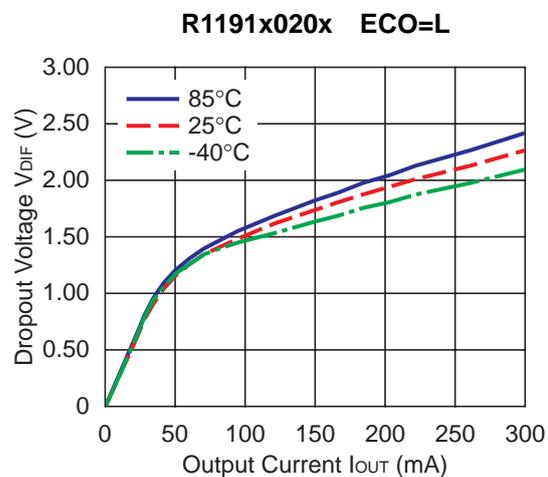
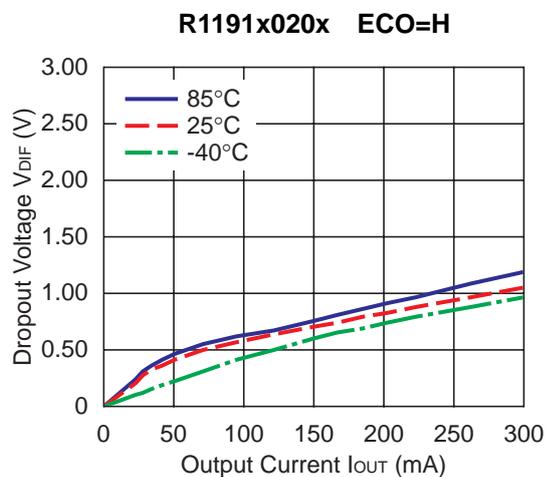
6) Standby Current vs. Input Voltage (C1=2.2 μ F, C2=4.7 μ F)



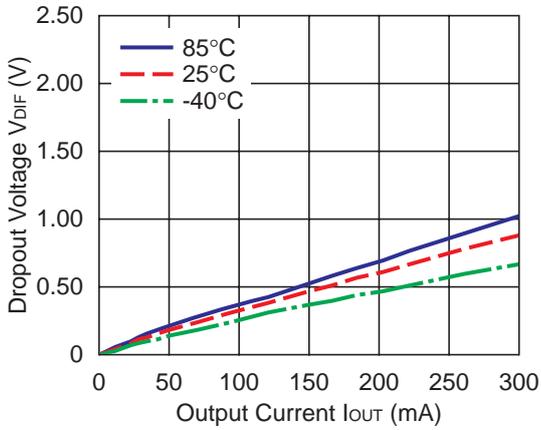
7) Reverse Current vs. Output Voltage (C1=2.2 μ F, C2=4.7 μ F, $V_{IN}=0$ V)



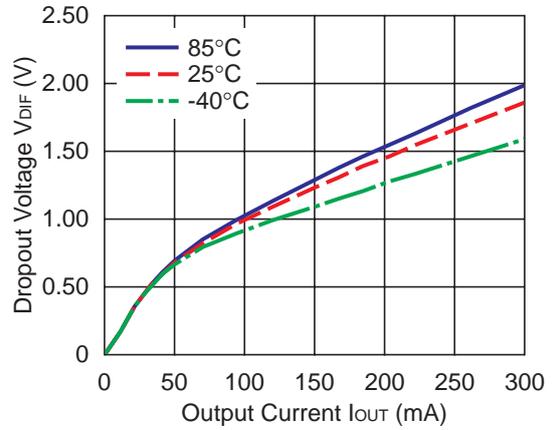
8) Dropout Voltage vs. Output Current (C1=2.2 μ F, C2=4.7 μ F)



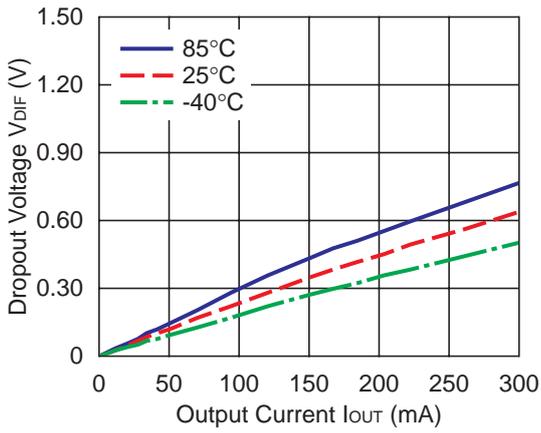
R1191x025x ECO=H



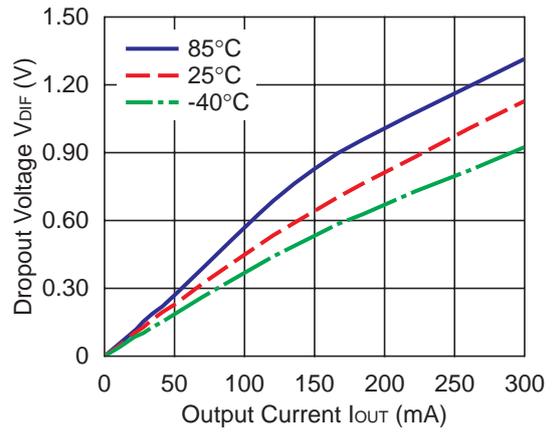
R1191x025x ECO=L



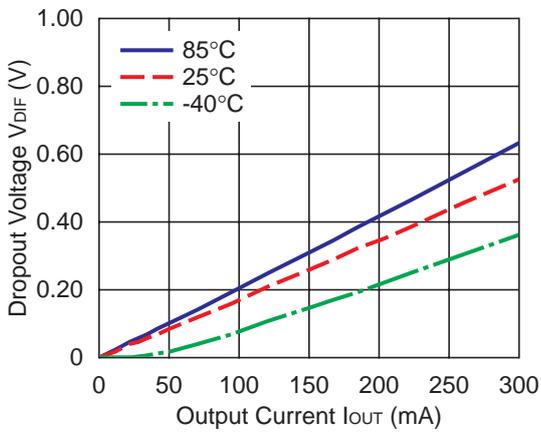
R1191x033x ECO=H



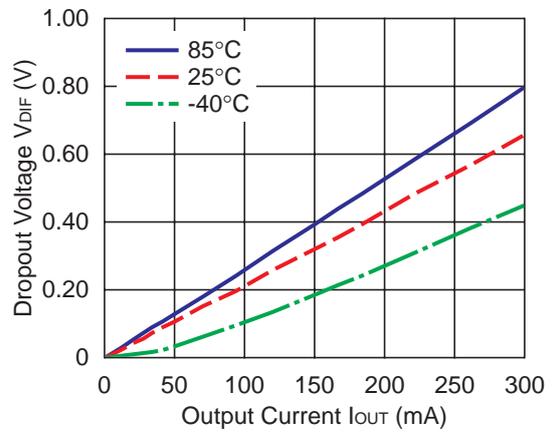
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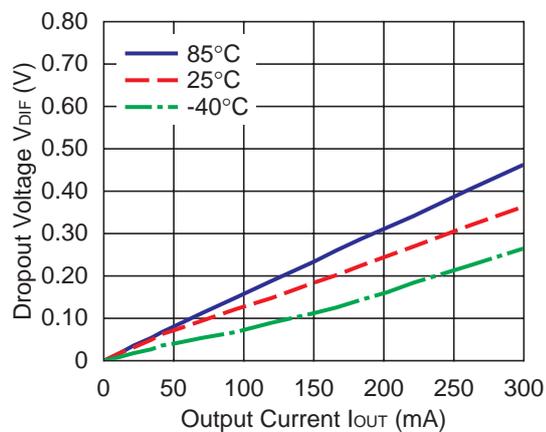
R1191x050x ECO=H



