200 mA 36 V Input Ultra Low Supply Current VR for Automotive Applications

NO.EC-348-160930

OUTLINE

The R8160x is a CMOS-based ultra low supply current voltage regulator featuring 200 mA output current and 36 V input voltage. This device consists of an Output Short-circuit Protection Circuit, an Over-current Protection Circuit, and a Thermal Shutdown Circuit in addition to the basic regulator circuits. The operating temperature range is between −40°C to 125°C, and the maximum input voltage is 36 V. All these features allow this device to become an ideal power source for ECUs.

The output voltages are internally fixed at either of the following: 3.3 V, 3.4 V, 5.0 V, 6.0 V, 8.0 V, 8.5 V and 9.0 V. The output voltage accuracy is ±1.6%.

The packages for this device range from high-density mounting to ultra high wattage. The R8160x is offered in a 5-pin SOT-23-5, a 5-pin SOT-89-5, and a 6-pin HSOP-6J package.

FEATURES

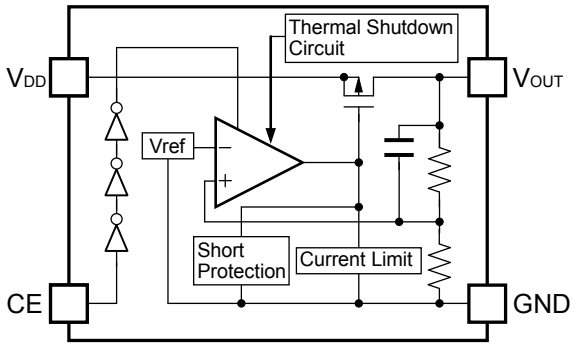
- Input Voltage Range (Maximum Rating) ····· 3.5 V to 36 V (50 V)
- Operating Temperature Range ····· –40°C to 125°C
- Supply Current ····· Typ. 2.2 μA
- Standby Current ····· Typ. 0.1 μA
- Dropout Voltage ····· Typ. 0.6 V (I_{OUT} = 200 mA, V_{OUT} = 5.0 V)
- Output Voltage Range ····· 3.3 V / 3.4 V / 5.0 V / 6.0 V / 8.0 V / 8.5 V / 9.0 V
  *Contact our sales representatives for other voltages.
- Output Voltage Accuracy ····· ±1.6%
- Line Regulation ····· Typ. 0.01%/V (V_{SET} + 1 V ≤ V_{IN} ≤ 36 V)
- Built-in Output Short-circuit Protection Circuit ····· Typ. 80 mA
- Built-in Over-current Protection Circuit ····· Typ. 350 mA
- Built-in Thermal Shutdown Circuit ····· Thermal Shutdown Temperature: Typ. 160°C
- Ceramic capacitors are recommended to be used with this device ····· C_{OUT} = 0.1 μF or more
- Packages ····· SOT-23-5, SOT-89-5, HSOP-6J

APPLICATIONS

- Power source for ECUs such as EV inverter and battery charge control unit

BLOCK DIAGRAM

R8160xxxxB



SELECTION GUIDE

The set output voltage and the package type are user-selectable.

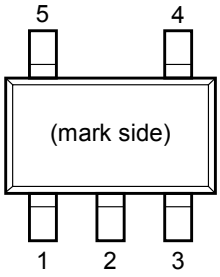
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R8160NxxxB-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes
R8160HxxxB-T1-FE	SOT-89-5	1,000 pcs	Yes	Yes
R8160SxxxB-E2-FE	HSOP-6J	1,000 pcs	Yes	Yes

xxx: Specify the set output voltage (V_{SET})
3.3 V (033) / 3.4 V (034) / 5.0 V (050) / 6.0 V (060) / 8.0 V (080) / 8.5 V (085) / 9.0 V (090)
*Contact our sales representatives for other voltages.

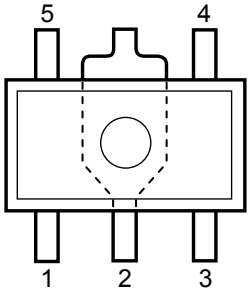
R8 Automotive Class Code

Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
−40°C to 125°C	−40°C to 125°C	High and Low Temperature

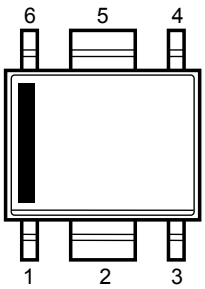
PIN DESCRIPTIONS



SOT-23-5



SOT-89-5



HSOP-6J

SOT-23-5

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

*1 The GND pin must be wired together when it is mounted on board.

SOT-89-5

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

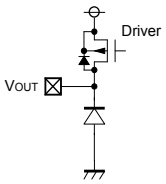
*2 The GND pin must be wired together when it is mounted on board.

HSOP-6J

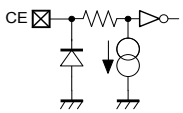
Pin No.	Symbol	Description
1	V_{OUT}	Output Pin
2	GND*3	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	GND*3	Ground Pin
5	GND*3	Ground Pin
6	V_{DD}	Input Pin

*3 The GND pin must be wired together when it is mounted on board.

PIN EQUIVALENT CIRCUIT DIAGRAMS



V_{OUT} Pin



CE Pin

ABSOLUTE MAXIMUM RATINGS

Symbol	Item			Rating	Unit
V_{IN}	Input Voltage			−0.3 to 50	V
V_{IN}	Peak Input Voltage*1			60	V
V_{CE}	Input Voltage (CE Pin)			−0.3 to 50	V
V_{OUT}	Output Voltage			−0.3 to V_{IN} + 0.3 ≤ 50	V
I_{OUT}	Output Current			300	mA
P_D	Power Dissipation*2	SOT-23-5	Standard Land Pattern	525	mW
		SOT-89-5	Standard Land Pattern	1120	
			High Wattage Land Pattern	1620	
		HSOP-6J	Standard Land Pattern	2100	
			Ultra High Wattage Land Pattern	3400	
Tj	Junction Temperature			−40 to 150	°C
Tstg	Storage Temperature Range			−55 to 150	°C

*1 Duration time: 200 ms

*2 Refer to *PACKAGE INFORMATION* for detailed information.

ABSOLUTE MAXIMUM RATINGS

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

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	3.5 to 36	V
Ta	Operating Temperature Range	−40 to 125	°C

RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if 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

C_{IN} = C_{OUT} = 0.1 µF, unless otherwise noted.

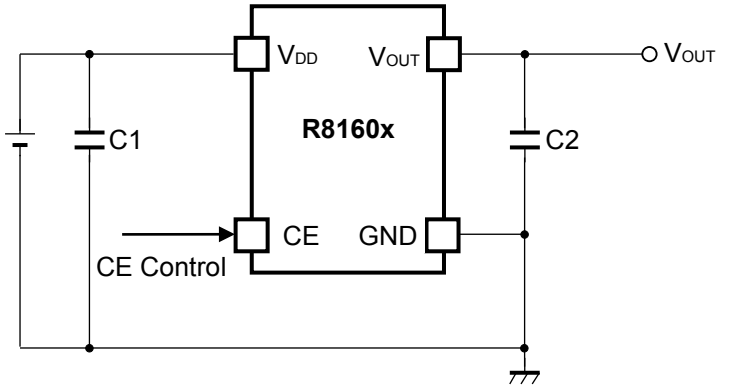
R8160xxxxB (−40°C ≤ Ta ≤ 125°C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
I_{SS}	Supply Current	V_{IN} = 14 V, I_{OUT} = 0 mA	V_{SET} ≤ 5.0 V		2.2	6.5	µA
			5.0 V < V_{SET}		2.5	6.8	
Istandby	Standby Current	V_{IN} = 36 V, V_{CE} = 0 V			0.1	1.0	µA
V_{OUT}	Output Voltage	V_{SET} + 1 V ≤ V_{IN} ≤ 36 V, I_{OUT} = 1 mA	Ta = 25°C	×0.994		×1.006	V
			−40°C ≤ Ta ≤ 125°C	×0.984		×1.016	
ΔV_{OUT} /ΔI_{OUT}	Load Regulation	V_{IN} = V_{SET} + 3.0 V, 1 mA ≤ I_{OUT} ≤ 200 mA		Refer to the *Product-specific Electrical Characteristics*			mV
ΔV_{OUT} /ΔV_{IN}	Line Regulation	V_{SET} + 1 V ≤ V_{IN} ≤ 36 V, I_{OUT} = 1 mA		-0.02	0.01	0.02	%/V
V_{DIF}	Dropout Voltage	I_{OUT} = 200 mA		Refer to the *Product-specific Electrical Characteristics*			V
I_{LIM}	Output Current Limit	V_{IN} = V_{SET} + 3.0 V		220	350	420	mA
I_{SC}	Short Current Limit	V_{IN} = 3.5 V, V_{OUT} = 0 V		60	80	110	mA
V_{CEH}	CE Input Voltage “H”			2.0		36	V
V_{CEL}	CE Input Voltage “L”			0		1.0	V
I_{PD}	CE Pull-down Current	V_{CE} = 2 V			0.2	0.6	µA
T_{TSD}	Thermal Shutdown Temparature	Junction Temperature		150	160		°C
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		125	135		°C

R8160xxxxB Product-specific Electrical Characteristics (−40°C ≤ Ta ≤ 125°C)

Product Name	V_{OUT} (V) (Ta = 25°C)			V_{OUT} (V) (−40°C ≤ Ta ≤ 125°C)			$\Delta V_{OUT}/\Delta I_{OUT}$ (mV)			V_{DIF} (V)	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
R8160x033B	3.2802	3.30	3.3198	3.2472	3.30	3.3528	-10	10	40	0.8	2.0
R8160x034B	3.3796	3.40	3.4204	3.3456	3.40	3.4544					
R8160x050B	4.9700	5.00	5.0300	4.9200	5.00	5.0800				0.6	1.7
R8160x060B	5.9640	6.00	6.0360	5.9040	6.00	6.0960	-18	18	72		
R8160x080B	7.9520	8.00	8.0480	7.8720	8.00	8.1280				0.5	1.3
R8160x085B	8.4490	8.50	8.5510	8.3640	8.50	8.6360					
R8160x090B	8.9460	9.00	9.0540	8.8560	9.00	9.1440					

TYPICAL APPLICATIONS



C1 = Ceramic 0.1 µF
C2 = Ceramic 0.1 µF

R8160x Typical Applications

TECHNICAL NOTES

Phase Compensation

In the R8160x, phase compensation is provided to secure stable operation even when the load current is varied. For this purpose, make sure to use 0.1 µF or more of a capacitor (C2).

