

# RICOH

## R1160x SERIES

### 3-MODE 200mA LDO REGULATOR

NO.EA-083-140530

#### OUTLINE

The R1160x Series consist of CMOS-based voltage regulator ICs with high output voltage accuracy, low supply current, and low ON-resistance. Each of these voltage regulator ICs consists of a voltage reference unit, an error amplifier, resistors for setting Output Voltage, a current limit circuit, and a chip enable circuit.

These ICs perform with low dropout voltage and a chip enable function. To prevent the destruction by over current, current limit circuit is included. The R1160x 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 to 1/10 at Low Power Mode compared with Fast Transient Mode. Output voltage is maintained between FT mode and LP mode.

The output voltage of these ICs is internally fixed with high accuracy. Since the packages for these ICs are SOT-23-5 and SON-6 packages, high density mounting of the ICs on boards is possible.

#### FEATURES

- Supply Current (Low Power Mode)..... Typ. 3.5 $\mu$ A ( $V_{OUT} \leq 1.5V$ )
- Supply Current (Fast Transient Mode)..... Typ. 40 $\mu$ A
- Supply Current (Standby Mode)..... Typ. 0.1 $\mu$ A
- Dropout Voltage ..... Typ. 0.14V ( $I_{OUT}=200mA$ ,  $V_{OUT}=2.8V$ )
- Ripple Rejection..... Typ. 70dB ( $f=1kHz$ , FT Mode)
- Temperature-Drift Coefficient of Output Voltage ..... Typ.  $\pm 100ppm/^{\circ}C$
- Line Regulation ..... Typ. 0.05%/V
- Output Voltage Accuracy.....  $\pm 2.0%$  ( $\pm 3.0%$  at LP Mode)
- Output Voltage Range..... 0.8V to 3.3V (0.1V steps)  
(For other voltages, please refer to MARK INFORMATION.)
- Input Voltage Range ..... 1.4V to 6.0V
- Built-in Fold Back Protection Circuit ..... Typ. 50mA (Current at short mode)
- Packages ..... SOT-23-5, SON-6

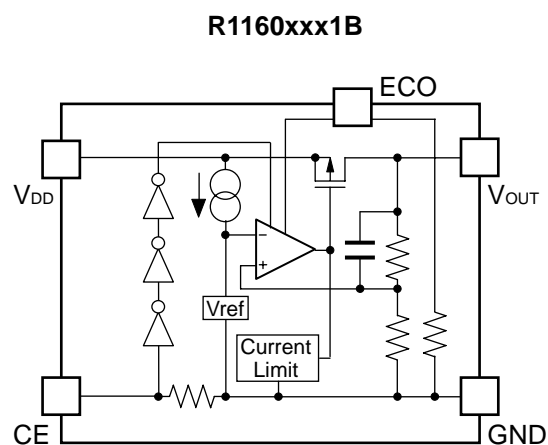
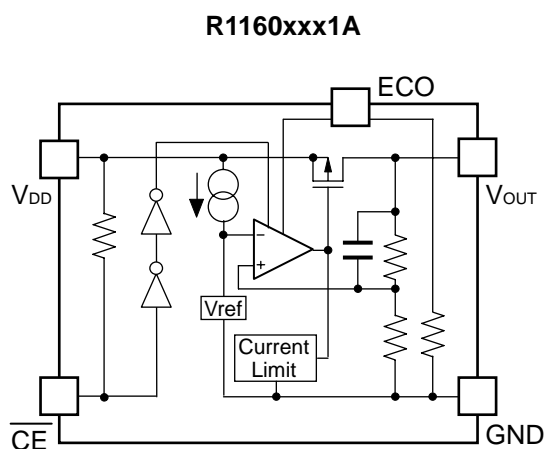
#### APPLICATIONS

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

\* R1160D (SON-6) is the discontinued product. As of March in 2015.

## R1160x

### BLOCK DIAGRAMS



### SELECTION GUIDE

The output voltage, chip enable polarity, and package, etc. for the ICs can be selected at the user's request.

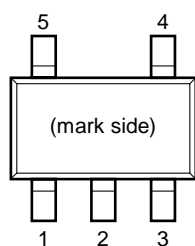
| Product Name     | Package  | Quantity per Reel | Pb Free | Halogen Free |
|------------------|----------|-------------------|---------|--------------|
| R1160Nxx1*-TR-FE | SOT-23-5 | 3,000 pcs         | Yes     | Yes          |
| R1160Dxx1*-TR-FE | SON-6    | 3,000 pcs         | Yes     | Yes          |

xx: The output voltage can be designated in the range from 0.8V(08) to 3.3V(33) in 0.1V steps.  
(For other voltages, please refer to MARK INFORMATIONS.)

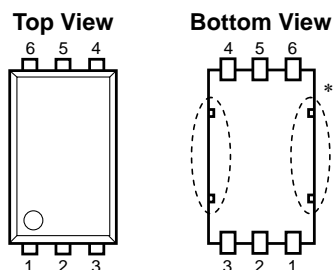
\* : CE pin polarity are options as follows.  
(A) "L" active type.  
(B) "H" active type.

## PIN CONFIGURATION

### • SOT-23-5



### • SON-6



## PIN DESCRIPTIONS

### • SOT-23-5

| Pin No | Symbol                | Pin Description      |
|--------|-----------------------|----------------------|
| 1      | $V_{DD}$              | Input Pin            |
| 2      | GND                   | Ground Pin           |
| 3      | $\overline{CE}$ or CE | Chip Enable Pin      |
| 4      | ECO                   | MODE alternative pin |
| 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                   | MODE alternative pin |
| 5      | GND                   | Ground Pin           |
| 6      | $\overline{CE}$ or CE | Chip Enable Pin      |

\*) 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.

**R1160x**

**ABSOLUTE MAXIMUM RATINGS**

| Symbol    | Item                                       | Rating               | Unit |
|-----------|--|----------------------|------|
| $V_{IN}$  | Input Voltage                              | 6.5                  | V    |
| $V_{ECO}$ | Input Voltage ( ECO Pin)                   | -0.3 to $V_{IN}+0.3$ | V    |
| $V_{CE}$  | Input Voltage ( $\overline{CE}$ or CE Pin) | -0.3 to $V_{IN}+0.3$ | V    |
| $V_{OUT}$ | Output Voltage                             | -0.3 to $V_{IN}+0.3$ | V    |
| $I_{OUT}$ | Output Current                             | 250                  | mA   |
| $P_D$     | Power Dissipation (SOT-23-5)*              | 420                  | mW   |
|           | Power Dissipation (SON-6)*                 | 500                  | mW   |
| $T_{opt}$ | Operating Temperature Range                | -40 to 85            | °C   |
| $T_{stg}$ | Storage Temperature Range                  | -55 to 125           | °C   |

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

**ABSOLUTE MAXIMUM RATINGS**

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field.

The functional operation at or over these absolute maximum ratings is not assured.

**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

### • R1160xxx1A

T<sub>opt</sub>=25°C

| Symbol                               | Item                                    | Conditions   | Min.             | Typ. | Max.            | Unit   |
|--------------------------------------|---|--|------------------|------|-----------------|--------|
| V <sub>OUT</sub>                     | Output Voltage (FT Mode)                | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub><br>1μA ≤ I <sub>OUT</sub> ≤ 30mA *1   | ×0.98<br>(-30mV) |      | ×1.02<br>(30mV) | V      |
|                                      | Output Voltage (LP Mode)                | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =GND<br>1μA ≤ I <sub>OUT</sub> ≤ 30mA *2   | ×0.97<br>(-45mV) |      | ×1.03<br>(45mV) | V      |
| I <sub>OUT</sub>                     | Output Current                          | V <sub>IN</sub> -V <sub>OUT</sub> =1V  | 200              |      |                 | mA     |
| ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Load Regulation (FT Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub><br>1mA ≤ I <sub>OUT</sub> ≤ 200mA   |                  | 20   | 40              | mV     |
|                                      | Load Regulation (LP Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =GND<br>1mA ≤ I <sub>OUT</sub> ≤ 100mA   |                  | 10   | 40              | mV     |
| V <sub>DIF</sub>                     | Dropout Voltage                         | Refer to the ELECTRICAL CHARACTERISTICS by OUTPUT VOLTAGE  |                  |      |                 |        |
| I <sub>SS1</sub>                     | Supply Current (FT Mode)                | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub> ,   |                  | 40   | 70              | μA     |
| I <sub>SS2</sub>                     | Supply Current (LP Mode)                | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V,<br>V <sub>OUT</sub> ≤ 1.5V, V <sub>ECO</sub> =GND   |                  | 3.5  | 6.0             | μA     |
|                                      |   | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V,<br>V <sub>OUT</sub> ≥ 1.6V, V <sub>ECO</sub> =GND   |                  | 4.5  | 8.0             | μA     |
| I <sub>standby</sub>                 | Supply Current (Standby)                | V <sub>IN</sub> =V <sub>CE</sub> =Set V <sub>OUT</sub> +1V<br>V <sub>ECO</sub> =GND or V <sub>IN</sub>   |                  | 0.1  | 1.0             | μA     |
| ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | Line Regulation (FT Mode)               | Set V <sub>OUT</sub> +0.5V ≤ V <sub>IN</sub> ≤ 6V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =V <sub>IN</sub><br>(In case that V <sub>OUT</sub> ≤ 0.9V,<br>1.4V ≤ V <sub>IN</sub> ≤ 6V) |                  | 0.05 | 0.20            | %/V    |
|                                      | Line Regulation (LP Mode)               | Set V <sub>OUT</sub> +0.5V ≤ V <sub>IN</sub> ≤ 6V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =GND<br>(In case that V <sub>OUT</sub> ≤ 0.9V,<br>1.4V ≤ V <sub>IN</sub> ≤ 6V)             |                  | 0.10 | 0.30            | %/V    |
| RR                                   | Ripple Rejection (FT Mode)              | f=1kHz, Ripple 0.2Vp-p<br>V <sub>IN</sub> =Set V <sub>OUT</sub> +1V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =V <sub>IN</sub>   |                  | 70   |                 | dB     |
| V <sub>IN</sub>                      | Input Voltage                           |  | 1.4              |      | 6.0             | V      |
| ΔV <sub>OUT</sub> /ΔT <sub>opt</sub> | Output Voltage Temperature Coefficient  | I <sub>OUT</sub> =30mA<br>-40°C ≤ T <sub>opt</sub> ≤ 85°C  |                  | ±100 |                 | ppm/°C |
| I <sub>SC</sub>                      | Short Current Limit                     | V <sub>OUT</sub> =0V   |                  | 50   |                 | mA     |
| R <sub>PUC</sub>                     | $\overline{CE}$ Pull-up Resistance      |  | 2.0              | 5.0  | 14.0            | MΩ     |
| R <sub>PDE</sub>                     | ECO Pull-down Resistance                |  | 1.5              | 5.0  | 14.0            | MΩ     |
| V <sub>CEH</sub>                     | $\overline{CE}$ , ECO Input Voltage "H" |  | 1.0              |      | V <sub>IN</sub> | V      |
| V <sub>CEL</sub>                     | $\overline{CE}$ , ECO Input Voltage "L" |  | 0                |      | 0.3             | V      |

\*1 : ±30mV Tolerance for V<sub>OUT</sub> ≤ 1.5V\*2 : ±45mV Tolerance for V<sub>OUT</sub> ≤ 1.5V

\* R1160D (SON-6) is the discontinued product. As of March in 2015.

## R1160x

### • R1160xxx1B

T<sub>opt</sub>=25°C

| Symbol                               | Item                                   | Conditions   | Min.              | Typ. | Max.             | Unit   |
|--------------------------------------|--|--|-------------------|------|------------------|--------|
| V <sub>OUT</sub>                     | Output Voltage (FT Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub><br>1μA ≤ I <sub>OUT</sub> ≤ 30mA *1   | ×0.980<br>(-30mV) |      | ×1.020<br>(30mV) | V      |
|                                      | Output Voltage (LP Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =GND<br>1μA ≤ I <sub>OUT</sub> ≤ 30mA *2   | ×0.970<br>(-45mV) |      | ×1.030<br>(45mV) | V      |
| I <sub>OUT</sub>                     | Output Current                         | V <sub>IN</sub> -V <sub>OUT</sub> =1V  | 200               |      |                  | mA     |
| ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Load Regulation (FT Mode)              | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub><br>1mA ≤ I <sub>OUT</sub> ≤ 200mA   |                   | 20   | 40               | mV     |
|                                      | Load Regulation (LP Mode)              | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =GND<br>1mA ≤ I <sub>OUT</sub> ≤ 100mA   |                   | 10   | 40               | mV     |
| V <sub>DIF</sub>                     | Dropout Voltage                        | Refer to the ELECTRICAL CHARACTERISTICS by OUTPUT VOLTAGE  |                   |      |                  |        |
| I <sub>SS1</sub>                     | Supply Current (FT Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V, V <sub>ECO</sub> =V <sub>IN</sub>   |                   | 40   | 70               | μA     |
| I <sub>SS2</sub>                     | Supply Current (LP Mode)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V,<br>V <sub>OUT</sub> ≤ 1.5V, V <sub>ECO</sub> =GND   |                   | 3.5  | 6.0              | μA     |
|                                      |  | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V,<br>V <sub>OUT</sub> ≥ 1.6V, V <sub>ECO</sub> =GND   |                   | 4.5  | 8.0              | μA     |
| I <sub>standby</sub>                 | Supply Current (Standby)               | V <sub>IN</sub> =Set V <sub>OUT</sub> +1V<br>V <sub>CE</sub> =GND, V <sub>ECO</sub> =GND or V <sub>IN</sub>  |                   | 0.1  | 1.0              | μA     |
| ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | Line Regulation (FT Mode)              | Set V <sub>OUT</sub> +0.5V ≤ V <sub>IN</sub> ≤ 6.0V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =V <sub>IN</sub><br>(In case that V <sub>OUT</sub> ≤ 0.9V,<br>1.4V ≤ V <sub>IN</sub> ≤ 6V) |                   | 0.05 | 0.20             | %/V    |
|                                      | Line Regulation (LP Mode)              | Set V <sub>OUT</sub> +0.5V ≤ V <sub>IN</sub> ≤ 6.0V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =GND<br>(In case that V <sub>OUT</sub> ≤ 0.9V,<br>1.4V ≤ V <sub>IN</sub> ≤ 6V)             |                   | 0.10 | 0.30             | %/V    |
| RR                                   | Ripple Rejection (FT Mode)             | f=1kHz, Ripple 0.2Vp-p<br>V <sub>IN</sub> =Set V <sub>OUT</sub> +1V<br>I <sub>OUT</sub> =30mA, V <sub>ECO</sub> =V <sub>IN</sub>   |                   | 70   |                  | dB     |
| V <sub>IN</sub>                      | Input Voltage                          |  | 1.4               |      | 6.0              | V      |
| ΔV <sub>OUT</sub> /ΔT <sub>opt</sub> | Output Voltage Temperature Coefficient | I <sub>OUT</sub> =30mA<br>-40°C ≤ T <sub>opt</sub> ≤ 85°C  |                   | ±100 |                  | ppm/°C |
| I <sub>SC</sub>                      | Short Current Limit                    | V <sub>OUT</sub> =0V   |                   | 50   |                  | mA     |
| R <sub>PDC</sub>                     | CE Pull-down Resistance                |  | 2.0               | 5.0  | 14.0             | MΩ     |
| R <sub>PDE</sub>                     | ECO Pull-down Resistance               |  | 1.5               | 5.0  | 14.0             | MΩ     |
| V <sub>CEH</sub>                     | CE, ECO Input Voltage "H"              |  | 1.0               |      | V <sub>IN</sub>  | V      |
| V <sub>CEL</sub>                     | CE, ECO Input Voltage "L"              |  | 0                 |      | 0.3              | V      |