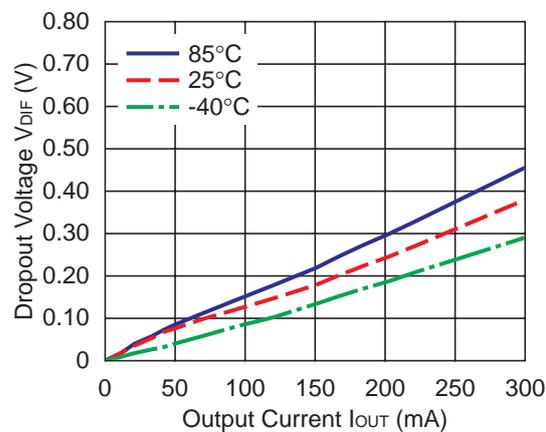
R1191x050x ECO=L



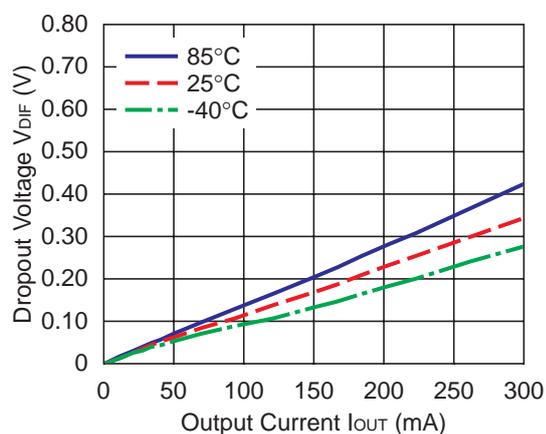
R1191x120x ECO=H



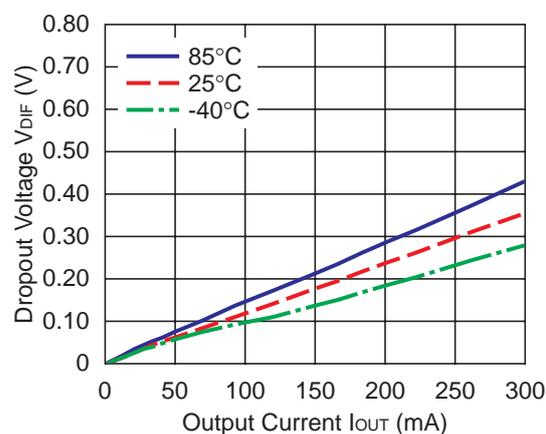
R1191x120x ECO=L



R1191x150x ECO=H

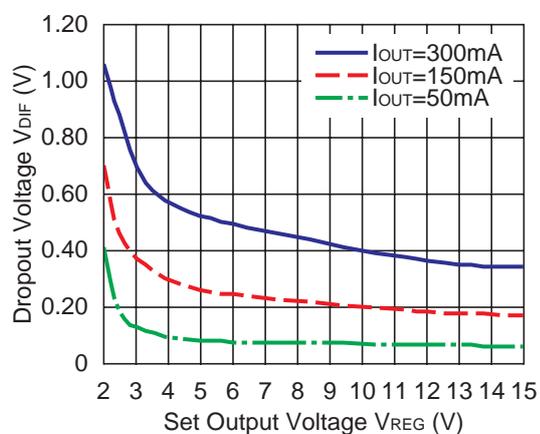


R1191x150x ECO=L

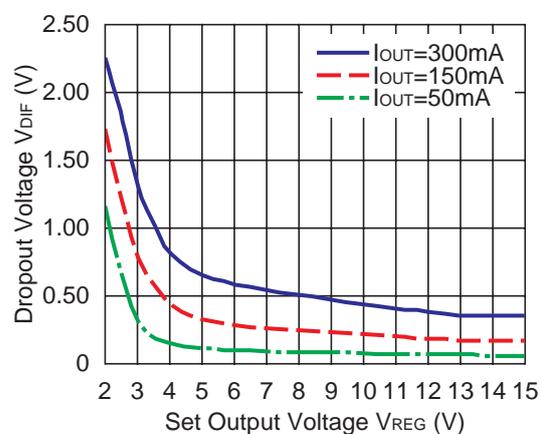


9) Dropout Voltage vs Set Output Voltage ($C1=2.2\mu\text{F}$, $C2=4.7\mu\text{F}$, $T_{opt}=25^\circ\text{C}$)

R1191x ECO=H

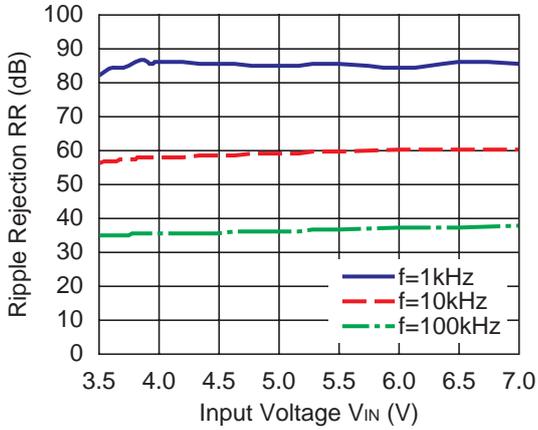


R1191x ECO=L

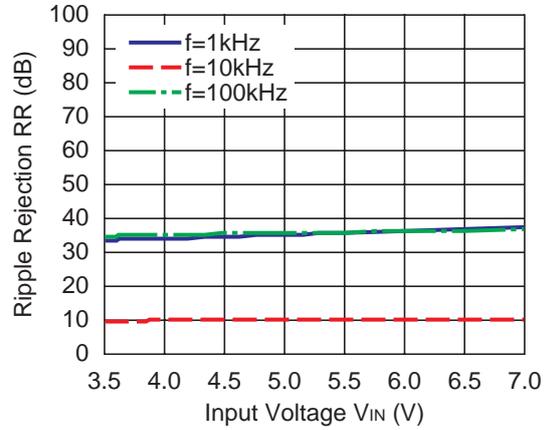


10) Ripple Rejection vs. Input Voltage (C1=none, C2=4.7μF, I_{OUT}=30mA, Ripple=0.5Vp-p, T_{opt}=25°C)

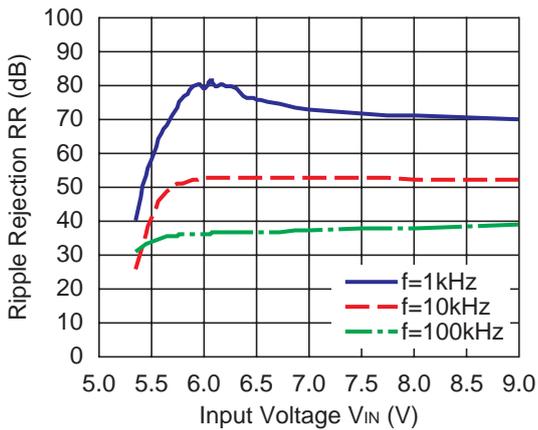
R1191x020x ECO=H



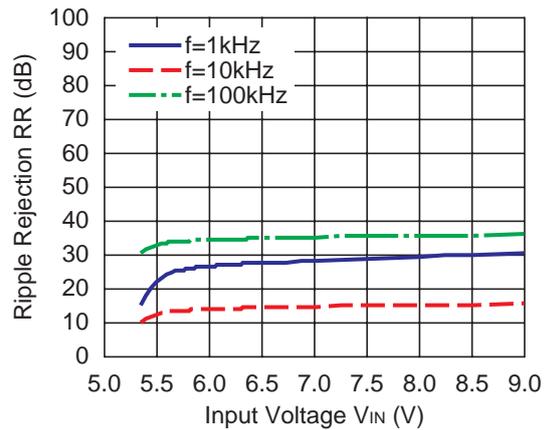
R1191x020x ECO=L



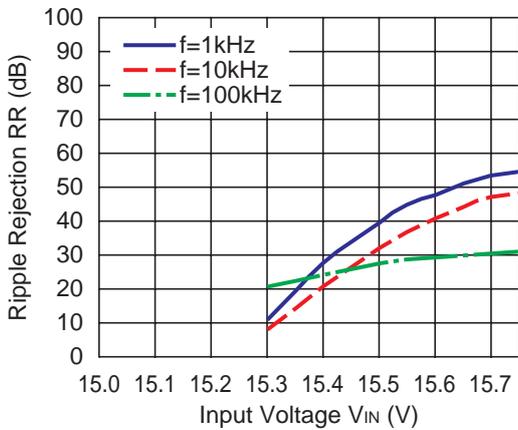
R1191x050x ECO=H



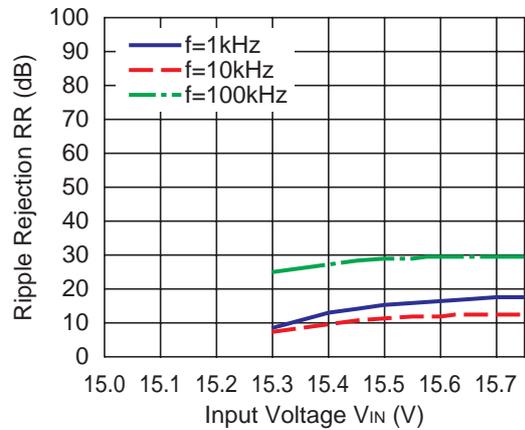
R1191x050x ECO=L



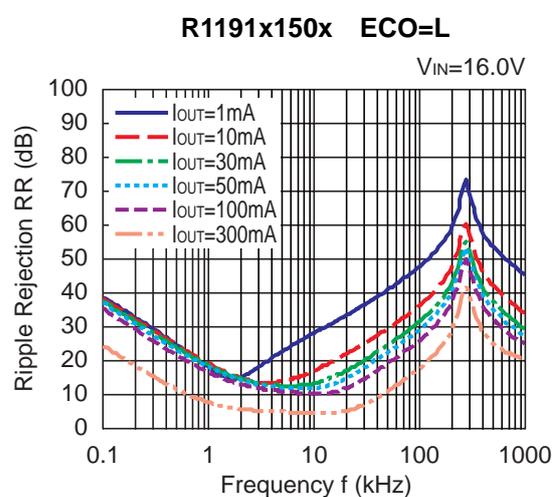
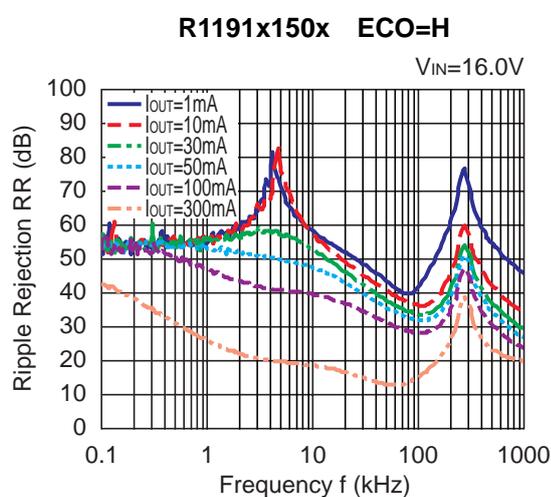
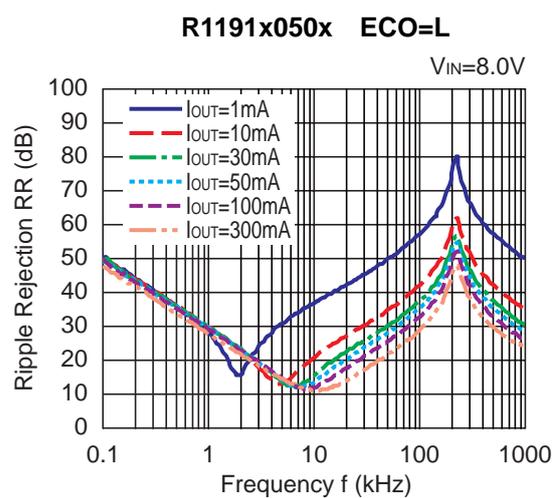
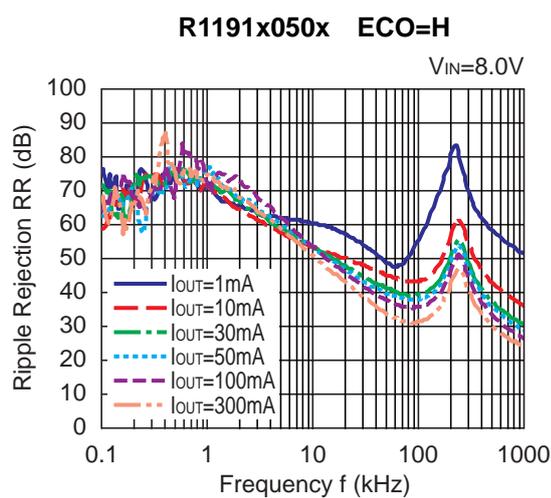
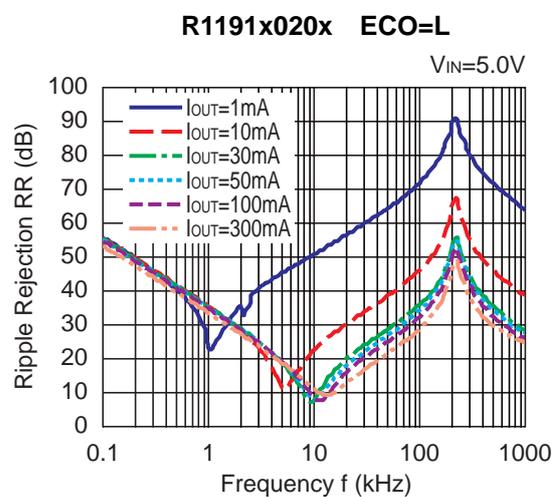
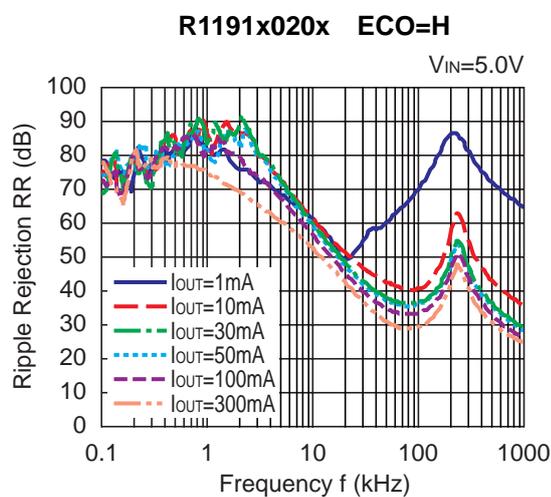
R1191x150x ECO=H