In case of using a tantalum type capacitor and the ESR (Equivalent Series Resistance) value of the capacitor is large, the output might be unstable. Evaluate the circuit including consideration of frequency characteristics.

Connect 0.1 µF or more of a capacitor (C1) between V_{DD} and GND, and as close as possible to the pins.

PCB Layout

For SOT-23-5 package type, wire the following GND pins together: No. 1 and No. 2

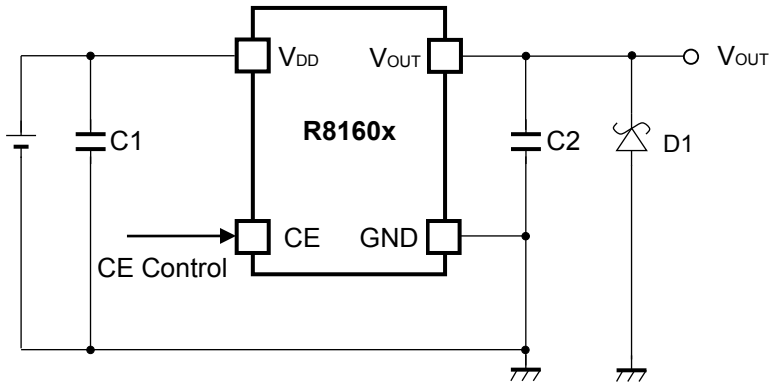
For SOT-89-5 package type, wire the following GND pins together: No. 2 and No. 4.

For HSOP-6J package type, wire the following GND pins together: No. 2, No. 4, and No. 5.

Thermal Shutdown

R8160x has a built-in thermal shutdown circuit, which stops the regulator operation if the junction temperature of this device increases to 160°C (Typ.) or higher. If the temperature drops to 135°C (Typ.) or lower, the regulator restarts the operation. Unless eliminating the overheating problem, the regulator turns on and off repeatedly and as a result, a pulse shaped output voltage is generated.

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION



C1 = Ceramic 0.1 µF
C2 = Ceramic 0.1 µF

When a sudden surge of electrical current travels along the V_{OUT} pin and GND due to a short-circuit, electrical resonance of a circuit involving an output capacitor (C2) and a short circuit inductor generates a negative voltage and may damage the device or the load devices. Connecting a schottky diode (D1) between the V_{OUT} pin and GND has the effect of preventing damage to them.

PACKAGE INFORMATION

POWER DISSIPATION (SOT-23-5)

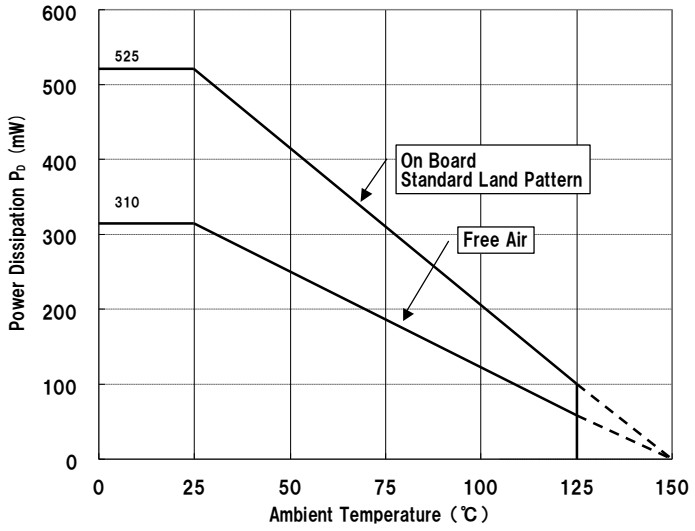
Power Dissipation (P_D) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:

Measurement Conditions

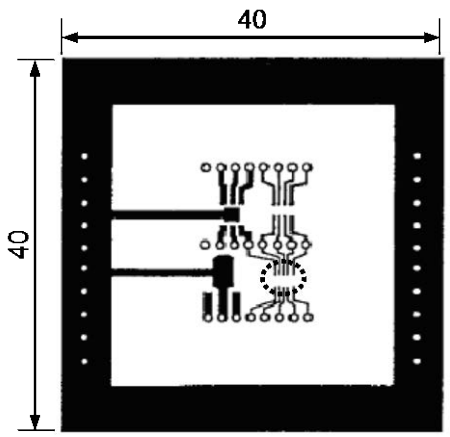
	Standard Test Land Pattern
Environment	Mounting on Board (Wind velocity = 0 m/s)
Board Material	Glass cloth epoxy plastic (Double sided)
Board Dimensions	40 mm x 40 mm x 1.6 mm
Copper Ratio	Top side: Approx. 50%, Back side: Approx. 50%
Through-holes	ϕ 0.5 mm x 44 pcs

Measurement Result: (Ta = 25°C, Tjmax = 150°C)

	Standard Test Land Pattern	Free Air
Power Dissipation	525 mW	310 mW
Thermal Resistance	θja = (150 - 25°C)/0.525 W = 238°C/W	400°C/W



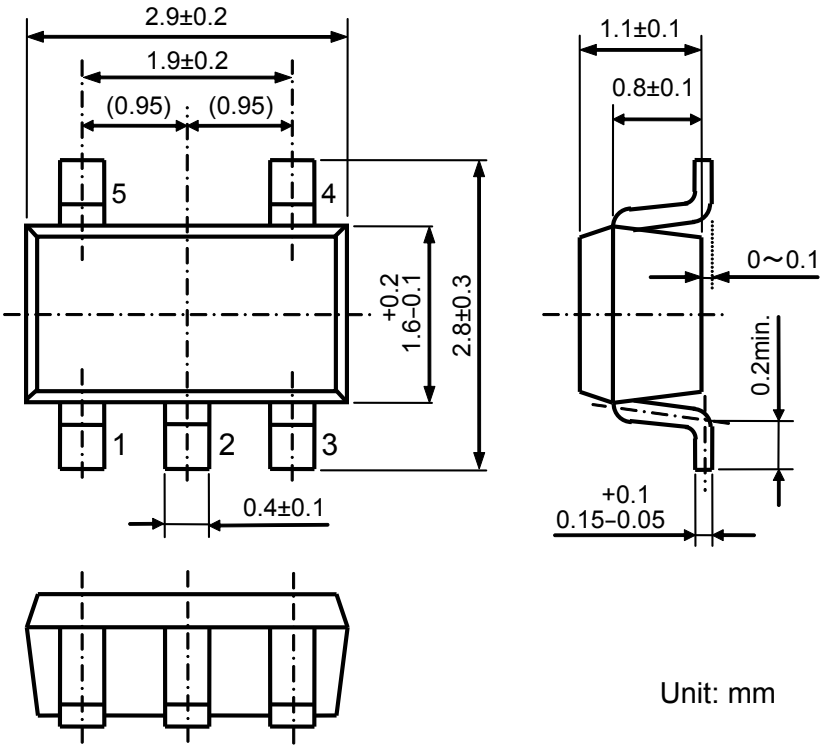
Ambient Temperature vs. Power Dissipation



IC Mount Area (Unit: mm)

Measurement Board Pattern

PACKAGE DIMENSIONS (SOT-23-5)



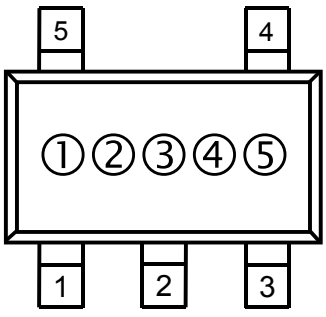
SOT-23-5 Package Dimensions

MARK SPECIFICATION (SOT-23-5)

①②: Product Code … **Refer to *MARK SPECIFICATION TABLE (SOT-23-5)***

③④⑤: Lot Number … Alphanumeric Serial Number

⑤: : Lot Sub Number …Alphanumeric Serial Number



SOT-23-5 Mark Specification

MARK SPECIFICATION TABLE (SOT-23-5)

R8160NxxxB

Product Name	①	②	V_{SET}
R8160N033B	A	0	3.3 V
R8160N034B	A	1	3.4 V
R8160N050B	A	2	5.0 V
R8160N060B	A	3	6.0 V
R8160N080B	A	4	8.0 V
R8160N085B	A	5	8.5 V
R8160N090B	A	6	9.0 V

