Automatic Mode Shift 36V 300mA LDO

NO.EA-185-111026

OUTLINE

The R1510S Series are CMOS-based voltage regulator (LDO) ICs with a voltage detector (VD) that can provide 300mA of output current. Each IC is equipped with a voltage detector and a regulator that can provide the maximum 36V of operating voltage. This series has ECO function, which achieves low-power consumption and high-speed transient response by switching the ICs to low-power consumption mode at light load condition and switching to high-speed mode at heavy load condition.

The switching point is internally fixed inside the ICs. The ICs switch from low-power consumption mode to high-speed mode when I_{OUT}=12mA (Typ.), and switch from high-speed mode to low-power consumption mode when I_{OUT}=3mA (Typ.).

Each IC is composed of a reference voltage unit, an error amplifier, a resistor network for setting output voltage, an output current limit circuit for preventing overcurrent destruction, and a thermal shutdown circuit. The output voltage and the detector threshold are internally fixed inside the IC.

The output voltage accuracy is ±1.6% and the detector threshold accuracy is ±1.7%. The output voltage type is Nch open drain. The versions for the ICs are selectable from A version (CE, V_{IN} Detector), B version (SENSE Detector), C version (Release Delay Circuit, V_{IN} Detector), and D version (Release Delay Circuit, V_{OUT} Detector).

FEATURES

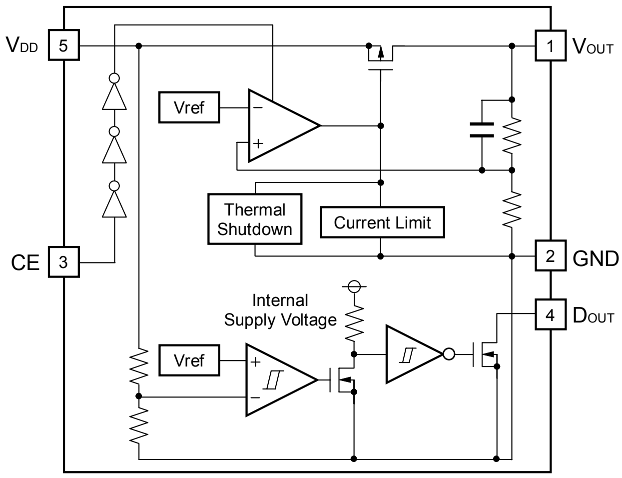
- Supply Current ··· Typ. 110μA (High Speed Mode, V_{IN}=14V)
- Supply Current ··· Typ. 12.5μA (Low-power Consumption Mode, V_{IN}=14V)
- Supply Current (Standby Mode) ··· Typ. 10μA (CE=0V, A Version)
- Input Voltage Range ··· Max. 36.0V
- Output Voltage Range ··· 2.5V to 12.0V (0.1V steps)
  * For other voltages, please refer to “Mark Specification Table”.
- Dropout Voltage ··· Typ. 1.0V (I_{OUT}=300mA, V_{OUT}=5V)
- Output Voltage Accuracy ··· ±1.6% (Ta=25ºC)
- Temperature Characteristics ··· Typ. ±150ppm/ºC (Output Voltage)
- Detector Threshold ··· 2.3V to 12.0V (0.1V steps)
- Detector Threshold Accuracy ··· ±1.7% (Ta=25ºC)
- Temperature Characteristics ··· Typ. ±100ppm/ºC (Detector Threshold)
- Output Type ··· Nch Open Drain
- Operating Temperature Range ··· -40ºC to 110ºC
- Line Regulation ··· Typ. 0.01%/V
- Package ··· HSOP-8E
- Built-in Short Current Limit Circuit ··· Typ. 50mA
- Built-in Overcurrent Protection Circuit
- Built-in Thermal Shutdown Circuit ··· Shutdown Temperature: Typ. 140ºC,
  Release Temperature: Typ. 130ºC
- Ceramic Capacitor Corresponding ··· 6.8μF or more

APPLICATIONS

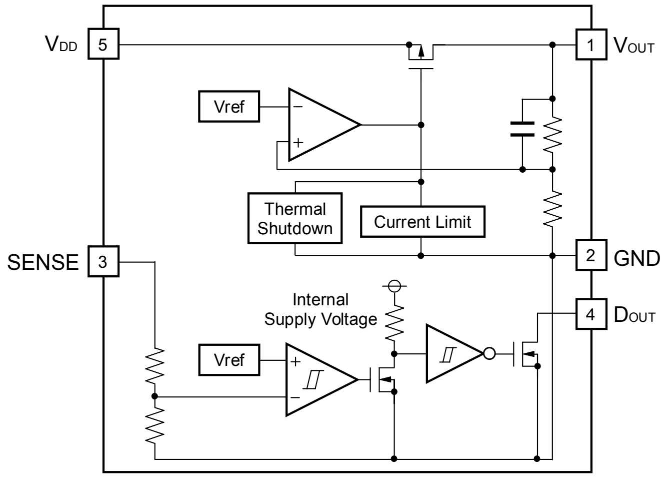
- Power source for car audios, car navigation systems, car accessories such as ETC system, etc.
- Power source for notebook PCs, digital TVs, telephones, private LAN systems, etc.
- Power source for office equipments such as copiers, printers, facsimiles, scanners, projectors, etc.

BLOCK DIAGRAMS

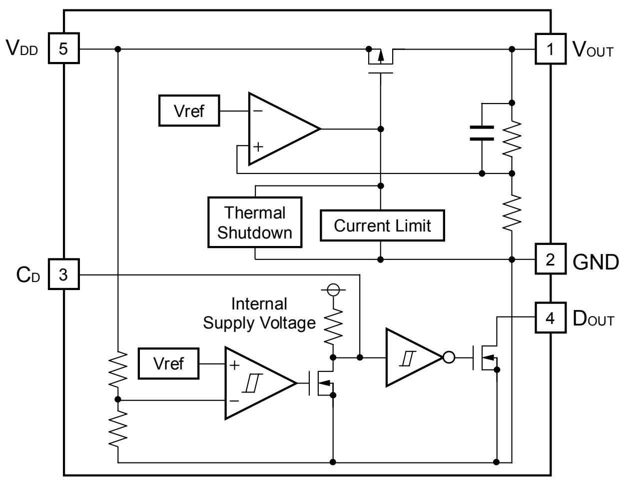
R1510SxxxA
(CE Pin, V_{IN} Detector)



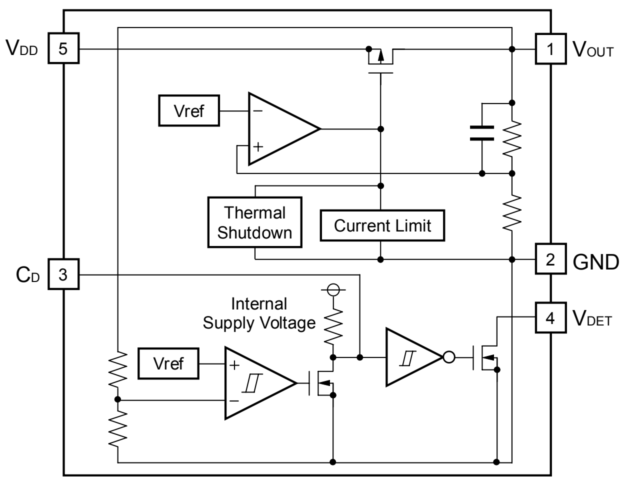
R1510SxxxB
(SENSE Detector)



R1510SxxxC
(C_D Pin, V_{IN} Detector)



R1510SxxxD
(C_D Pin, V_{OUT} Detector)



SELECTION GUIDE

The users can select VR output voltage, VD detector threshold, and version that best fit their requirements.

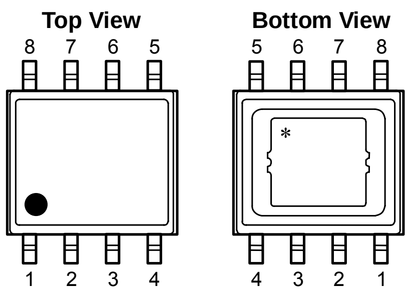
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1510Sxxx∗-E2-FE	HSOP-8E	1,000pcs	Yes	Yes

xxx: Select the ideal combination of the output voltage (V_{OUT}) and the detector threshold ($-V_{DET}$) from the code number starting from 001.
Note: As for the standard voltages, please refer to “Mark Specification Table”.

∗: Select the ideal version from A to D.
(A) Built-in Chip Enable, V_{IN} Detector
(B) SENSE Detector Threshold
(C) Built-in Release Delay Circuit, V_{IN} Detector
(D) Built-in Release Delay Circuit, V_{OUT} Detector

PIN CONFIGURATIONS

• **HSOP-8E**



PIN DESCRIPTIONS

Pin No.	Symbol	Description
1	V_{OUT}	VR Output Pin
2	NC	No Connection
3	TP*3	Test Pin
4	D_{OUT}	VD Output Pin (Nch Open Drain)
5	CE	A Version: Chip Enable Pin (“H” Active)
	SENSE*1	B Version: VD Sense Pin
	C_D*2	C, D Versions: Release Output Delay (Power-on Reset) Time Setting Pin
6	TP*3	Test Pin
7	GND	Ground Pin
8	V_{DD}	Input Pin

∗) The tab on the reverse side of the IC is in GND level and it should be connected to GND pin (recommended) or should be left open.
∗1) B version monitors SENSE pin voltage.
∗2) The relese output delay time of voltage detector can be set by connecting a capacitor to C_D pin.
∗3) TP pin should be connected to GND.

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	–0.3 to 50	V
V_{CE}	Input Voltage (CE Pin, A Version)	–0.3 to 7.0	V
V_{SENSE}	Input Voltage (SENSE Pin, B Version)	–0.3 to 50	V
V_{CD}	Input Voltage (C_D Pin, C or D Version)	–0.3 to 7.0	V
V_{OUT}	Output Voltage (VR)	–0.3 to V_{IN}+0.3≦50	V
V_{RESET}	Output Voltage (VD)	–0.3 to 7.0	V
$I_{OUT}1$	Output Current (VR)	450	mA
$I_{OUT}2$	Output Current (VD)	20	mA
P_D	Power Dissipation (HSOP-8E) (Standard Test Land Pattern)*	2900	mW
Ta	Operating Temperature Range	–40 to 110	°C
Tstg	Storage Temperature Range	–55 to 125	°C

∗) For Power Dissipation and Standard Test Land Pattern, 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 lifetime 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

R1510SxxxA Series

V_{IN}=14.0V, CE=5.0V, C_{OUT}=6.8μF, Rpull-up=100kΩ, Vpull-up=5.0V, unless otherwise noted.

The values in [ ] are applicable under the condition of - 40ºC ≦Ta ≦110ºC.

For all

Ta=20ºC

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage		3.5		36	V
$I_{SS}1$	Supply Current (Low-power Consumption Mode)	I_{OUT}=0A		12.5	27	μA
$I_{SS}2$	Supply Current (High Speed Mode)	I_{OUT}=20mA		110	174	μA
Istandby	Standby Current (Standby Mode)	CE=0V		10	23	μA
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		140		ºC
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		130		ºC

VR

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	I_{OUT}=1mA Setting Voltage: 2.5V to 12.0V	Ta=25ºC	×0.984		×1.016	V
			–40ºC≦Ta≦110ºC	×0.955		×1.045	
$I_{OUT}1$	Output Current	$V_{IN}=V_{OUT}$+3.2V (V_{OUT}＜5.0V) $V_{IN}=V_{OUT}$+2.0V (V_{OUT}≧5.0V)		300			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$V_{IN}=V_{OUT}$+3.2V (V_{OUT}＜5.0V) $V_{IN}=V_{OUT}$+2.0V (V_{OUT}≧5.0V)					mV
		0.1mA≦I_{OUT}≦7mA (Low-power Consumption Mode)	V_{OUT}≦5.0V		7	13	
			V_{OUT}＞5.0V		10	20	
		0.1mA≦I_{OUT}≦20mA	V_{OUT}≦5.0V		10	45	
			V_{OUT}＞5.0V		20	75	
		0.1mA≦I_{OUT}≦300mA	V_{OUT}≦5.0V		40	100	
			V_{OUT}＞5.0V		60	170	
V_{DIF}	Dropout Voltage	I_{OUT}=7mA (Low-power Consumption Mode)	V_{OUT}＜5.0V		0.5	1.8	V
			V_{OUT}≧5.0V		0.3	0.95	
		I_{OUT}=300mA	V_{OUT}＜5.0V		1.5	3.2	
			V_{OUT}≧5.0V		1.0	2.0	
I_{OUTH}	High Speed Mode Switching Current	I_{OUT}=Light Load to Heavy Load		8.5	12	16.3	mA
I_{OUTL}	Low-power Consumption Mode Switching Current	I_{OUT}=Heavy Load to Light Load		1	3	5	mA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	3.5V≦V_{IN}≦36V (2.5V≦V_{OUT}≦3.5V) V_{OUT}+0.5V≦V_{IN}≦36V (V_{OUT}＞3.5V) I_{OUT}=1mA			0.01	0.05	%/V
$\Delta V_{OUT}/\Delta Ta$	Output Voltage Temperature Coefficient	–40ºC≦Ta≦110ºC			±150		ppm/ºC

I_{SC}	Short Current Limit	V_{OUT}=0V		50		mA
V_{CEH}	CE Input Voltage “H”		1.5		5.5	V
V_{CEL}	CE Input Voltage “L”				0.7	V

VD

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$-V_{DET}$	Detector Threshold	V_{IN} Detector Setting Voltage Range: 2.3 V to 12.0V	Ta=25ºC	×0.983		×1.017	V
			–40ºC≦Ta≦110ºC	×0.97		×1.03	
V_{HYS}	Detector Threshold Hysteresis			$-V_{DET}$ ×0.025	$-V_{DET}$ ×0.05	$-V_{DET}$ ×0.075	V
V_{DDL}	Minimum Operating Voltage*1					1.8	V
$I_{OUT}2$	Output Current (Nch Driver)	V_{IN}≧1.8V, D_{OUT}=0.1V		0.59			mA
		V_{IN}≧3.0V, D_{OUT}=0.1V		1.16			
		V_{IN}≧4.0V, D_{OUT}=0.1V		1.39			
I_{LEAK}	Nch Driver Leakage Current	D_{OUT}=7V				0.33	μA
V_{RESET}	Pull-up Voltage					5.5	V
Δ-V_{DET}/ΔTa	Detector Threshold Temperature Coefficient	–40ºC≦Ta≦110ºC			±100		ppm /ºC
t_{PLH}	Release Output Delay Time*2				20		μs

The values in ☐ have been tested and guaranteed by Design Engineering.
All test categories were tested on the products under the pulse load condition (Tj≈Ta=25ºC) except Output Voltage Temperature Coefficient and Detector Threshold Temperature Coefficient.

∗1) Minimum operating voltage is defined as the power supply voltage of which output voltage becomes lower than 0.1V at the detection.

∗2) Release output delay time is defined as the time to be taken for V_{IN} to change from 2V to ($-V_{DET}$)+1V, and for D_{OUT} output to become “H”.

R1510SxxxB Series

V_{IN}=SENSE=14.0V, C_{OUT}=6.8μF, Rpull-up=100kΩ, Vpull-up=5.0V, unless otherwise noted.

The values in ☐ are applicable under the condition of - 40ºC ≦ Ta ≦ 110ºC.