R1191x150x ECO=L

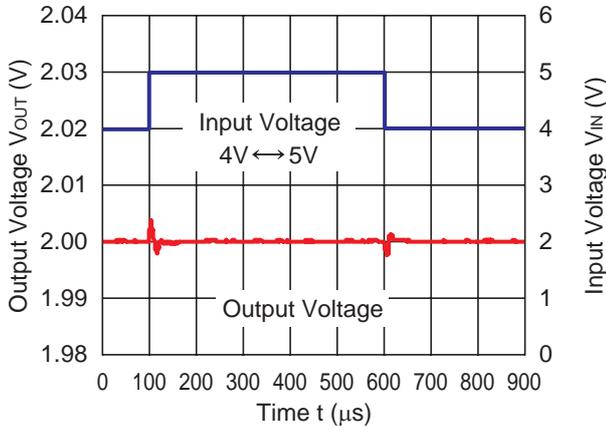


11) Ripple Rejection vs. Frequency (C1= none, C2=4.7 μ F, Ripple=0.5Vp-p, Topt=25°C)

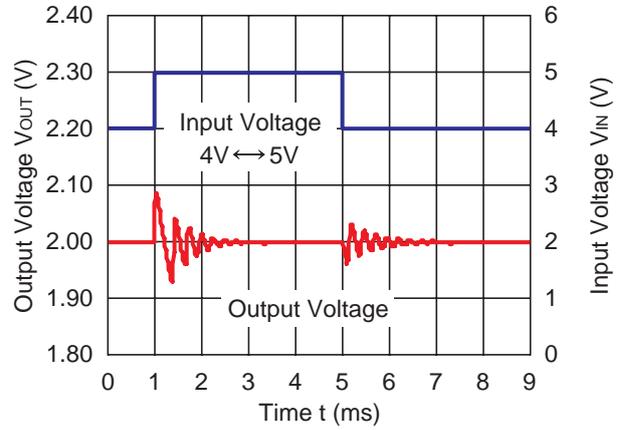


12) Input Transient Response (C1=none, C2=4.7μF, I_{OUT}=1mA, tr=tf=1μs, T_{opt}=25°C)

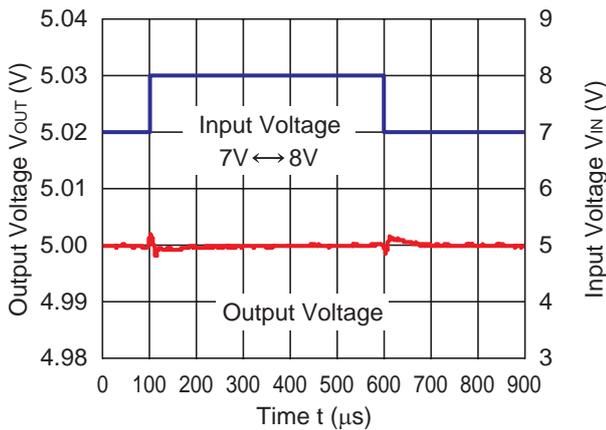
R1191x020x ECO=H



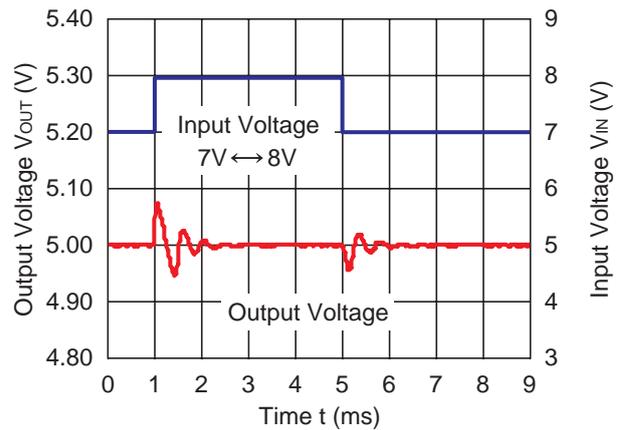
R1191x020x ECO=L



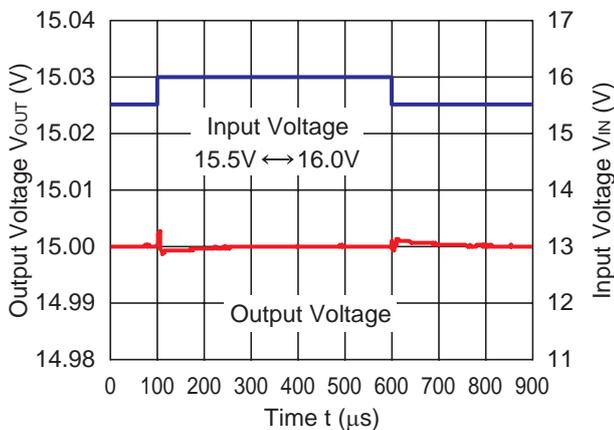
R1191x050x ECO=H



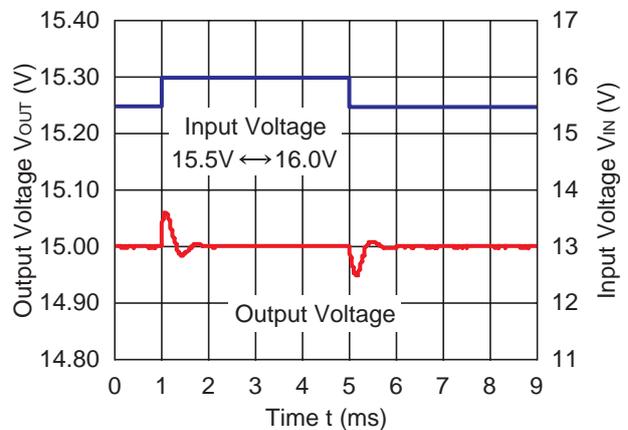
R1191x050x ECO=L



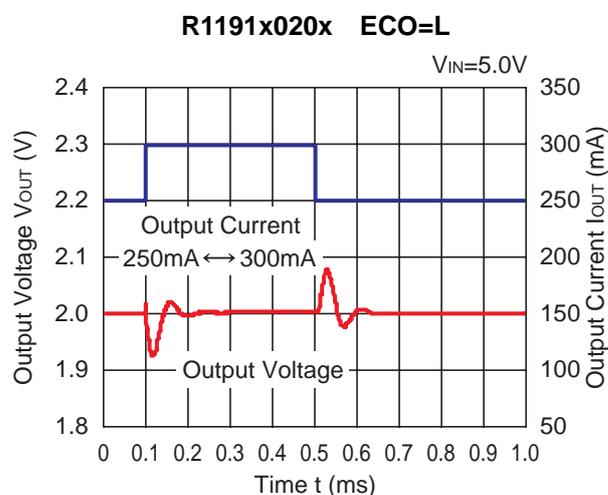
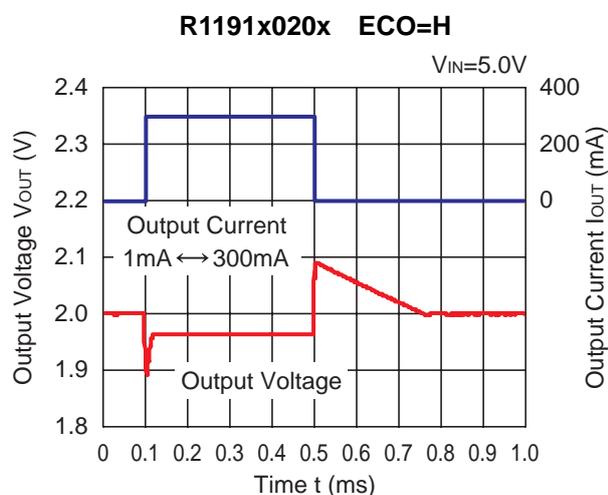
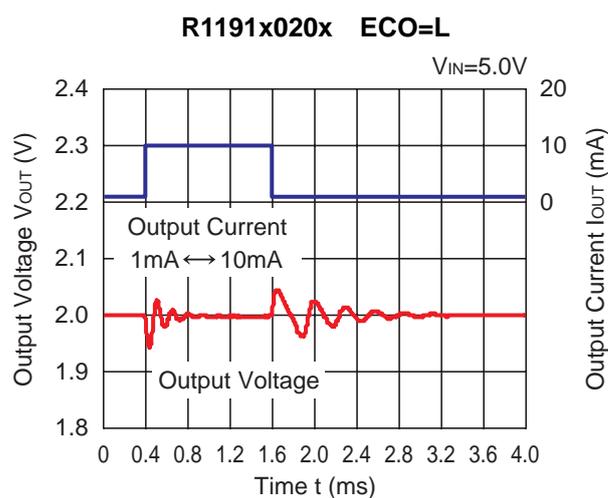
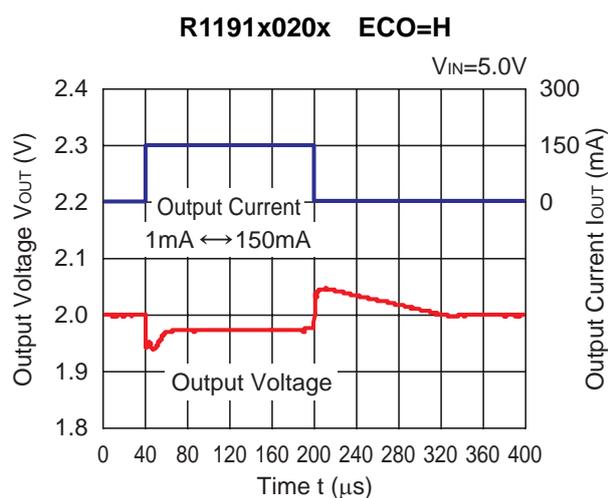
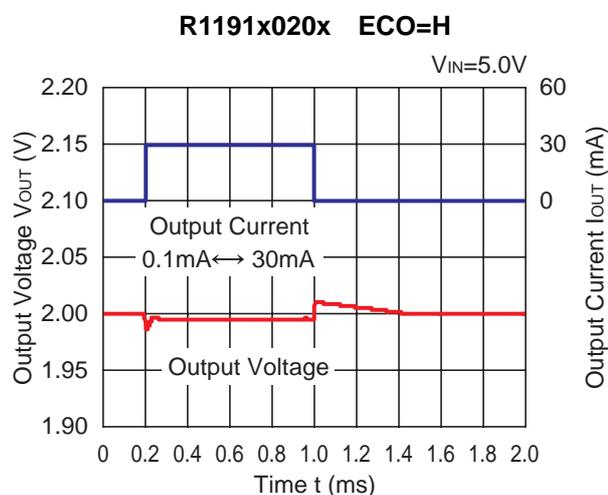
R1191x150x ECO=H