POWER DISSIPATION (SOT-89-5)

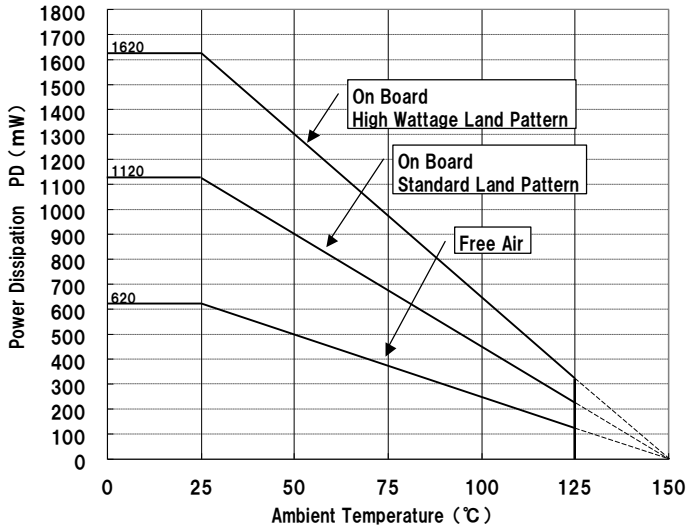
Power Dissipation (P_D) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:

Measurement Conditions

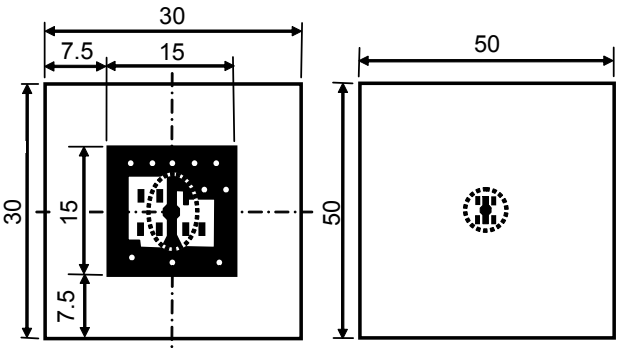
	High Wattage Land Pattern	Standard Land Pattern
Environment	Mounting on Board (Wind velocity = 0 m/s)	Mounting on Board (Wind velocity = 0 m/s)
Board Material	Glass cloth epoxy plastic (Double sided)	Glass cloth epoxy plastic (Double sided)
Board Dimensions	30 mm × 30 mm × 1.6 mm	50 mm × 50 mm × 1.6 mm
Copper Ratio	Top side : Approx. 20% , Back side : Approx. 100%	Top side : Approx. 10% , Back side : Approx. 100%
Through-hole	ϕ0.85 mm × 10 pcs	-

Measurement Result (Ta = 25°C, Tjmax = 150°C)

	High Wattage Land Pattern	Standard Land Pattern	Free Air
Power Dissipation	1620 mW	1120 mW	620 mW
Thermal Resistance	77°C/W	111°C /W	200°C /W



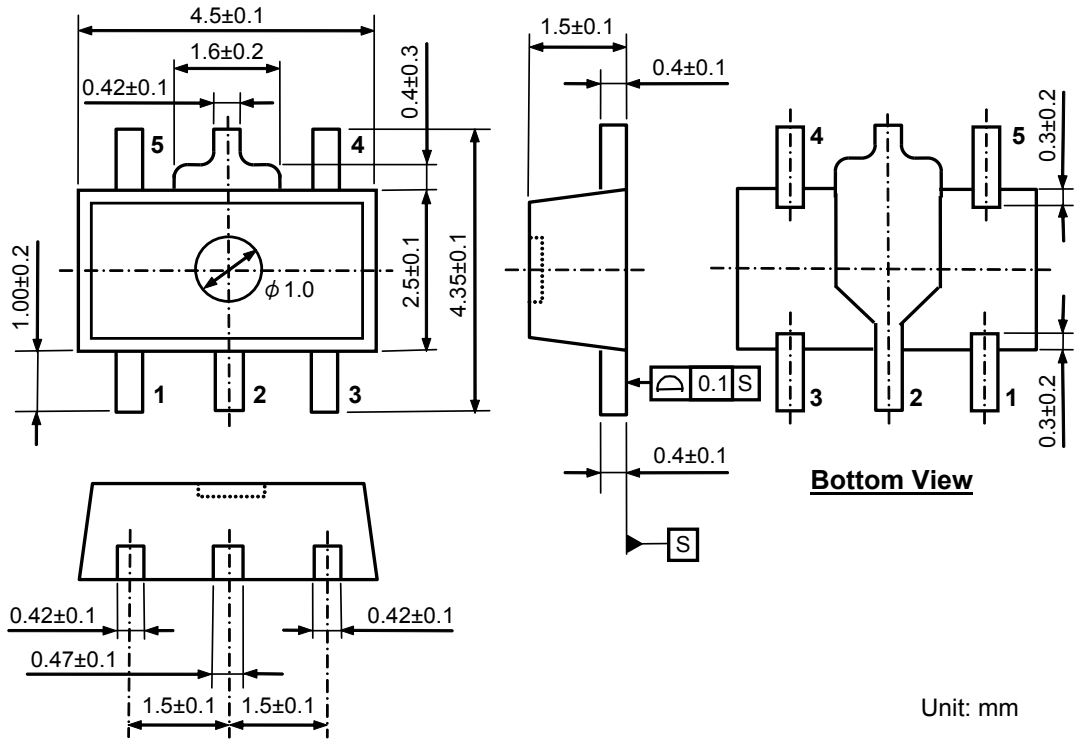
Power Dissipation vs. Ambient Temperature



IC Mount Area (Unit: mm)

Measurement Board Pattern

PACKAGE DIMENSIONS (SOT-89-5)



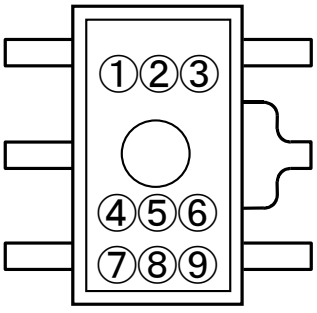
SOT-89-5 Package Dimensions

MARK SPECIFICATION (SOT-89-5)

①②③④: Product Code … **Refer to *MARK SPECIFICATION TABLE (SOT-89-5)***

⑤⑥⑦⑧: Lot Number … Alphanumeric Serial Number

⑨: Lot Sub Number …Alphanumeric Serial Number



SOT-89-5 Mark Specification

MARK SPECIFICATION TABLE (SOT-89-5)

R8160HxxxB

Product Name	①	②	③	④	V_{SET}
R8160H033B	K	3	3	B	3.3 V
R8160H034B	K	3	4	B	3.4 V
R8160H050B	K	5	0	B	5.0 V
R8160H060B	K	6	0	B	6.0 V
R8160H080B	K	8	0	B	8.0 V
R8160H085B	K	8	5	B	8.5 V
R8160H090B	K	9	0	B	9.0 V

POWER DISSIPATION (HSOP-6J)

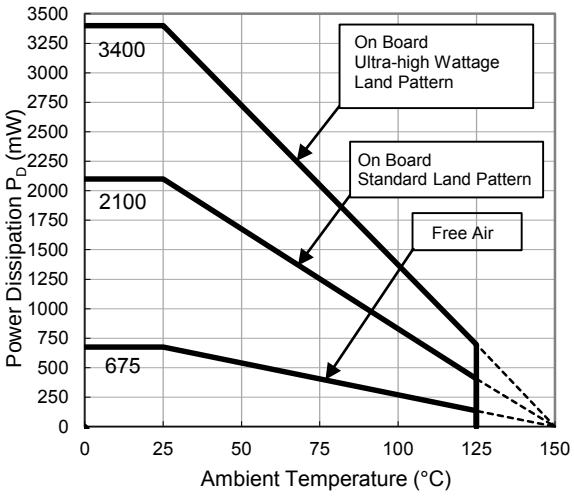
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

Measurement Conditions

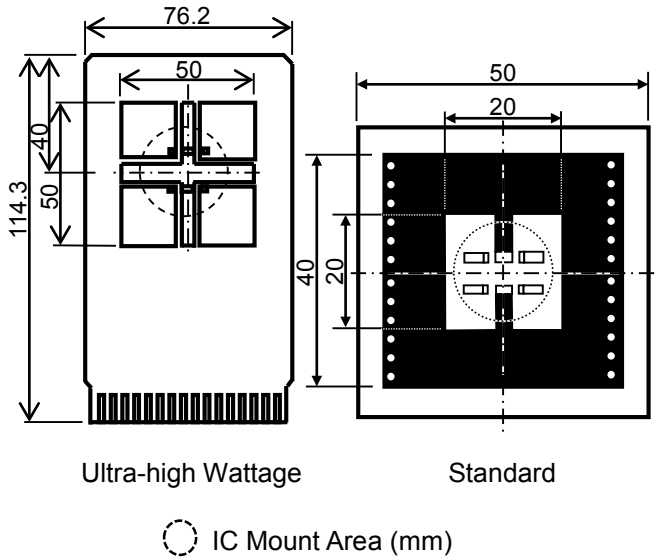
	Ultra-high Wattage Land Pattern	Standard Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-layer Board)	Glass Cloth Epoxy Plastic (Double-sided Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm	50 mm × 50 mm × 1.6 mm
Copper Ratio	96%	50%
Through-holes	ϕ 0.3 mm × 28 pcs	ϕ 0.5 mm × 24 pcs

