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SII

S-1702 Series

SUPER-LOW CURRENT CONSUMPTION 150 mA VOLTAGE REGULATOR WITH BUILT-IN HIGH-ACCURACY VOLTAGE DETECTOR AND RESET INPUT FUNCTION

www.sii-ic.com

Rev.2.2_01

The S-1702 Series, developed based on CMOS technology, is a 150 mA output positive voltage regulator with a low dropout voltage, a high-accuracy output voltage, and low current consumption.
The S-1702 Series includes a voltage regulator with high-accuracy output voltage of ±1.0% allowing to use a ceramic capacitor of 1.0 µF or more, and a voltage detector that monitors the output/input voltage of the regulator. It also includes an overcurrent protection circuit that prevents the output current from exceeding the current capacitance of the output transistor and an output forcible discharge circuit for the regulator operation off.
Small SNT-6A package is available for the S-1702 Series. And an external small capacitor can be used, enabling high-density mounting. Its super-low current consumption makes the S-1702 Series ideal for mobile devices.

■ Features

Regulator block

- Output voltage: 1.5 V to 5.5 V, selectable in 0.05 V step
- Output voltage accuracy: ±1.0%
- Current consumption: Current consumption of regulator block: 9 µA typ., 16 µA max.
- Output current: Possible to output 150 mA ($V_{IN} \geq V_{OUT(S)} + 1.0$ V)*1
- Built-in overcurrent protection circuit: Limits overcurrent of output transistor.
- Built-in ON / OFF forcible discharge circuit: Ensures long battery life, discharges output load instantaneously.
- Ripple rejection: 70 dB typ. (f = 1.0 kHz)

Detector block

- Detection voltage: 1.3 V to 5.2 V, selectable in 0.05 V step
- Built-in high-accuracy voltage detection circuit: ±1.0%
  Monitoring output/input or monitoring external input by option (detector output)
- External reset input: Forcible assertion of detector output by external reset pin (RESX) input

Overall

- Correlation temperature gradient in the regulator and the detector blocks
- Current consumption: During operation*2: 10 µA typ., 18 µA max.
- Operation temperature range: Ta = −40°C to +85°C
- Lead-free (Sn 100%), halogen-free

***1.** Attention should be paid to the power dissipation of the package when the output current is large.
***2.** Excluding current flowing in pull-up and pull-down resistors connected to the ON / OFF or RESX pins

■ Applications

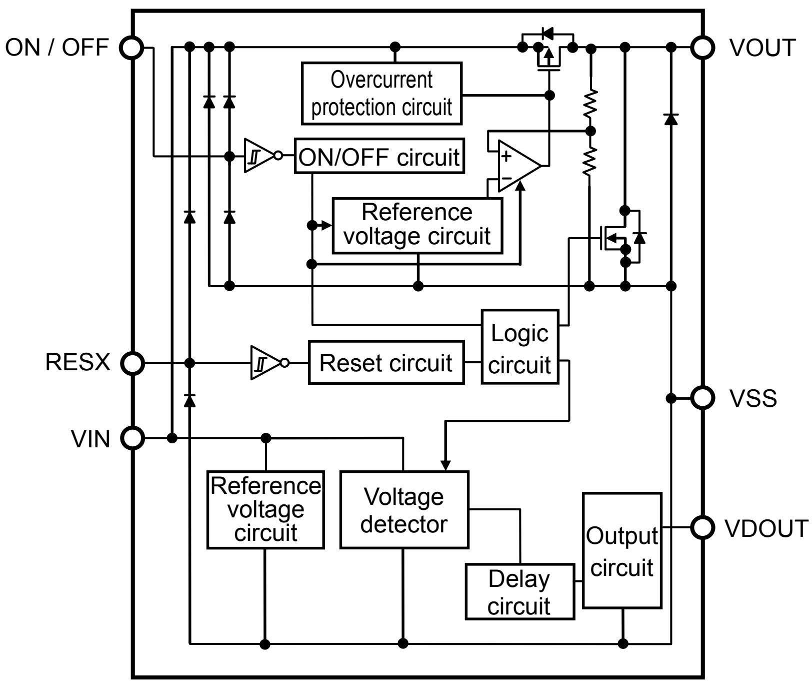
- Wireless power supply circuit block for cellular phone
- Power supply circuit block for health care product
- Power supply circuit block for various mobile device