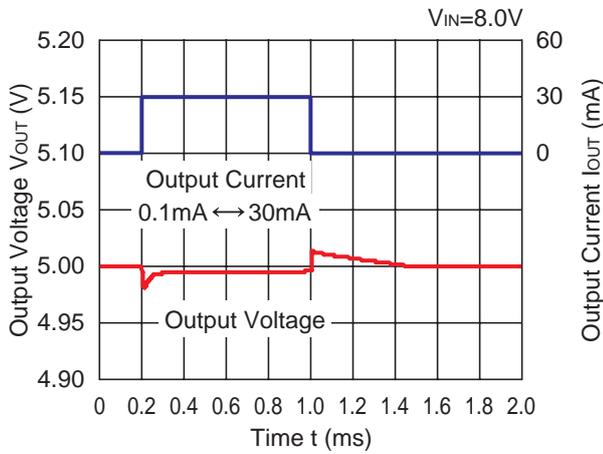
R1191x150x ECO=L



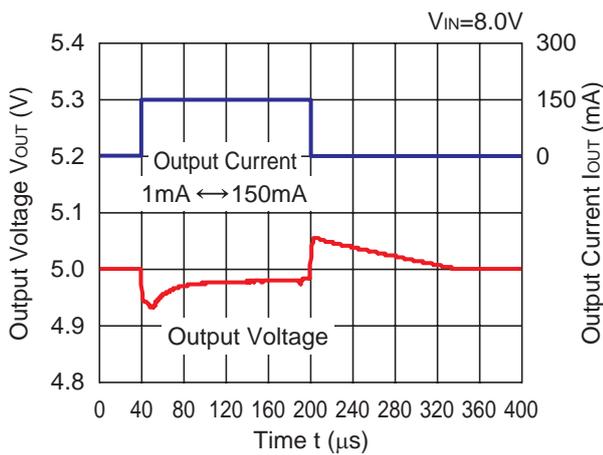
13) Load Transient Response ($C_1=2.2\mu\text{F}$, $C_2=4.7\mu\text{F}$, $t_r=t_f=0.1\mu\text{s}$, $T_{opt}=25^\circ\text{C}$)