\*1 : ±30mV Tolerance for V<sub>OUT</sub> ≤ 1.5V

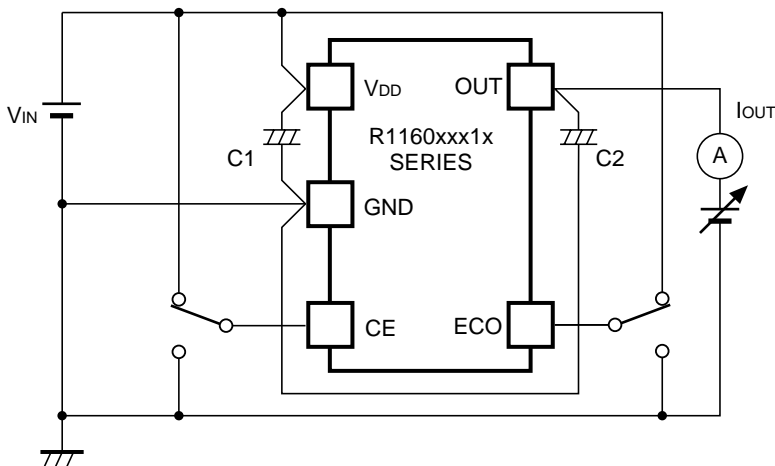
\*2 : ±45mV Tolerance for V<sub>OUT</sub> ≤ 1.5V

• ELECTRICAL CHARACTERISTICS by OUTPUT VOLTAGE

T<sub>opt</sub>=25°C

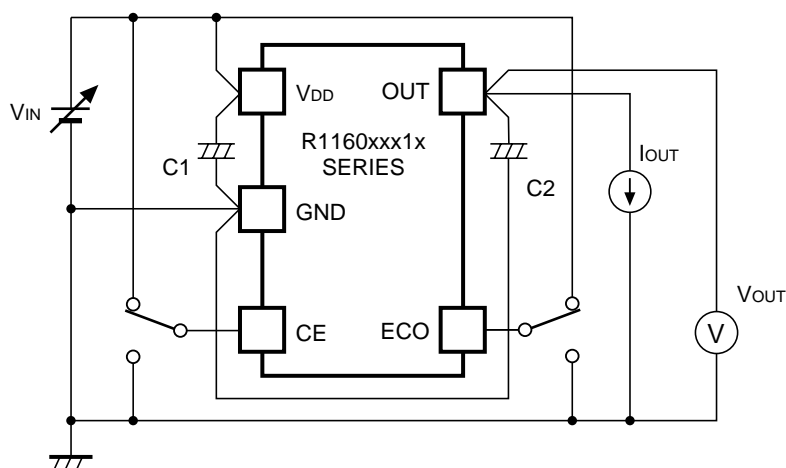
| Output Voltage<br>V <sub>OUT</sub> (V) | Dropout Voltage V <sub>DIF</sub> (V) |      |                                  |
|--|--------------------------------------|------|----------------------------------|
|  | Condition                            | Typ. | Max.                             |
| 0.8 ≤ V <sub>OUT</sub> ≤ 0.9           | I <sub>OUT</sub> =200mA              | 0.40 | 0.70                             |
| 1.0 ≤ V <sub>OUT</sub> ≤ 1.4           |                                      | 0.30 | 0.50                             |
| 1.5 ≤ V <sub>OUT</sub> ≤ 2.5           |                                      | 0.20 | 0.30                             |
| 2.6 ≤ V <sub>OUT</sub>                 |                                      | 0.14 | 0.20 (ECO="H")<br>0.25 (ECO="L") |

TEST CIRCUITS



C1=Tantal 1.0μF  
C2=Tantal 2.2μF

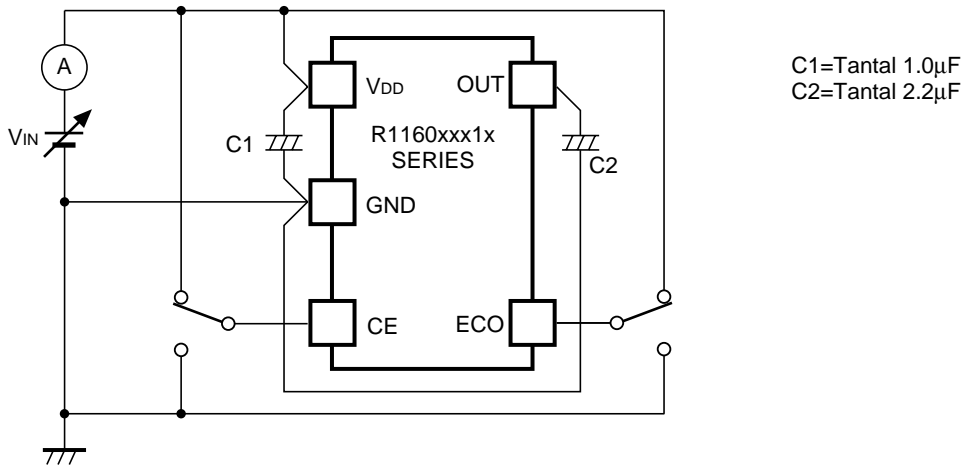
Fig.1 Output Voltage vs. Output Current Test Circuit



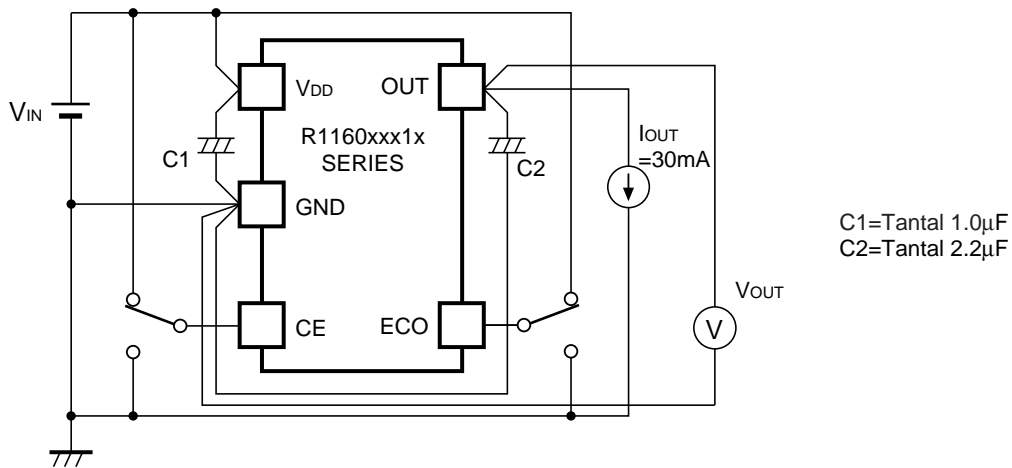
C1=Tantal 1.0μF  
C2=Tantal 2.2μF

Fig.2 Output Voltage vs. Input Voltage Test Circuit

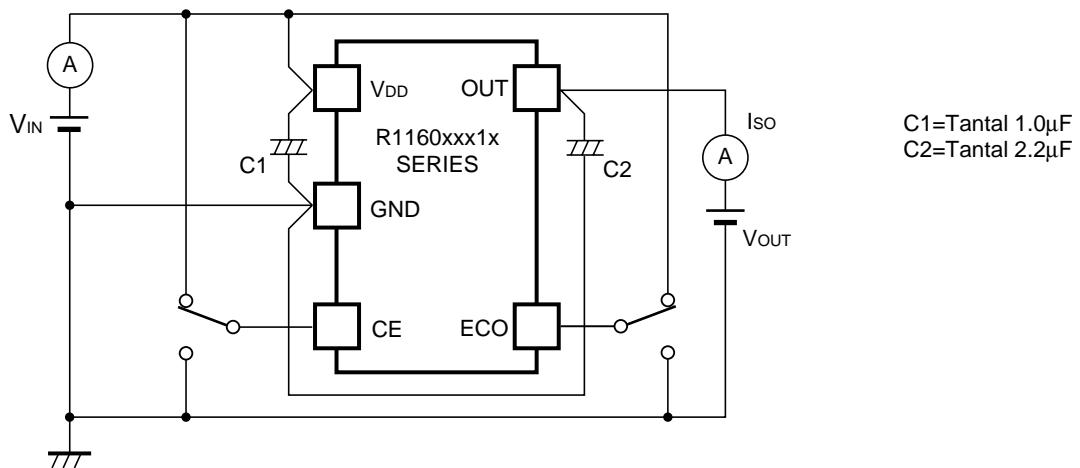
**R1160x**



**Fig.3 Supply Current vs. Input Voltage Test Circuit**



**Fig.4 Output Voltage vs. Temperature Test Circuit**



**Fig.5 Supply Current vs. Temperature Test Circuit**



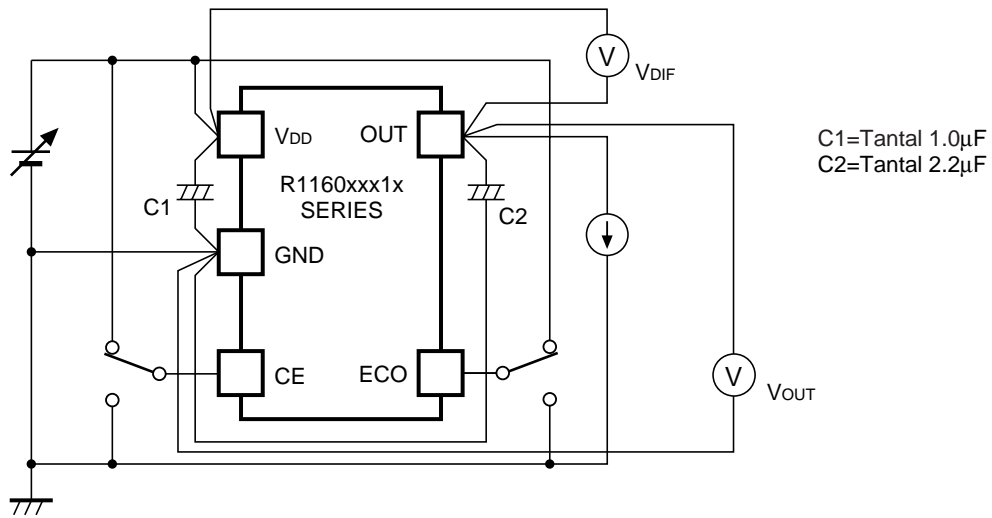


Fig. 6 Dropout Voltage vs. Output Current/ Set Output Voltage Test Circuit

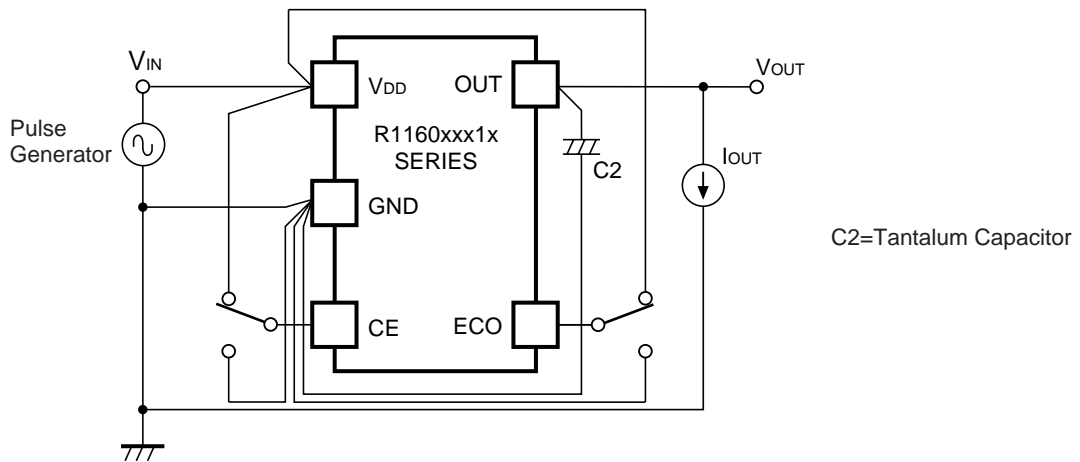


Fig. 7 Ripple Rejection Test Circuit

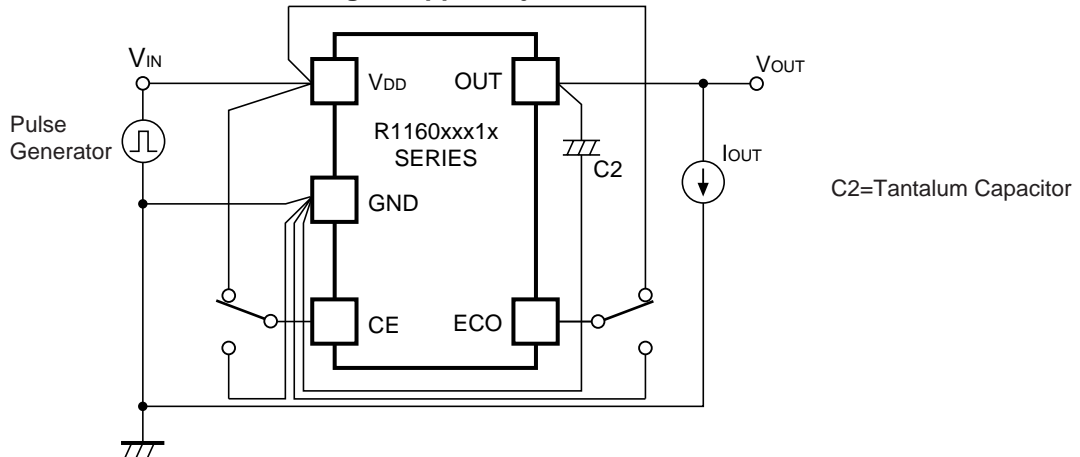
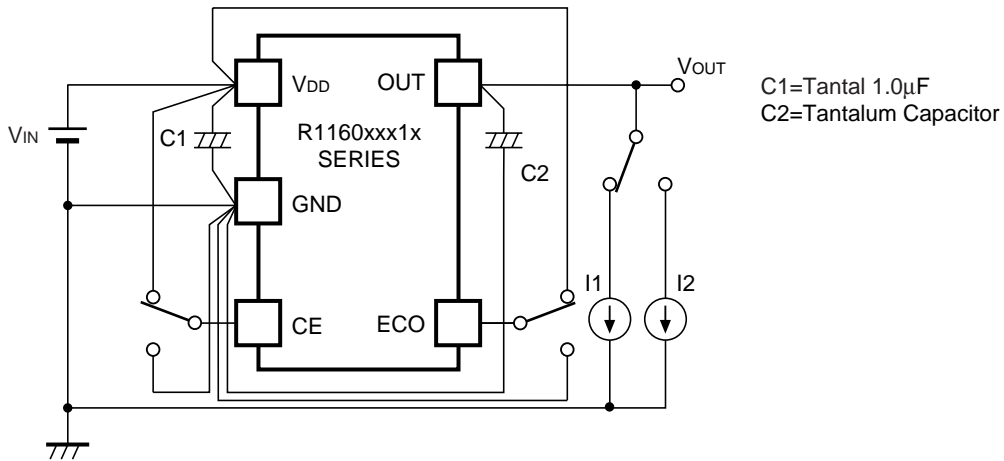


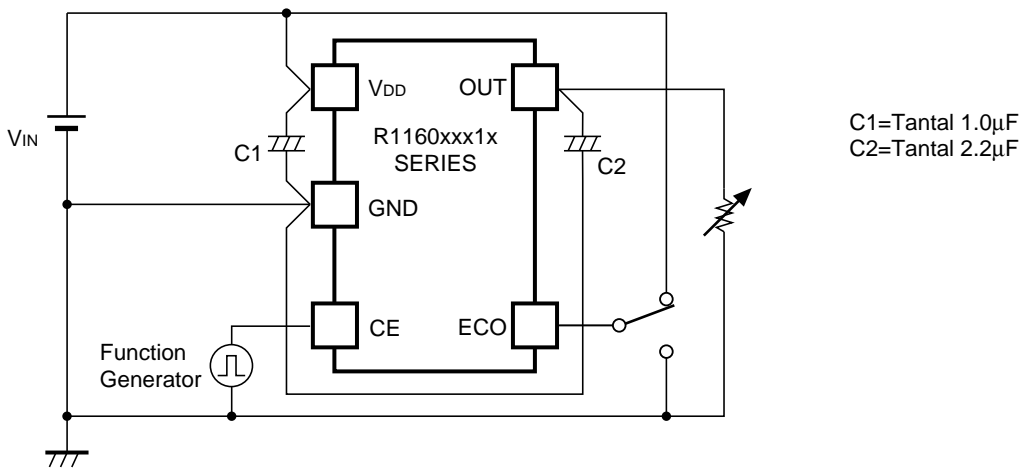
Fig.8 Input Transient Response Test Circuit

\* R1160D (SON-6) is the discontinued product. As of March in 2015.