For all

Ta=25ºC

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage		3.5		36	V
$I_{SS}1$	Supply Current (Low-power Consumption Mode)	I_{OUT}=0A		12.5	22	μA
$I_{SS}2$	Supply Current (High Speed Mode)	I_{OUT}=20mA		110	174	μA
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		140		ºC
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		130		ºC

VR

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	I_{OUT}=1mA Setting Voltage: 2.5V to 12.0V	Ta=25ºC	×0.984		×1.016	V
			−40ºC≦Ta≦110ºC	×0.955		×1.045	
$I_{OUT}1$	Output Current	V_{IN}=V_{OUT}+3.2V (V_{OUT}<5.0V) V_{IN}=V_{OUT}+2.0V (V_{OUT}≧5.0V)		300			mA
ΔV_{OUT}/ ΔI_{OUT}	Load Regulation	V_{IN}=V_{OUT}+3.2V (V_{OUT}<5.0V) V_{IN}=V_{OUT}+2.0V (V_{OUT}≧5.0V)					mV
		0.1mA≦I_{OUT}≦7mA (Low-power Consumption Mode)	V_{OUT}≦5.0V		7	13	
			V_{OUT}>5.0V		10	20	
		0.1mA≦I_{OUT}≦20mA	V_{OUT}≦5.0V		10	45	
			V_{OUT}>5.0V		20	75	
		0.1mA≦I_{OUT}≦300mA	V_{OUT}≦5.0V		40	100	
			V_{OUT}>5.0V		60	170	
V_{DIF}	Dropout Voltage	I_{OUT}=7mA (Low-power Consumption Mode)	V_{OUT}<5.0V		0.5	1.8	V
			V_{OUT}≧5.0V		0.3	0.95	
		I_{OUT}=300mA	V_{OUT}<5.0V		1.5	3.2	
			V_{OUT}≧5.0V		1.0	2.0	
I_{OUTH}	High Speed Mode Switching Current	I_{OUT} = Light Load to Heavy Load		8.5	12	16.3	mA
I_{OUTL}	Low-power Consumption Mode Switching Current	I_{OUT} = Heavy Load to Light Load		1	3	5	mA
ΔV_{OUT}/ ΔV_{IN}	Line Regulation	3.5V≦V_{IN}≦36V (2.5V≦V_{OUT}≦3.5V) V_{OUT}+0.5V≦V_{IN}≦36V (V_{OUT}>3.5V) I_{OUT}=1mA			0.01	0.05	%/V
ΔV_{OUT}/ ΔTa	Output Voltage Temperature Coefficient	−40ºC≦Ta≦110ºC			±150		ppm /ºC
I_{SC}	Short Current Limit	V_{OUT}=0V			50		mA

VD

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$-V_{DET}$	Detector Threshold	V_{IN} Detector Setting Voltage: 2.3 V to 12.0V	Ta=25ºC	×0.983		×1.017	V
			–40ºC≦Ta≦110ºC	×0.97		×1.03	
V_{HYS}	Detector Threshold Hysteresis			$-V_{DET}$ ×0.025	$-V_{DET}$ ×0.05	$-V_{DET}$ ×0.075	V
R_{SENSE}	SENSE Resistance	$-V_{DET}$<6.0V		1.5		64	MΩ
		$-V_{DET}$≧6.0V		3.6		57	
V_{DDL}	Minimum Operating Voltage					3.0	V
$I_{OUT}2$	Output Current (Nch Driver)	V_{IN}≧3.0V, D_{OUT}=0.1V		1.16			mA
		V_{IN}≧4.0V, D_{OUT}=0.1V		1.39			
I_{LEAK}	Nch Driver Leakage Current	D_{OUT}=7V				0.33	μA
V_{RESET}	Pull-up Voltage					5.5	V
Δ-V_{DET}/ ΔTa	Detector Threshold Temperature Coefficient	–40ºC≦Ta≦110ºC			±100		ppm /ºC
t_{PLH}	Release Output Delay Time *1				20		μs
V_{SENSE}	SENSE Pin Input Voltage					36	V

The values in ☐ have been tested and guaranteed by Design Engineering.
All test categories were tested on the products under the pulse load condition (Tj≈Ta=25ºC) except Output Voltage Temperature Coefficient and Detector Threshold Temperature Coefficient.
∗1) Release output delay time is defined as the time to be taken for SENSE to change from 2V to ($-V_{DET}$)+1V, and for D_{OUT} output to become “H”.

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 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.

R1510SxxxC Series

V_{IN}=14.0V, C_{OUT}=6.8μF, C_D=0.01μF, Rpull-up=100kΩ, Vpull-up=5.0V, unless otherwise noted.
The values in □ are applicable under the condition of - 40ºC ≦Ta ≦110ºC.

For all

Ta=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage		3.5		36	V
$I_{SS}1$	Supply Current (Low-power Consumption Mode)	I_{OUT}=0A		12.5	27	μA
$I_{SS}2$	Supply Current (High Speed Mode)	I_{OUT}=20mA		110	174	μA
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		140		ºC
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		130		ºC

VR

Ta=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	I_{OUT}=1mA Setting Voltage: 2.5V to 12.0V	Ta=25ºC	×0.984		×1.016	V
			–40ºC≦Ta≦110ºC	×0.955		×1.045	
$I_{OUT}1$	Output Current	V_{IN}=V_{OUT}+3.2V (V_{OUT}<5.0V) V_{IN}=V_{OUT}+2.0V (V_{OUT}≧5.0V)		300			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	V_{IN}=V_{OUT}+3.2V (V_{OUT}<5.0V) V_{IN}=V_{OUT}+2.0V (V_{OUT}≧5.0V)					mV
		0.1mA≦I_{OUT}≦7mA (Low-power Consumption Mode)	V_{OUT}≦5.0V		7	13	
			V_{OUT}>5.0V		10	20	
		0.1mA≦I_{OUT}≦20mA	V_{OUT}≦5.0V		10	45	
			V_{OUT}>5.0V		20	75	
		0.1mA≦I_{OUT}≦300mA	V_{OUT}≦5.0V		40	100	
			V_{OUT}>5.0V		60	170	
V_{DIF}	Dropout Voltage	I_{OUT}=7mA (Low-power Consumption Mode)	V_{OUT}<5.0V		0.5	1.8	V
			V_{OUT}≧5.0V		0.3	0.95	
		I_{OUT}=300mA	V_{OUT}<5.0V		1.5	3.2	
			V_{OUT}≧5.0V		1.0	2.0	
I_{OUTH}	High Speed Mode Switching Current	I_{OUT}=Light Load to Heavy Load		8.5	12	16.3	mA
I_{OUTL}	Low-power Consumption Mode Switching Current	I_{OUT}=Heavy Load to Light Load		1	3	5	mA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	3.5V≦V_{IN}≦36V (2.5V≦V_{OUT}≦3.5V) V_{OUT}+0.5V≦V_{IN}≦36V (V_{OUT}>3.5V) I_{OUT}=1mA			0.01	0.05	%/V
$\Delta V_{OUT}/\Delta Ta$	Output Voltage Temperature Coefficient	–40ºC≦Ta≦110ºC			±150		ppm /ºC
I_{SC}	Short Current Limit	V_{OUT}=0V			50		mA

VD

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$-V_{DET}$	Detector Threshold	V_{IN} Detector Setting Voltage: 2.3 V to 12.0V	Ta=25ºC	×0.983		×1.017	V
			–40ºC≦Ta≦110ºC	×0.97		×1.03	
V_{HYS}	Detector Threshold Hysteresis			$-V_{DET}$ ×0.025	$-V_{DET}$ ×0.05	$-V_{DET}$ ×0.075	V
V_{DDL}	Minimum Operating Voltage *[1]					1.8	V
$I_{OUT}2$	Output Current (Nch Driver)	V_{IN}≧1.8V, D_{OUT}=0.1V		0.59			mA
		V_{IN}≧3.0V, D_{OUT}=0.1V		1.16			
		V_{IN}≧4.0V, D_{OUT}=0.1V		1.39			
I_{LEAK}	Nch Driver Leakage Current	D_{OUT}=7V				0.33	μA
V_{RESET}	Pull-up Voltage					5.5	V
Δ-V_{DET}/ΔTa	Detector Threshold Temperature Coefficient	–40ºC≦Ta≦110ºC			±100		ppm /ºC
tdelay	Release Output Delay Time*[2]			35	70	150	ms

The values in ☐ have been tested and guaranteed by Design Engineering.
All test categories were tested on the products under the pulse load condition (Tj≈Ta=25ºC) except Output Voltage Temperature Coefficient and Detector Threshold Temperature Coefficient.

∗1) Minimum operating voltage is defined as the power supply voltage of which output voltage becomes lower than 0.1V at the detection.

∗2) Release output delay time is defined as the time to be taken for V_{IN} to change from 2V to ($-V_{DET}$)+1V, and also for D_{OUT} output to become “H”.

ABSOLUTE MAXIMUM RATINGS

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R1510SxxxD Series

V_{IN}=14.0V, C_{OUT}=6.8µF, C_D=0.01µF, Rpull-up=100kΩ, Vpull-up=5.0V, unless otherwise noted.
The values in ☐ are applicable under the condition of - 40ºC ≦Ta ≦110ºC.

For all

Ta=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage		3.5		36	V
$I_{SS}1$	Supply Current (Low-power Consumption Mode)	I_{OUT}=0A		12.5	26	µA
$I_{SS}2$	Supply Current (High Speed Mode)	I_{OUT}=20mA		110	174	µA
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		140		ºC
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		130		ºC

VR

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{OUT}	Output Voltage	I_{OUT}=1mA Setting Voltage: 2.5V to 12.0V	Ta=25ºC	×0.984		×1.016	V
			–40ºC≦Ta≦110ºC	×0.955		×1.045	
$I_{OUT}1$	Output Current	$V_{IN}=V_{OUT}$+3.2V (V_{OUT}<5.0V) $V_{IN}=V_{OUT}$+2.0V (V_{OUT}≧5.0V)		300			mA
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation	$V_{IN}=V_{OUT}$+3.2V (V_{OUT}<5.0V) $V_{IN}=V_{OUT}$+2.0V (V_{OUT}≧5.0V)					mV
		0.1mA≦I_{OUT}≦7mA (Low-power Consumption Mode)	V_{OUT}≦5.0V		7	13	
			V_{OUT}>5.0V		10	20	
		0.1mA≦I_{OUT}≦20mA	V_{OUT}≦5.0V		10	45	
			V_{OUT}>5.0V		20	75	
		0.1mA≦I_{OUT}≦300mA	V_{OUT}≦5.0V		40	100	
			V_{OUT}>5.0V		60	170	
V_{DIF}	Dropout Voltage	I_{OUT}=7mA (Low-power Consumption Mode)	V_{OUT}<5.0V		0.5	1.8	V
			V_{OUT}≧5.0V		0.3	0.95	
		I_{OUT}=300mA	V_{OUT}<5.0V		1.5	3.2	
			V_{OUT}≧5.0V		1.0	2.0	
I_{OUTH}	High Speed Mode Switching Current	I_{OUT}=Light Load to Heavy Load		8.5	12	16.3	mA
I_{OUTL}	Low-power Consumption Mode Switching Current	I_{OUT}=Heavy Load to Light Load		1	3	5	mA
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	3.5V≦V_{IN}≦36V (2.5V≦V_{OUT}≦3.5V) V_{OUT}+0.5V≦V_{IN}≦36V (V_{OUT}>3.5V) I_{OUT}=1mA			0.01	0.05	%/V
$\Delta V_{OUT}/\Delta Ta$	Output Voltage Temperature Coefficient	–40ºC≦Ta≦110ºC			±150		ppm/ºC
I_{SC}	Short Current Limit	V_{OUT}=0V			50		mA

VD

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$-V_{DET}$	Detector Threshold	V_{IN} Detector Setting Voltage: 2.3 V to 10.6V	Ta=25ºC	×0.983		×1.017	V
			–40ºC≦Ta≦110ºC	×0.97		×1.03	
V_{HYS}	Detector Threshold Hysteresis			$-V_{DET}$ ×0.025	$-V_{DET}$ ×0.05	$-V_{DET}$ ×0.075	V
V_{DDL}	Minimum Operating Voltage*1					1.8	V
$I_{OUT}2$	Output Current (Nch Driver)	V_{IN}≧1.8V, D_{OUT}=0.1V		0.59			mA
		V_{IN}≧3.0V, D_{OUT}=0.1V		1.16			
		V_{IN}≧4.0V, D_{OUT}=0.1V		1.39			
I_{LEAK}	Nch Driver Leakage Current	D_{OUT}=7V				0.33	μA
V_{RESET}	Pull-up Voltage					5.5	V
Δ-V_{DET}/ ΔTa	Detector Threshold Temperature Coefficient	–40ºC≦Ta≦110ºC			±100		ppm /ºC
tdelay	Release Output Delay Time *2			35	70	150	ms

The values in ☐ have been tested and guaranteed by Design Engineering.
All test categories were tested on the products under the pulse load condition (Tj≈Ta=25ºC) except Output Voltage Temperature Coefficient and Detector Threshold Temperature Coefficient.

∗1) Minimum operating voltage is defined as the power supply voltage of which output voltage becomes lower than 0.1V at the detection.

∗2) Release output delay time is defined as the time to be taken for V_{OUT} to change from 2V to ($-V_{DET}$)+1V, and also for D_{OUT} output to become “H”.

ABSOLUTE MAXIMUM RATINGS

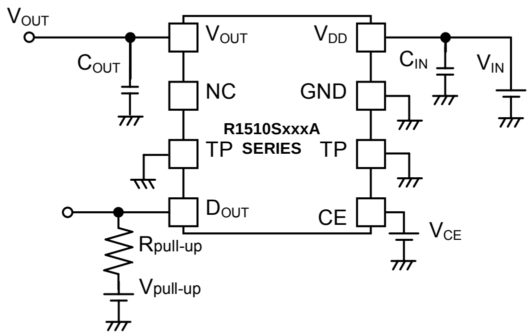
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

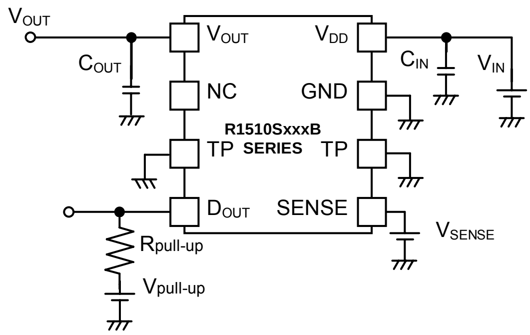
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic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

TYPICAL APPLICATIONS

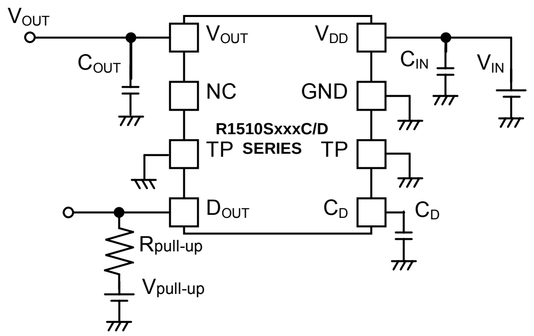
R1510SxxxA



R1510SxxxB



R1510SxxxC/D



C_{IN}=0.1µF, C_{OUT}=6.8µF (Ceramic)
Rpull-up=100kΩ

NOTES CONCERNING EXTERNAL PARTS

Phase Compensation

This IC is using the capacitance of output capacitor (C_{OUT}) and the ESR as phase compensation for the stable operation of the ICs even if the output load varies. Therefore, please make sure to use a capacitor (C_{OUT}) with 6.8µF or more.

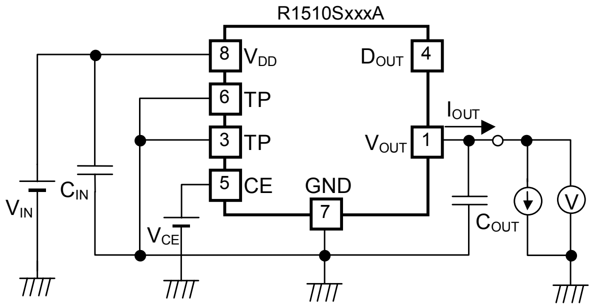
If the ESR value is large, the output may result in unstable, therefore, please make full evaluation on the temperature characteristics and the frequency characteristics.

PCB Layout and GND Wiring

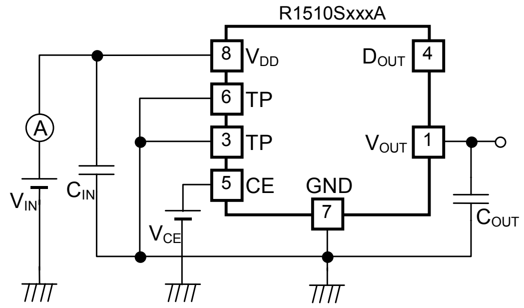
The high impedances of V_{DD} and GND could be a reason for the noise pickup and unstable operation. Therefore, make the impedances of V_{DD} and GND as low as possible. A capacitor (C_{IN}) with 0.1µF or more has to be connected between V_{DD} pin and GND pin, and the wirings between them have to be short as possible. The capacitor (C_{OUT}) for phase compensation has to be connected between V_{OUT} pin and GND pin, and the wirings between them have to be short as possible.