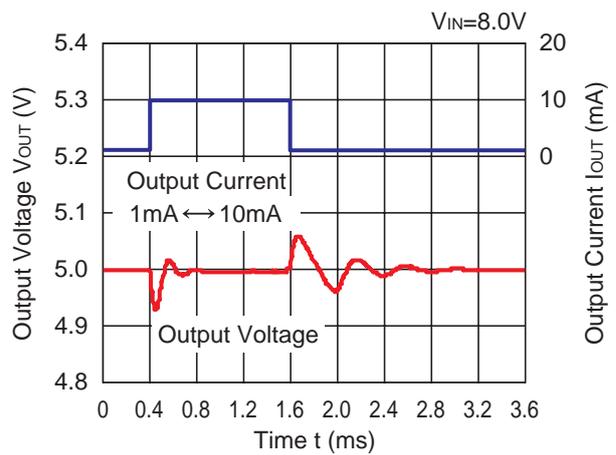
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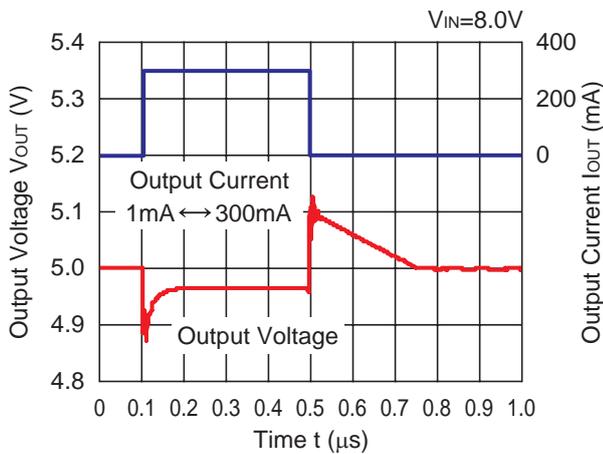
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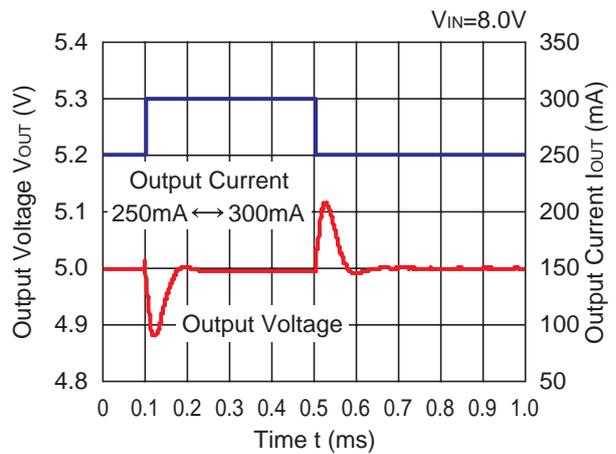
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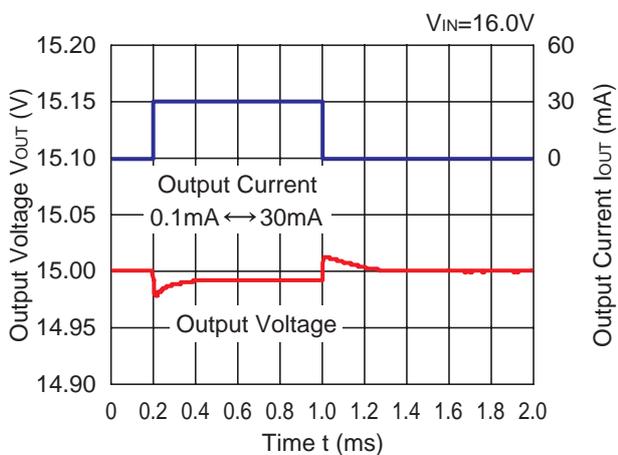
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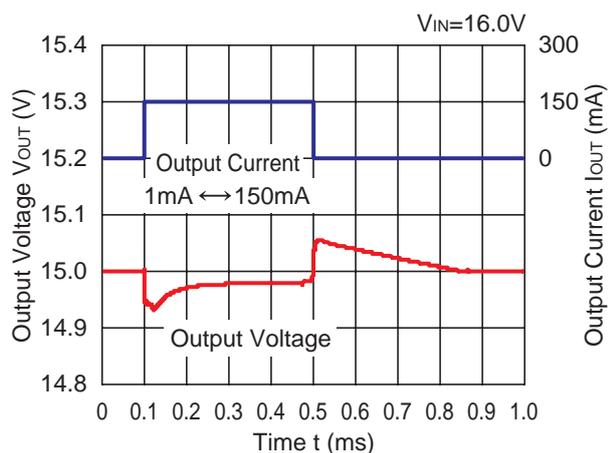
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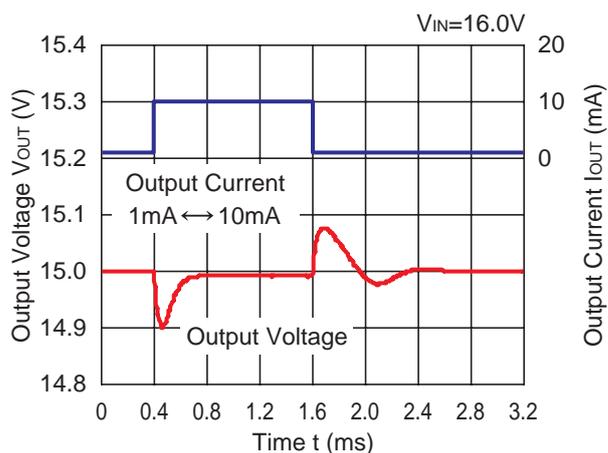
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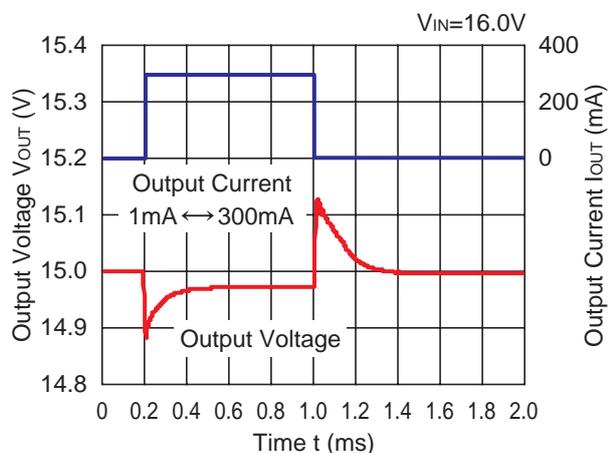
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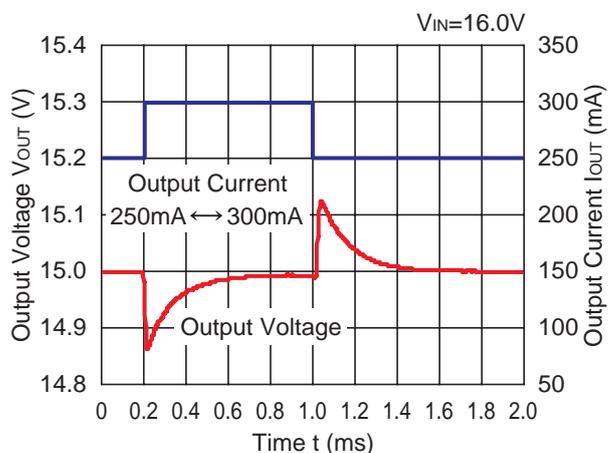
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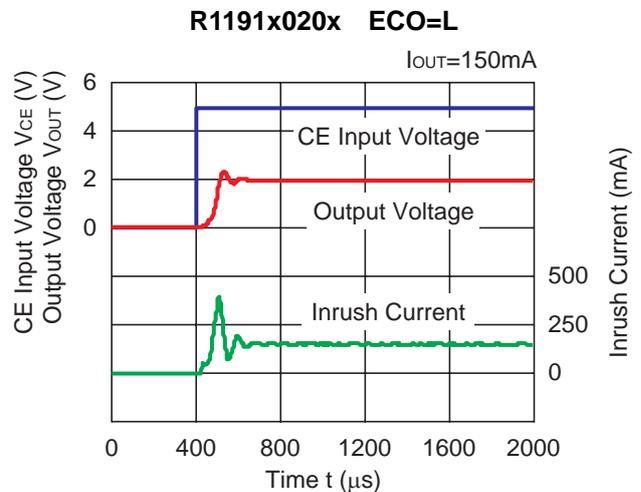
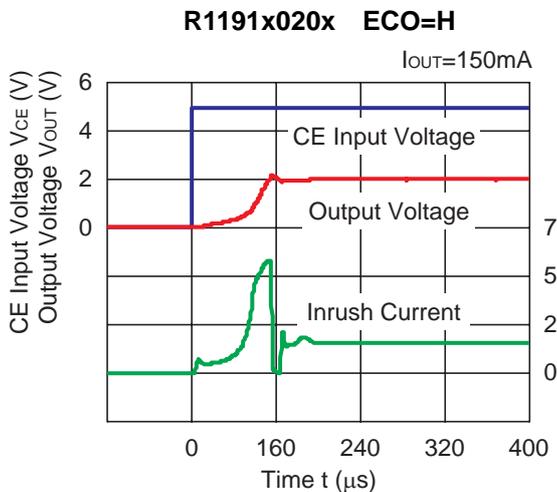
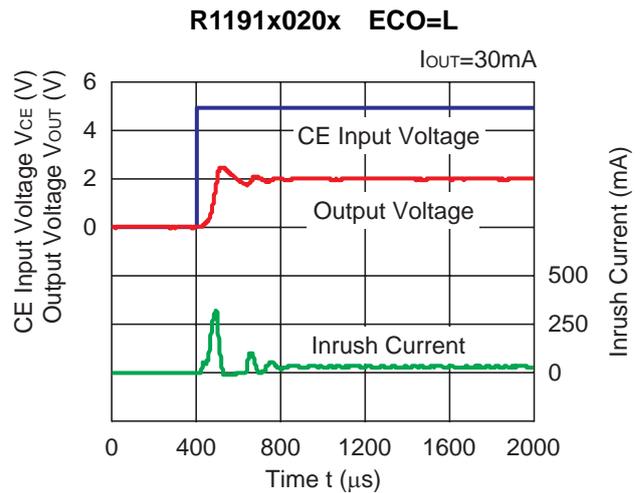
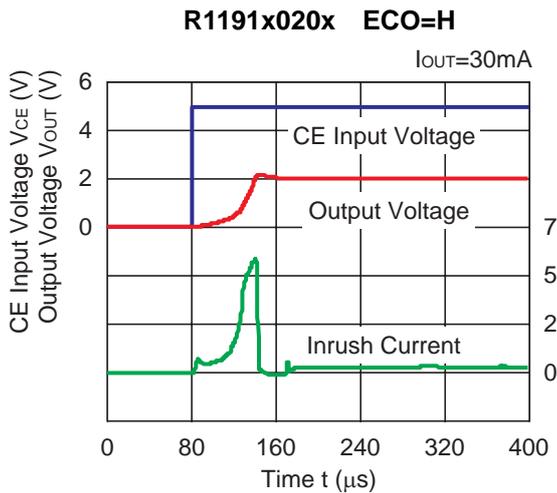
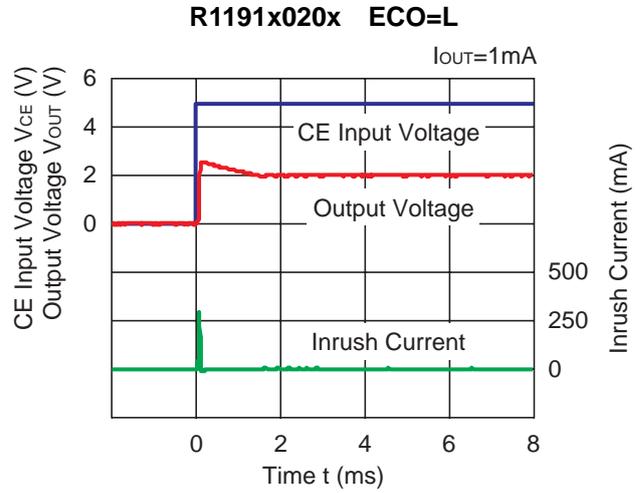
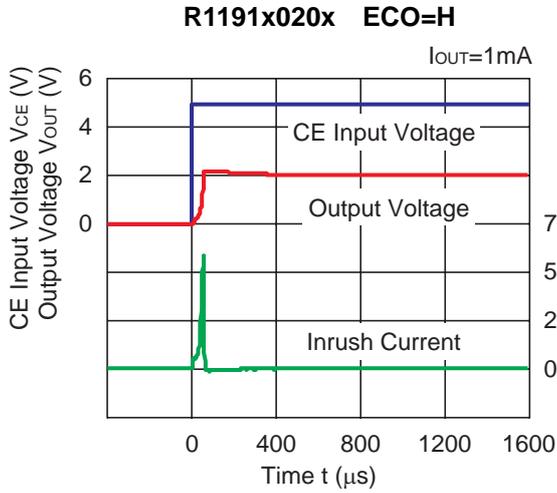
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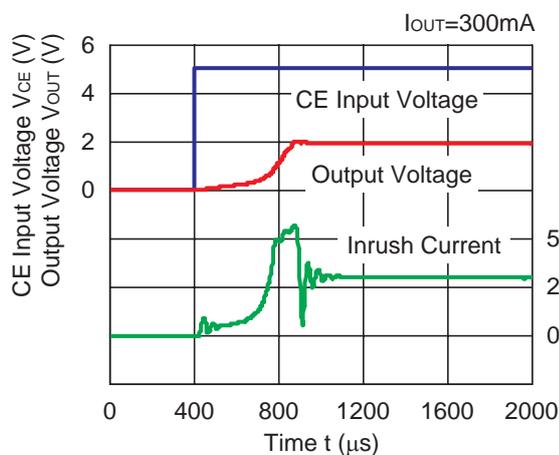
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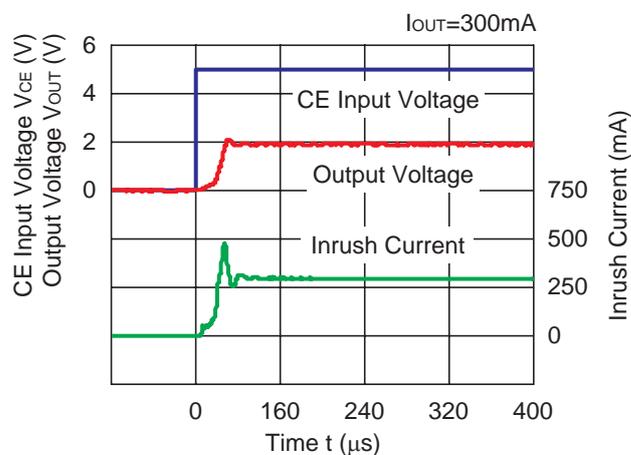
14) Inrush Current at Turn on($C1=2.2\mu\text{F}$, $C2=4.7\mu\text{F}$, $t_r=0.1\mu\text{s}$, $T_{opt}=25^\circ\text{C}$)