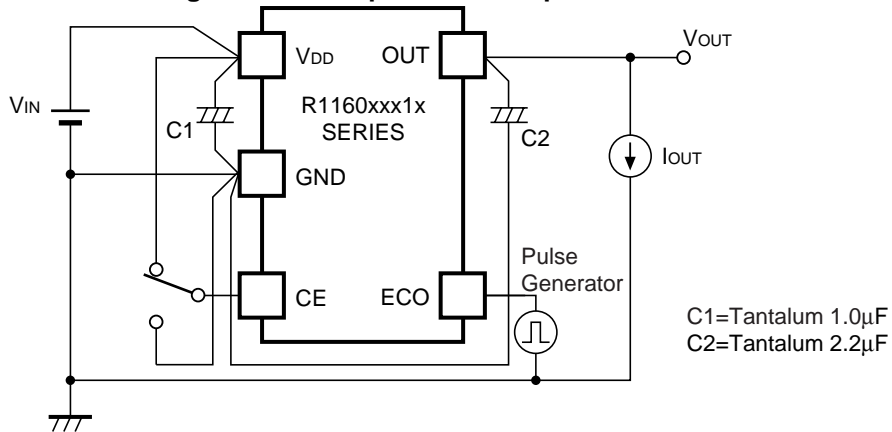
**R1160x**



**Fig.9 Load Transient Response Test Circuit**



**Fig.10 Turn on Speed with CE pin Test Circuit**



**Fig.11 MODE Transient Response Test Circuit**

\* R1160D (SON-6) is the discontinued product. As of March in 2015.

R1160x

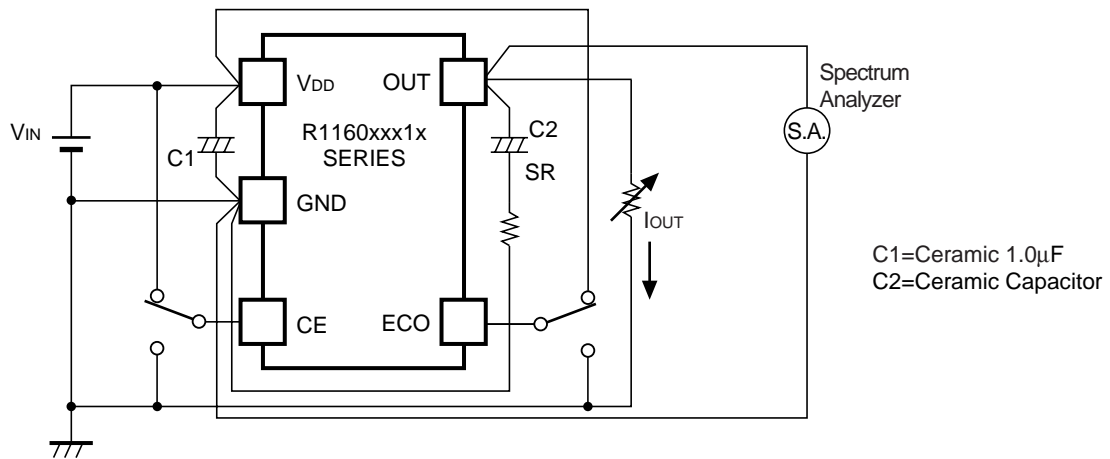
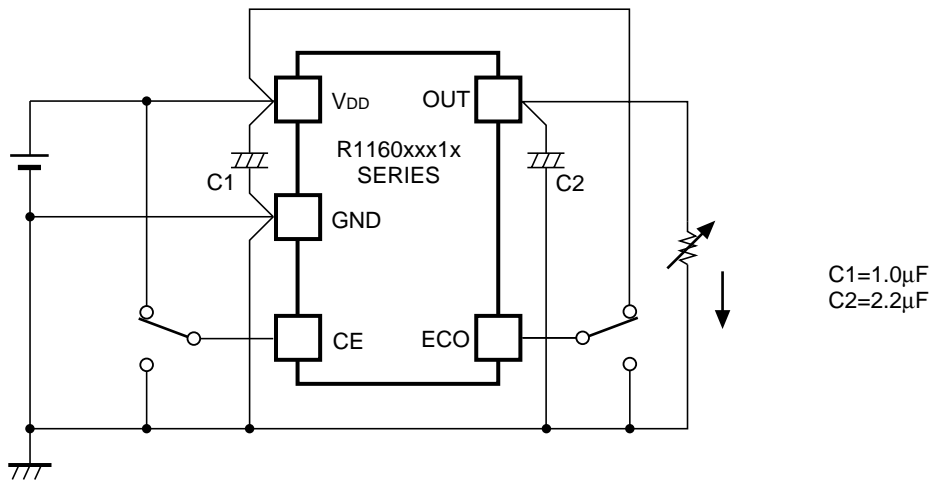


Fig.12 Output Noise Test Circuit (  $I_{OUT}$  vs. ESR )

## TYPICAL APPLICATION



(External Components)

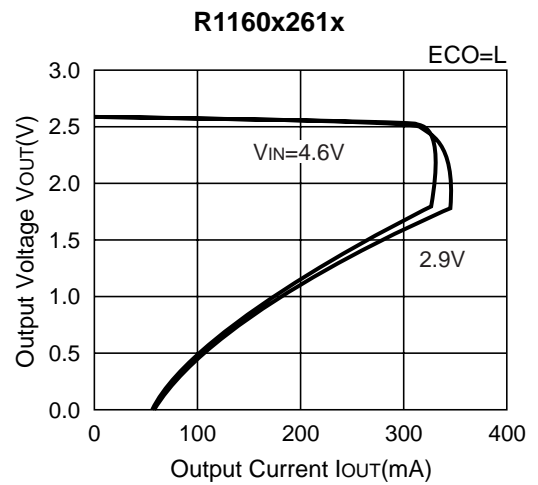
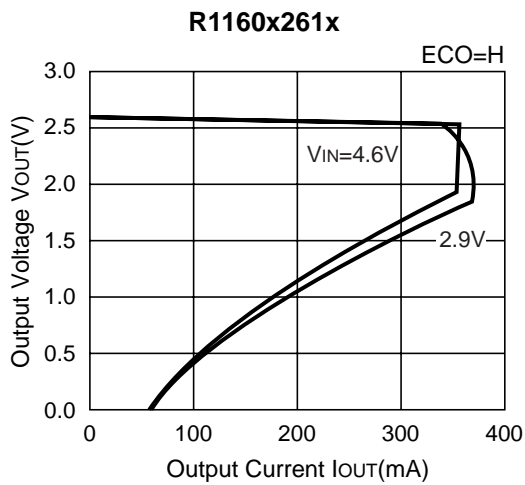
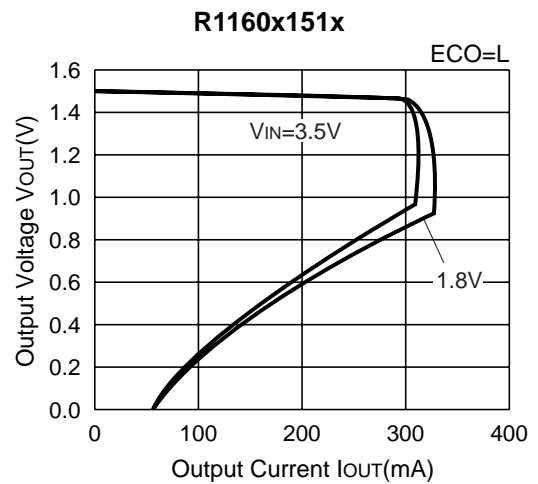
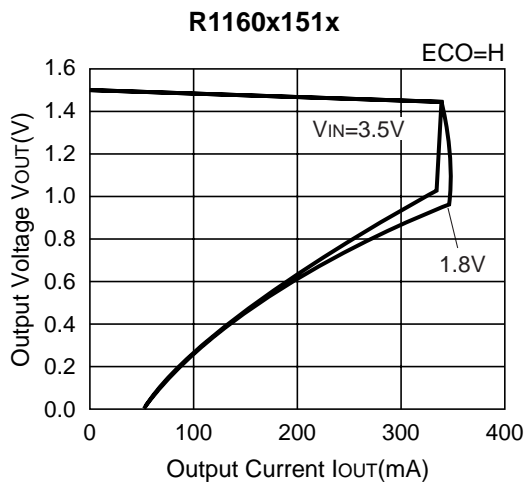
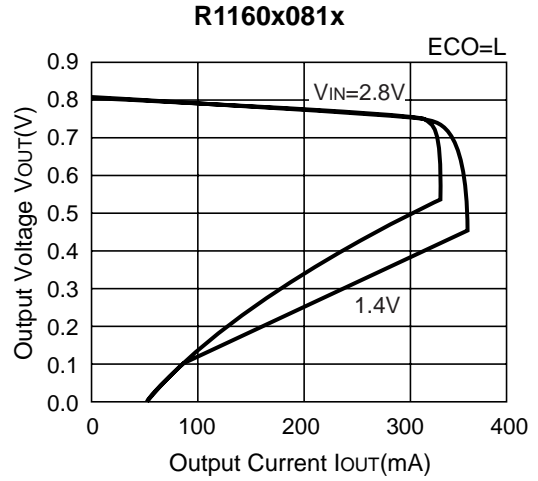
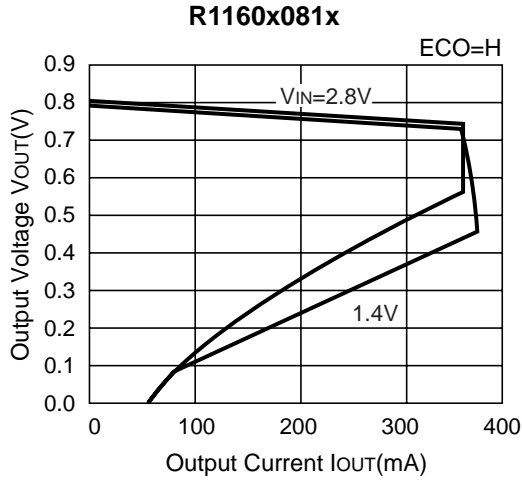
C1: Ceramic Capacitor 1 $\mu$ F

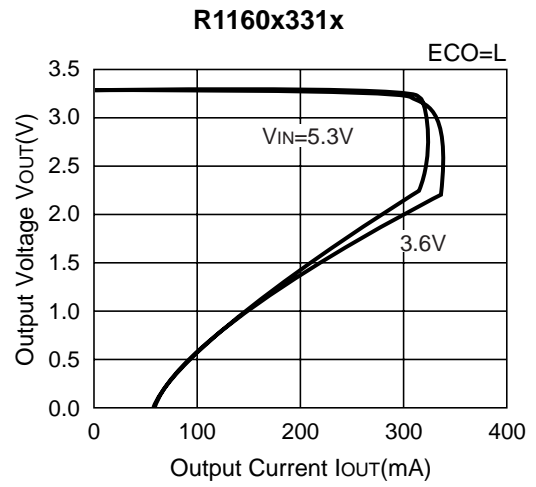
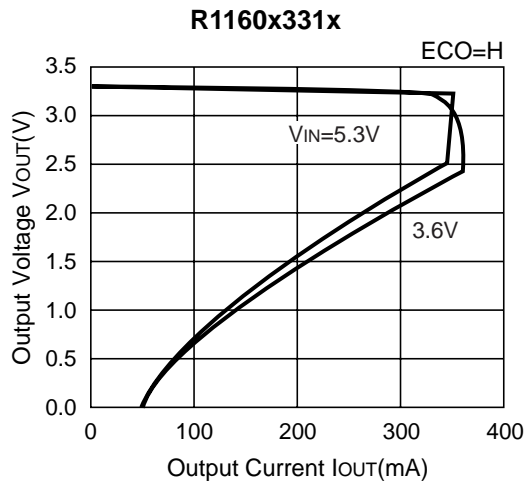
C2: Tantalum Capacitor 2.2 $\mu$ F

**R1160x**

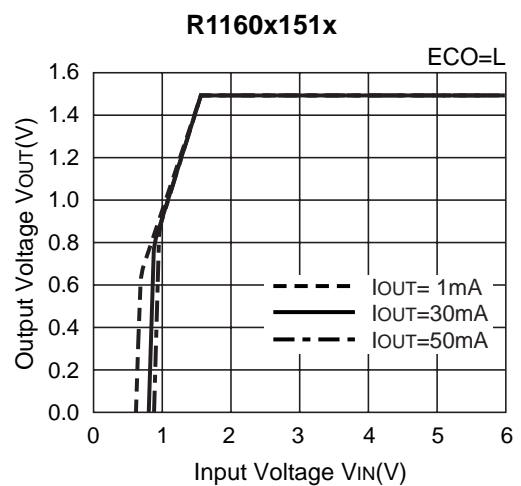
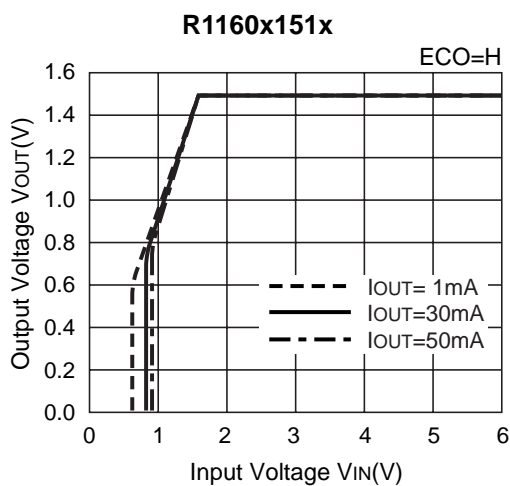
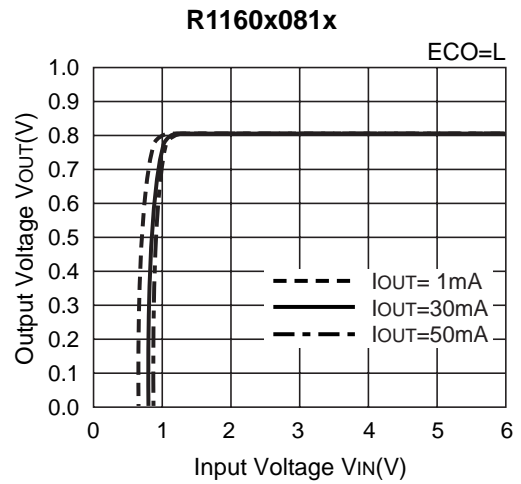
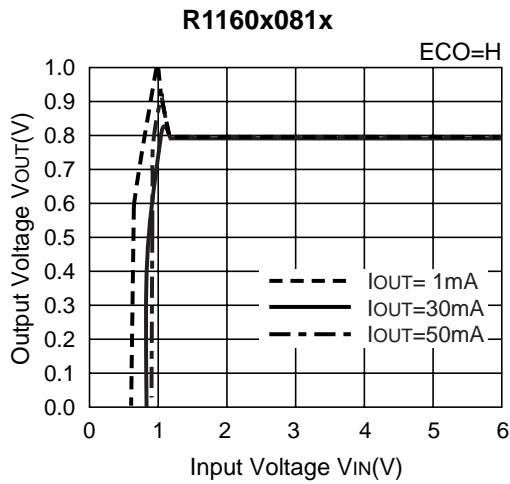
**TYPICAL CHARACTERISTICS**