TEST CIRCUITS

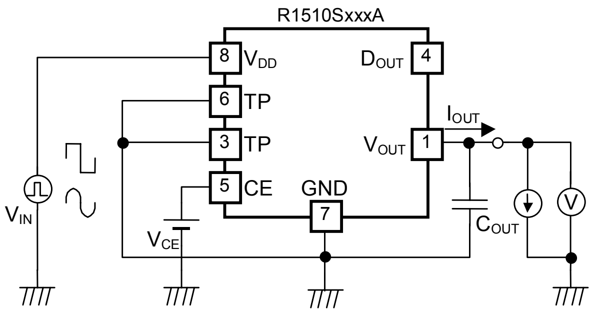
R1510SxxxA



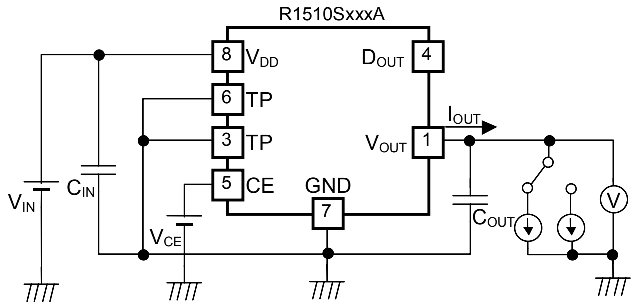
Test Circuit for Output Voltage and Noise



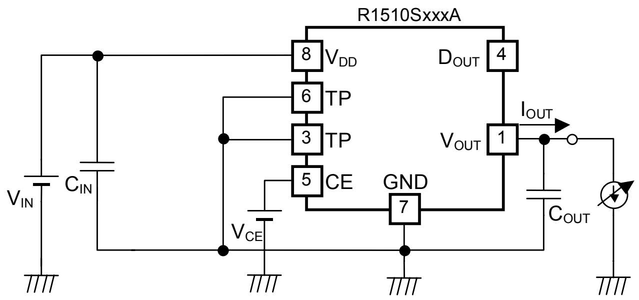
Test Circuit for Supply Current



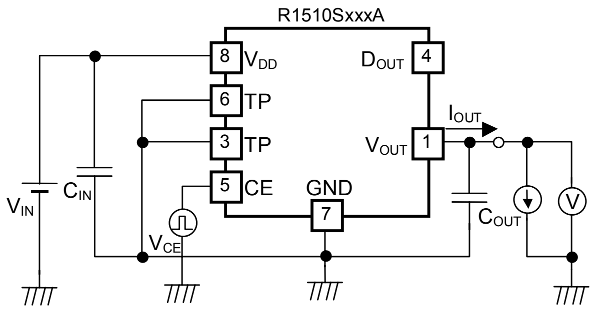
Test Circuit for Regulator Input Transient Response and Ripple Rejection



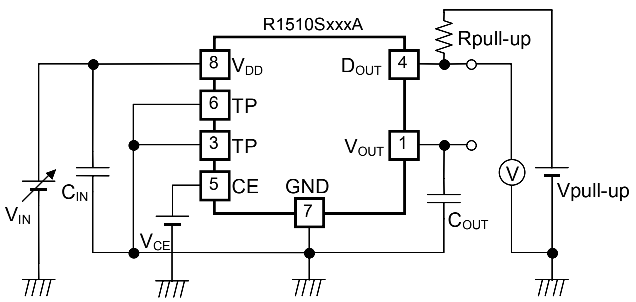
Test Circuit for Load Transient Response



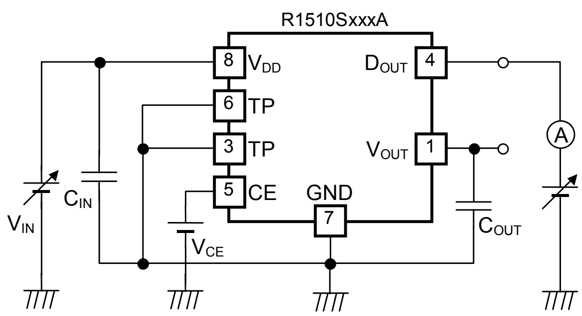
Test Circuit for Mode Switching Current



Test Circuit for CE Transient Response

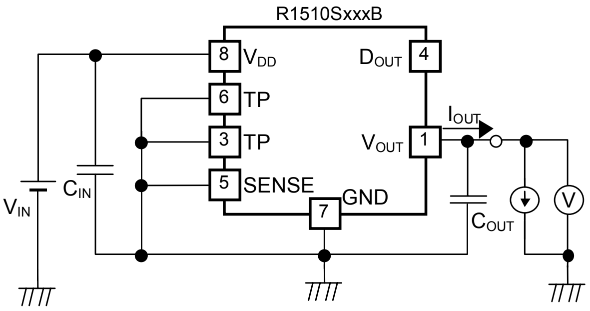


Test Circuit for Detector Threshold/ Release Voltage and Minimum Operating Voltage

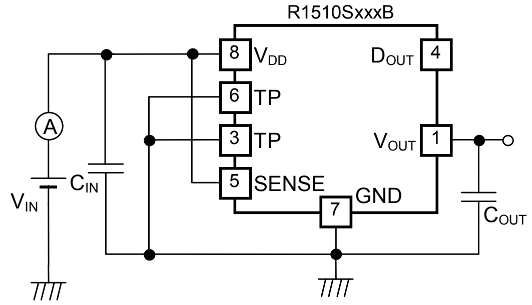


Test Circuit for Nch Driver Output Current

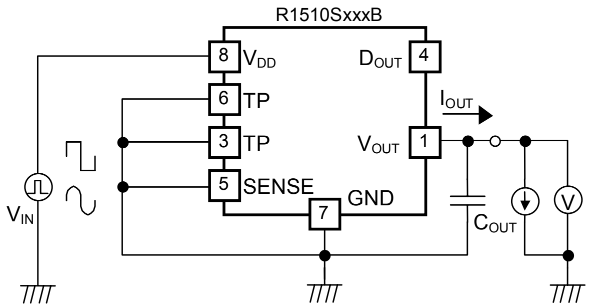
R1510SxxxB



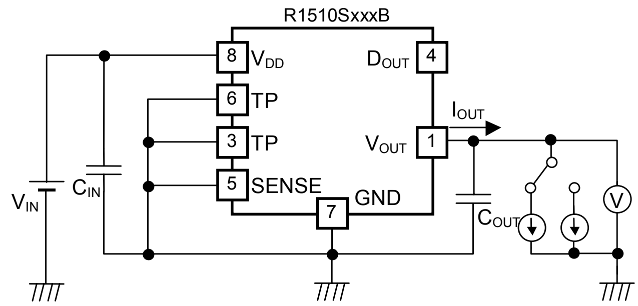
Test Circuit for Output Voltage and Noise



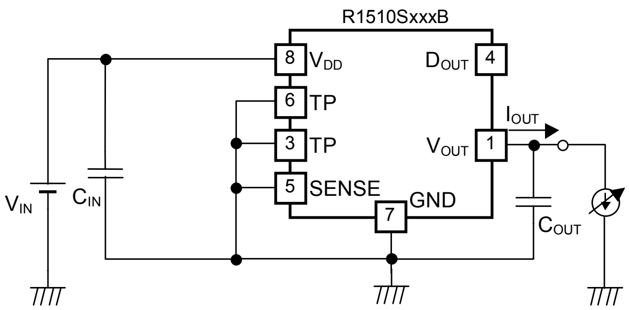
Test Circuit for Supply Current



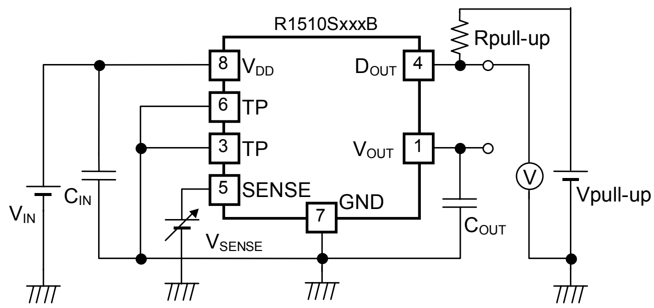
Test Circuit for Regulator Input Transient Response and Ripple Rejection



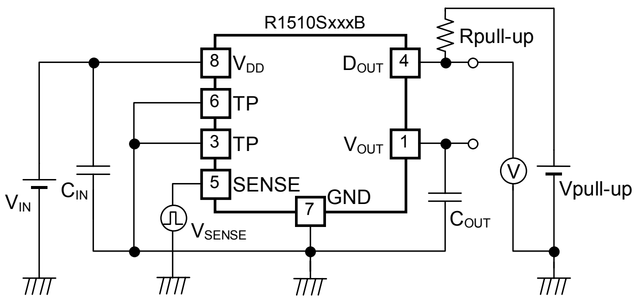
Test Circuit for Load Transient Response



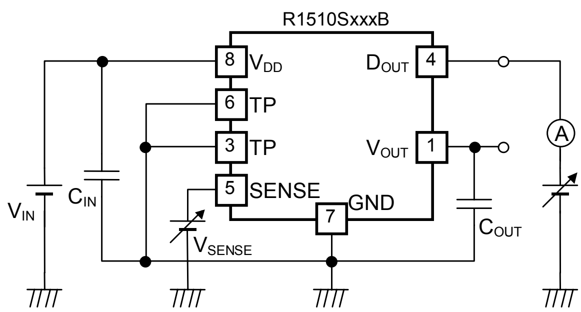
Test Circuit for Mode Switching Current



Test Circuit for Detector Threshold/ Release Voltage and Minimum Operating Voltage

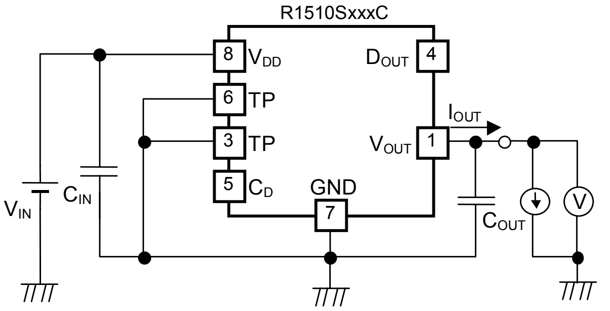


Test Circuit for Detect/ Release Output Delay Time

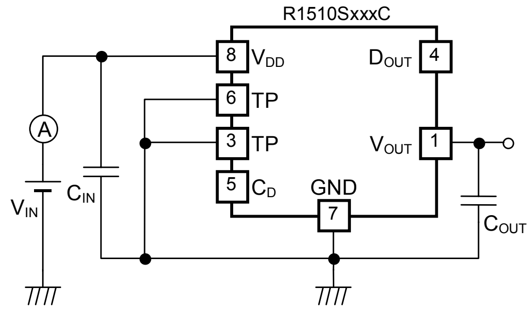


Test Circuit for Nch Driver Output/ Leakage

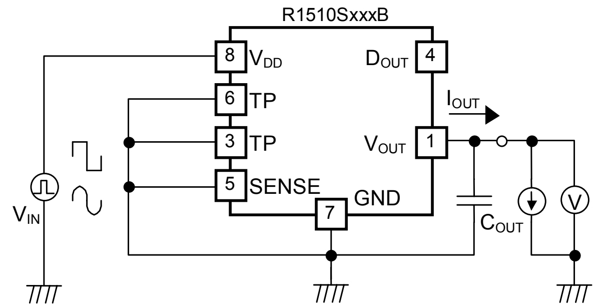
R1510SxxxC



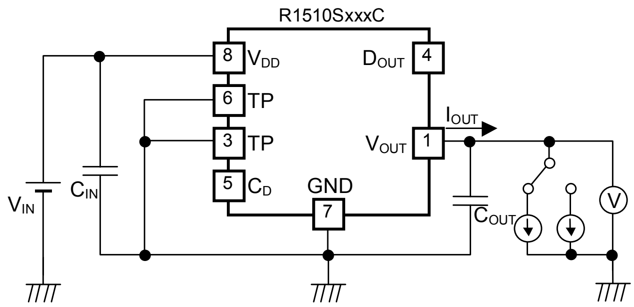
Test Circuit for Output Voltage and Noise



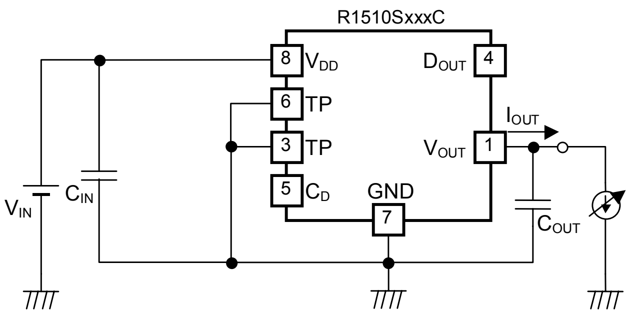
Test Circuit for Supply Current



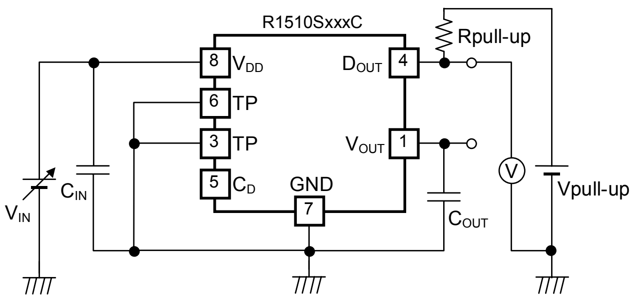
Test Circuit for Regulator Input Transient Response and Ripple Rejection



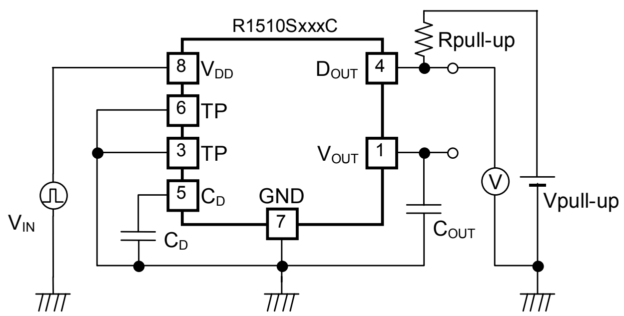
Test Circuit for Load Transient Response



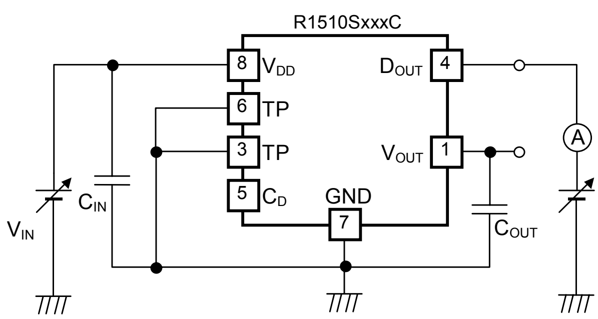
Test Circuit for Mode Switching Current



Test Circuit for Detector Threshold/ Release Voltage and Minimum Operating Voltage

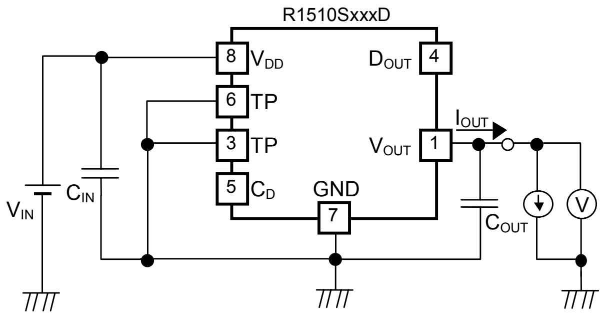


Test Circuit for Detect/ Release Output Delay Time

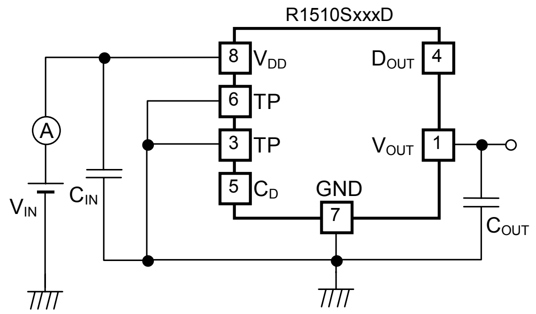


Test Circuit for Nch Driver Output Current

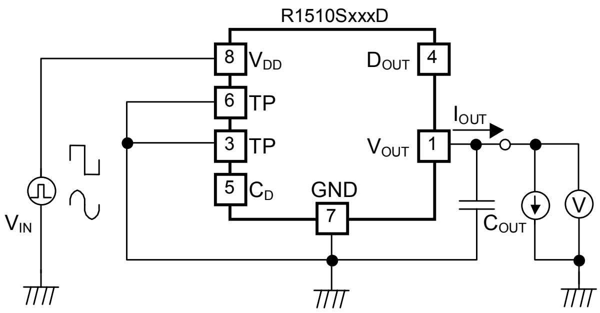
R1510SxxxD



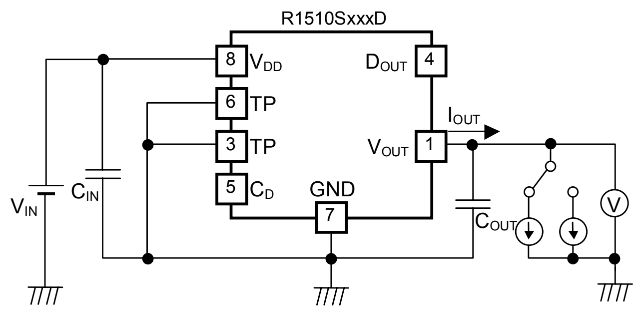
Test Circuit for Output Voltage and Noise



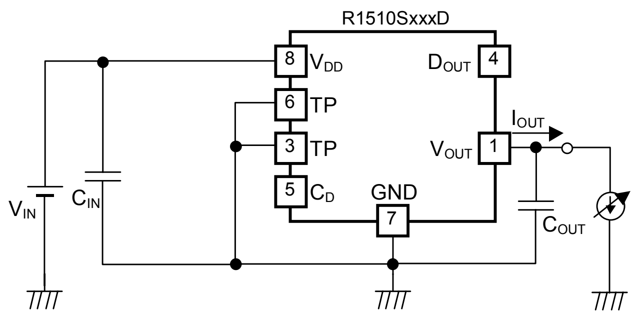
Test Circuit for Supply Current



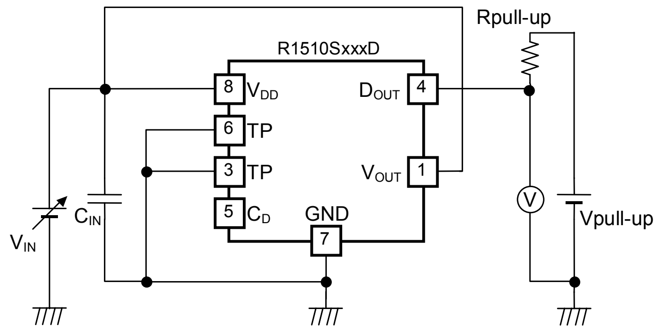
Test Circuit for Regulator Input Transient Response and Ripple Rejection



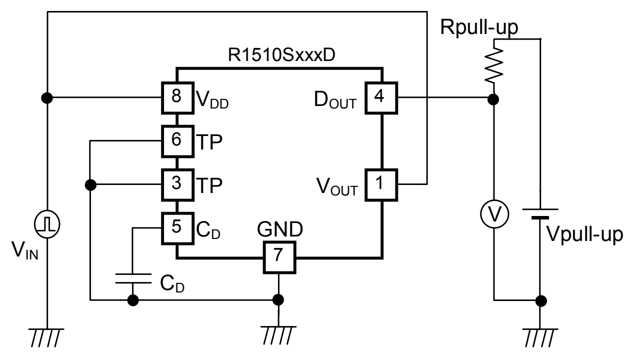
Test Circuit for Load Transient Response



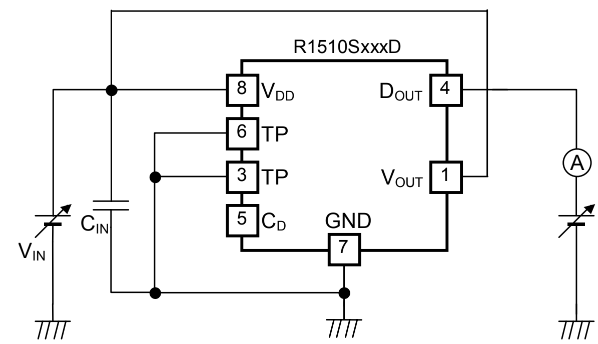
Test Circuit for Mode Switching Current



Test Circuit for Detector Threshold/ Release Voltage and Minimum Operating Voltage



Test Circuit for Detect/ Release Output Delay Time



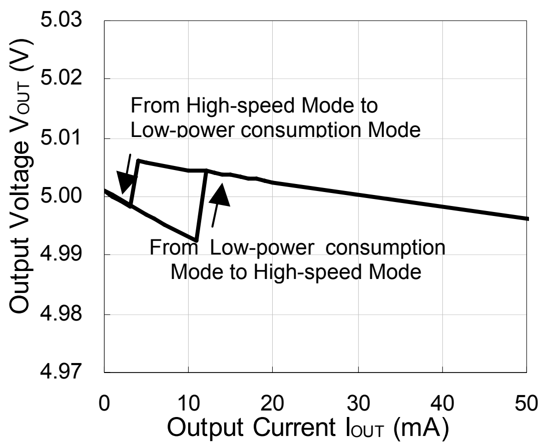
Test Circuit for Nch Driver Output Current

OPERATION MANUAL

Voltage Regulator (VR)

Voltage Regulator (VR) operates within the input voltage range of 3.5V to 36V. The output voltage is adjustable within the range of 2.5V to 12V by 0.1V step. By changing the current value of the control circuit according to the load current, the supply current at the light load condition can be minimized and also be able to achieve high speed response. When the load current becomes 12mA (Typ.) or more, the control circuit switches to high-speed mode and when the load current becomes 3mA or lower, it switches to low-power consumption mode. Hysteresis is set for the output current between 3mA to 12mA (Typ.).