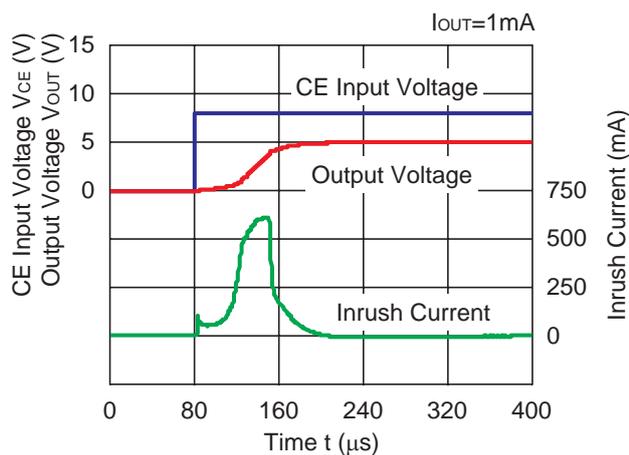
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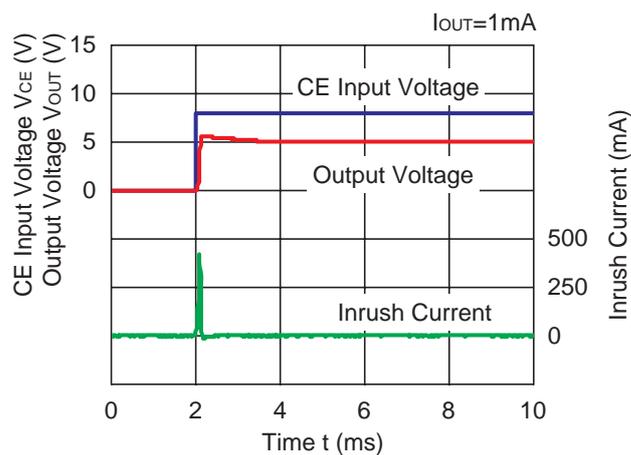
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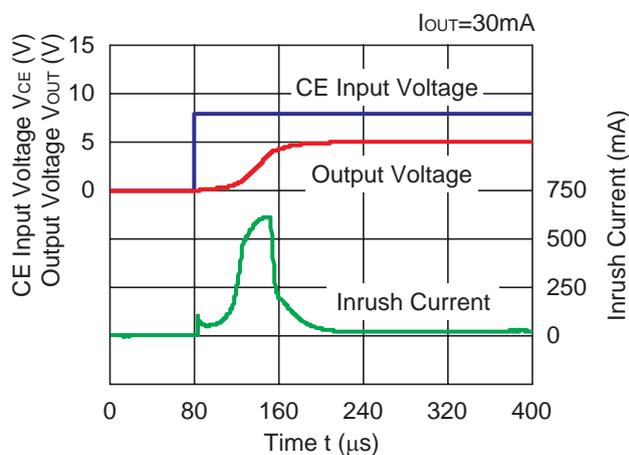
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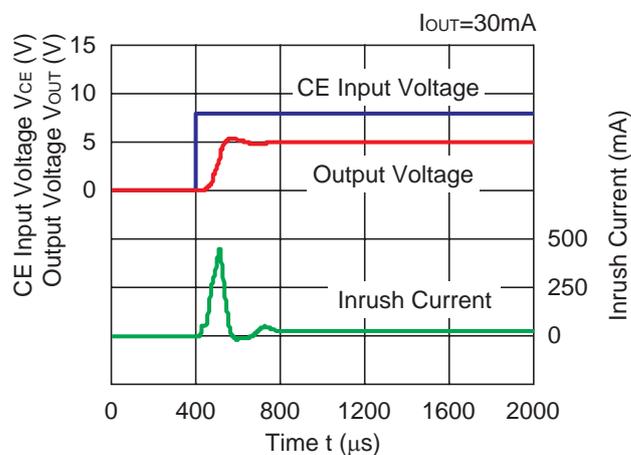
R1191x050x ECO=L



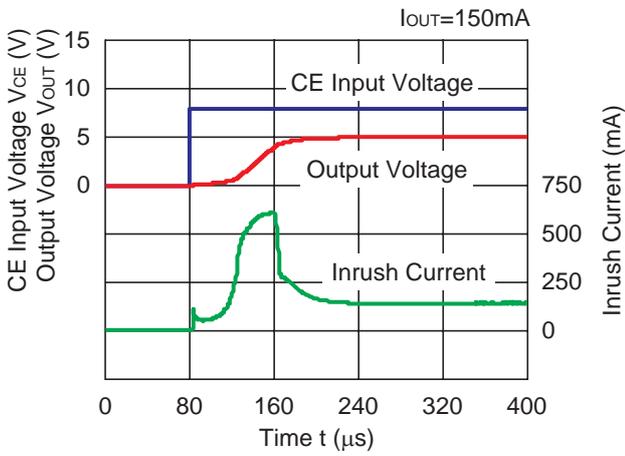
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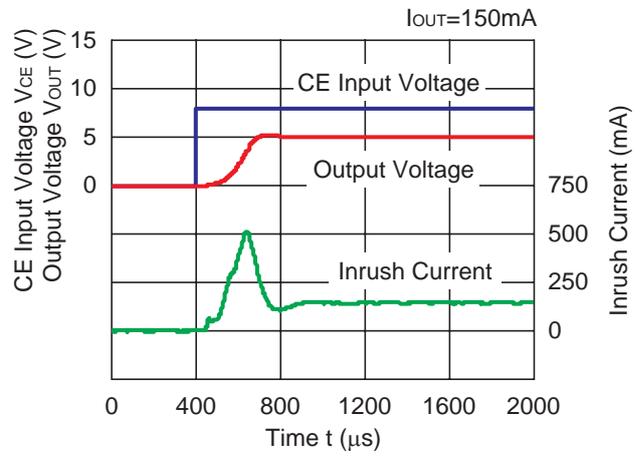
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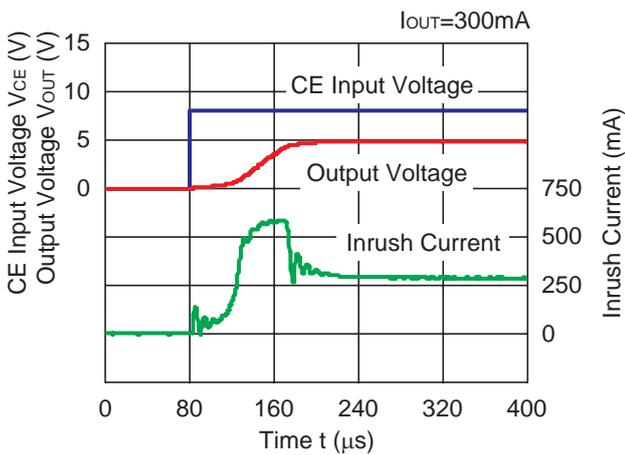
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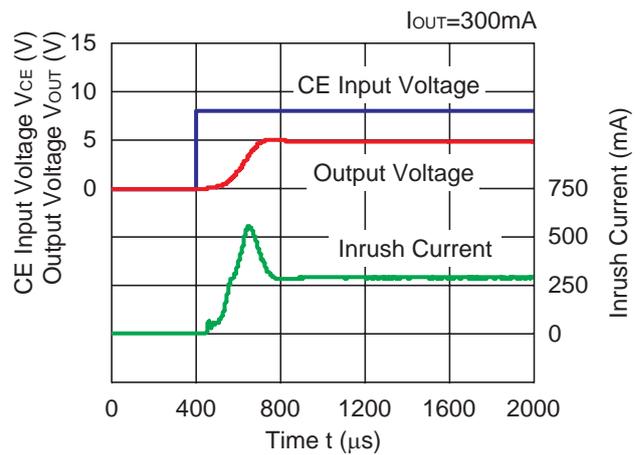
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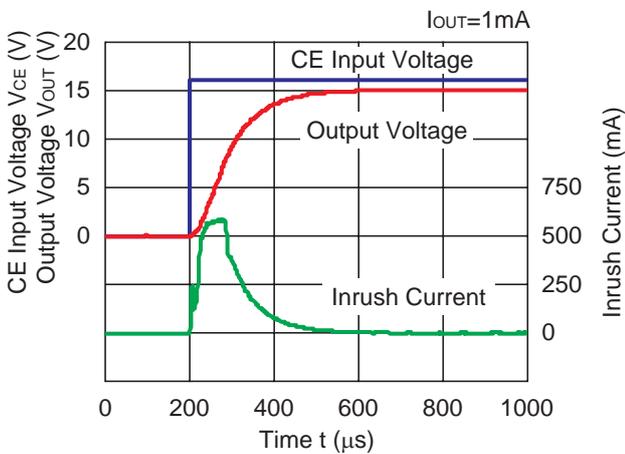
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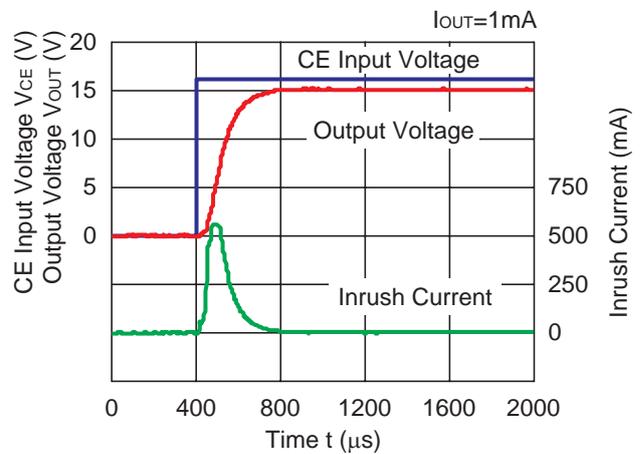
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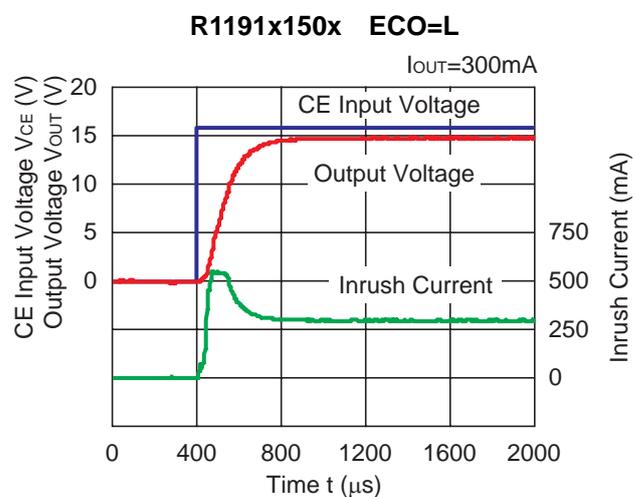
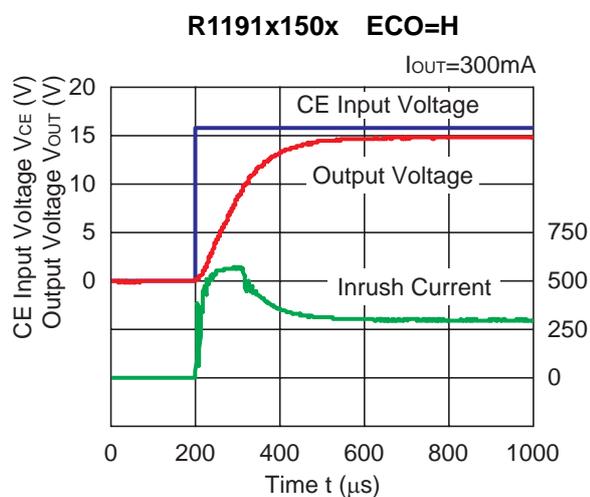
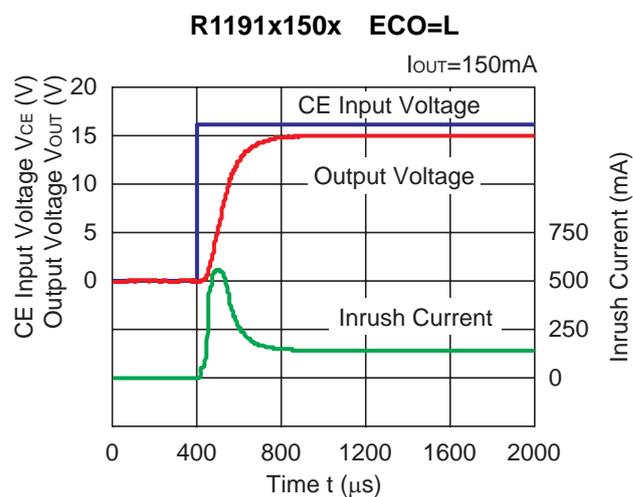
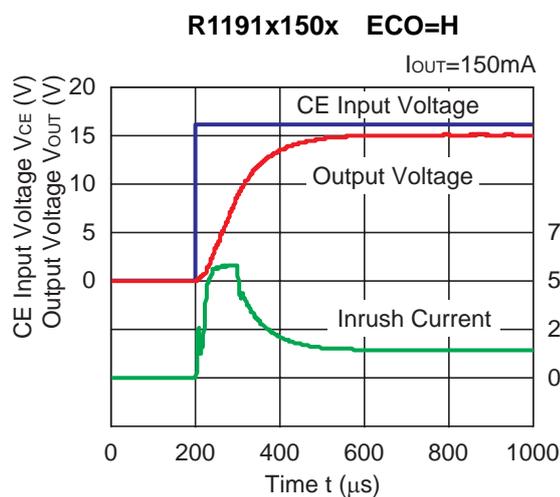
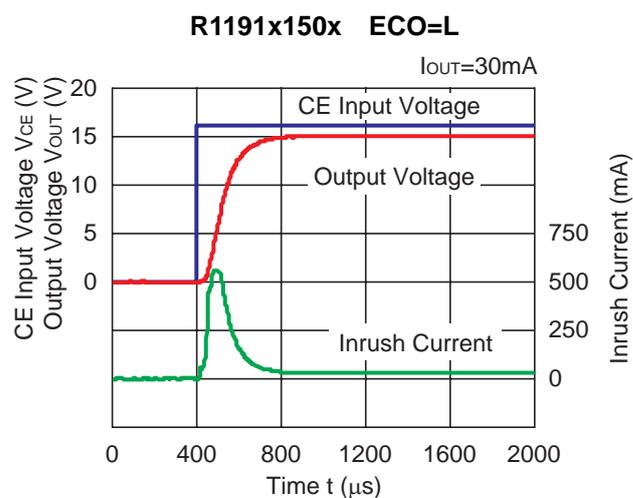
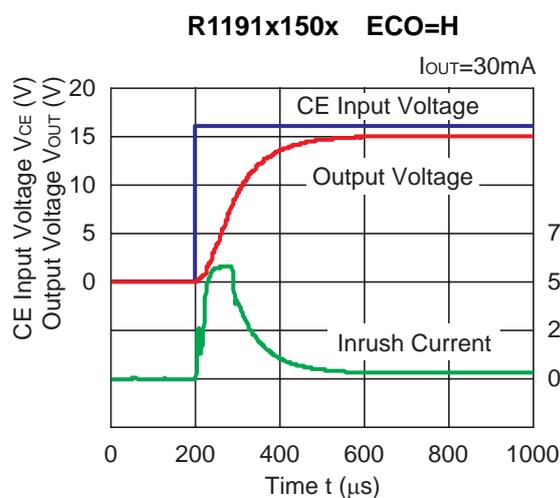