1) Output Voltage vs. Output Current

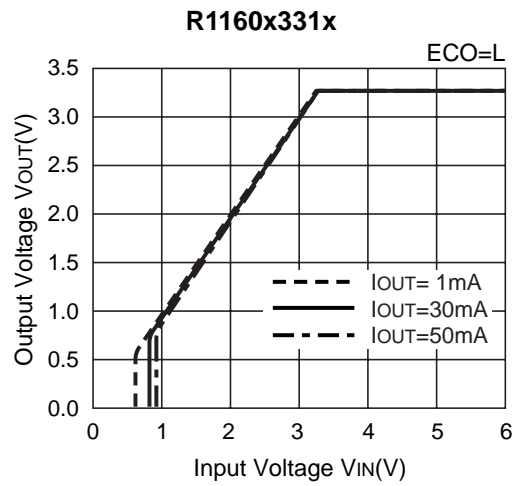
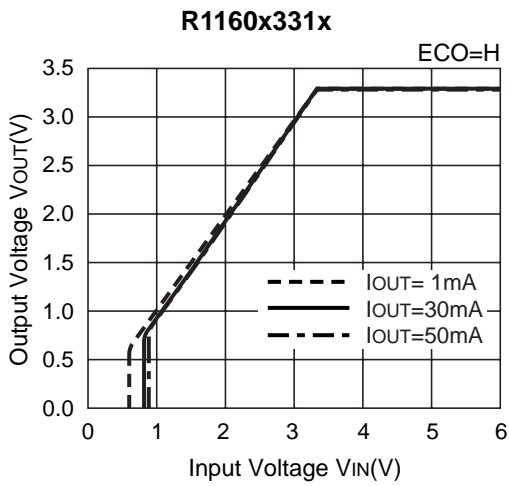
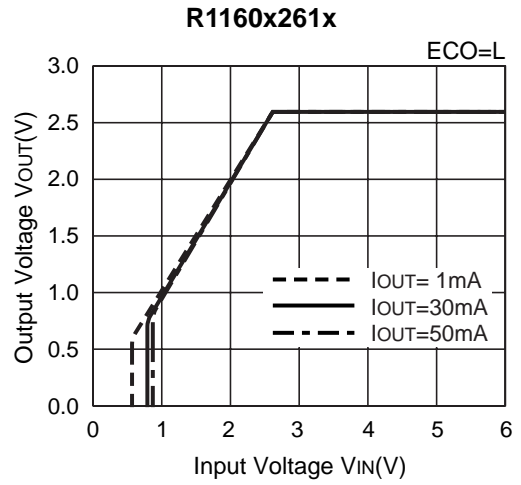
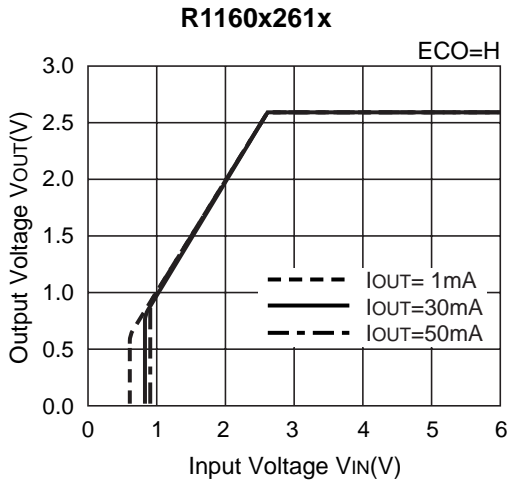




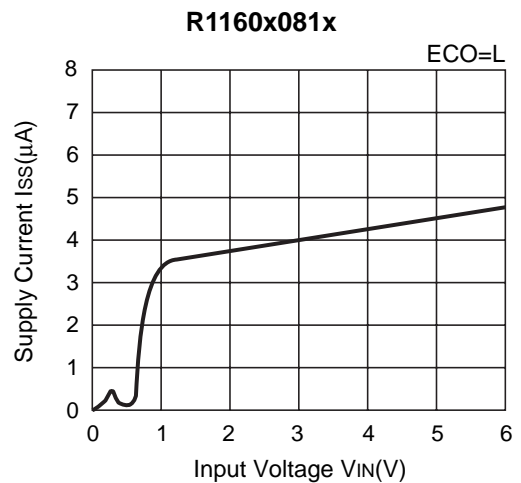
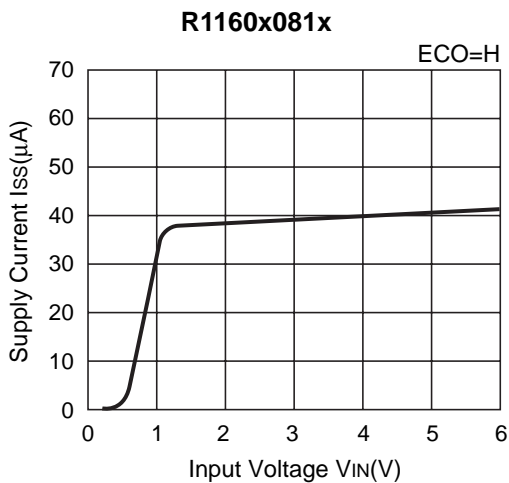
2) Output Voltage vs. Input Voltage

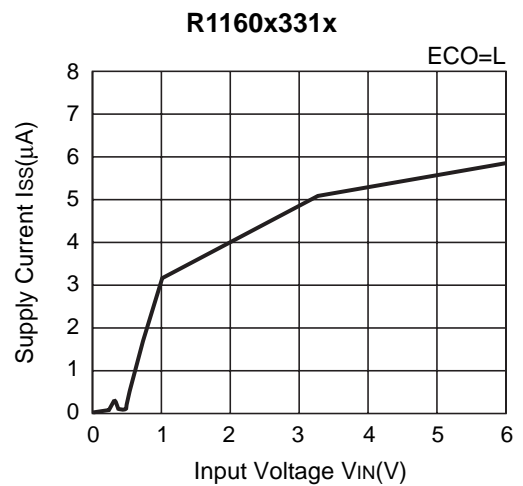
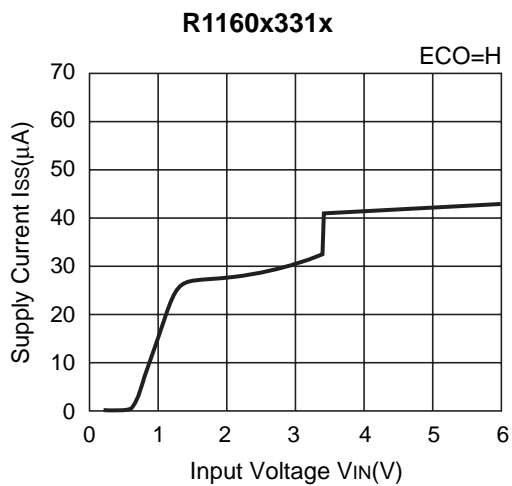
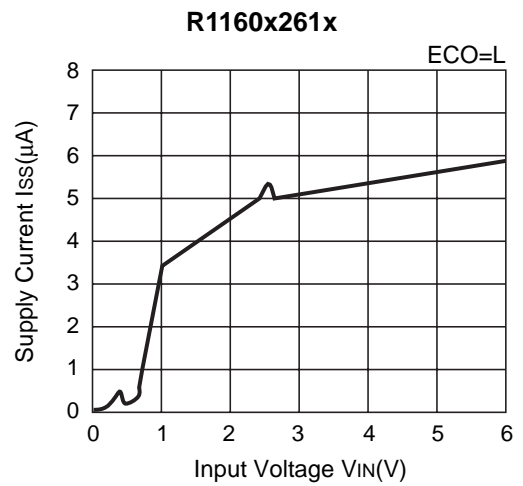
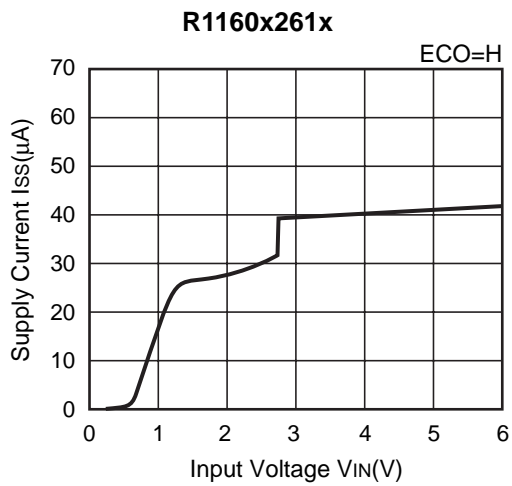
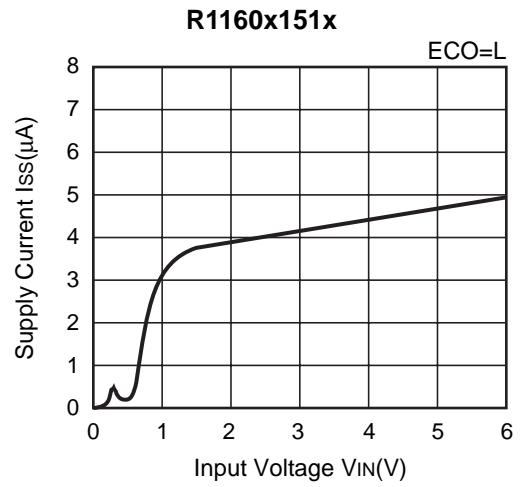
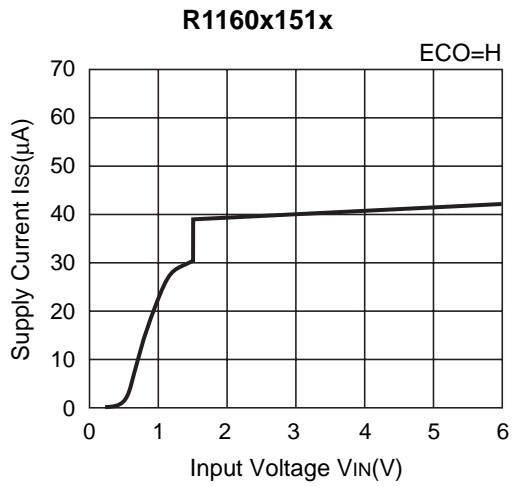


**R1160x**



3) Supply Current vs. Input Voltage

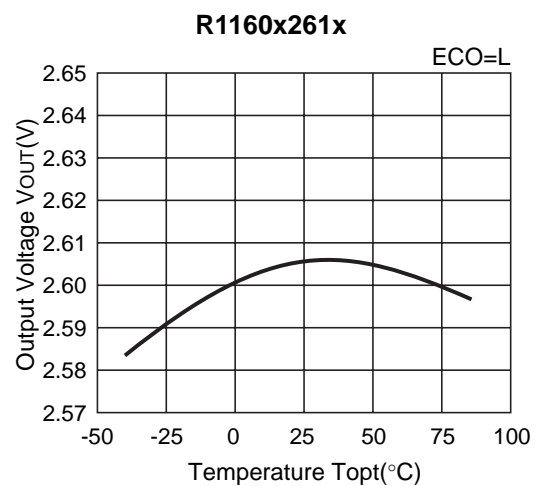
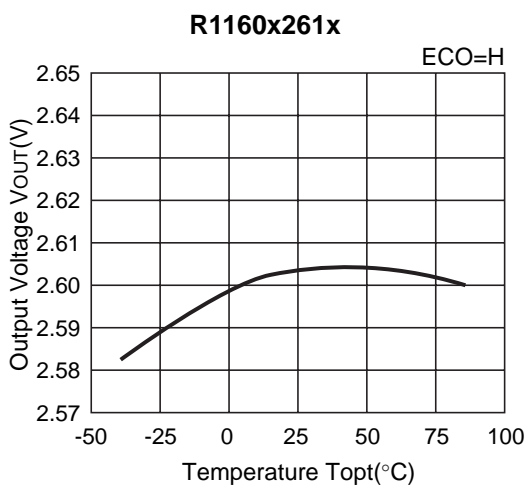
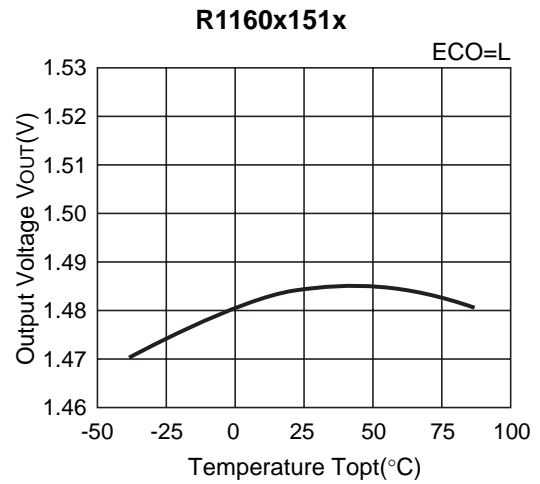
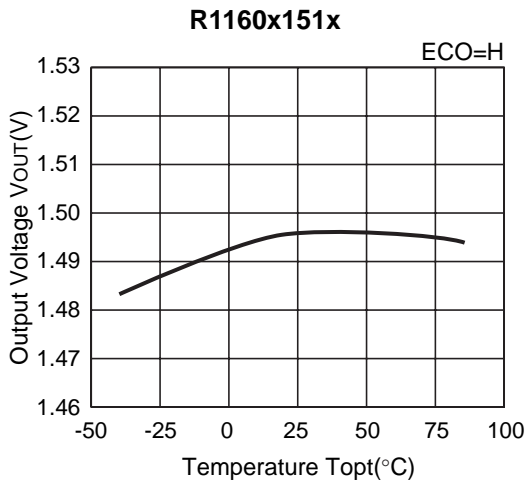
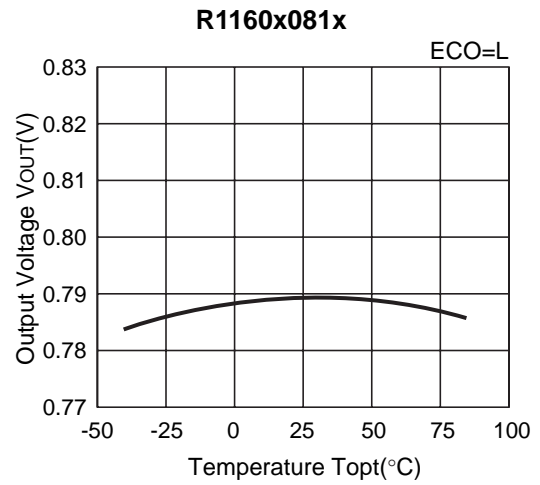
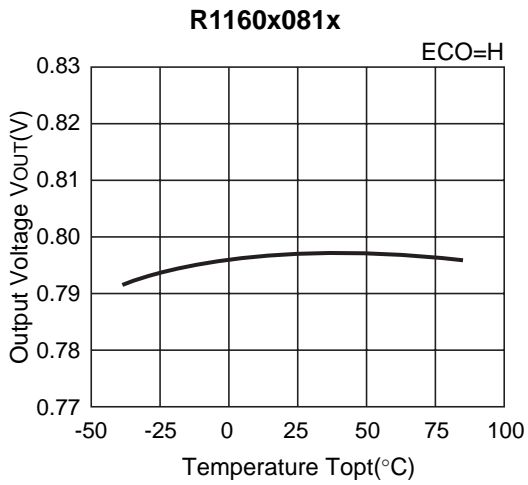




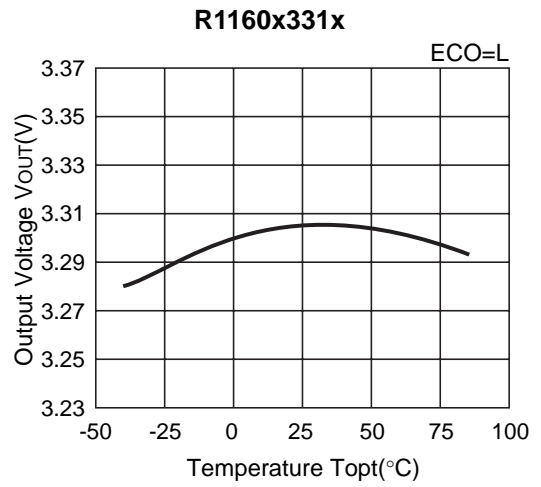
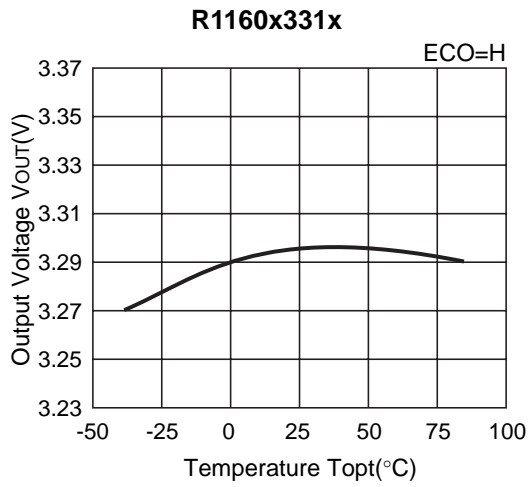
\* R1160D (SON-6) is the discontinued product. As of March in 2015.