These current values are internally fixed inside the ICs. When the mode switching is caused by the load current change, the output voltage will be changed as the graph below shows. The load current dependencies (Load Regulation) of output voltage in Electrical Characteristics have been tested at the following points: 0.1mA, 7mA (Low-power consumption mode), 20mA, and 300mA.



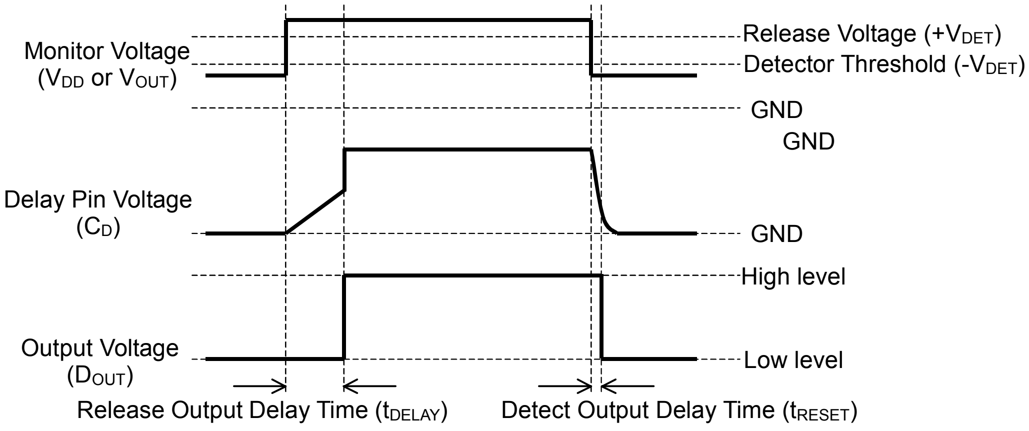
During the period of 100µsec immediately after High-speed mode is switched to Low-power consumption mode, the current value (I_{OUTH}), which switches Low-power consumption mode back to High-speed mode, is increased 3 times. Therefore, during this time period, the ICs can still operate with Low-power consumption mode even if the load current is between 12mA to 36mA (Typ.).

R1510SxxxA can turn on and off the operation of VR by CE pin.

Voltage Detector (VD)

Voltage Detector (VD) operates within the input voltage range of 1.8V to 36V (R1510SxxxA/C/D) and 3.0V to 36V (R1510SxxxB). The detector threshold is adjustable in the range of 2.3V to 12V by 0.1V step. If the monitor voltage is lower than the detector threshold, D_{OUT} outputs “L”. In the case of R1510SxxA/B, if the monitor voltage becomes more than the released voltage, D_{OUT} outputs “H”. In the case of R1510SxxxC/D, if the monitor voltage becomes more than the released voltage, the capacitor of the release output delay time pin (C_D) starts to get charged. D_{OUT} output maintains “L” until C_D reaches to the threshold value. Once C_D value becomes more than the threshold value, D_{OUT} outputs “H”. In the case of R1510SxxxC/D, if the monitor voltage becomes lower than the detector threshold, the capacitor of C_D starts to get discharged. Therefore, if the monitor voltage becomes more than the released voltage without electrical discharge, the release output delay time afterwards becomes less than the existing release output delay time (t_{DELAY}).

RICOH



R1510SxxxC/D

If V_{IN} voltage is raised suddenly from the less than the minimum operating voltage to the less than the release voltage, V_{IN} voltage momentarily passes through the unstable range (from 0V to the minimum operating voltage), therefore, D_{OUT} may output "H" (unstable) once then output "L" afterwards. Similarly, if V_{IN} voltage is raised from the less than the minimum operating voltage to the more than the release voltage, V_{IN} momentarily passes through the unstable range (from 0V to the minimum operating voltage), therefore, D_{OUT} may output "H" once.

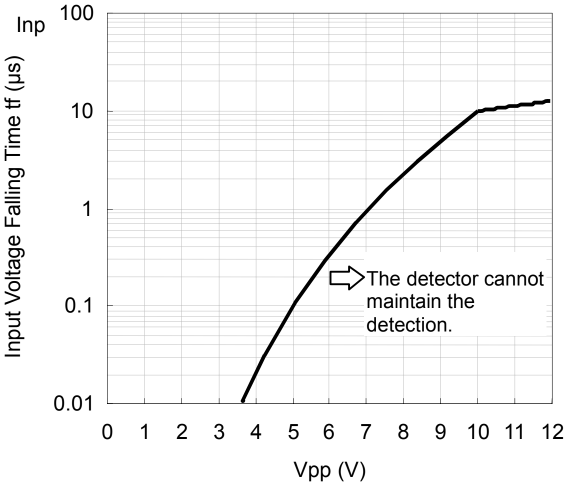
Release Output Delay Time

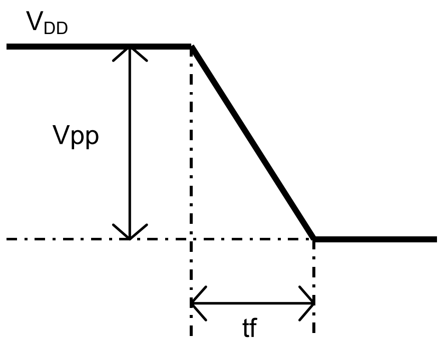
The release output delay time (Power-on Reset Time (t_{DELAY})) of R1510SxxxC/D can be set by the capacitor of C_D pin. The relationship between the capacitor capacitance and t_{DELAY} is as shown in the following equation.

$$t_{DELAY}(s)=7.0\times10^5\times C_D(F)$$

The upper limit of the capacitance value for the C_D pin capacitor is 1μF. The capacitor operates normally with more than 1μF; however, if the setting time (t_{DELAY}) is set longer, the setting time differences could become bigger. Also, if the detect output delay time becomes longer; the response of the VD output pin will be slow to make a momentary stop.

If the V_{DD} pin voltage is decreased with more than the through rate as it is shown in the graph below, the ICs do not operate normally. If there's any possibility of this, please minimize the voltage fluctuation of V_{DD} pin by using C_{IN}.





V_{DD} Input Waveform

Thermal Shutdown

If the junction temperature (Tj) becomes more than 140ºC(Typ.) due to the heat generation in the voltage regulator, the output driver will be turned off to protect the ICs and the voltage regulator output will be turned off. If the junction temperature becomes less than 130ºC(Typ.), the output driver will be turned on and the voltage regulator output will be turned on. Unless the cause of the heat generation is not removed, the voltage regulator repeats turns on and off, so the output voltage will be a pulsing form.

R1510SxxxD Voltage Setting

The voltage detector (VD) of R1510SxxxD detects the output voltage drop of the voltage regulator (VR). If the VD release voltage is set to more than the VR output voltage, the VD will not be canceled even if the VR output voltage returns to the normal value after VD detected the output voltage drop of VR. To avoid this, there have to be voltage differences between the voltage regulator's output voltage (V_{OUT}) and the voltage detector's release voltage ($+V_{DET}$). Also, the following conditions have to be met.

(VR Output Setting Voltage) x0.955-0.10>(VD Detect Setting Voltage) x1.03x1.075 ($2.5 \leqq V_{OUT} \leqq 5.0V$)

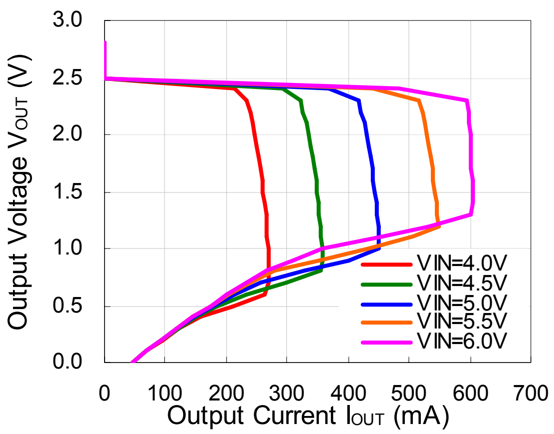
(VR Output Setting Voltage) x0.955-0.15>(VD Detect Setting Voltage) x1.03x1.075 ($5.0 < V_{OUT} \leqq 12.0V$)

In case of using the products with the VR output voltage and the VD detector threshold that is not met the above conditions, please make sure to give greater consideration on the system operation before use.

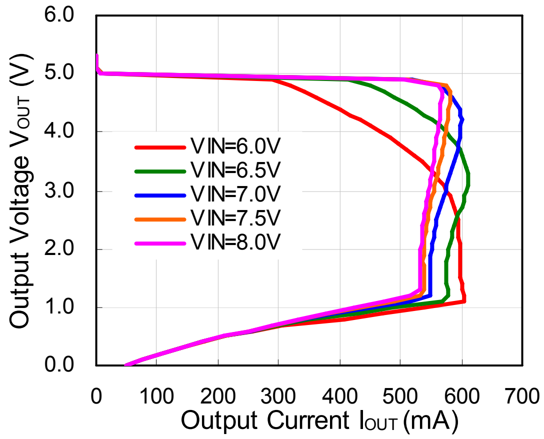
Characteristic Examples

1) Output Voltage Vs. Output Current (Ta=25ºC)

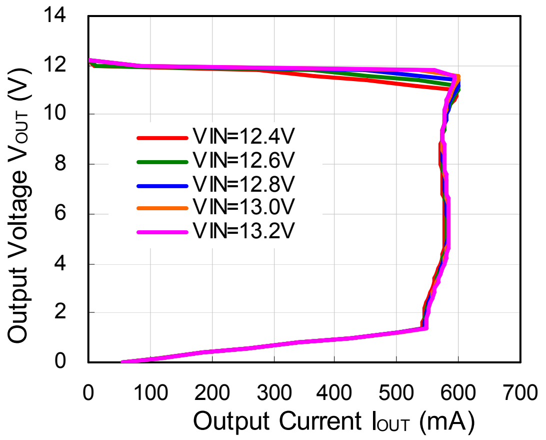
R1510S (VR=2.5V)



R1510S (VR=5.0V)

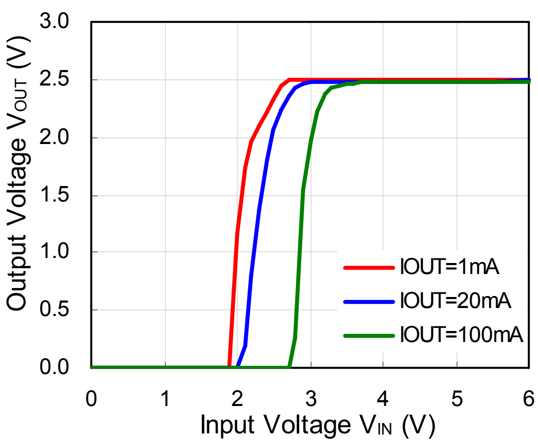


R1510S (VR=12.0V)

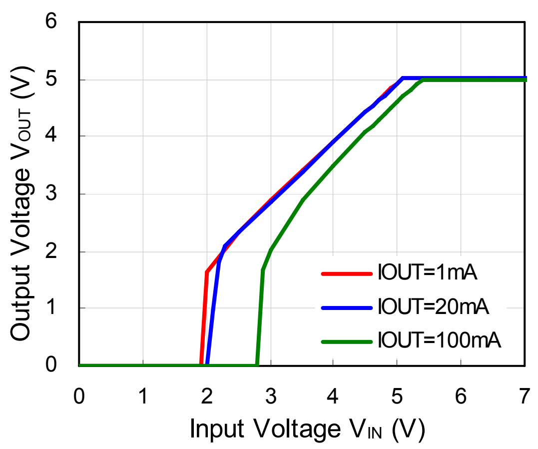


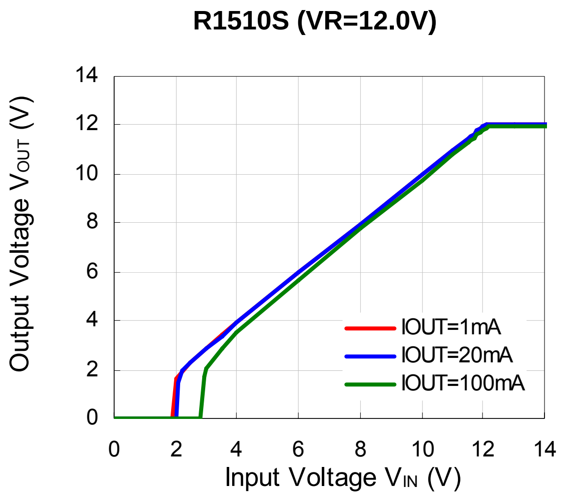
2) Output Voltage Vs. Input Voltage (Ta=25ºC)

R1510S (VR=2.5V)

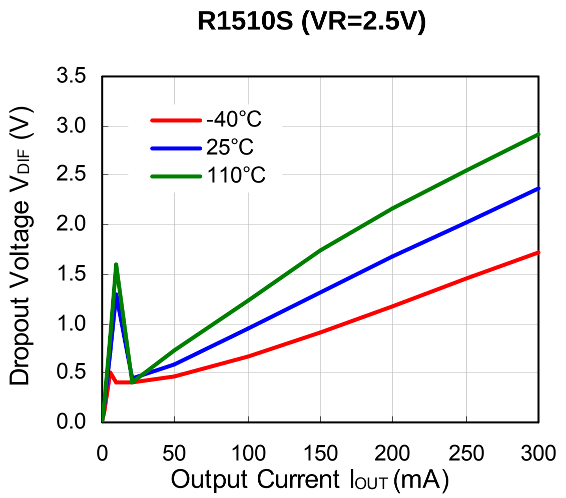


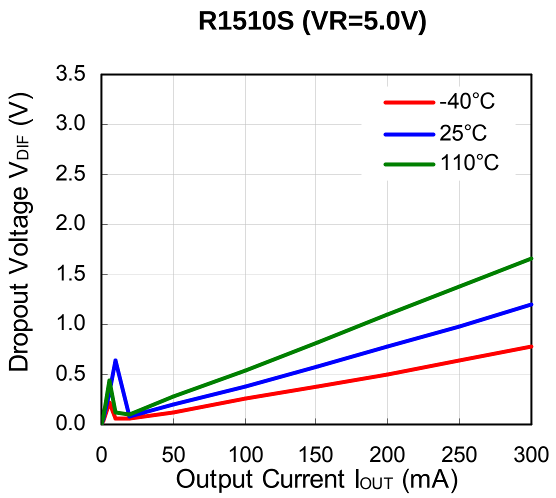
R1510S (VR=5.0V)