Measurement Result (Ta = 25°C, Tjmax = 150°C)

	Ultra-high Wattage Land Pattern	Standard Land Pattern	Free Air
Power Dissipation	3400 mW	2100 mW	675 mW
Thermal Resistance	37°C/W	59°C/W	185°C/W

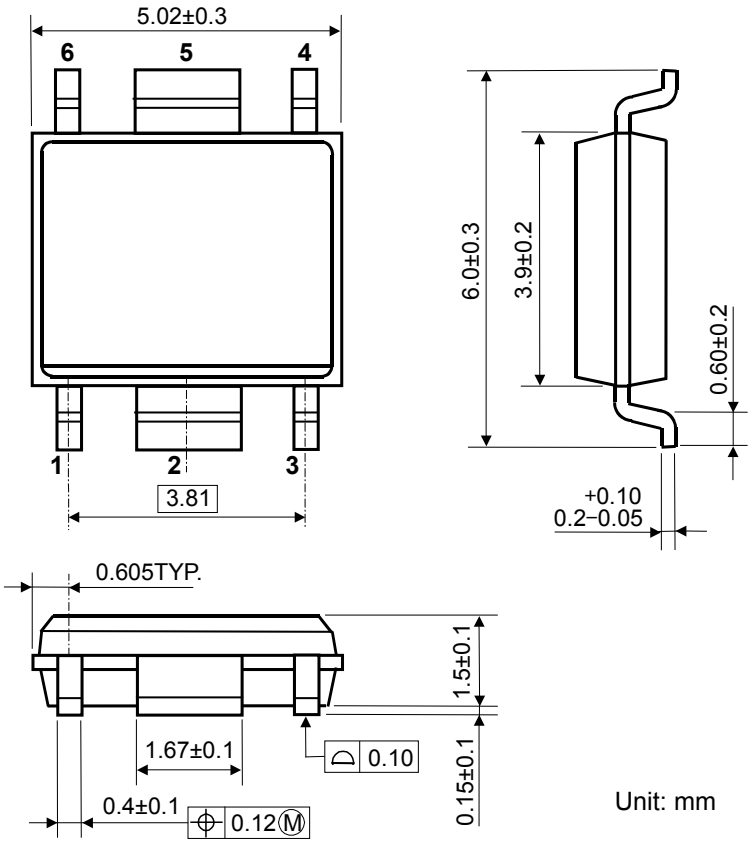


Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

PACKAGE DIMENSIONS (HSOP-6J)



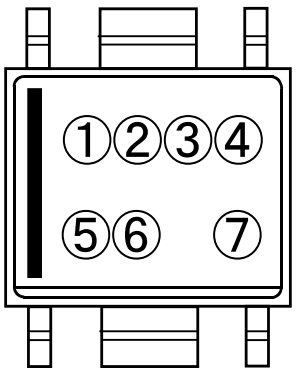
HSOP-6J Package Dimensions

MARK SPECIFICATION (HSOP-6J)

①②③④: Product Code … **Refer to *MARK SPECIFICATION TABLE (HSOP-6J)***

⑤⑥: Lot Number … Alphanumeric Serial Number

⑦: Lot Sub Number …Alphanumeric Serial Number



HSOP-6J Mark Specification

MARK SPECIFICATION TABLE (HSOP-6J)

R8160SxxxB

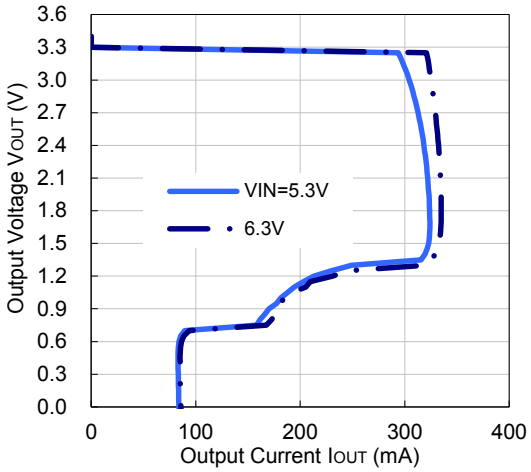
Product Name	①	②	③	④	V_{SET}
R8160S033B	B	3	3	B	3.3 V
R8160S034B	B	3	4	B	3.4 V
R8160S050B	B	5	0	B	5.0 V
R8160S060B	B	6	0	B	6.0 V
R8160S080B	B	8	0	B	8.0 V
R8160S085B	B	8	5	B	8.5 V
R8160S090B	B	9	0	B	9.0 V

TYPICAL CHARACTERISTICS

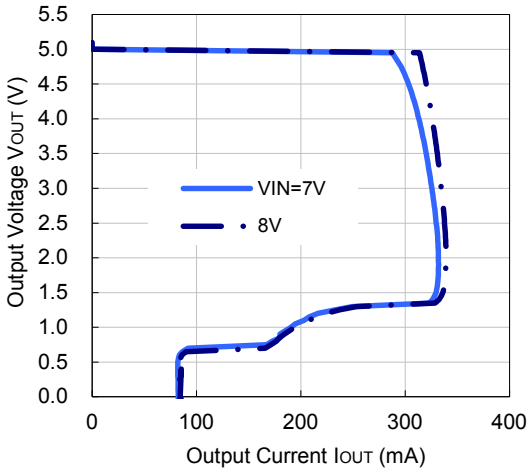
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

1) Output Voltage vs. Output Current (Ta = 25°C)

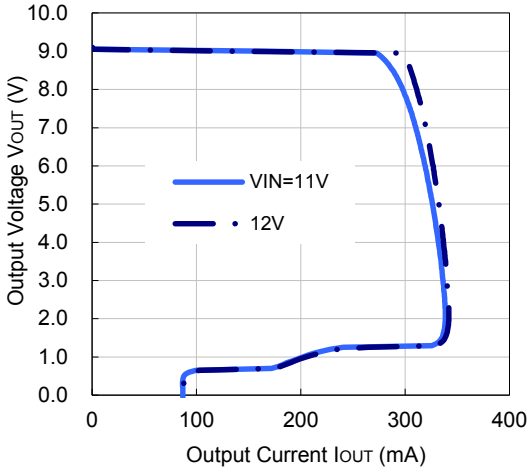
R8160x033B



R8160x050B

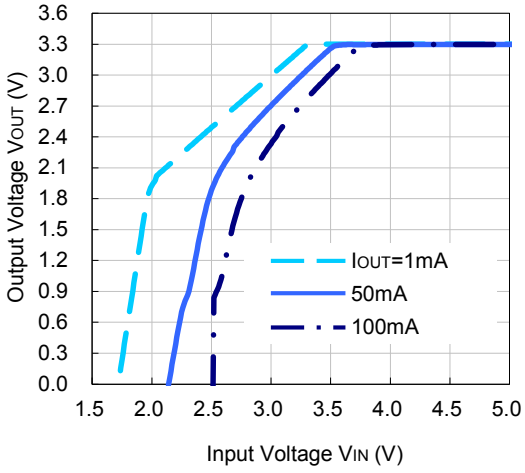


R8160x090B



2) Output Voltage vs. Input Voltage (Ta = 25°C)

R8160x033B



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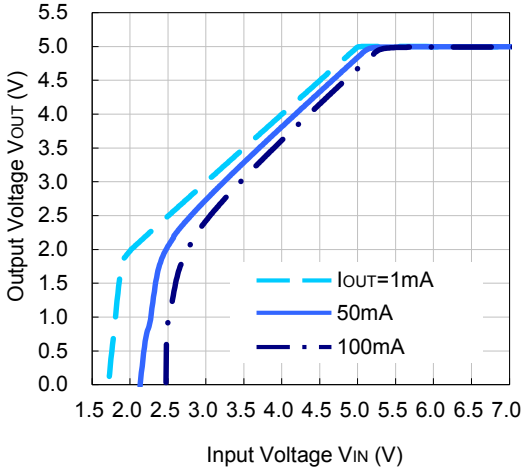

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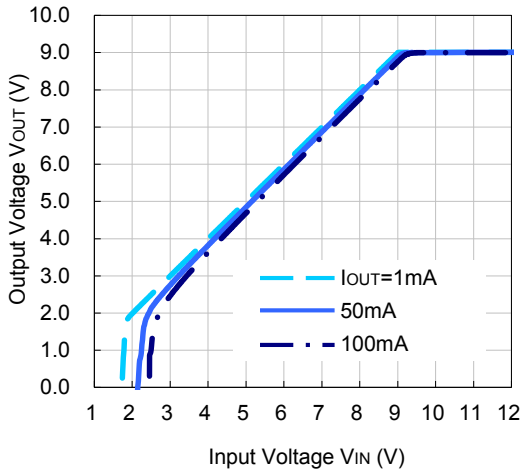
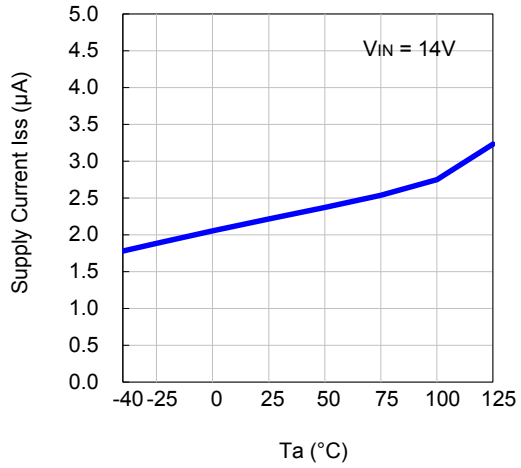