R1191x150x ECO=H

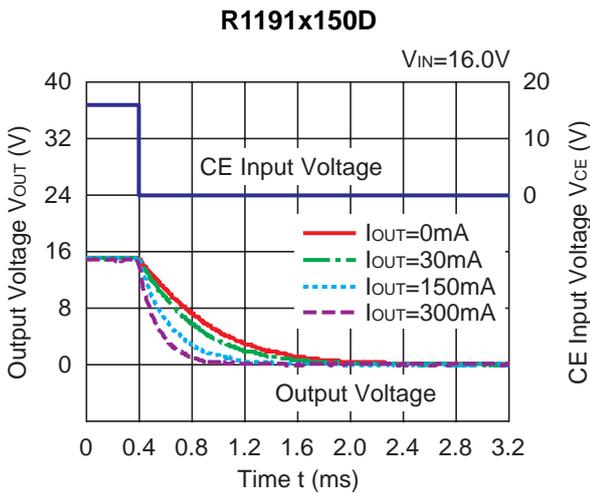
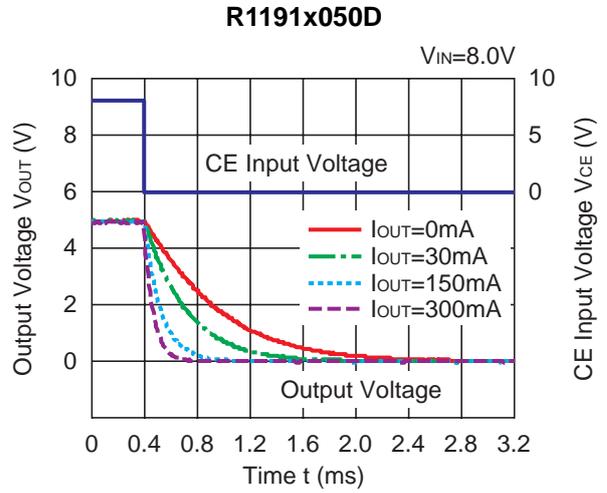
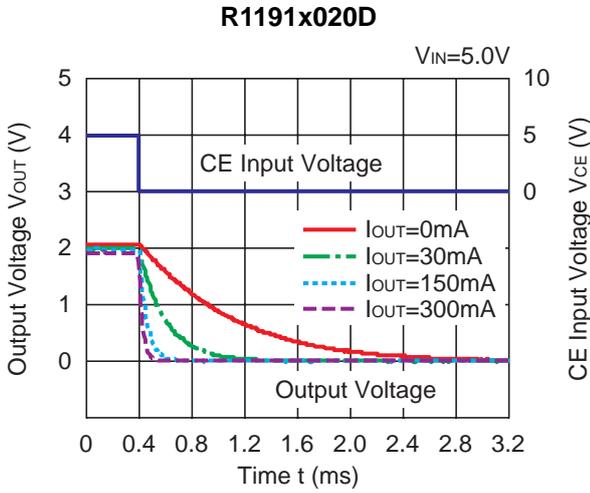


R1191x150x ECO=L



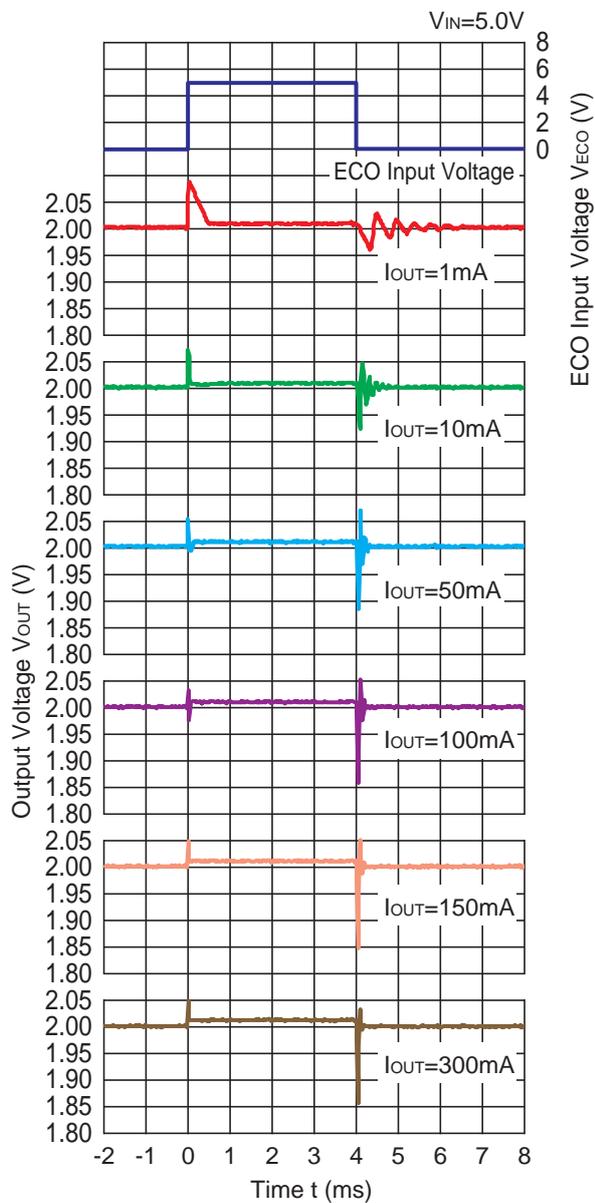


15) Turn Off Speed with CE pin (D Version) (C1=2.2μF, C2=4.7μF, tf=0.1μs, Topt=25°C)

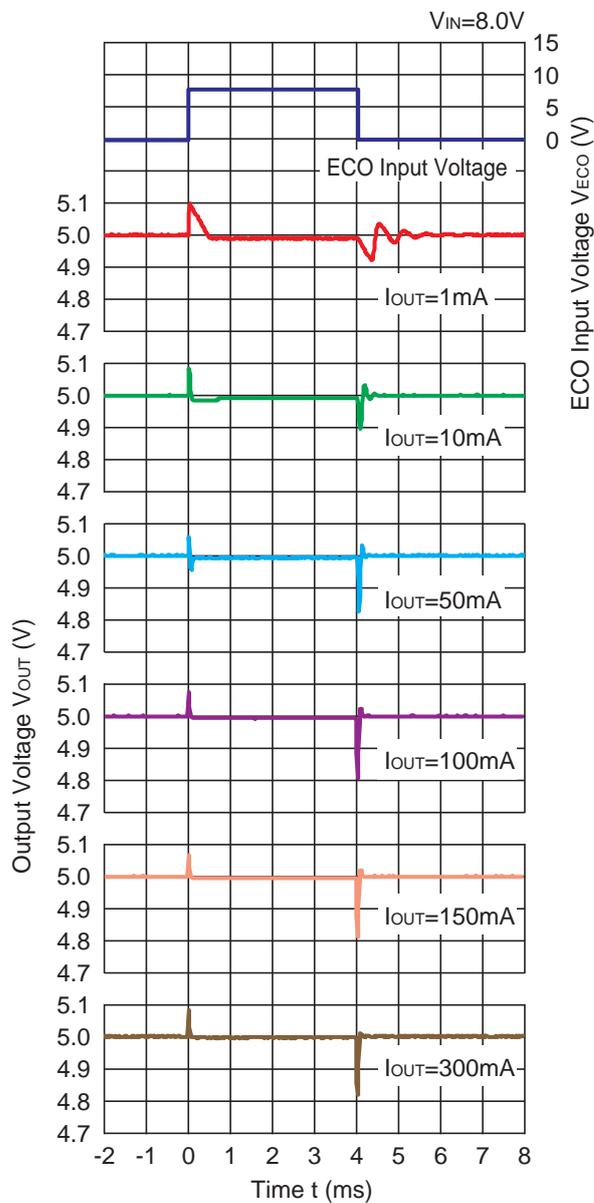


16) Output Voltage at Mode alternative point (C1=2.2μF, C2=4.7μF, tr=tf=0.1μs, Topt=25°C)