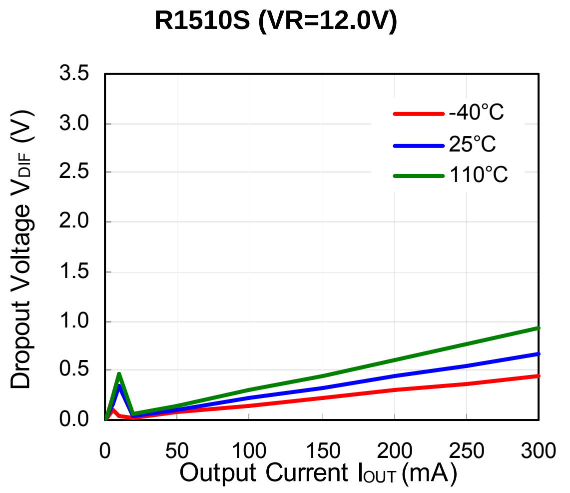




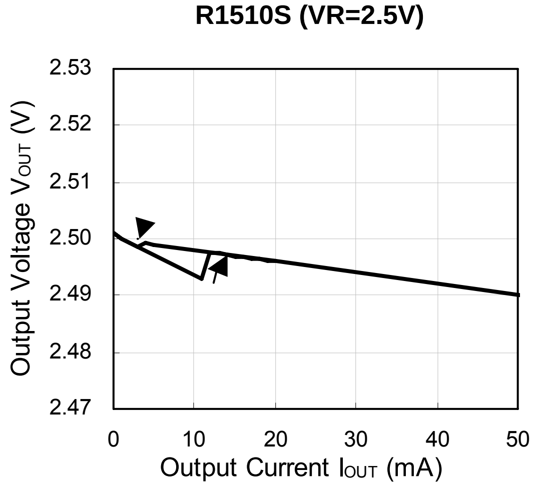
3) Dropout Voltage Vs. Output Current

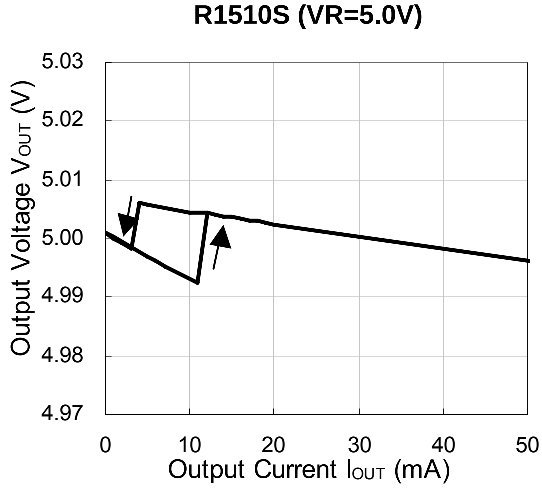


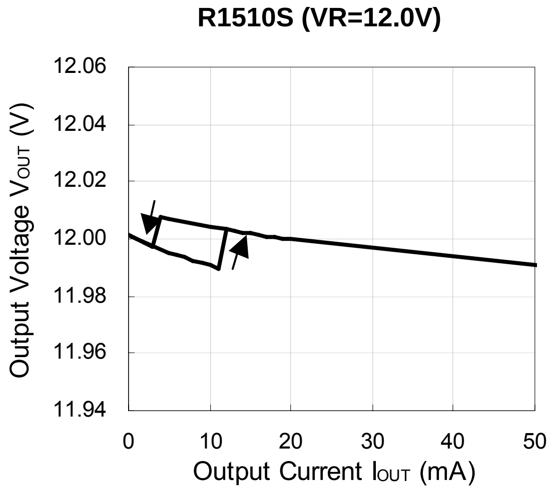




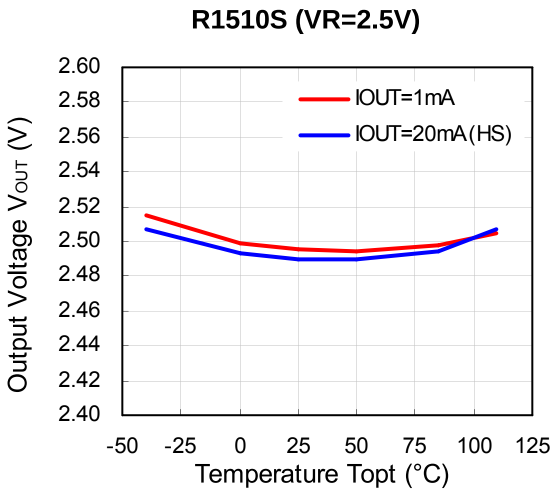
4) Output Voltage Vs. Output Current (Ta=25ºC)

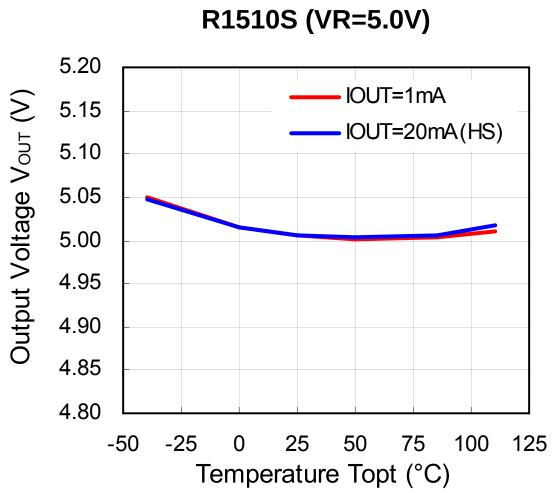


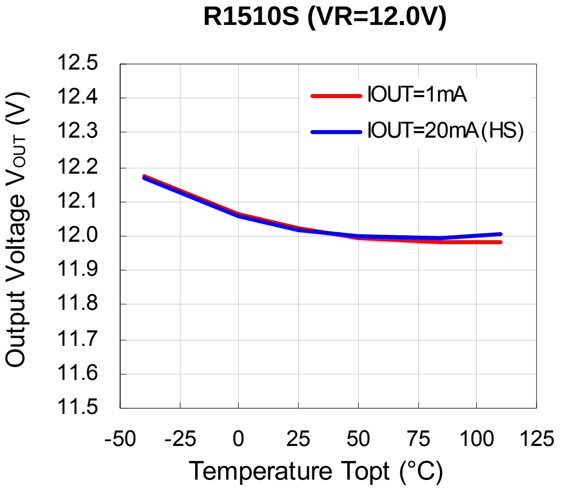




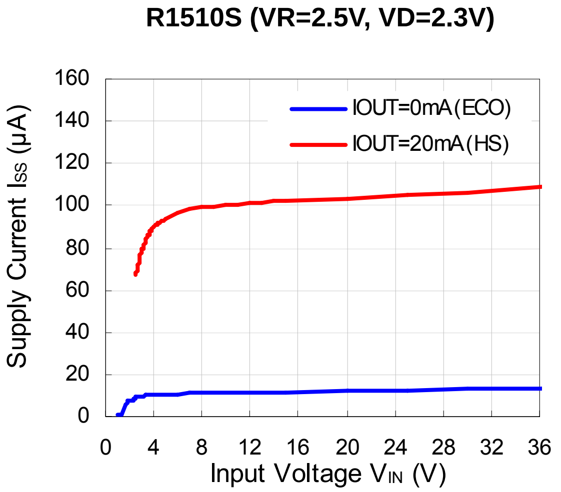
5) Output Voltage Vs. Operating Temperature

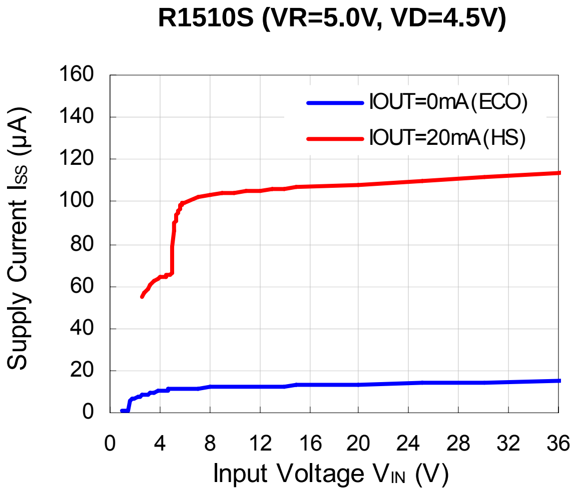


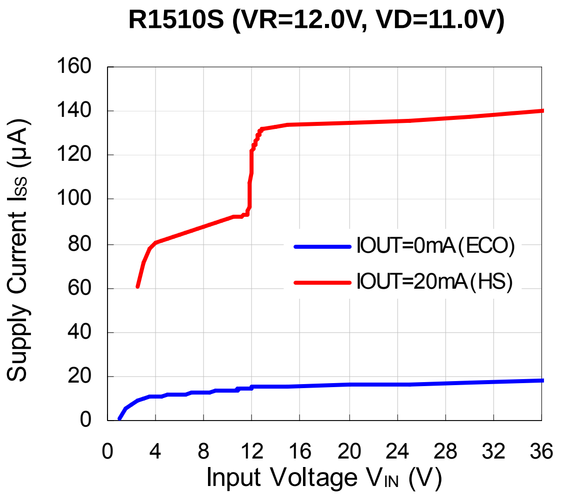




6) Supply Current Vs. Input Voltage

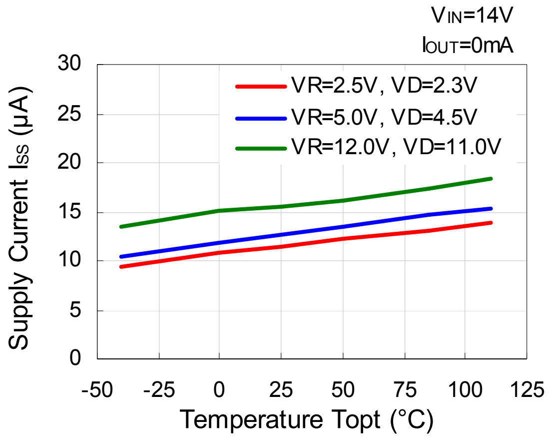




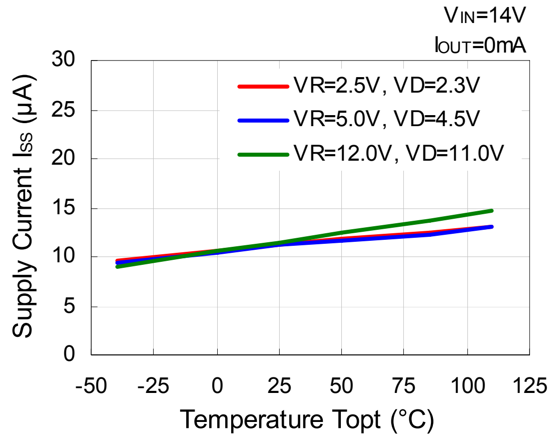


7) Supply Current Vs. Operating Temperature

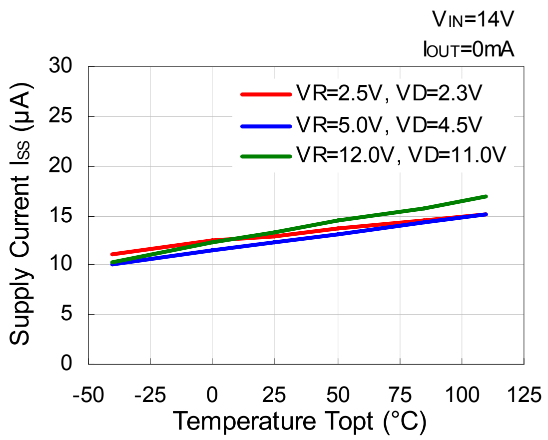
R1510SxxxA



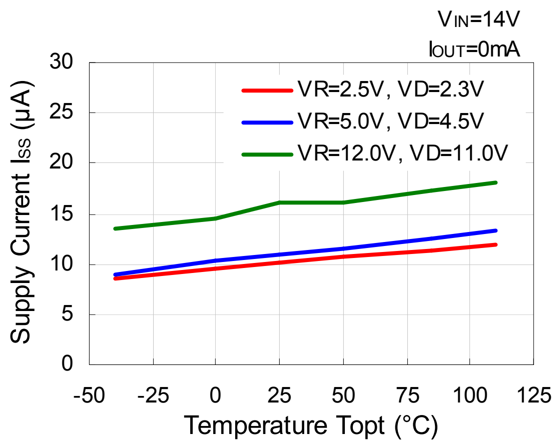
R1510SxxxB



R1510SxxxC

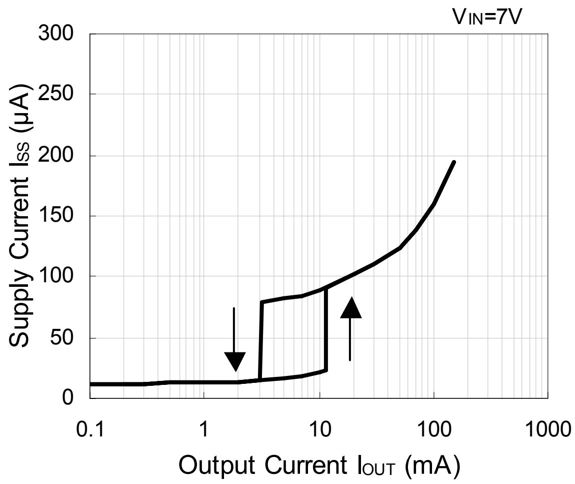


R1510SxxxD



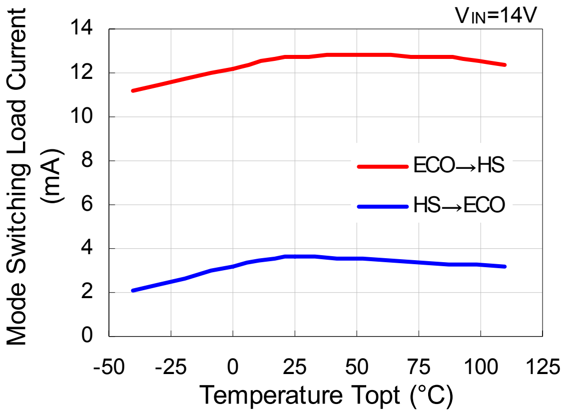
8) Supply Current Vs. Output Current (Ta=25ºC)

R1510SxxxA (VR=5.0V)



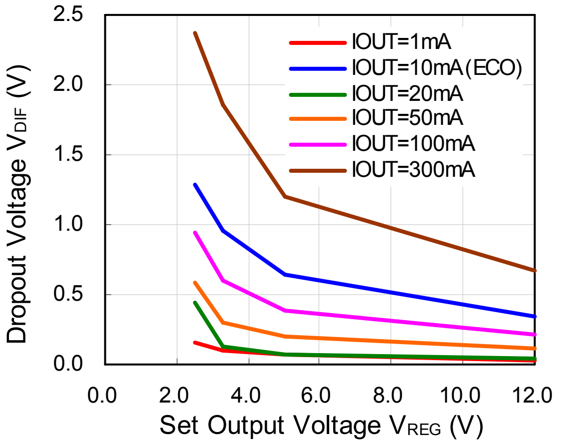
9) Mode Switching Load Current Vs. Operating Temperature

R1510S



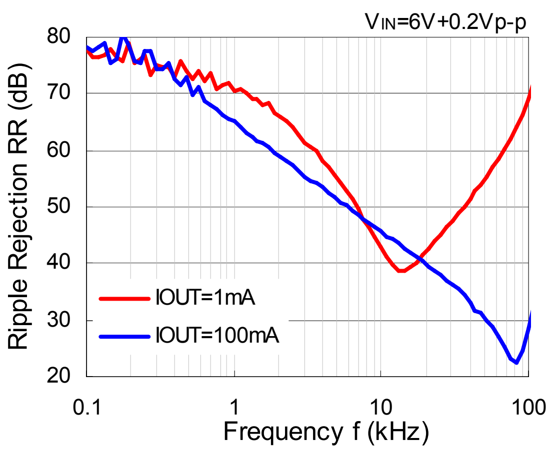
10) Dropout Voltage Vs. Set Output Voltage (Ta=25ºC)

R1510S

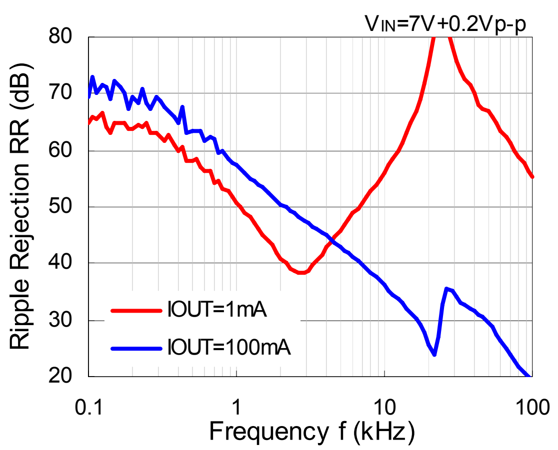


11) Ripple Rejection Vs. Frequency (Ta=25ºC)

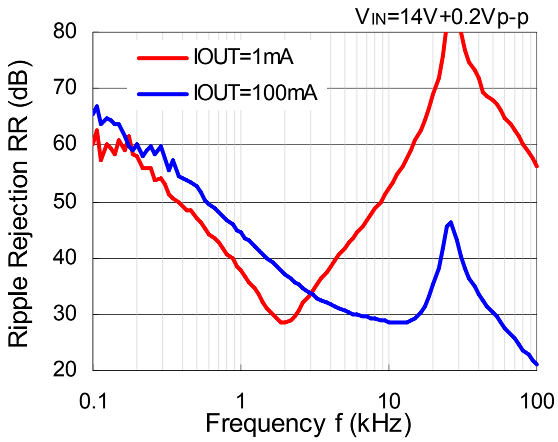
R1510S (VR=2.5V)