3) Supply Current vs. Temperature

R8160x033B



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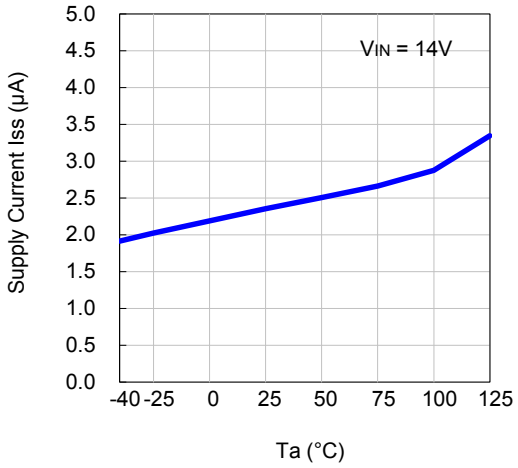

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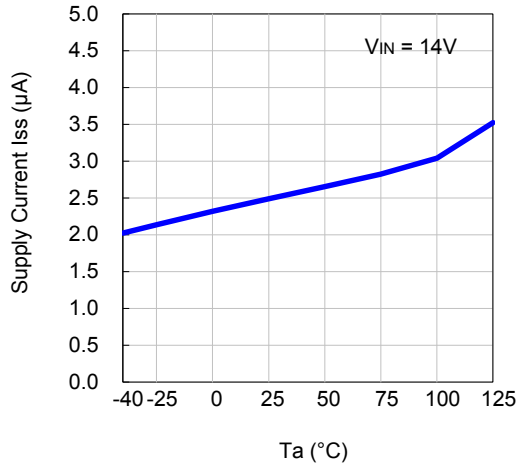
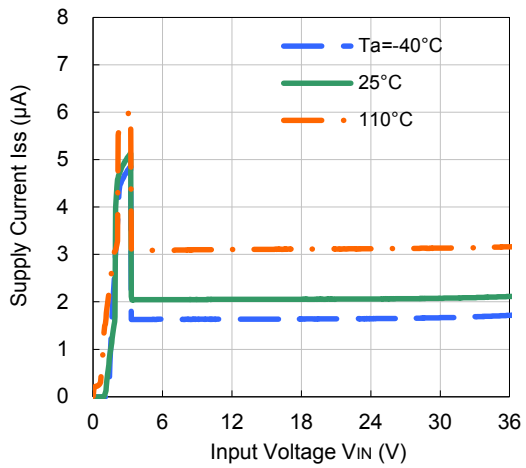
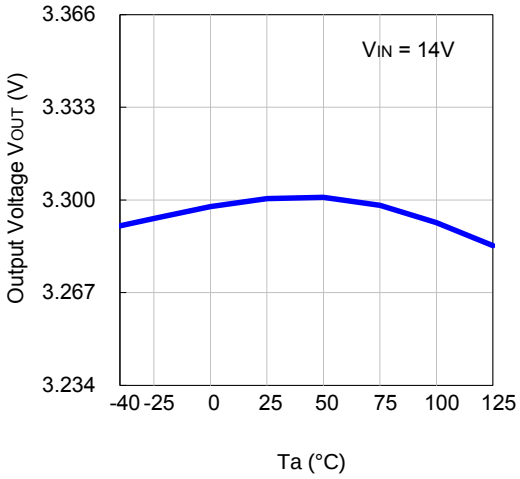


4) Supply Current vs. Input Voltage (R8160x033B)

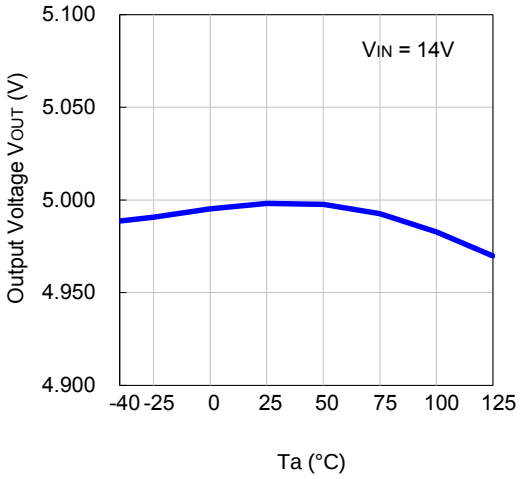


5) Output Voltage vs. Temperature (I_{OUT} = 1mA)

R8160x033B



R8160x050B



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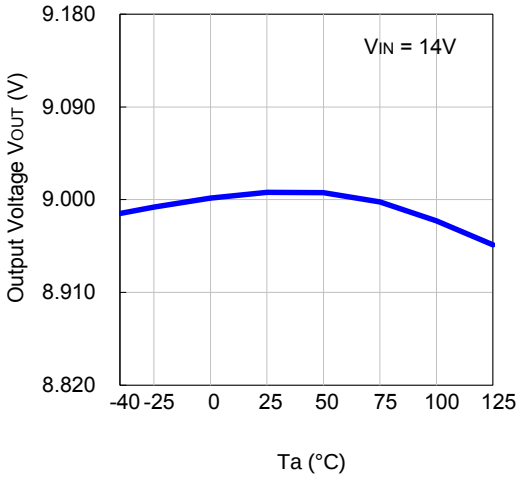
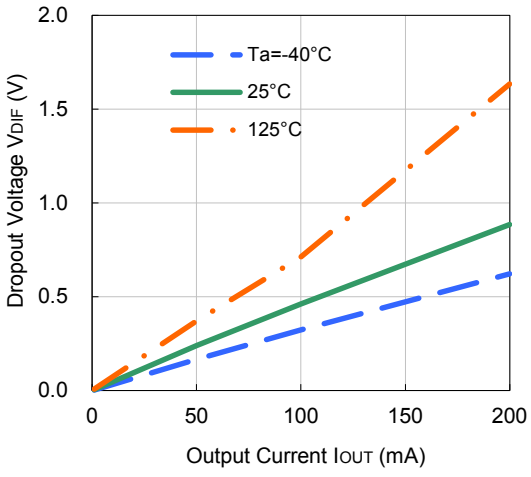


6) Dropout Voltage vs. Output Current

R8160x033B



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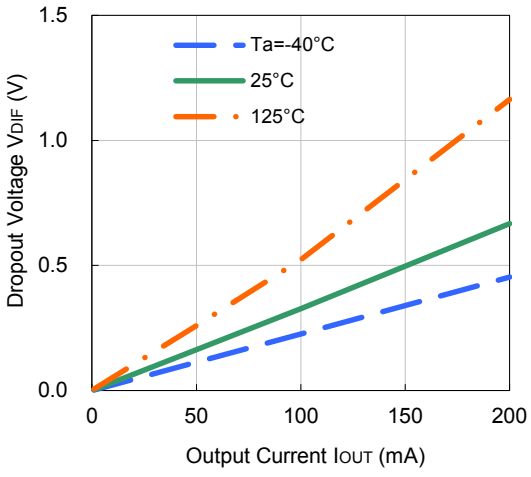

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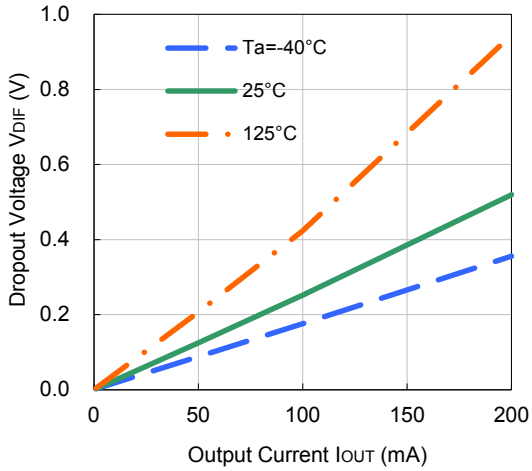
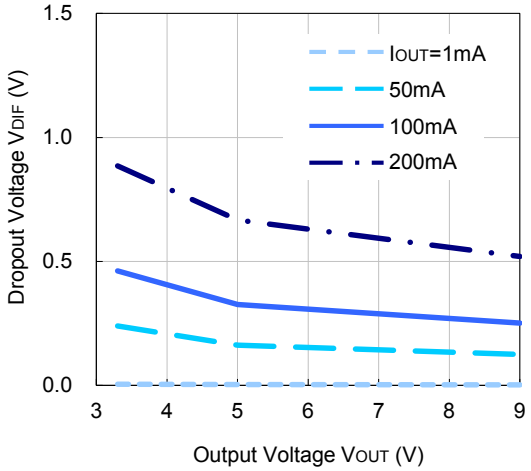
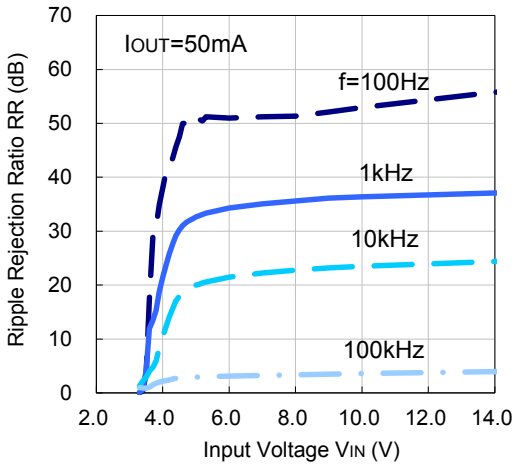