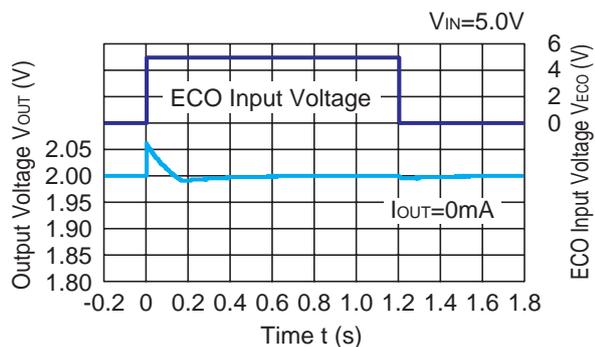
R1191x020x



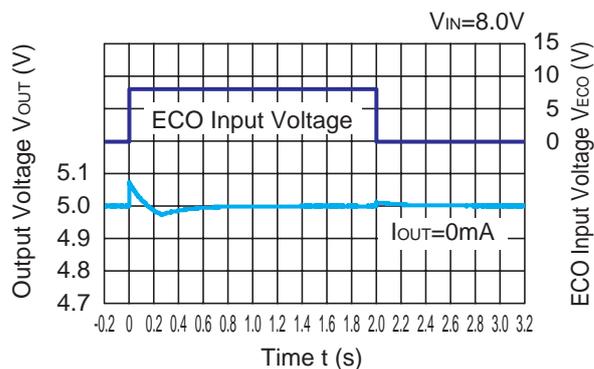
R1191x050x



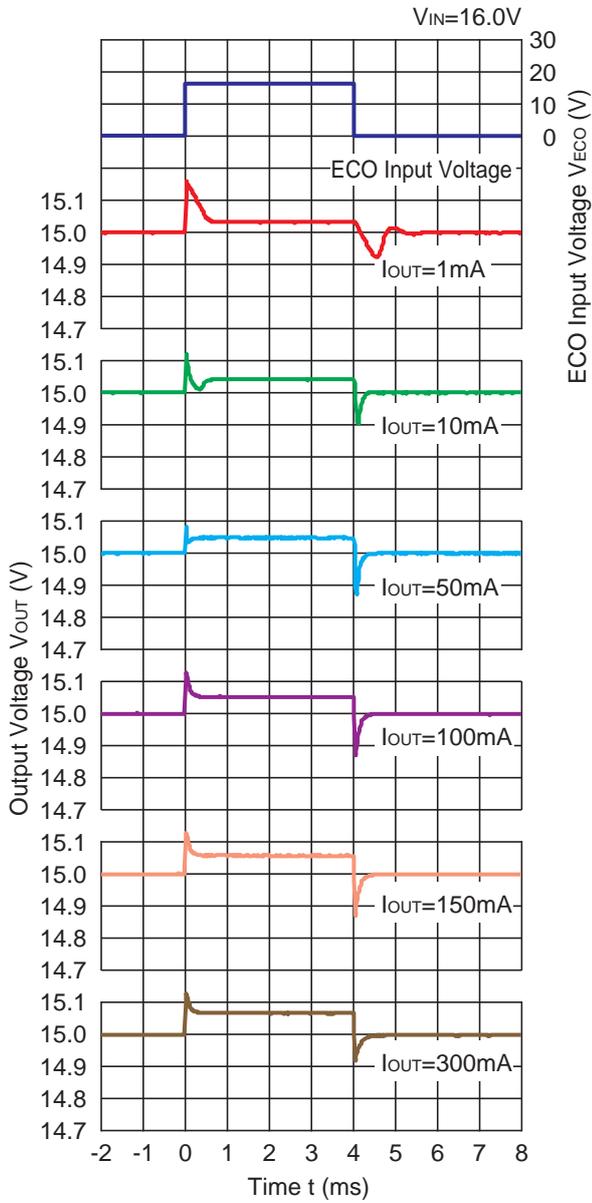
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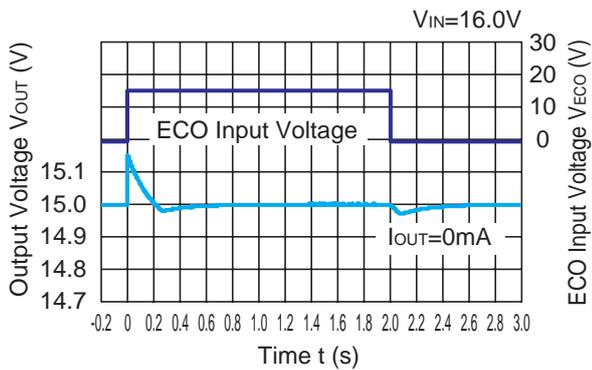
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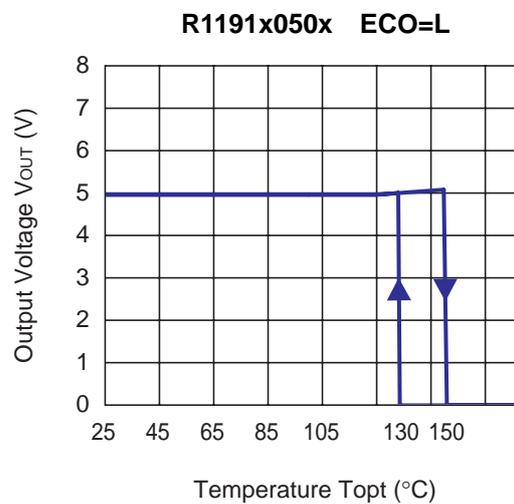
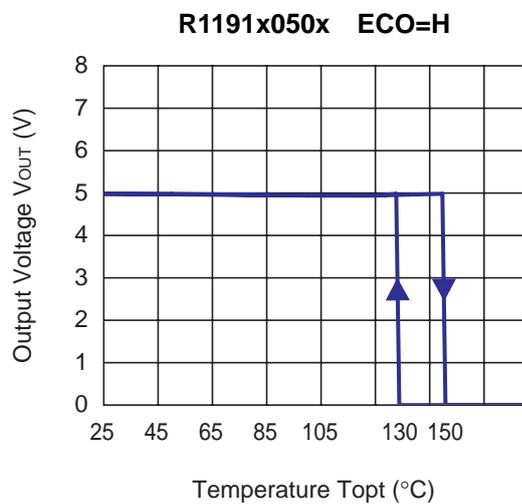


R1191x150x



R1191x150x



17) Thermal Shutdown Circuit (C1=2.2 μ F, C2=4.7 μ F, V_{IN}=16V, R_{LOAD}=1k Ω)

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

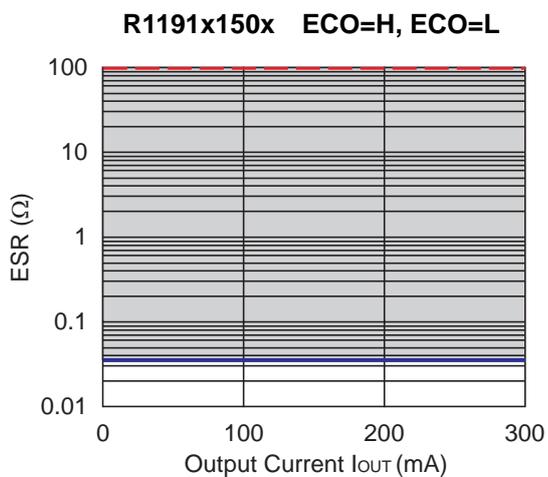
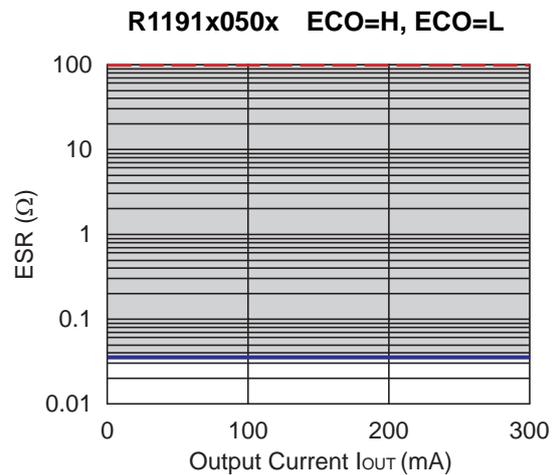
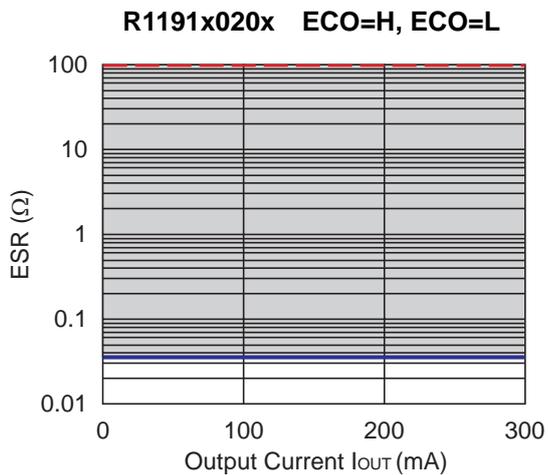
Frequency Band : 10Hz to 1MHz

Temperature : -40°C to 85°C

Hatched Area : Noise level is under $40\mu\text{Vms(Avg.)}$

C_{IN} : $2.2\mu\text{F}$ Murata (GRM32RB11E225KC01B)

C_{OUT} : $4.7\mu\text{F}$ Murata (GCM31CR71E475KA40)





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