R1510S (VR=5.0V)

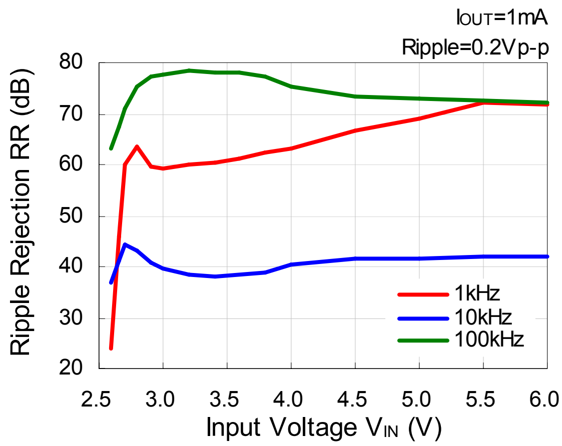


R1510S (VR=12.0V)

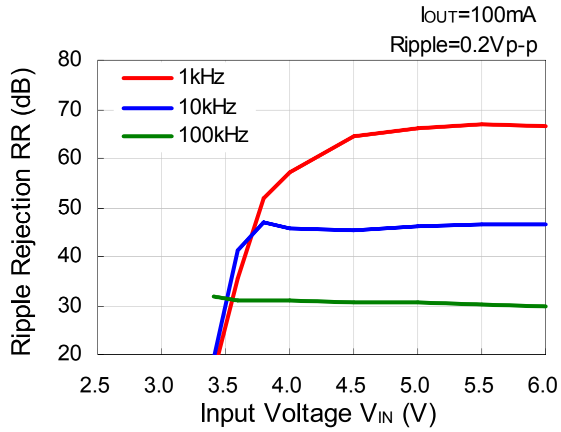


12) Ripple Rejection Vs. Input Voltage (Ta=25°C)

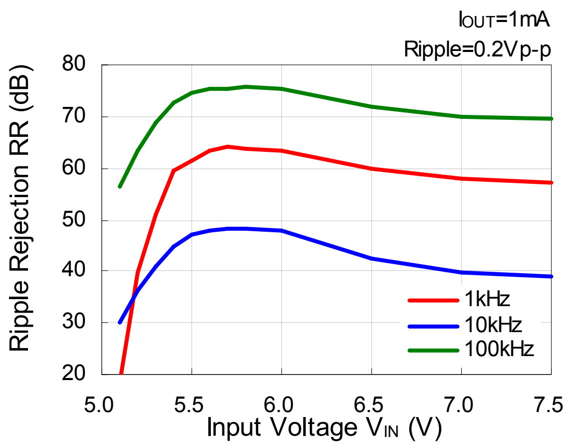
R1510S (VR=2.5V)



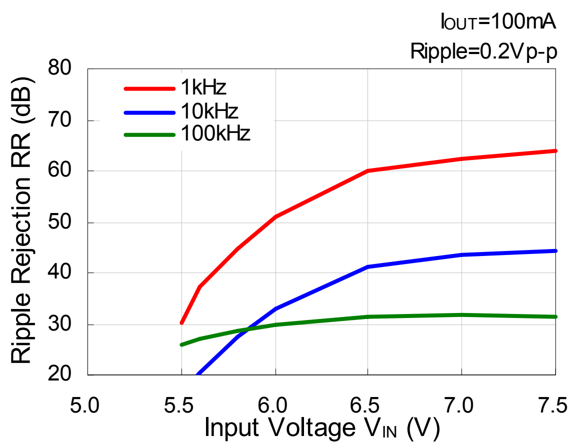
R1510S (VR=2.5V)



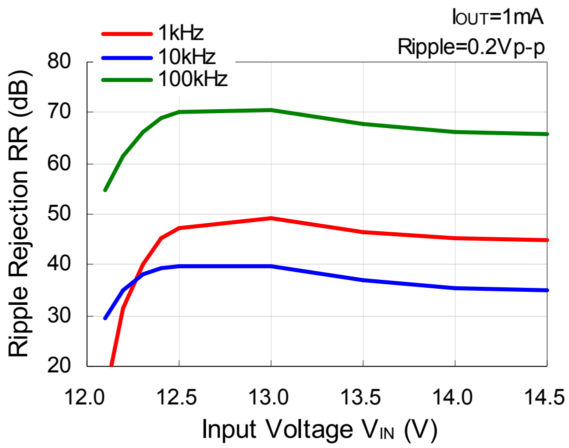
R1510S (VR=5.0V)



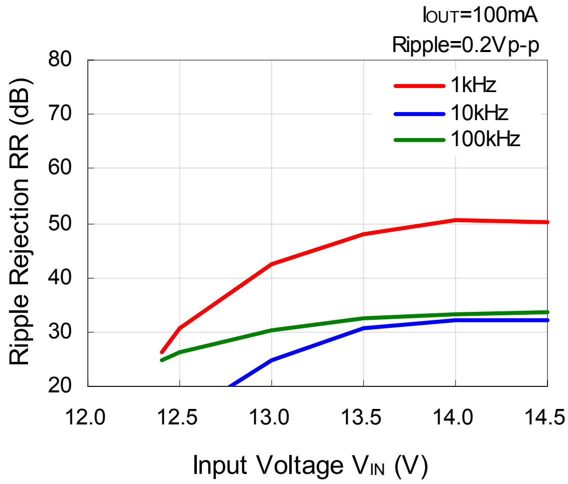
R1510S (VR=5.0V)



R1510S (VR=12.0V)

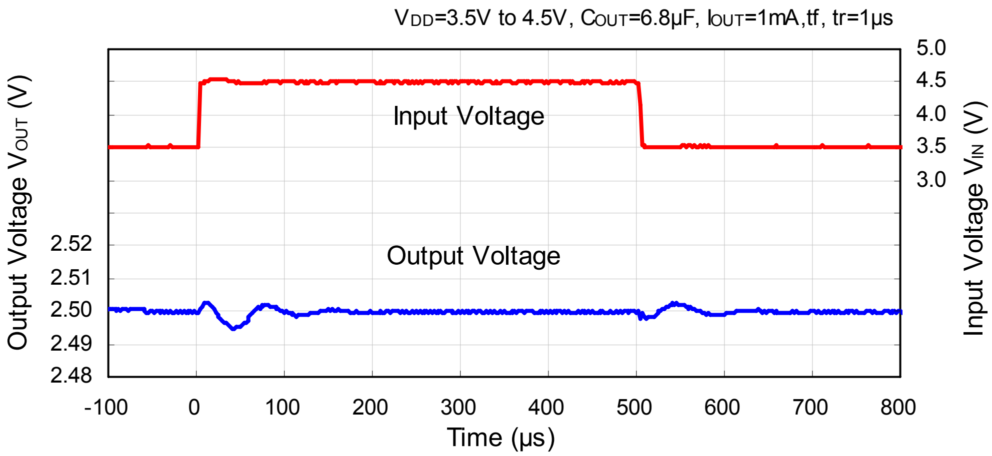


R1510S (VR=12.0V)

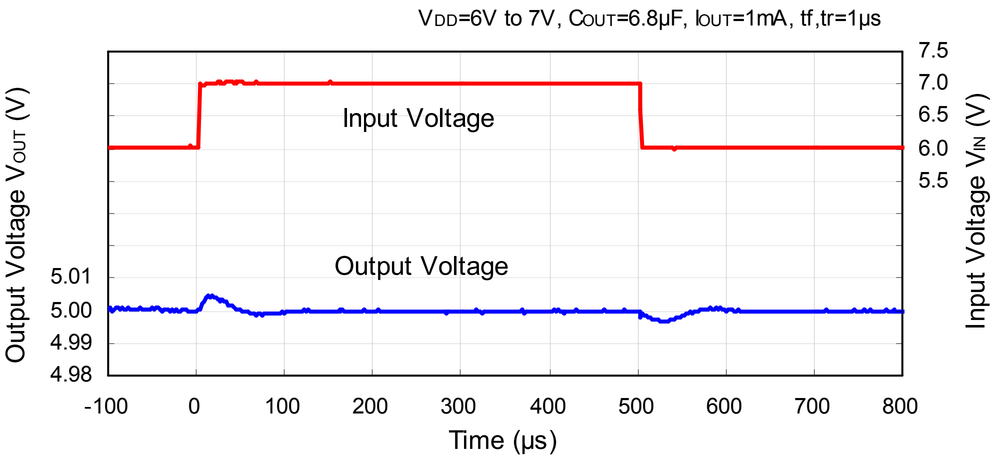


13) Input Transient Response (Ta=25°C)

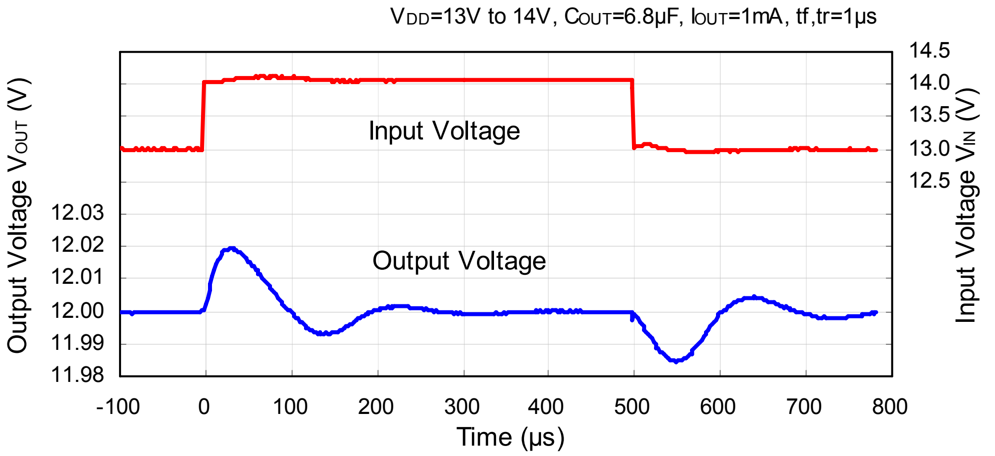
R1510S (VR=2.5V)



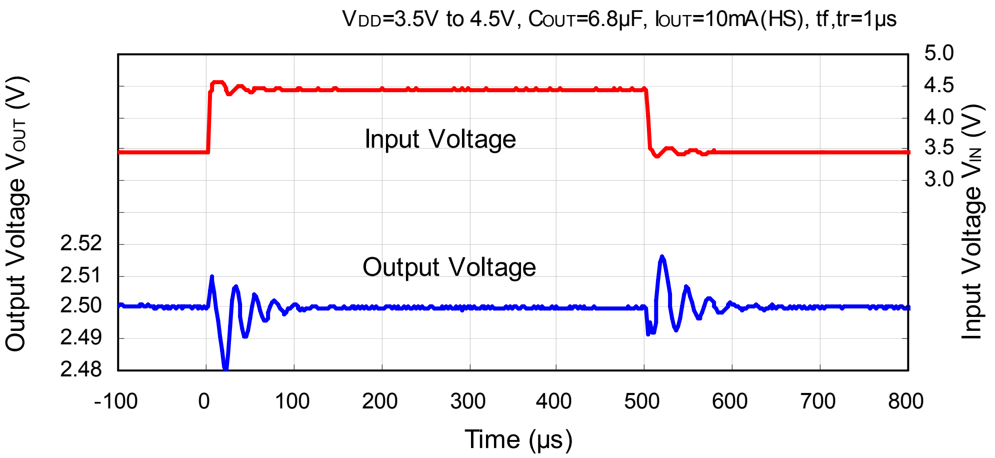
R1510S (VR=5.0V)



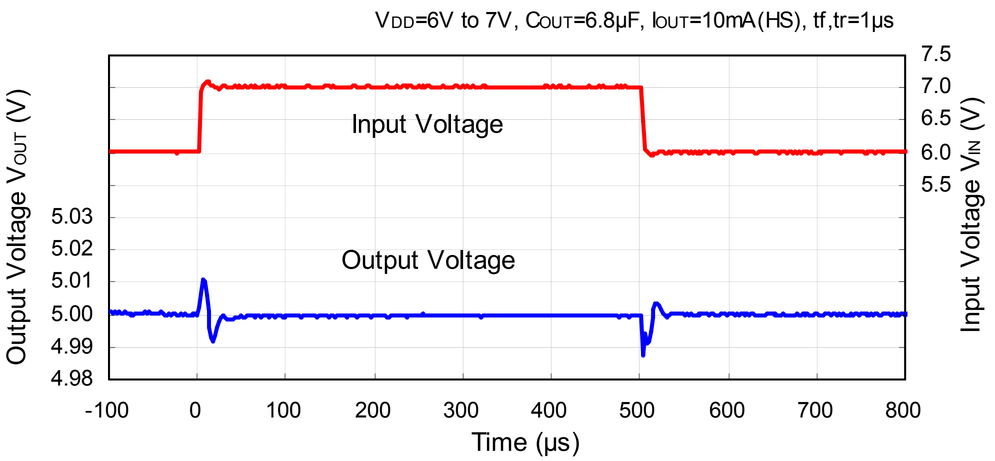
R1510S (VR=12.0V)

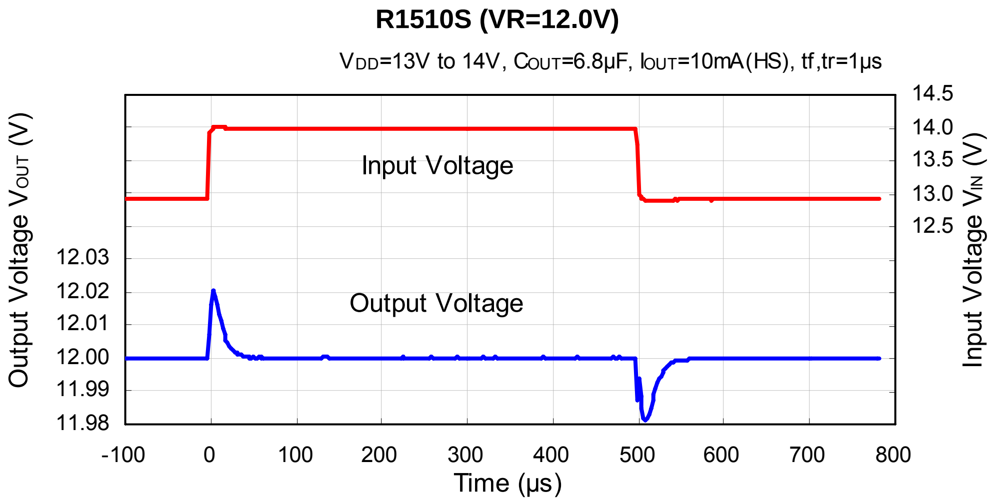


R1510S (VR=2.5V)

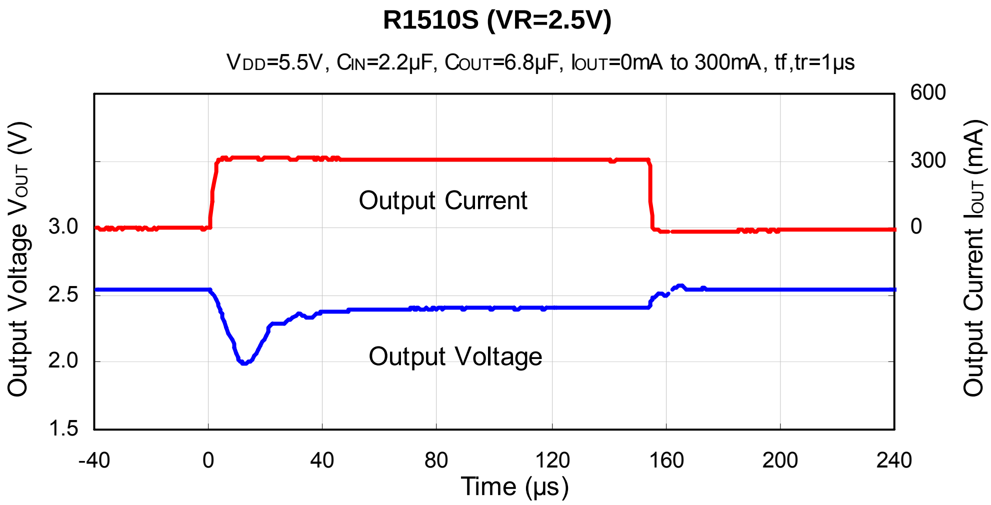


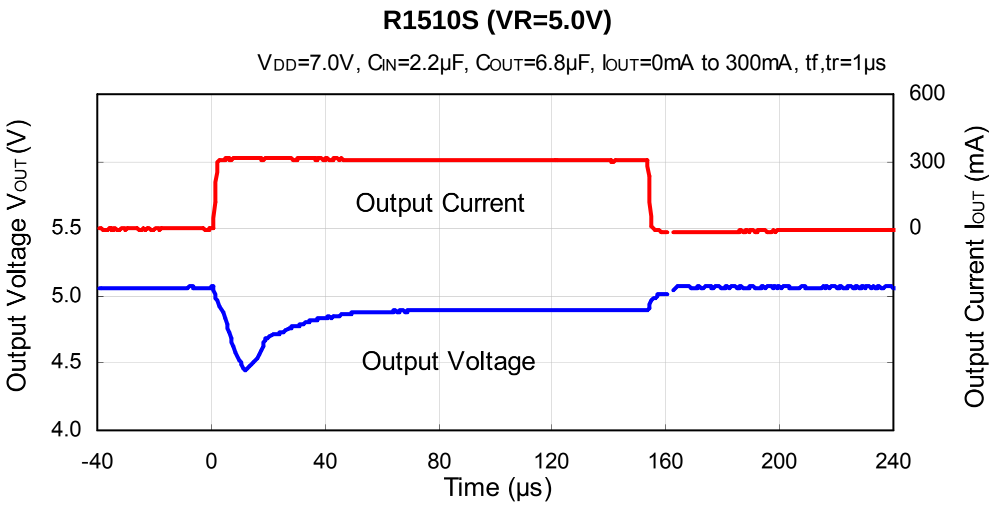
R1510S (VR=5.0V)