7) Dropout Voltage vs. Output Voltage (Ta = 25°C)



8) Ripple Rejection vs. Input Voltage (Ta = 25°C, Ripple = 0.2 Vpp)

R8160x033B



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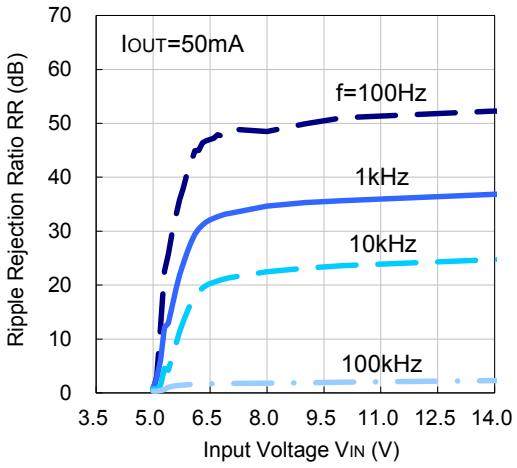

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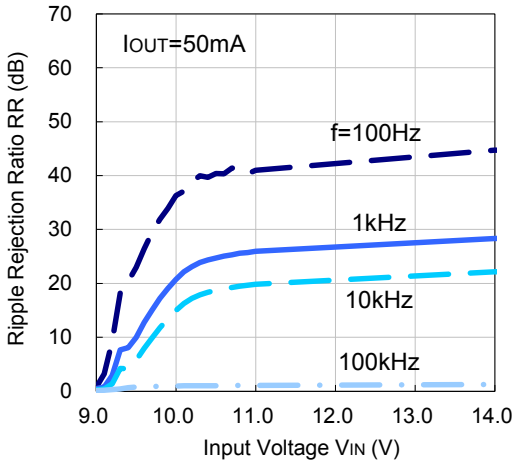
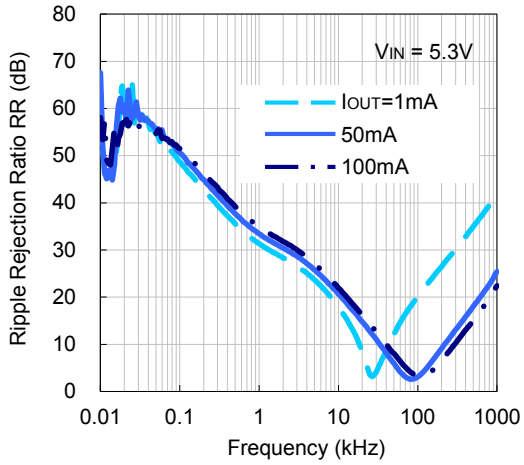


9) Ripple Rejection vs. Frequency (Ta = 25°C, Ripple = 0.2 Vpp)

R8160x033B



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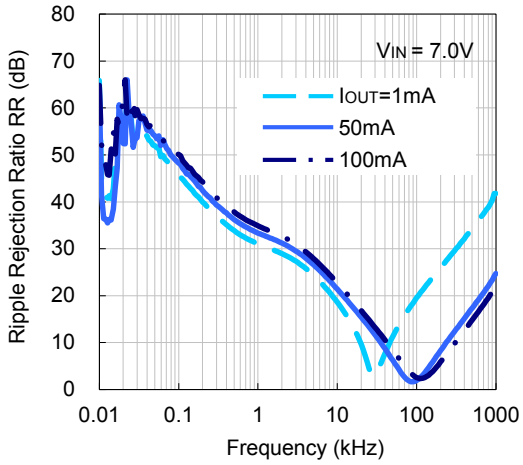

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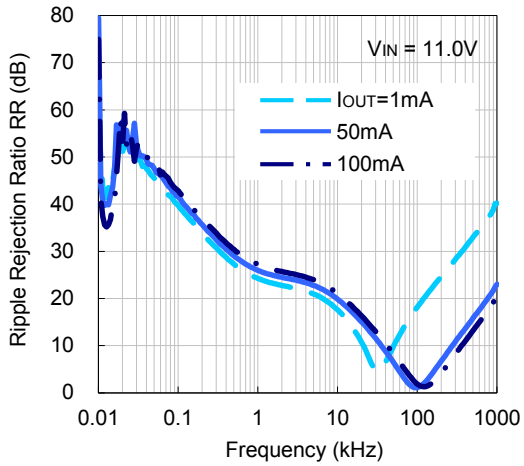
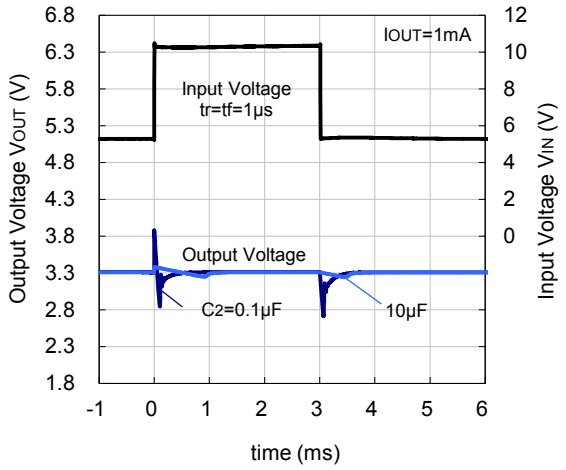


10) Input Transient Response (Ta = 25°C)

R8160x033B



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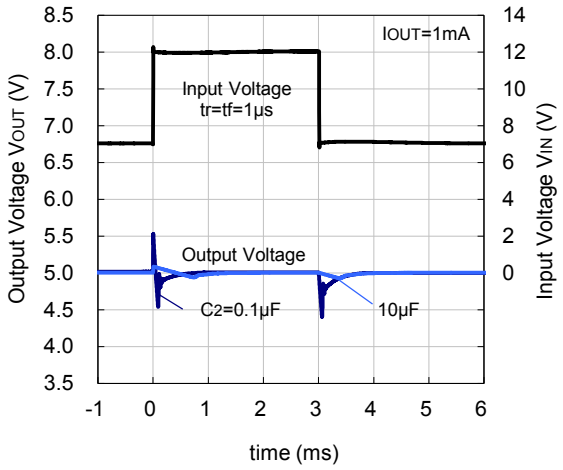

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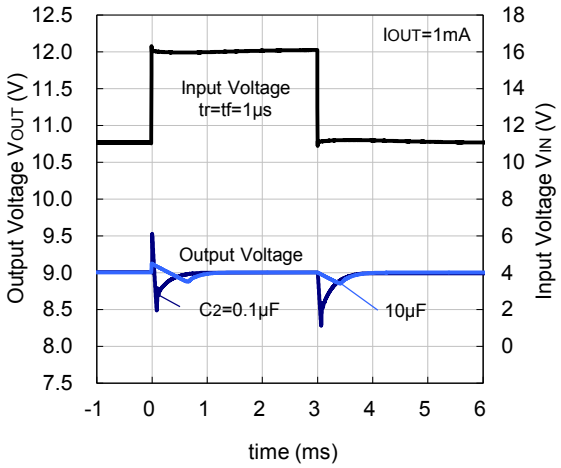
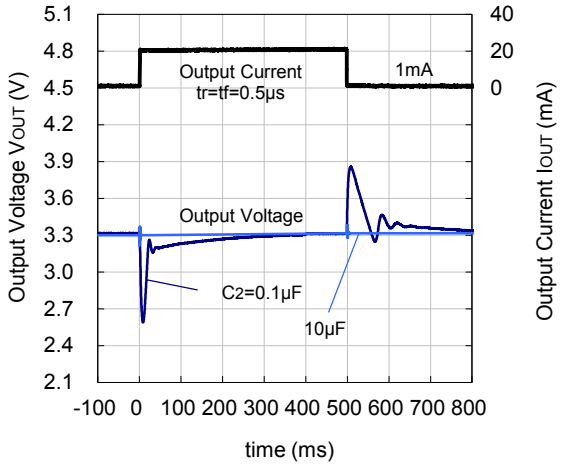


11) Load Transient Response (Ta = 25°C)

R8160x033B



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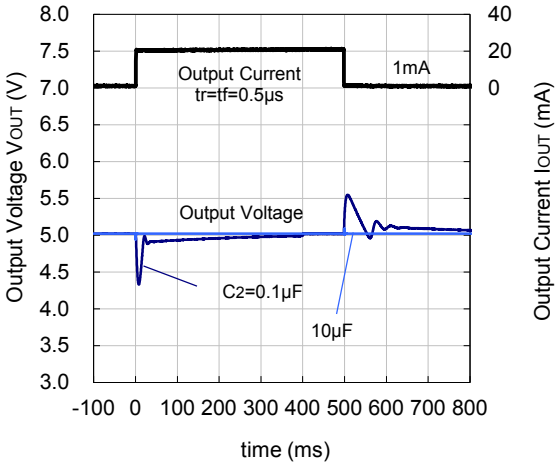