## R1160x

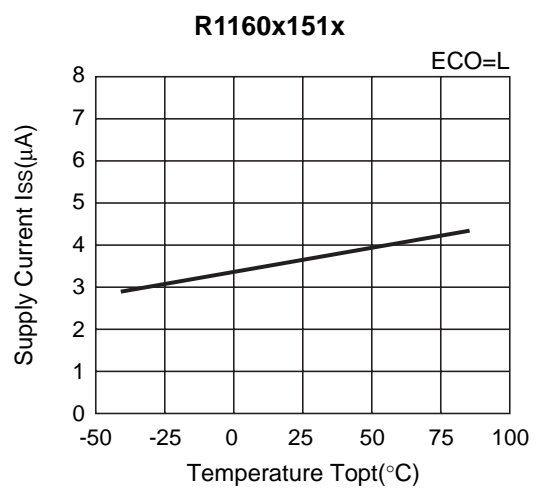
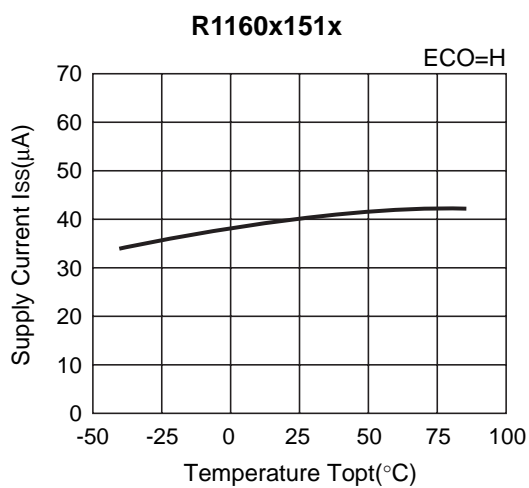
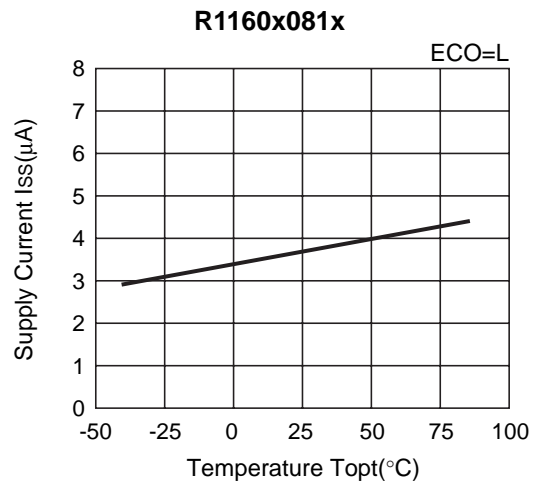
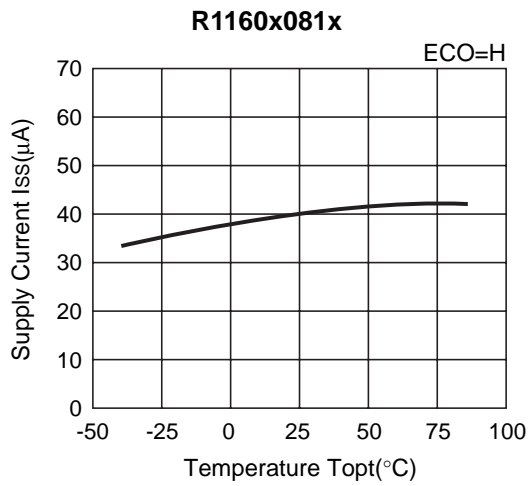
### 4) Output Voltage vs. Temperature





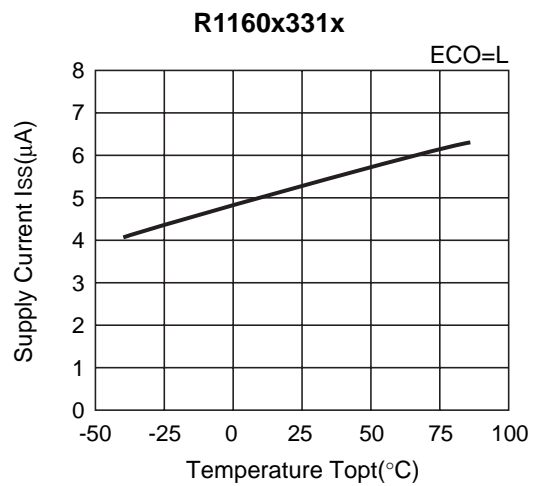
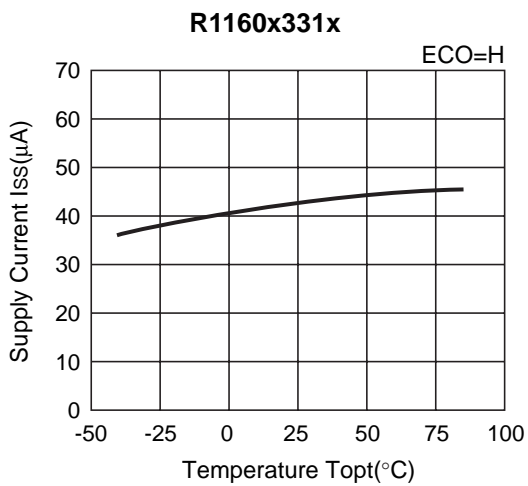
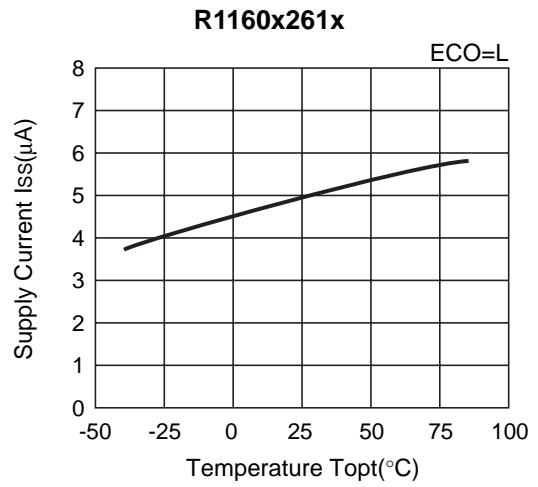
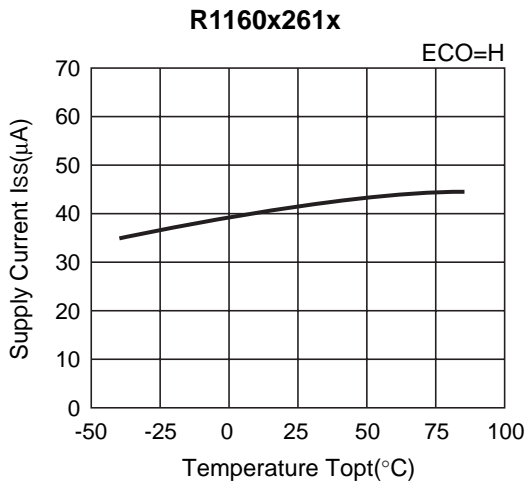


5) Supply Current vs. Input Voltage

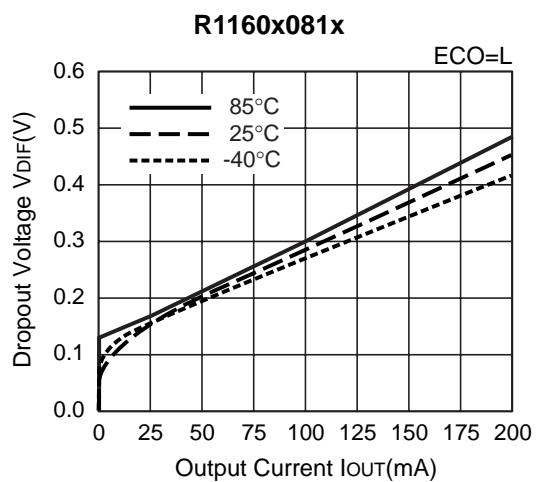
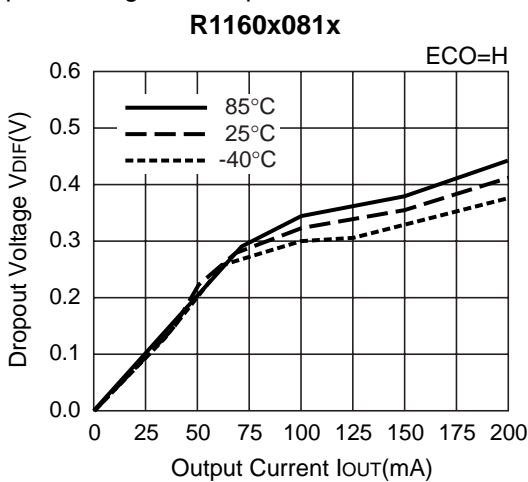


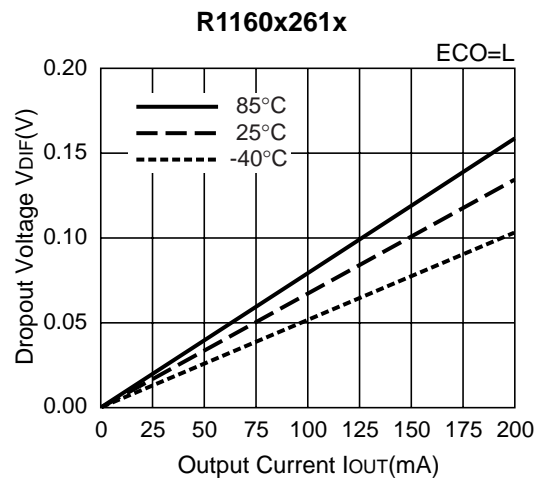
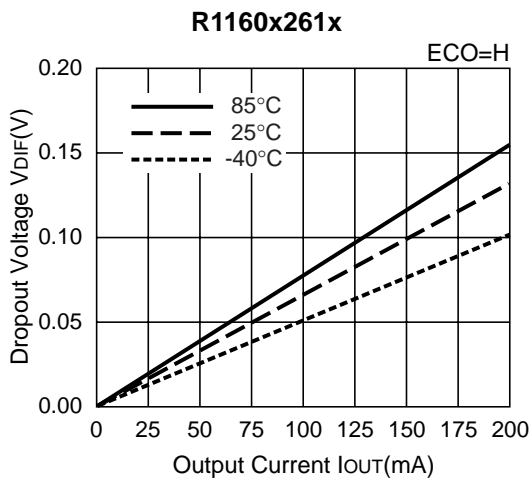
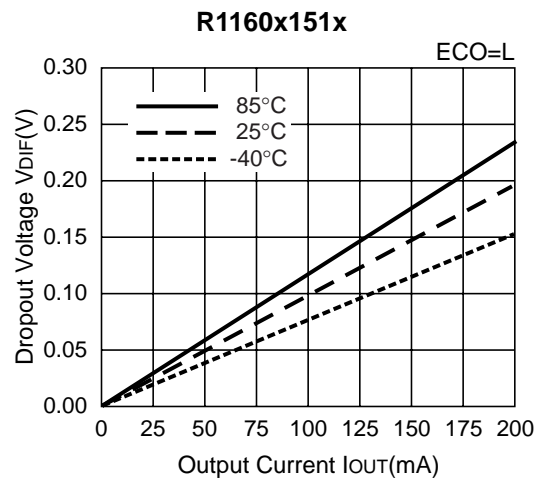
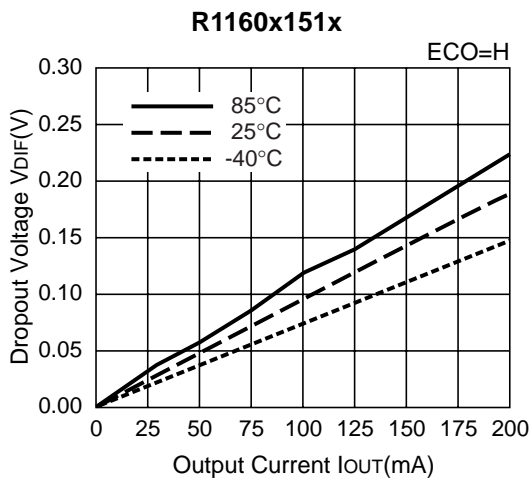
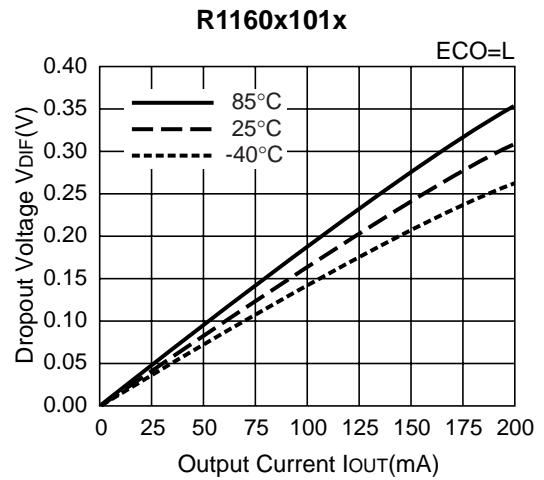
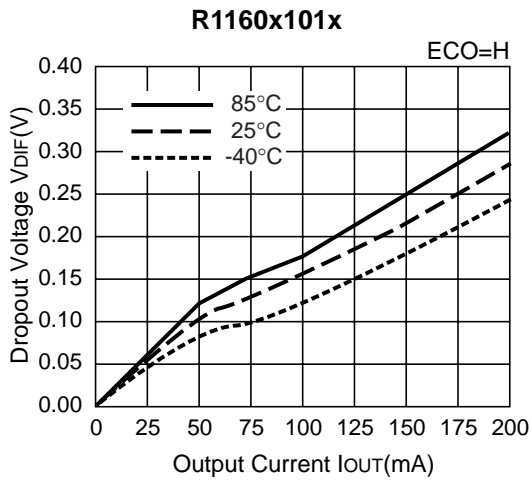
\* R1160D (SON-6) is the discontinued product. As of March in 2015.