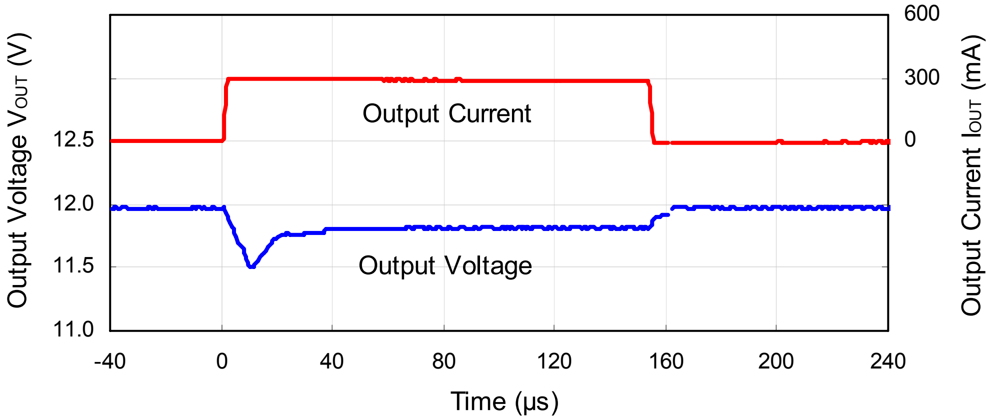
14) Load Transient Response (Ta=25ºC)





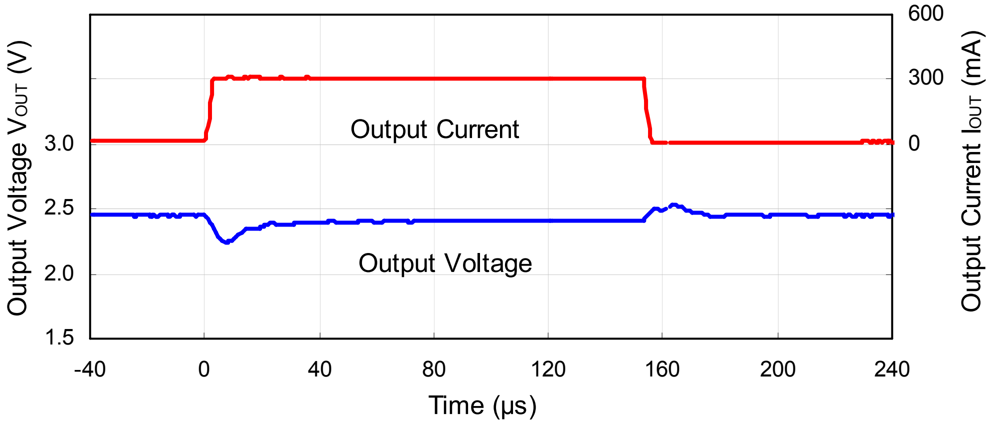
R1510S (VR=12.0V)

VDD=14V, CIN=2.2µF, COUT=6.8µF, IOUT=0mA to 300mA, tf,tr=1µs



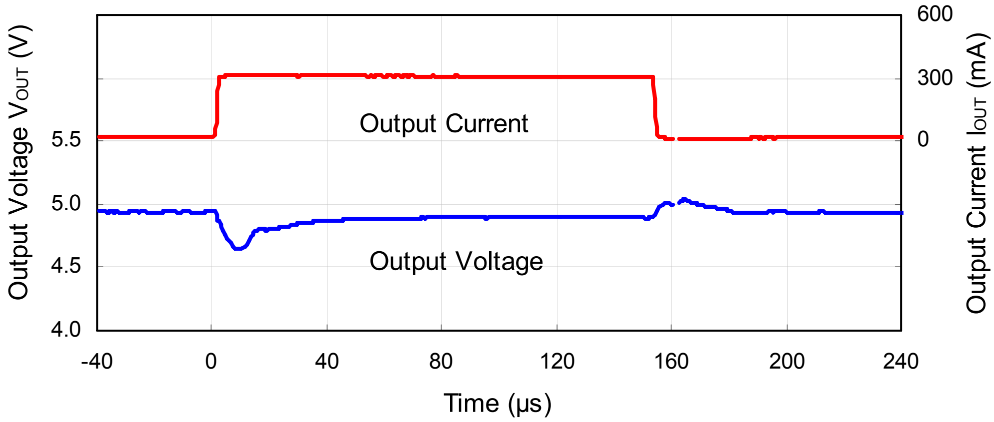
R1510S (VR=2.5V)

VDD=5.5V, CIN=2.2µF, COUT=6.8µF, IOUT=20mA to 300mA, tf,tr=1µs

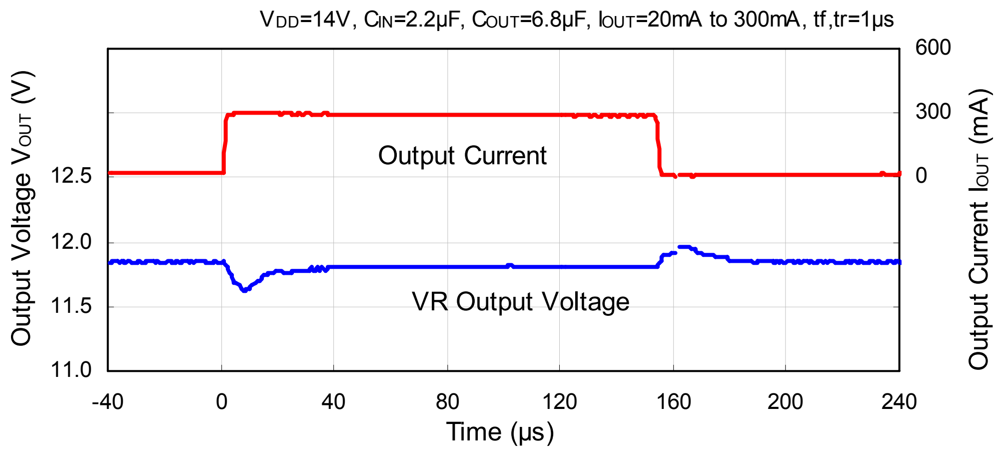


R1510S (VR=5.0V)

VDD=7V, CIN=2.2µF, COUT=6.8µF, IOUT=20mA to 300mA, tf,tr=1µs

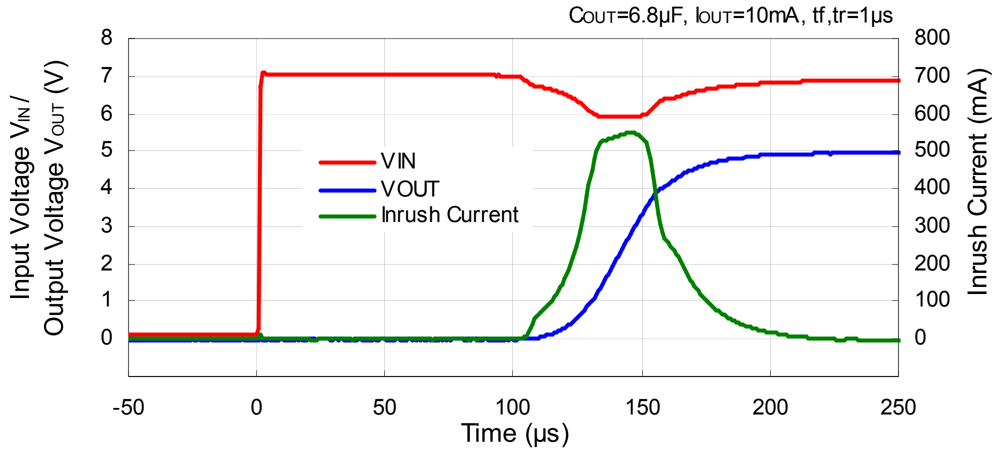


R1510S (VR=12.0V)



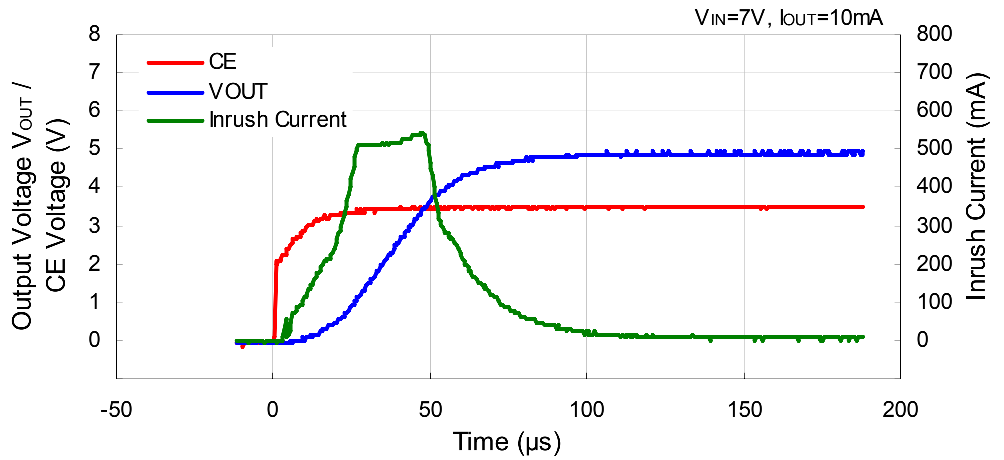
15) Start-up Waveform (Ta=25°C)

R1510SxxxB/C/D (VR=5.0V)



16) Start-up Waveform by CE (Ta=25°C)

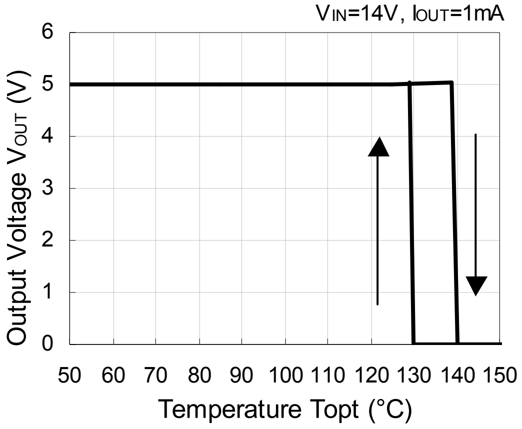
R1510SxxxA (VR=5.0V)



RICOH

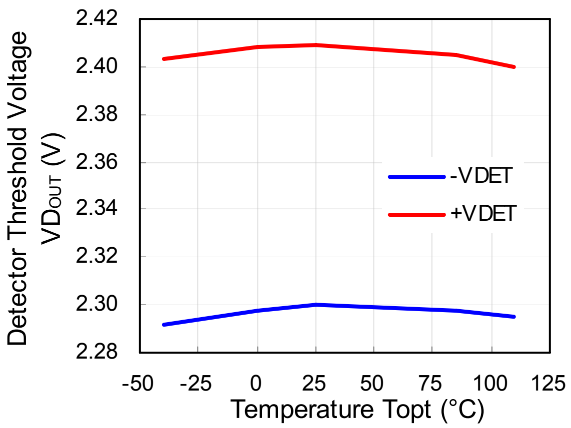
17) Thermal Shutdown

R1510S (VR=5.0V)

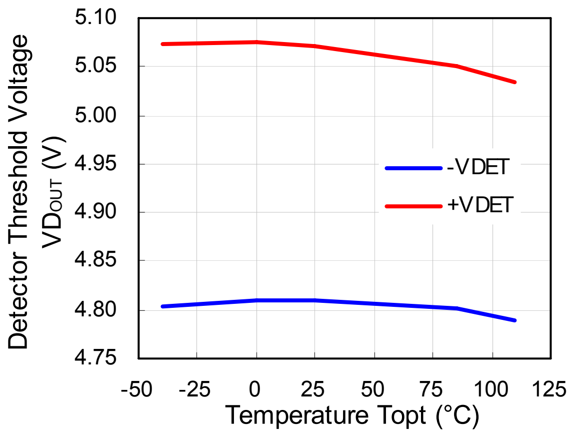


18) Detector Threshold Voltage Vs. Operating Temperature

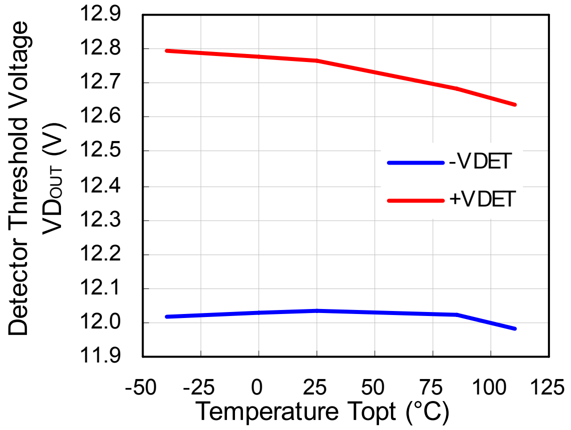
R1510S (VD=2.3V)



R1510S (VD=4.8V)

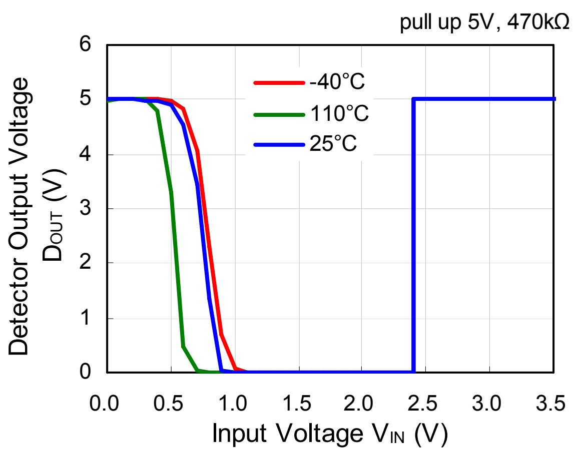


R1510S (VD=12.0V)

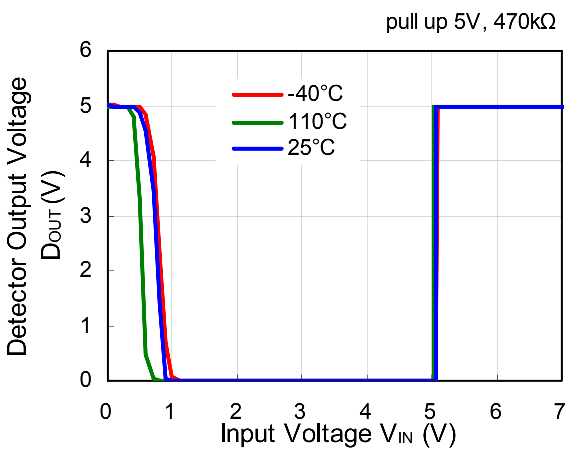


19) VD Output Voltage Vs. Input Voltage

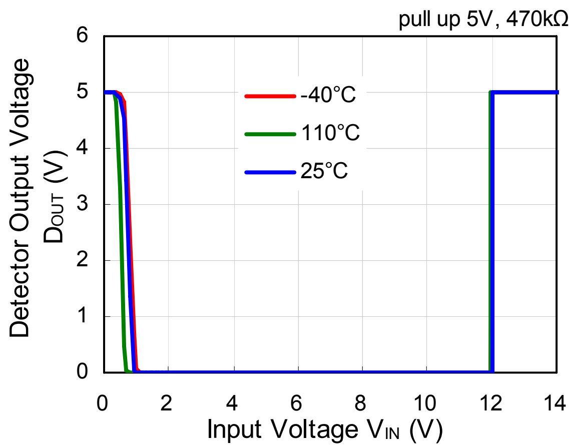
R1510SxxxA/C/D (VD=2.3V)



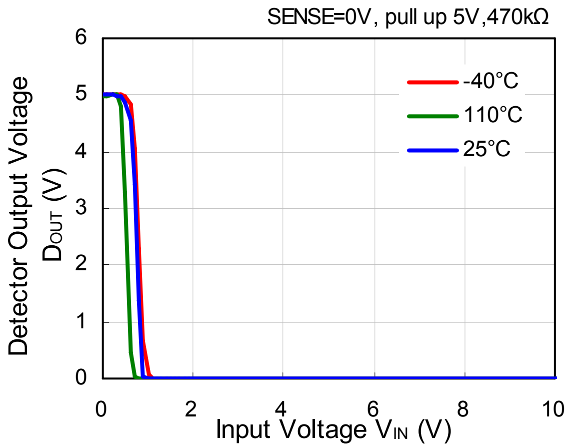
R1510SxxxA/C/D (VD=4.8V)



R1510SxxxA/C/D (VD=12.0V)