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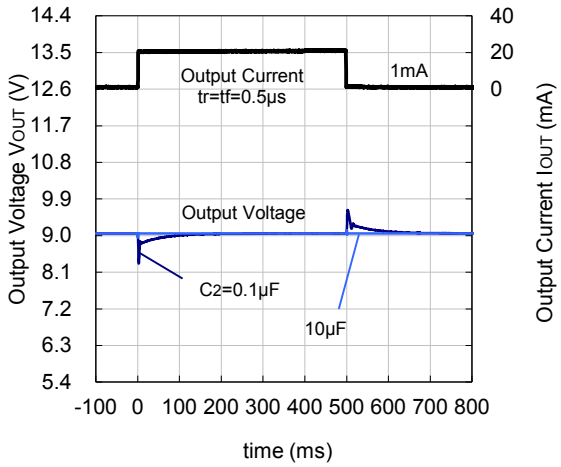
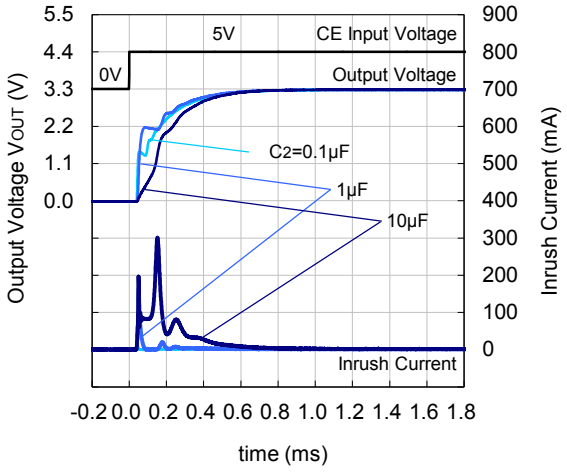
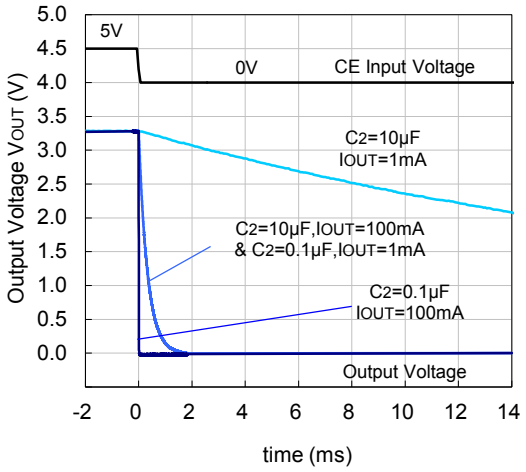


12) CE Transient Response (Ta = 25°C)

R8160x033B





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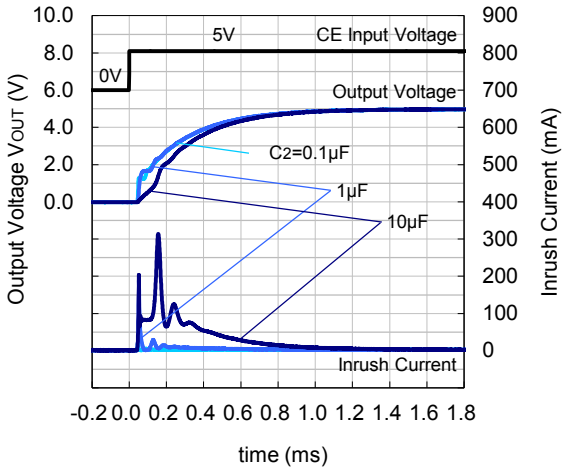

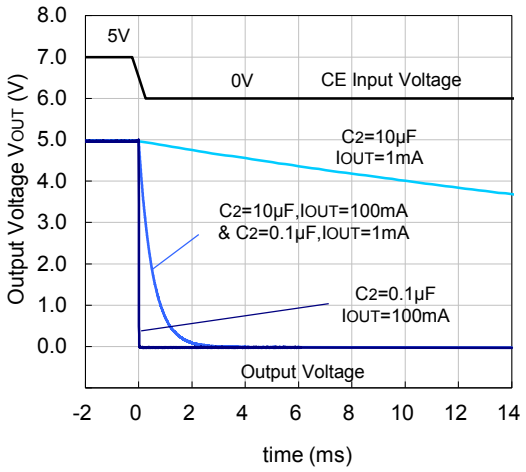

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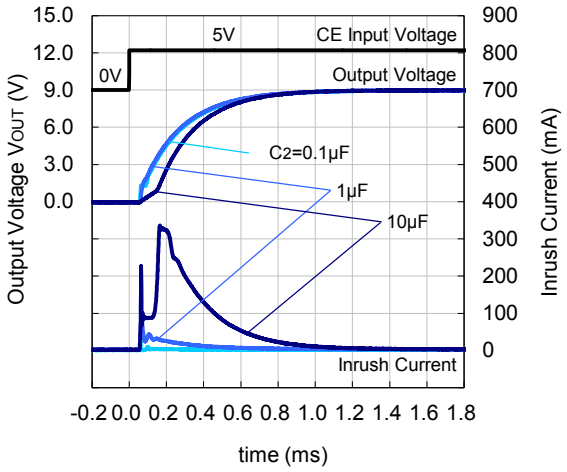
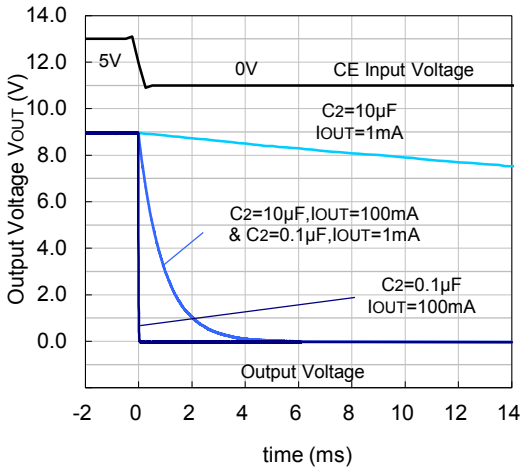
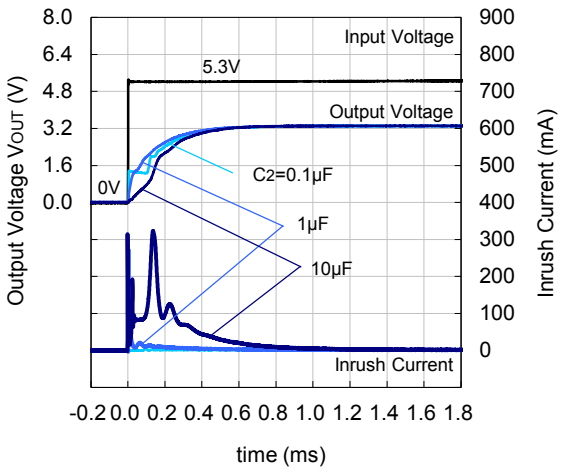




13) Power-on Transient Response (Ta = 25°C, V_{CE} = 5 V)

R8160x033B



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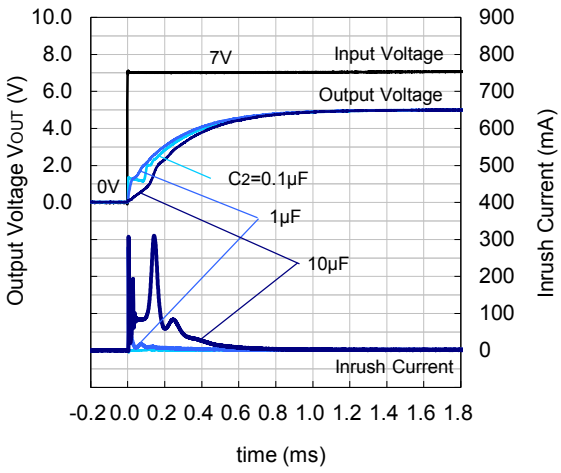

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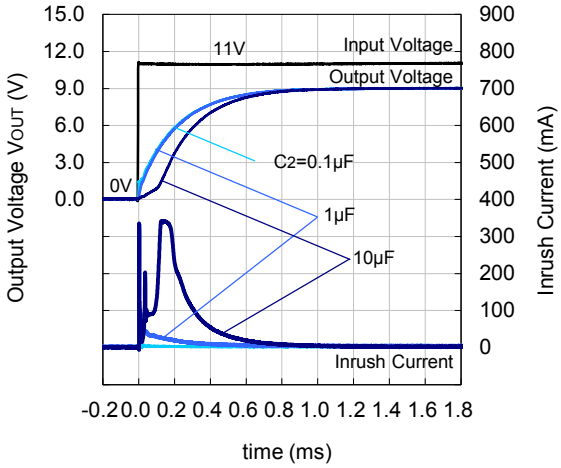
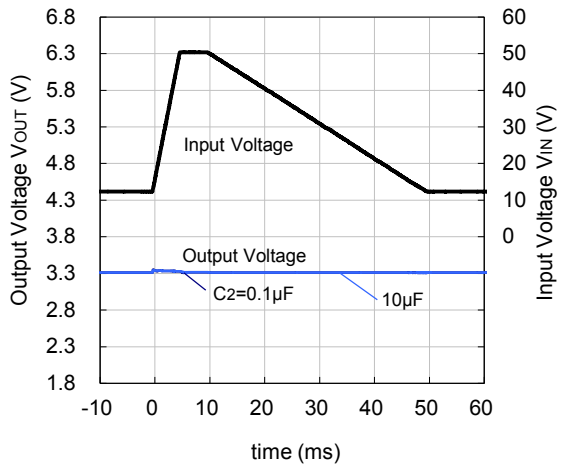


14) Load Dump (Ta = 25°C)