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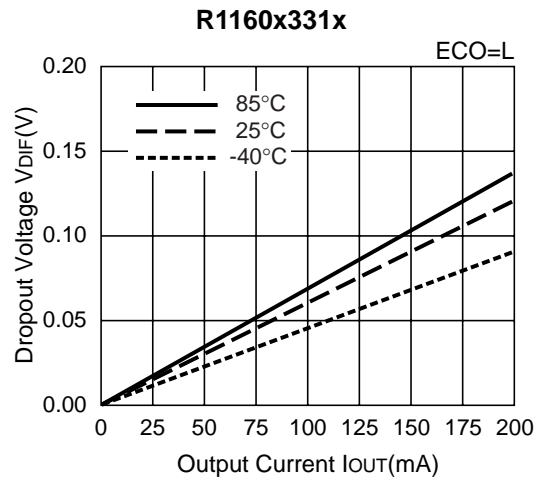
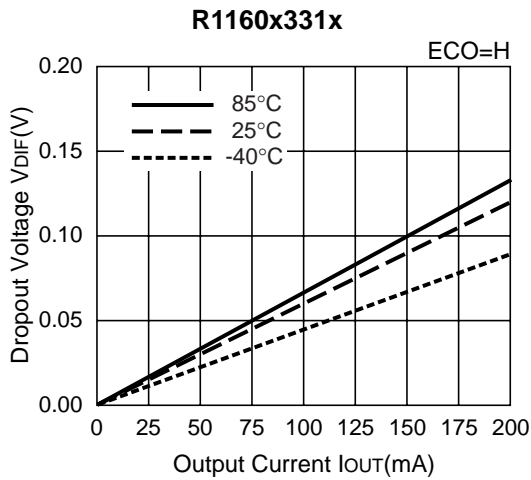


6) Dropout Voltage vs. Output Current

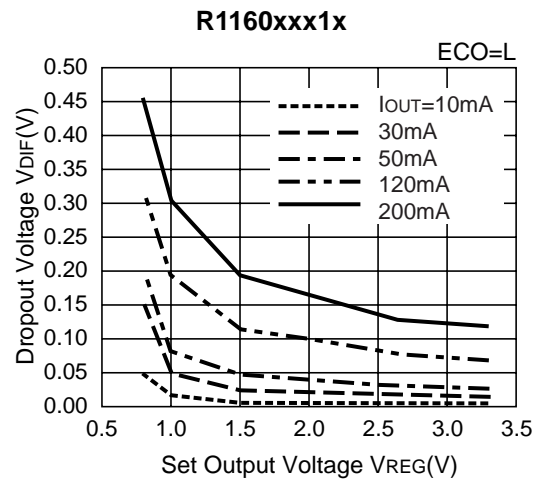
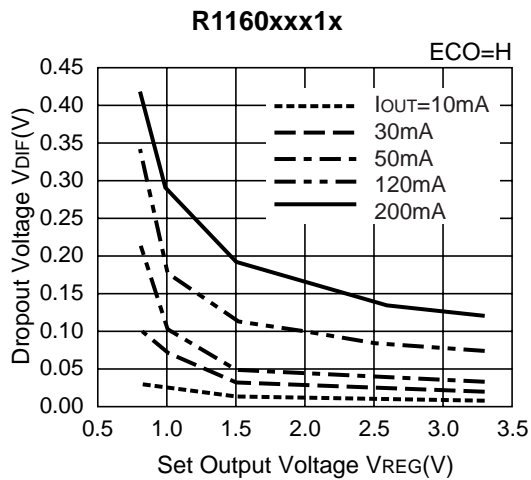




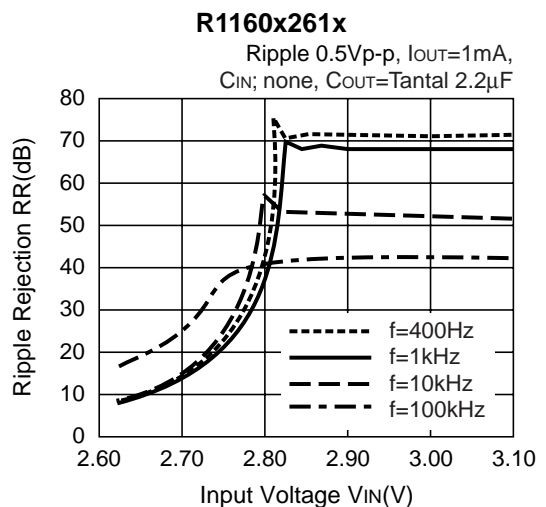
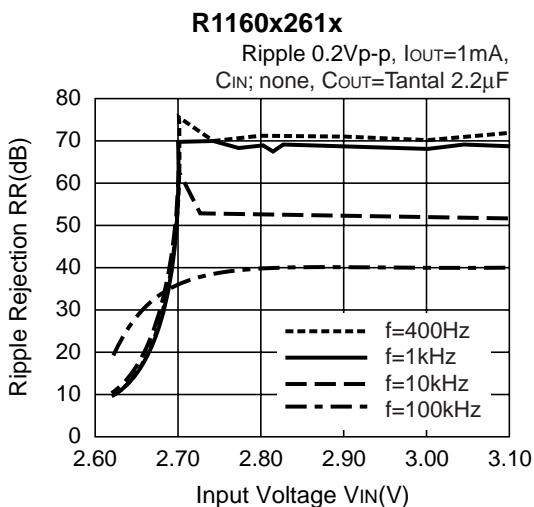
**R1160x**

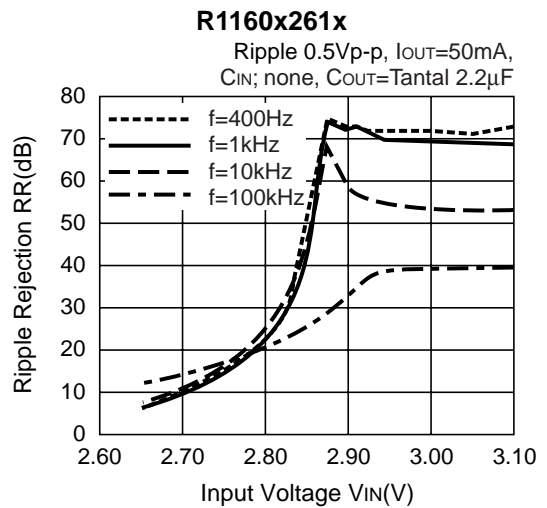
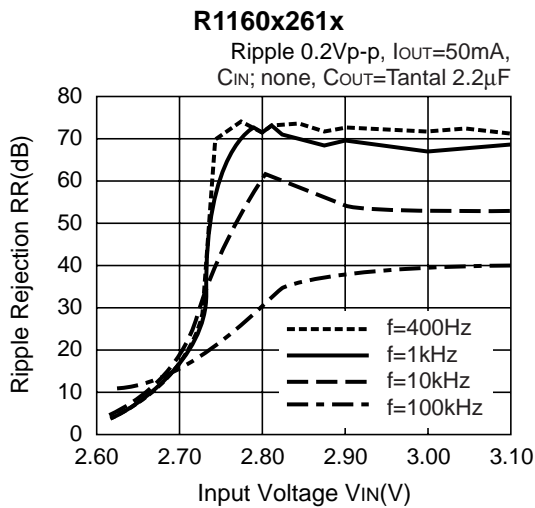
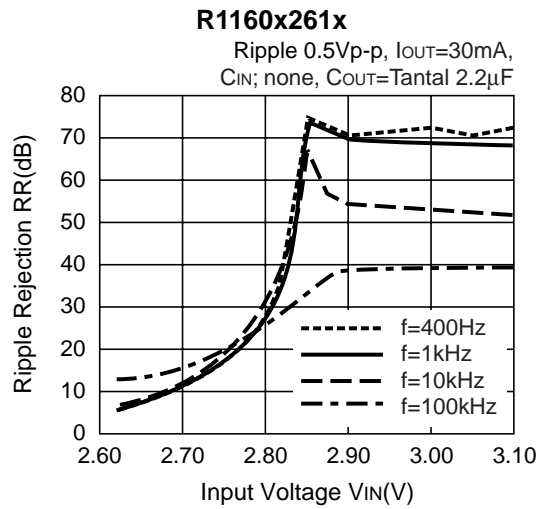
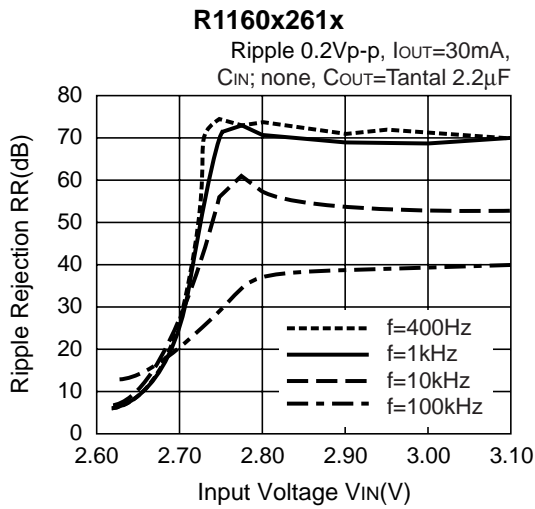


7) Dropout Voltage vs. Set Output Voltage ( $T_{opt}=25^{\circ}\text{C}$ )

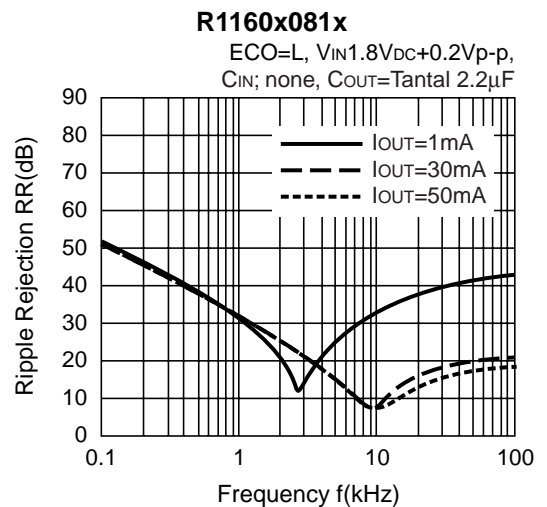
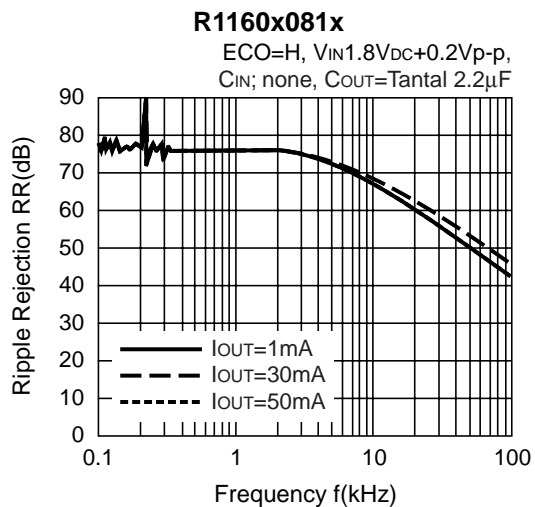


8) Ripple Rejection vs. Input Bias ( $T_{opt}=25^{\circ}\text{C}$ )

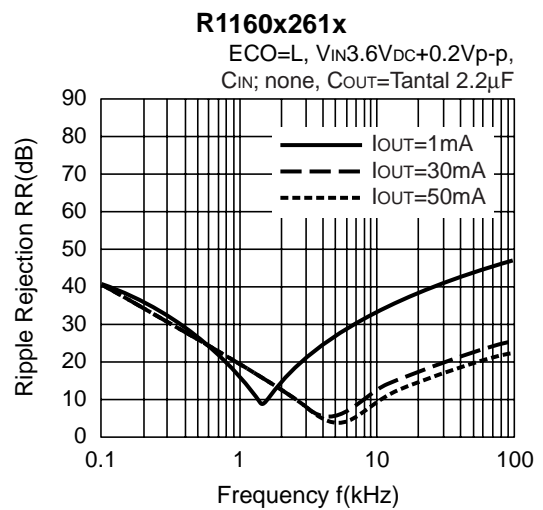
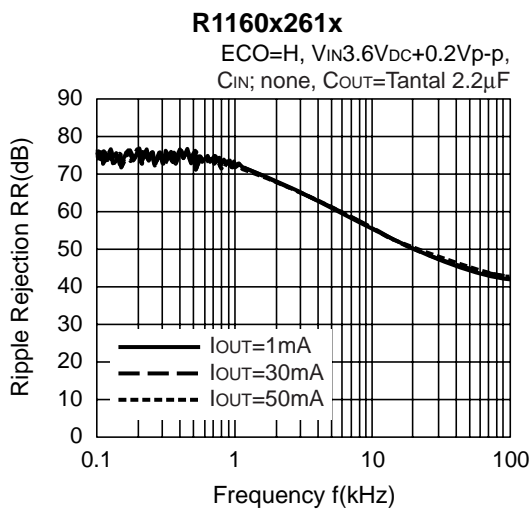
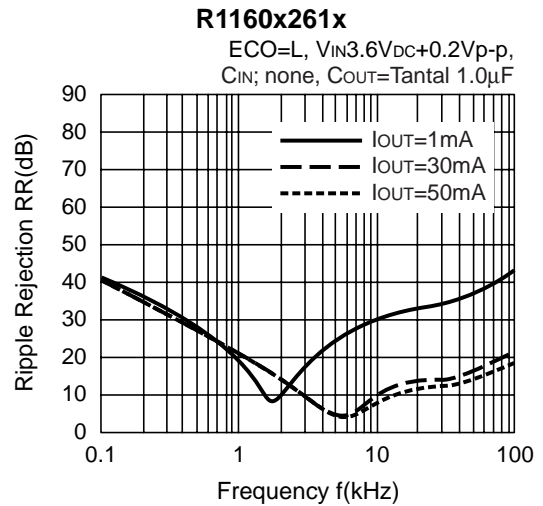
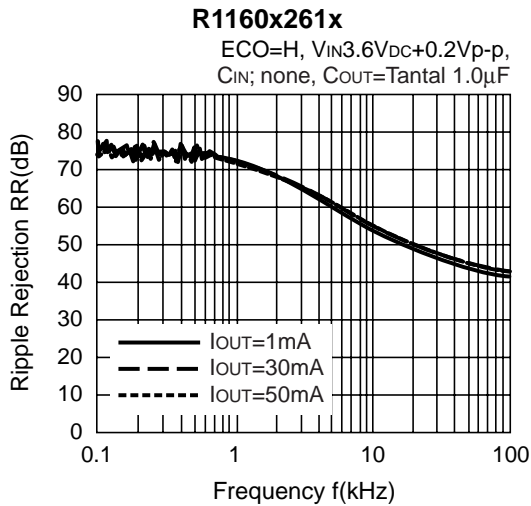
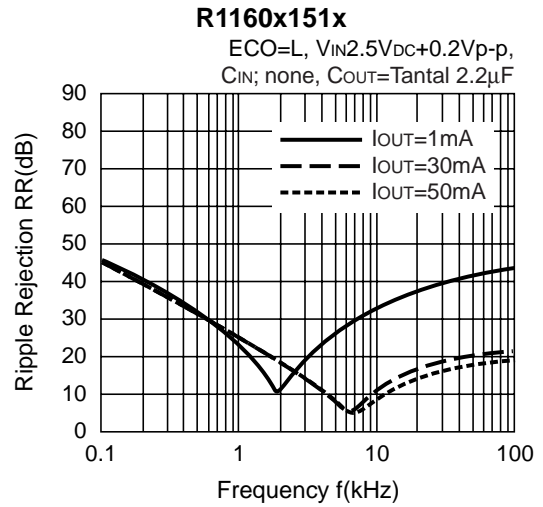
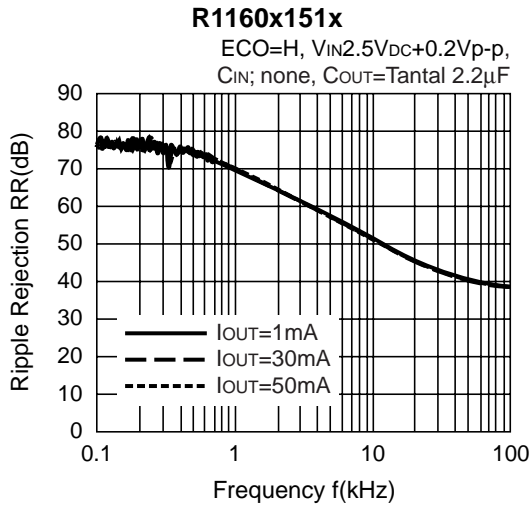