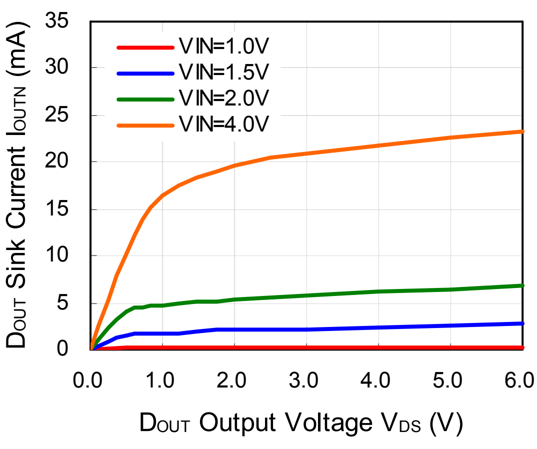


R1510SxxxB



20) D_{OUT} Sink Current Vs. D_{OUT} Output Voltage

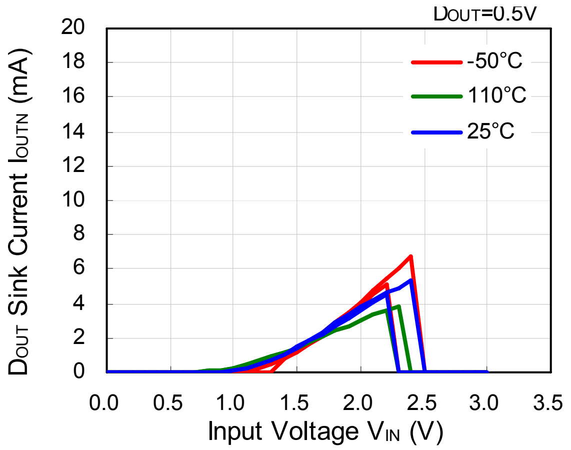
R1510S



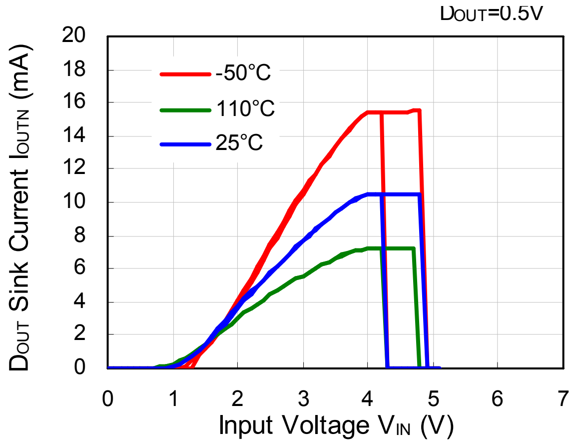
RICOH

21) D_{OUT} Sink Current Vs. Input Voltage

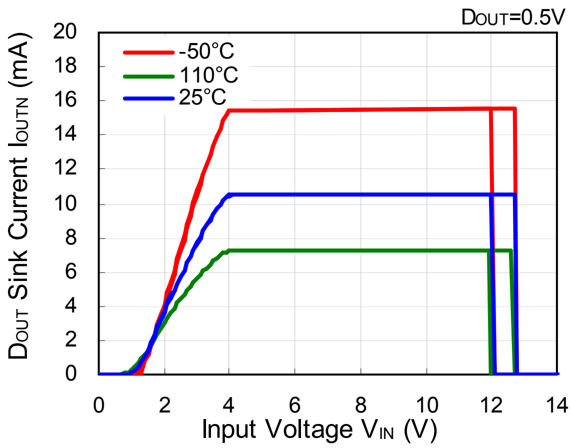
R1510S (VD=2.3V)



R1510S (VD=4.8V)

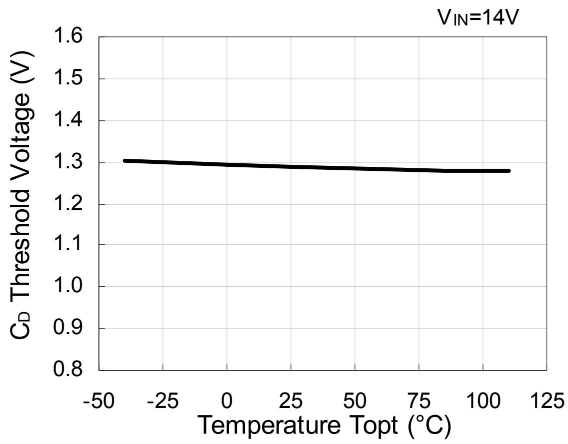


R1510S (VD=12.0V)



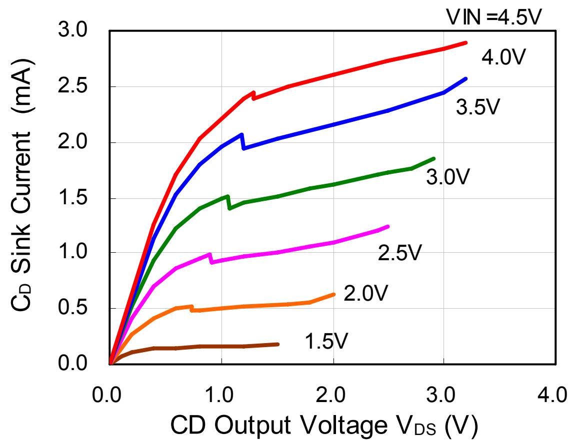
22) C_D Detector Threshold Vs. Operating Voltage

R1510SxxxC/D



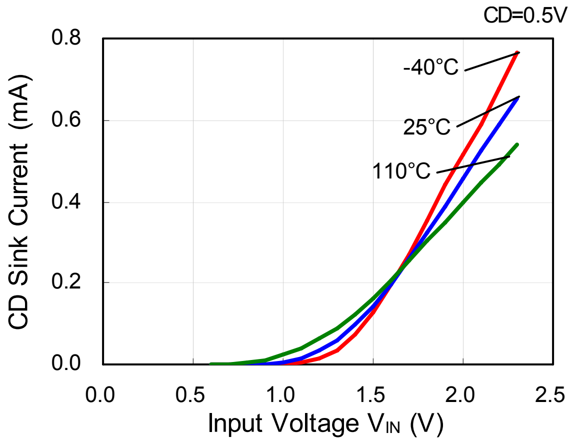
23) C_D Sink Current Vs. C_D Output Voltage

R1510SxxxC/D

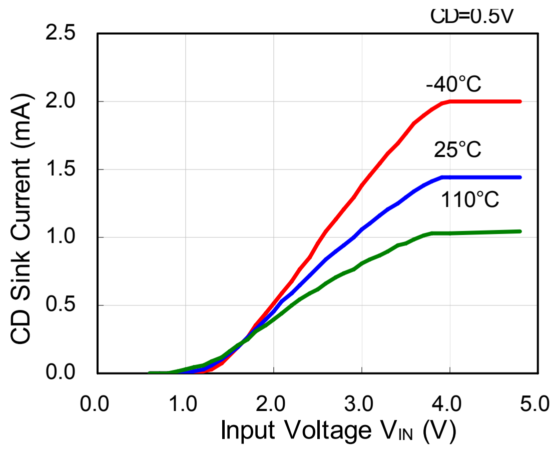


24) C_D Output Current Vs. Input Voltage

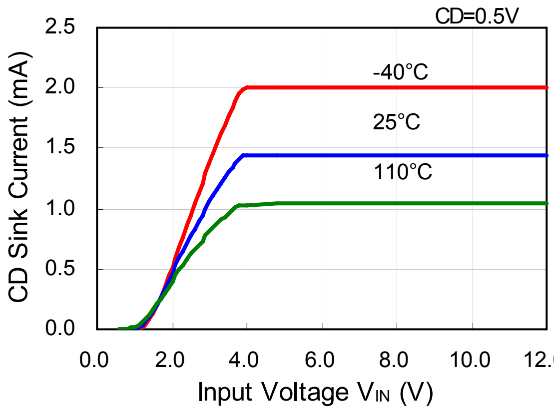
R1510SxxxC/D (VD=2.3V)



R1510SxxxC/D (VD=4.8V)

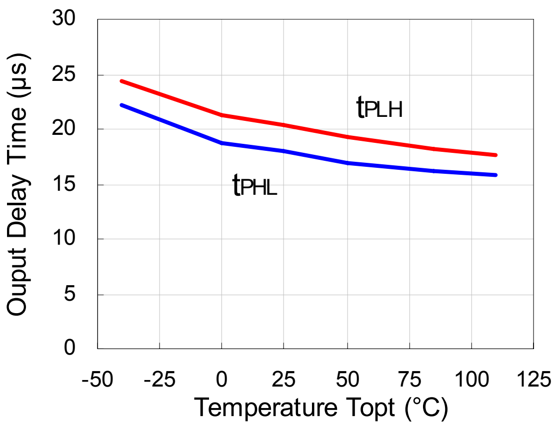


R1510SxxxC/D (VD=12.0V)



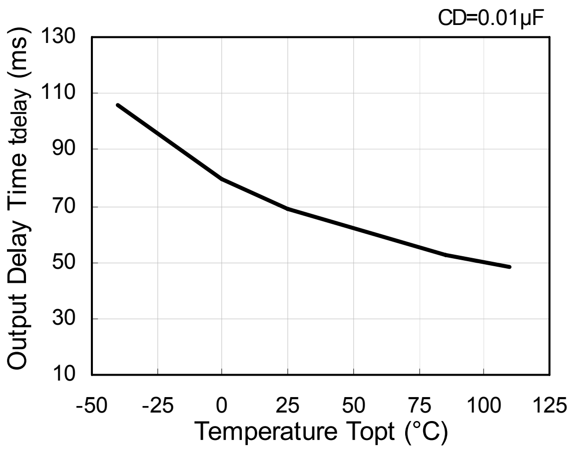
25) Output Delay Time Vs. Operating Temperature

R1510SxxxA/B



26) Release Output Delay Time Vs. Operating Temperature

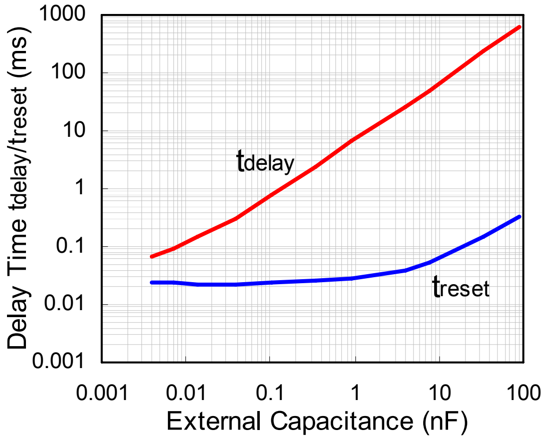
R1510SxxxC/D



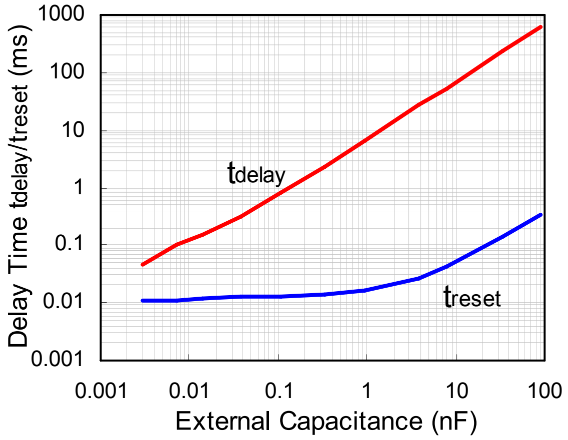
RICOH

27) Output Delay Time Vs. External Capacitance of Output Delay Pin

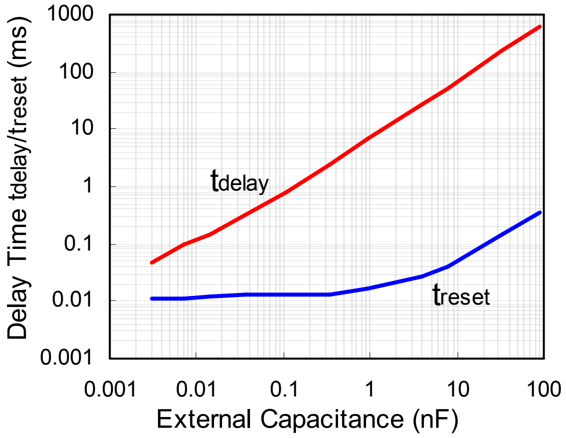
R1510SxxxC/D (VD=2.3V)



R1510SxxxC/D (VD=4.5V)



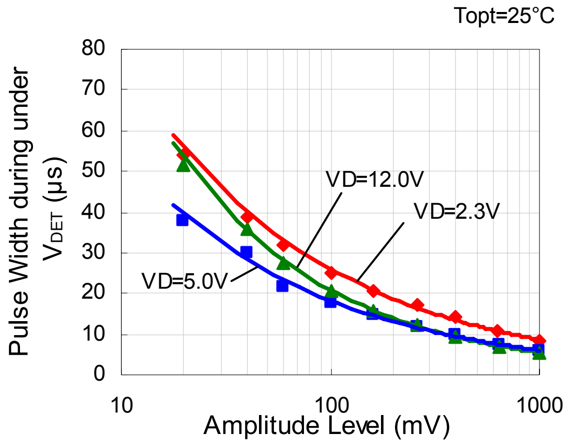
R1510SxxxC/D (VD=12.0V)

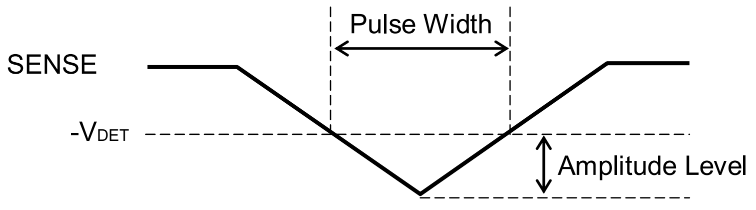


Detection Operation Glitch of SENSE Pin Voltage

The graph below shows that the pulse amplitude/ pulse width that can maintain the released condition when the pulse of less than the detector threshold voltage was input into SENSE pin.

R1510SxxxB





SENSE Input Waveform

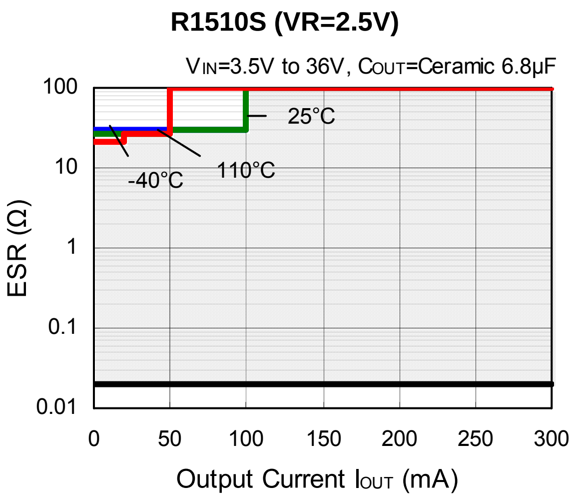
This graph shows the maximum pulse conditions that can maintain the released condition. Please be careful to the sizes of the pulse width and the pulse amplitude going into SENSE pin because if they are bigger than the sizes of the pulse width and the pulse amplitude in this graph, the reset signal may go off.

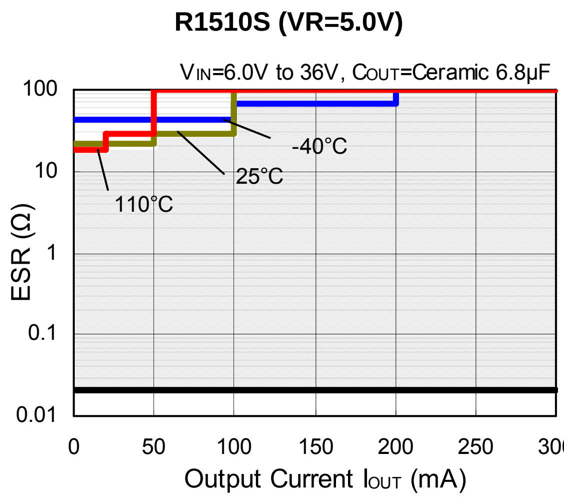
Equivalent Series Resistance Vs. Output Current

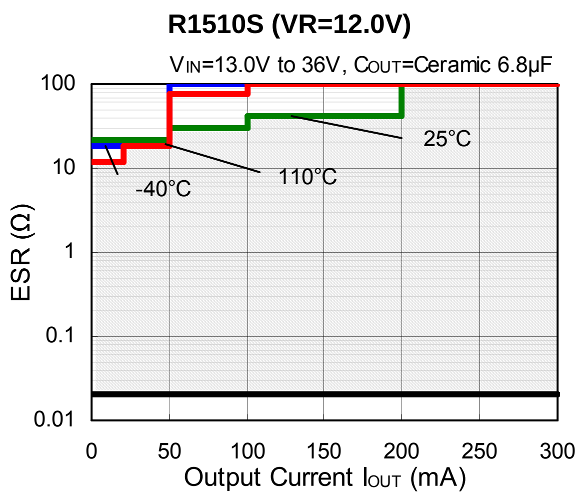
Ceramic type output capacitor is recommended for this series, however; low ESR type capacitor also could be used. For reference, the conditions below show the relationship between the output current (I_{OUT}) of which noise level is 40µV (average) or less and the ESR.

Measurement Conditions

- Noise Frequency Range: 10Hz to 2MHz
- Ambient Temperature: -40ºC to +110ºC
- Shaded Area: Noise level is 40µV (average) or less
- Output Capacitor: Ceramic 6.8µF







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■Ricoh awarded ISO 14001 certification.
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