R8160x033B



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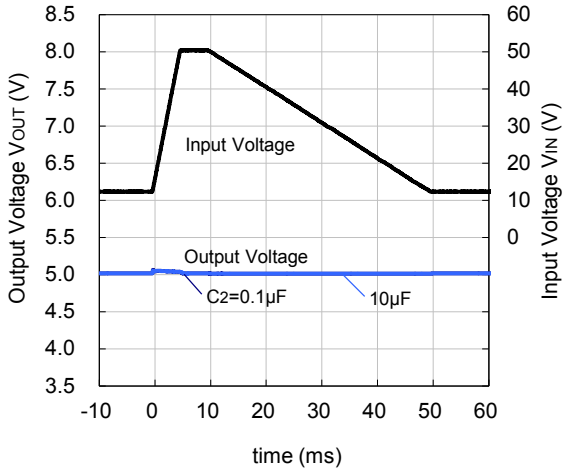

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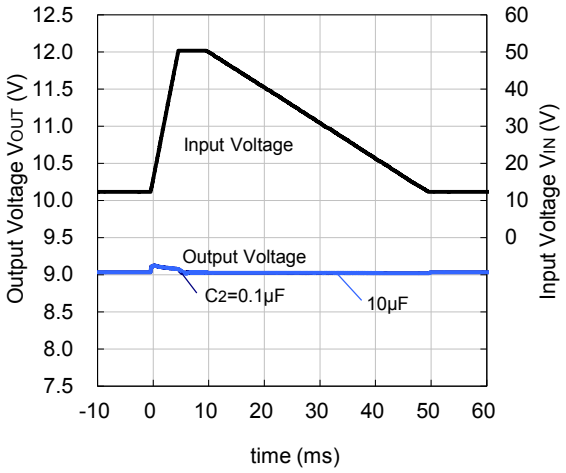
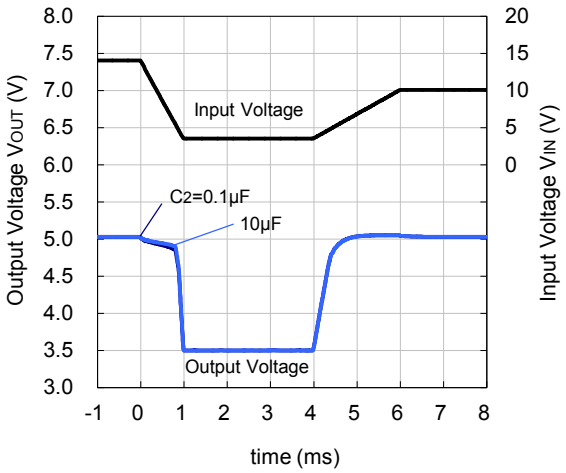
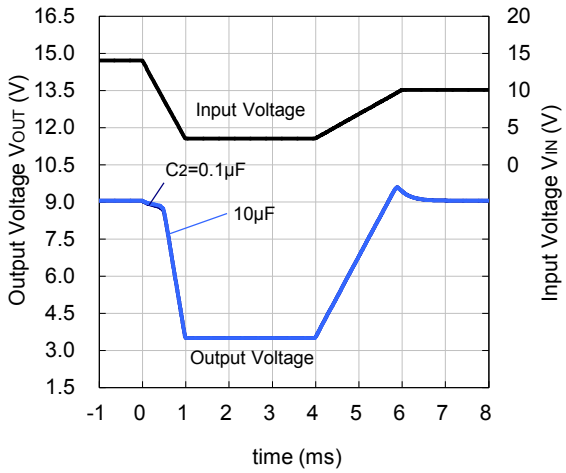


15) Cranking (Ta = 25°C)

R8160x050B



R8160x090B

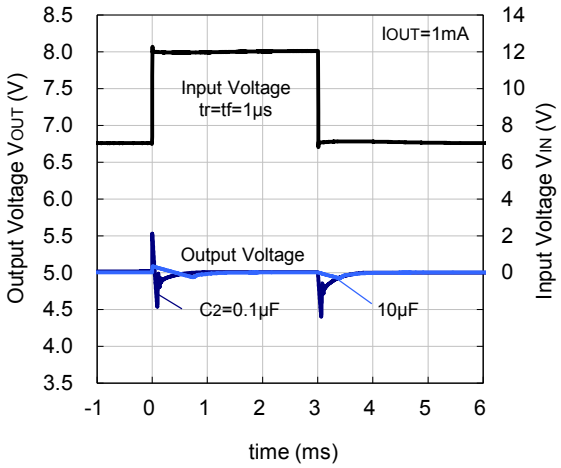


Input Transient/Load Transient vs. Output Capacity (C2)

R8160 performs a stable operation by using 0.1 µF of ceramic capacitor as the output capacitor. However, the variation of output voltage may not meet the demand of the system when input voltage and load current vary. In such cases, the variation of output voltage can be minimized significantly by using 10 µF or higher ceramic capacitor. When using a high-capacity electrolytic capacitor for the output line, place the electrolytic capacitor a few centimeters apart from the IC after arranging the ceramic capacitor close to the IC.

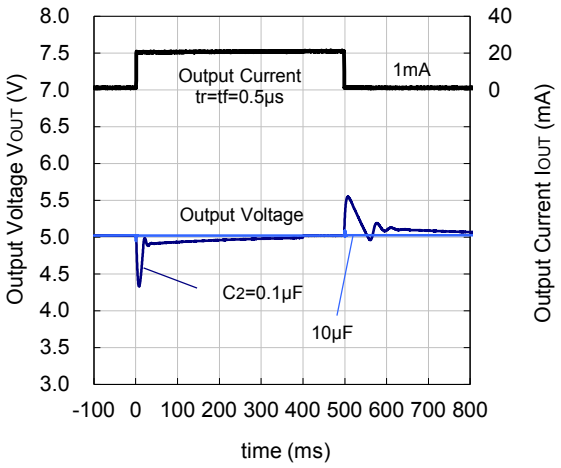
Input Transient Response

R8160x050B



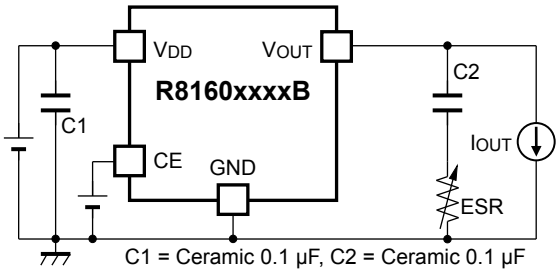
Load Transient Response

R8160x050B



ESR vs. Output Current

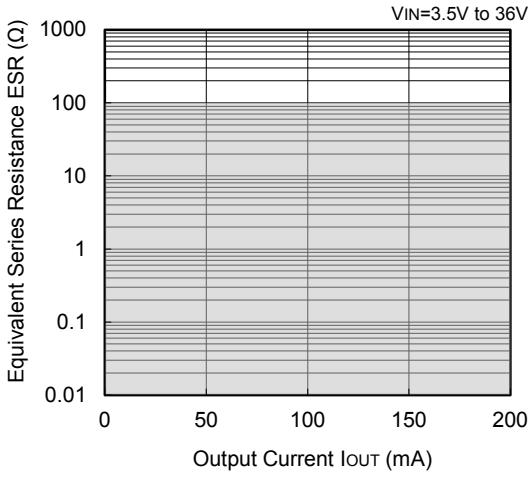
It is recommended that a ceramic type capacitor be used for this device. However, other types of capacitors having lower ESR can also be used. The relation between the output current (I_{OUT}) and the ESR of output capacitor is shown below.



Measurement Conditions

Frequency Band: 10 Hz to 2 MHz
Measurement Temperature: −40°C to 125°C
Hatched area: Noise level is 40 µV (average) or below
Ceramic Capacitors: C1 = 0.1 µF, C2 = 0.1 µF

R8160x033B



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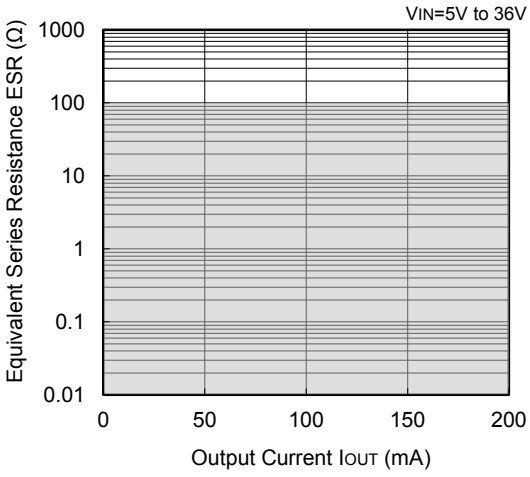

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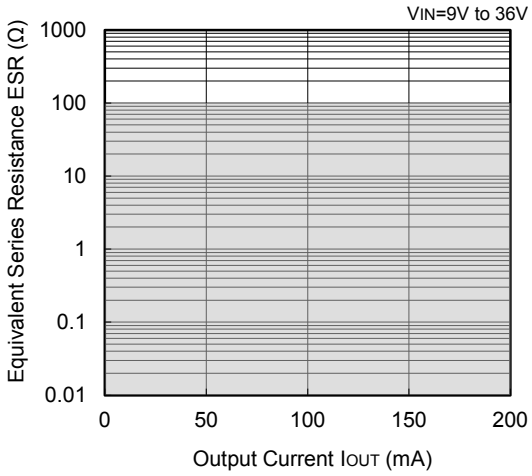

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