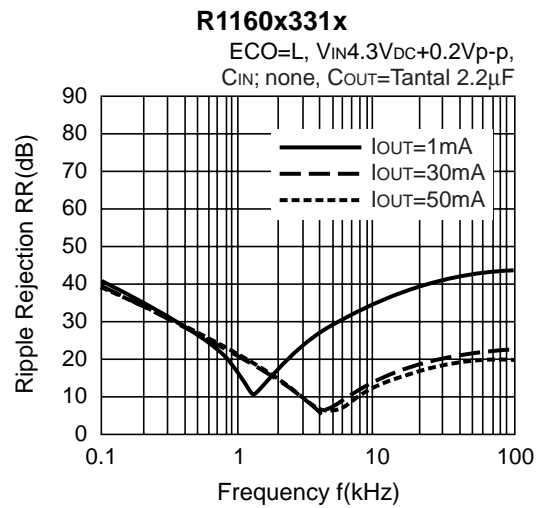
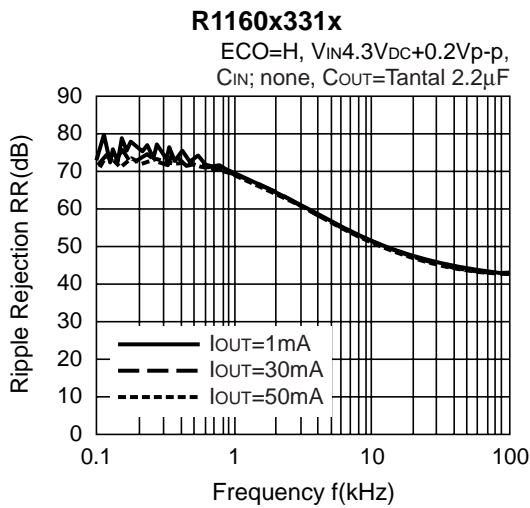
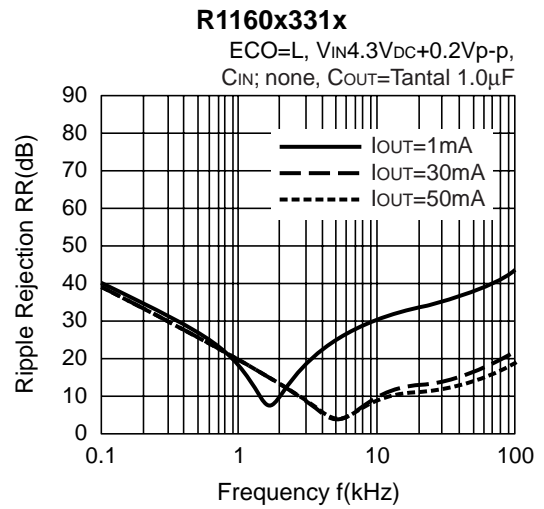
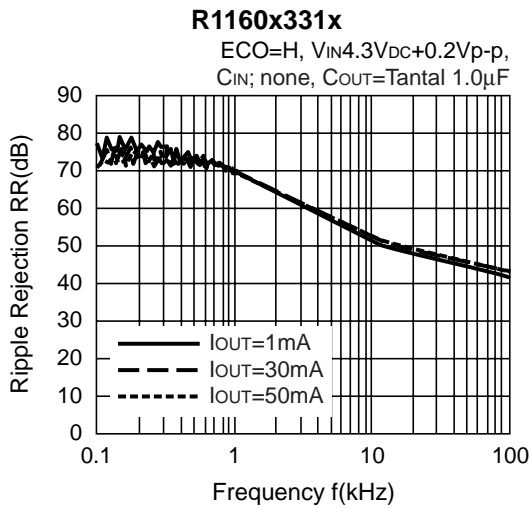


9) Ripple Rejection vs. Frequency

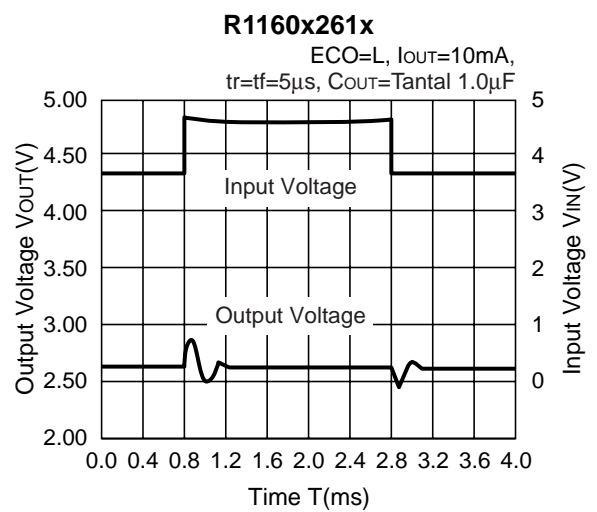
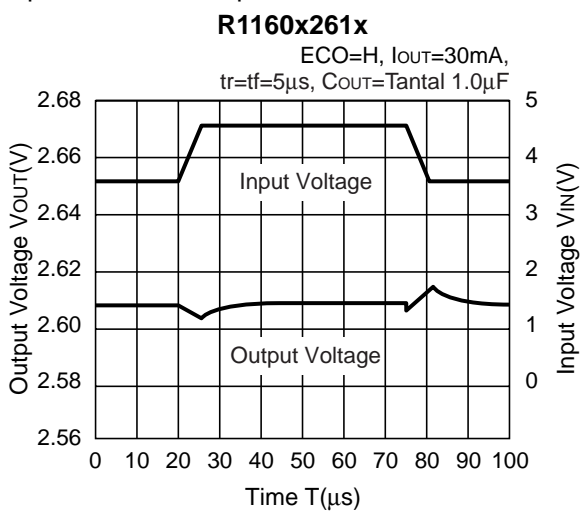


**R1160x**



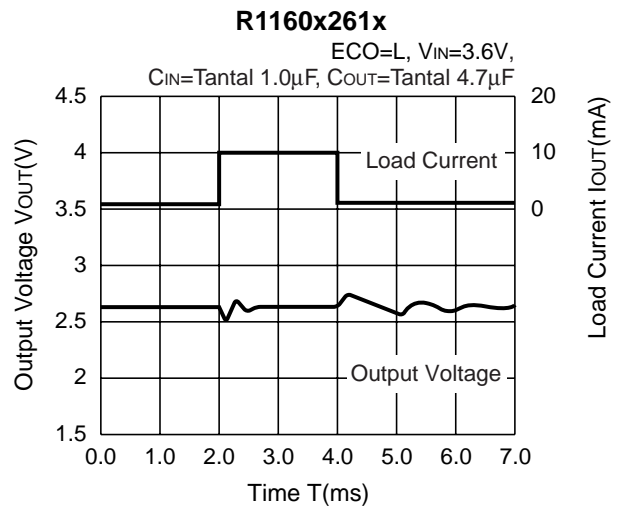
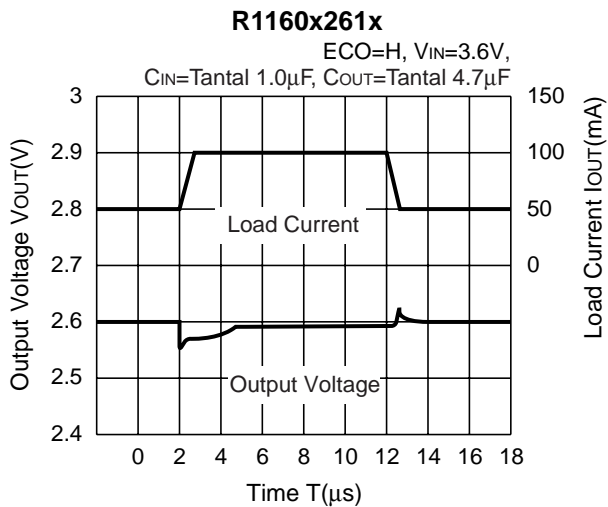
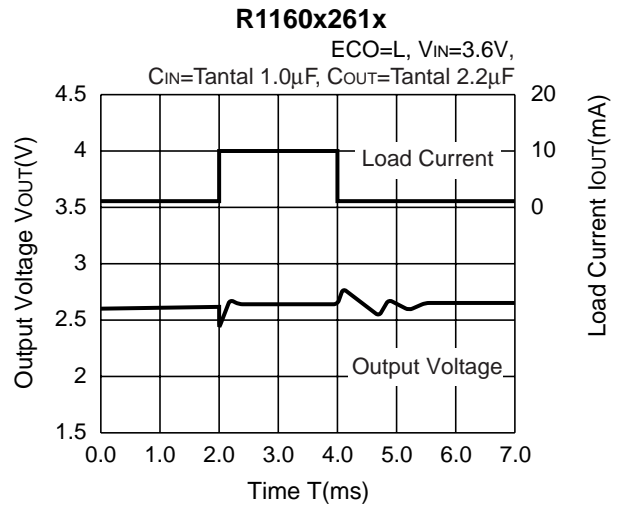
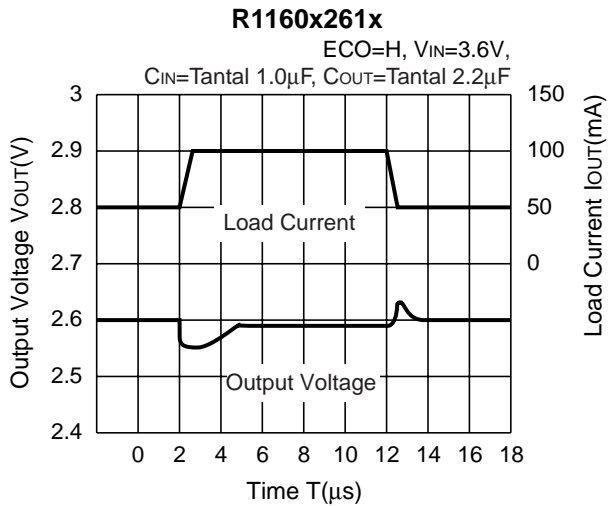
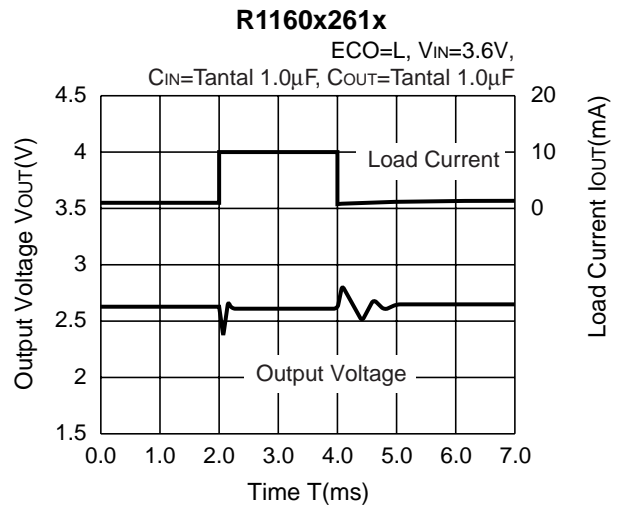
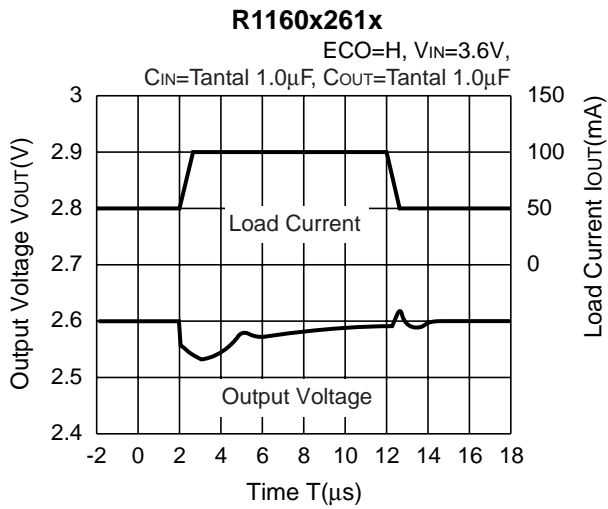


10) Input Transient Response



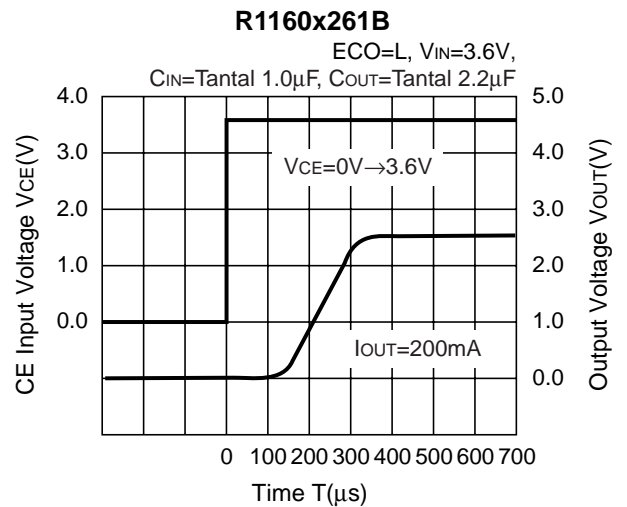
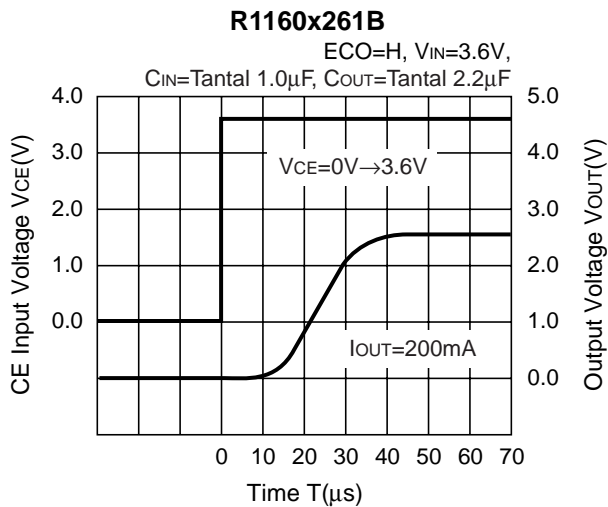
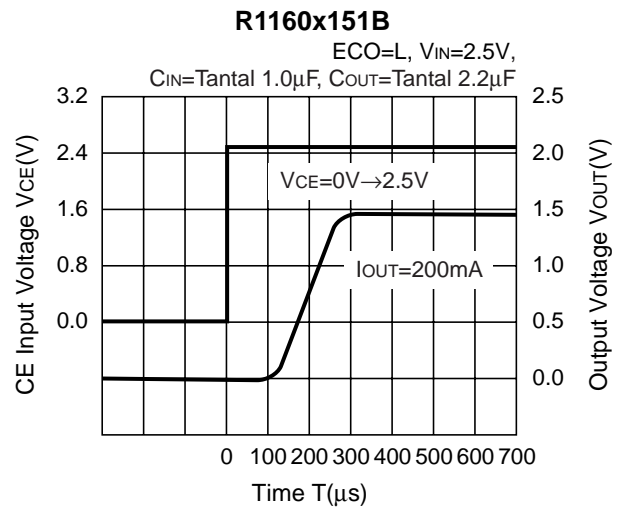
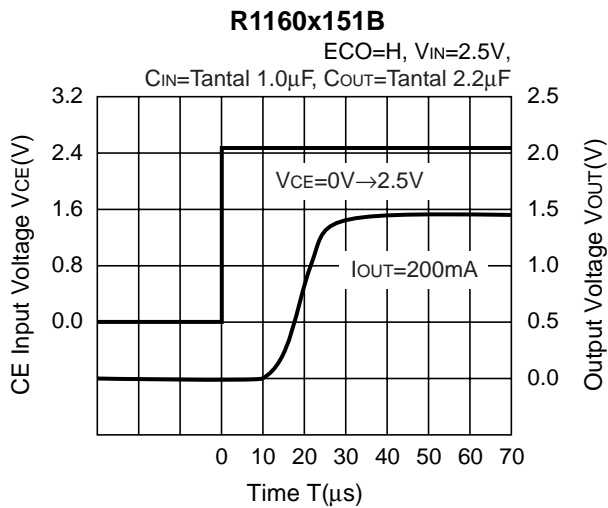
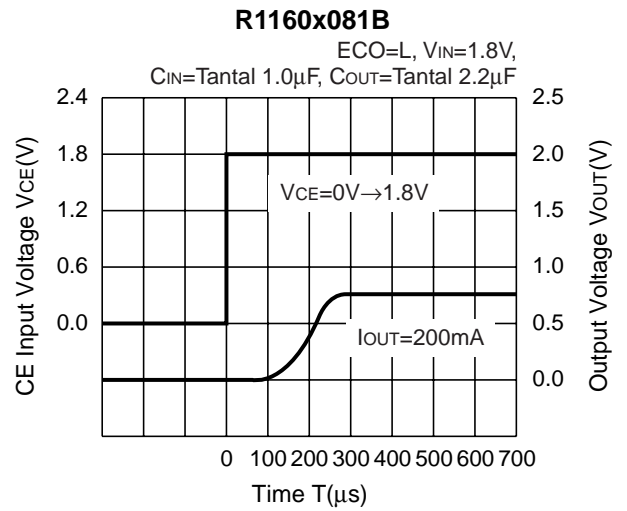
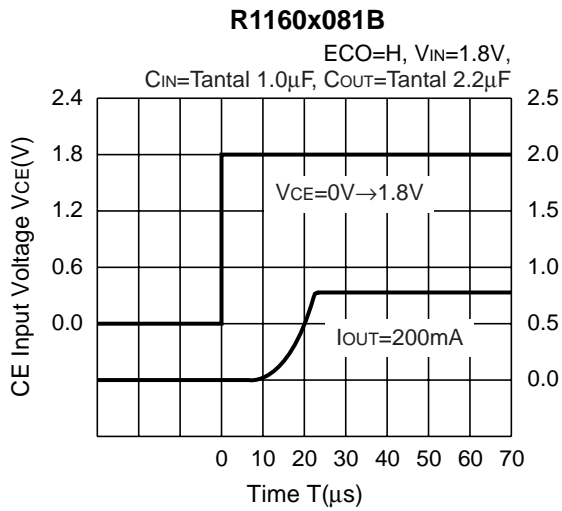
**R1160x**

11) Load Transient Response

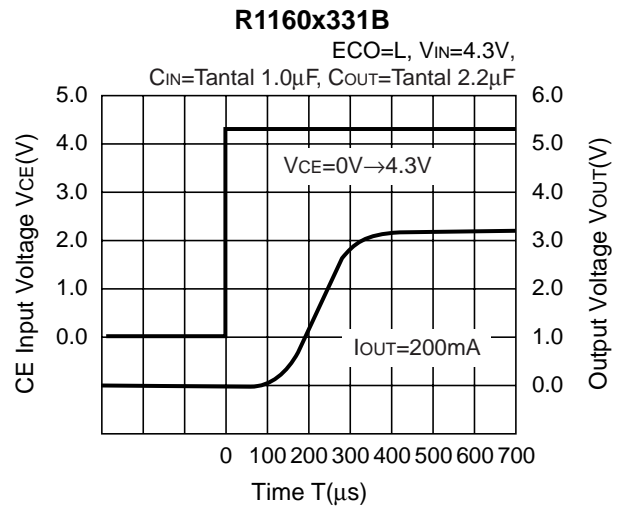
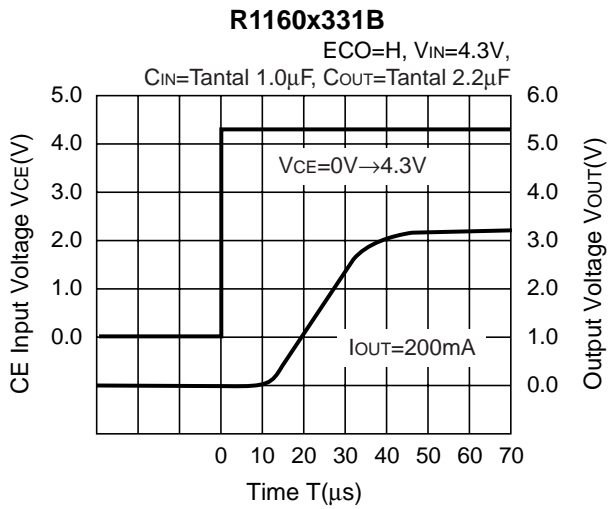




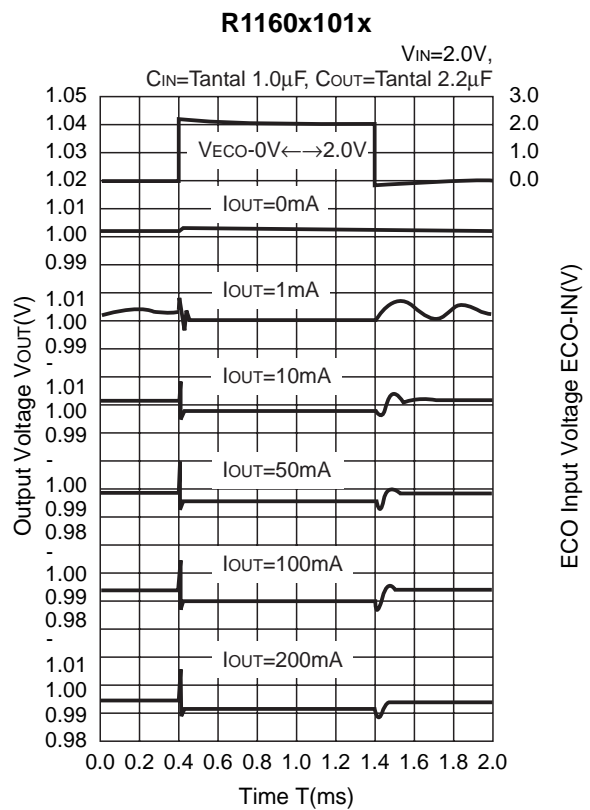
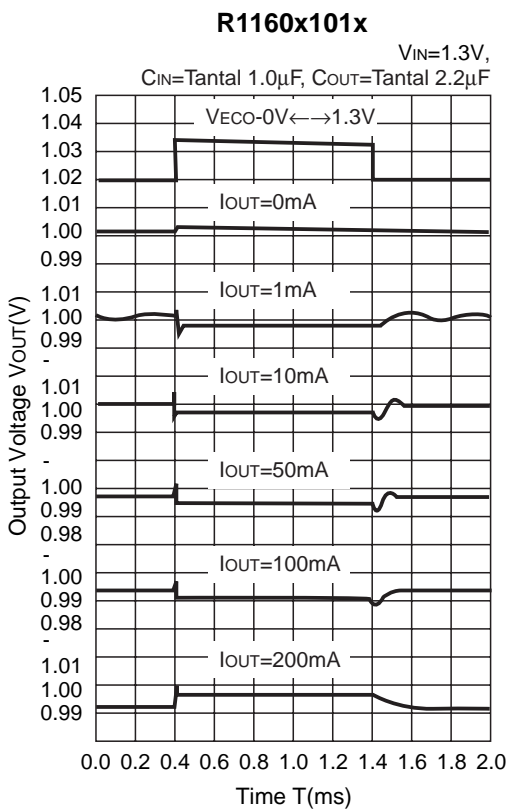
12) Turn on speed with CE pin

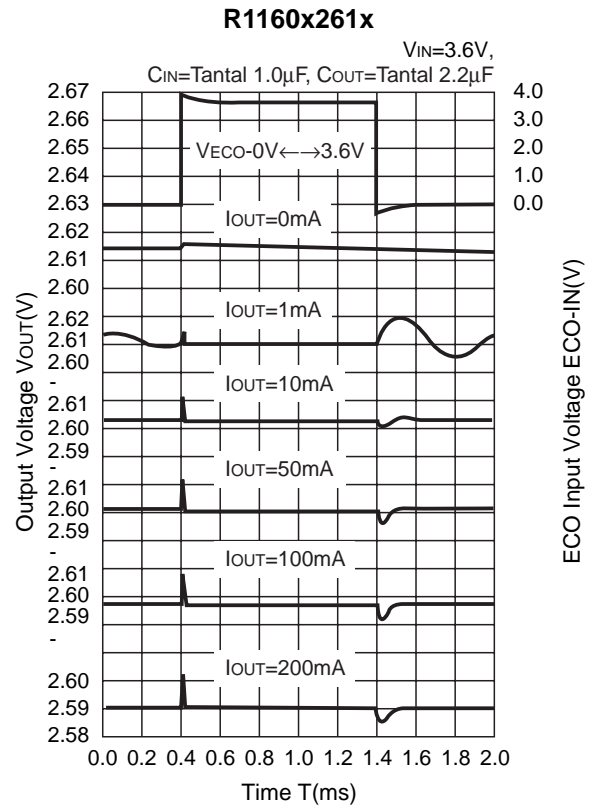
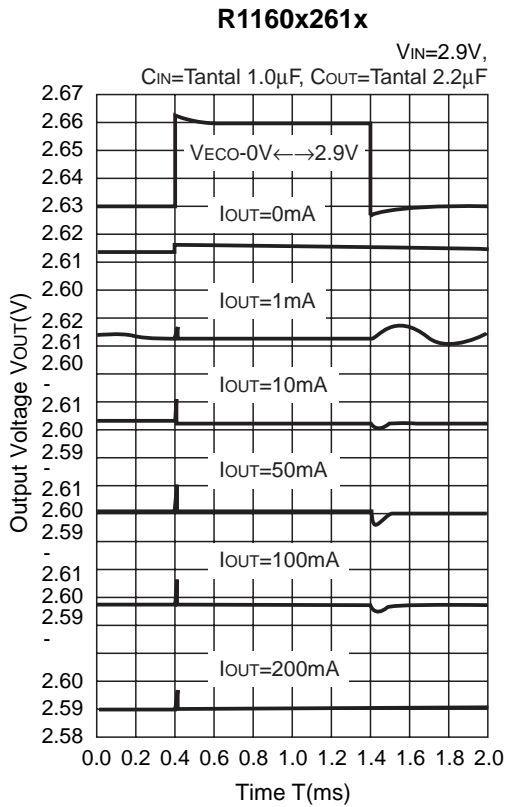


**R1160x**



13) Output Voltage at Mode alternative point



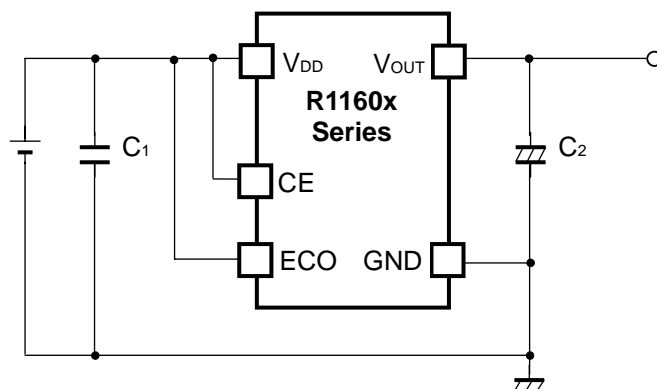


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## R1160x

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### TECHNICAL NOTES



(External Components)

C1: Ceramic Capacitor 1 $\mu$ F

C2: Tantalum Capacitor 2.2 $\mu$ F

When using these ICs, consider the following points:

#### 1. PCB Layout

Make  $V_{DD}$  and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as 1.0 $\mu$ F or more between  $V_{DD}$  and GND pin, and as close as possible to the pins.

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

#### 2. 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 2.2 $\mu$ F or more and good ESR (Equivalent Series Resistance).

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

If you use a tantalum type capacitor and ESR value of the capacitor is large, output might be unstable. Evaluate your circuit with considering frequency characteristics.

If you use a ceramic type output capacitor, please connect about 1 $\Omega$  resistor in series for the stability of output voltage.

Depending on the capacitor size, manufacturer, and part number, the bias characteristics and temperature characteristics are different. Evaluate the circuit with actual using capacitors.

## ESR vs. Output Current

When using these ICs, consider the following points:

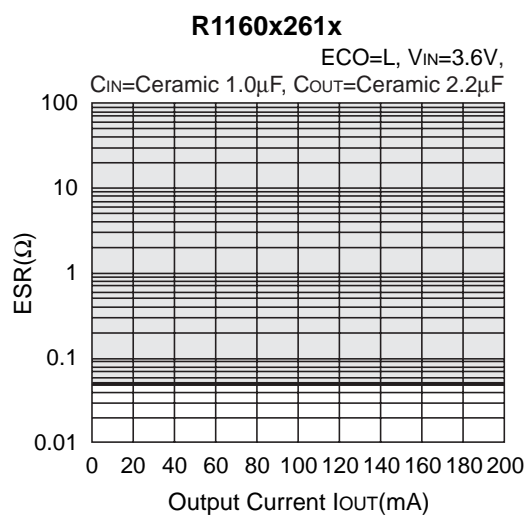
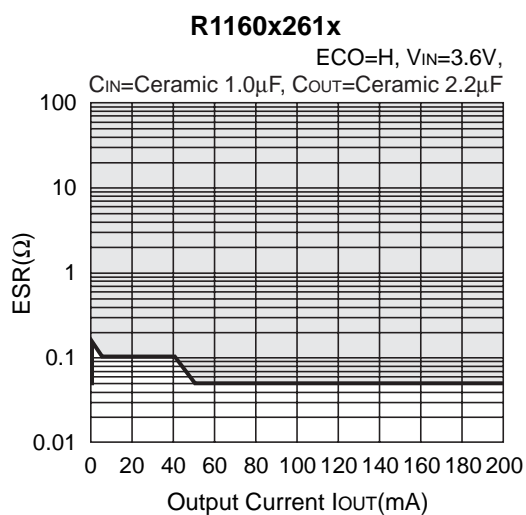
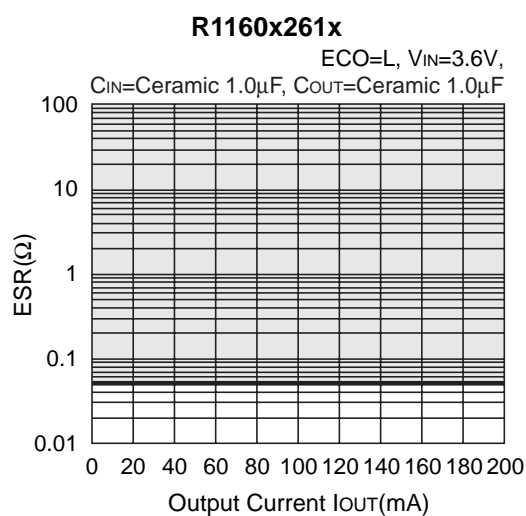
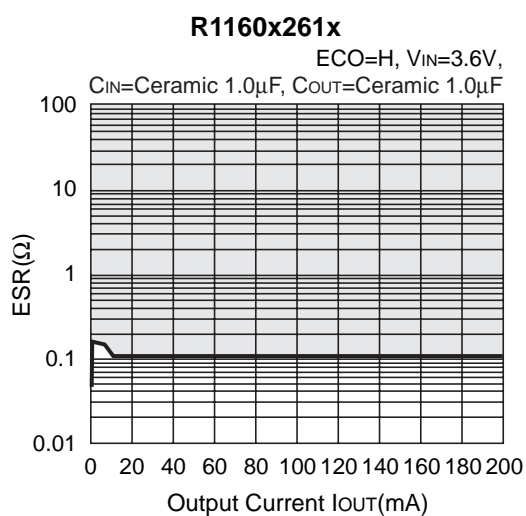
The relations between  $I_{OUT}$  (Output Current) and ESR of an output capacitor are shown below.

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

### Measurement conditions

Frequency Band : 10Hz to 2MHz

Temperature : 25°C

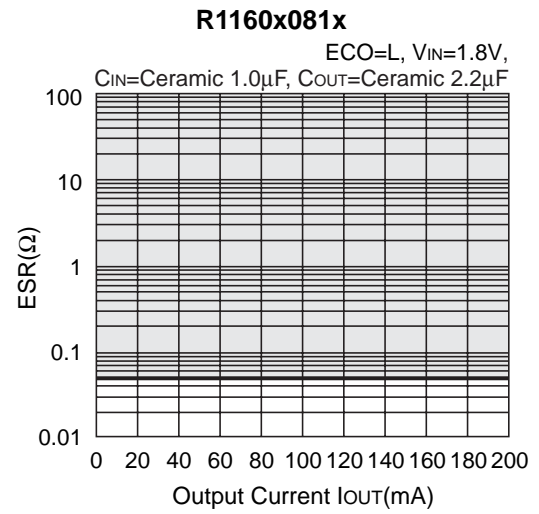
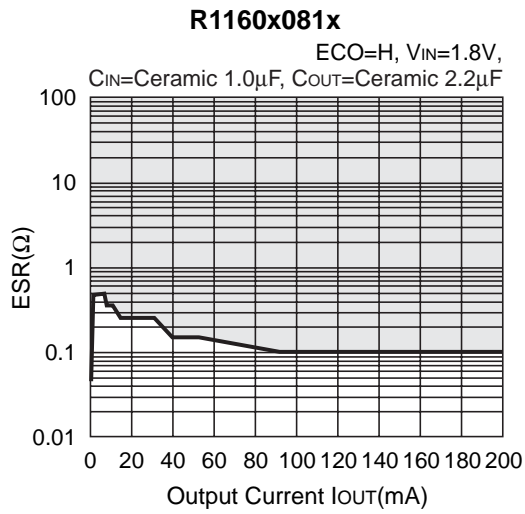


\* R1160D (SON-6) is the discontinued product. As of March in 2015.

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## R1160x

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8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
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