■ Package

- SNT-6A

■ Block Diagrams

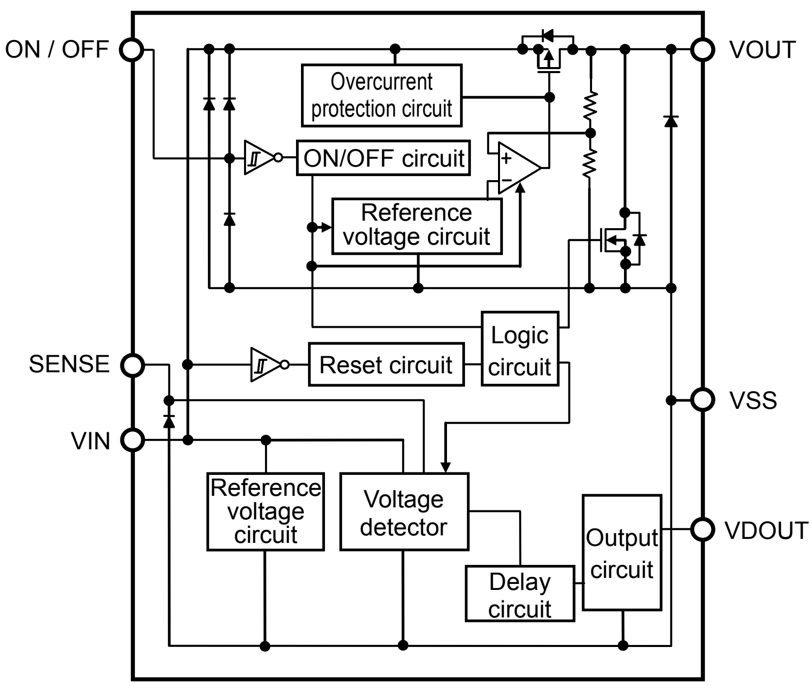
1. S-1702 Series A type to H type



Product Type	Detector Monitor Voltage	Discharge Shunt Function by ON / OFF and RESX Pins	
		Control by ON / OFF Pin	Control by RESX Pin
A	V_{OUT}	○	○
B	V_{OUT}	○	×
C	V_{OUT}	×	○
D	V_{OUT}	×	×
E	V_{IN}	○	○
F	V_{IN}	○	×
G	V_{IN}	×	○
H	V_{IN}	×	×

Figure 1

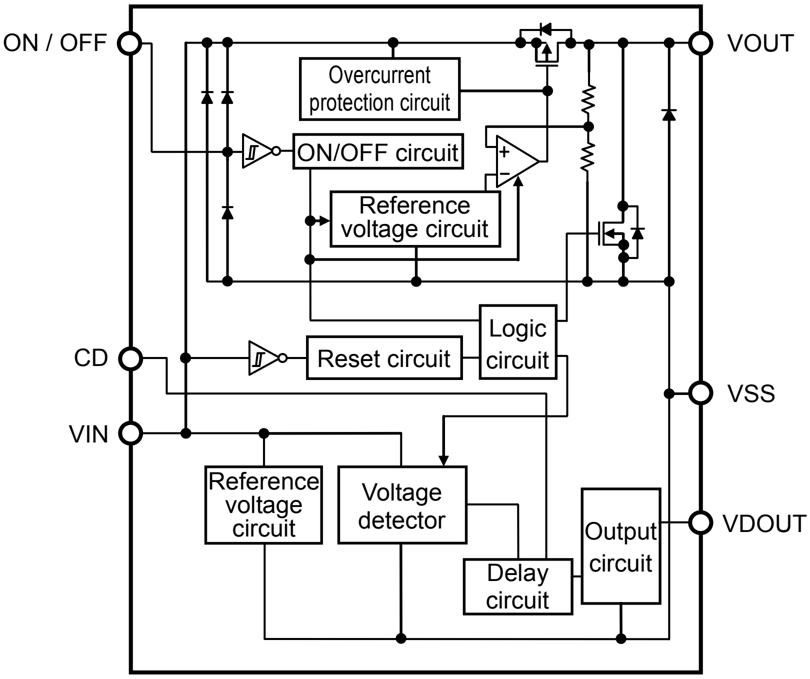
2. S-1702 Series J type and K type (external input detection type)



Product Type	Detector Monitor Voltage	Discharge Shunt Function by ON / OFF Pin
J	External input	○
K	External input	×

Figure 2

3. S-1702 Series L type to N type, P type (external delay type)



Product Type	Detector Monitor Voltage	Discharge Shunt Function by ON / OFF Pin
L	V_{OUT}	○
M	V_{OUT}	×
N	V_{IN}	○
P	V_{IN}	×

Figure 3

■ Product Name Structure

1. Product name

S-1702 x x x xx - I6T1 U

- U: Environmental code
  U : Lead-free (Sn 100%), halogen-free
- I6T1: Package abbreviation and IC packing specifications*1
  I6T1: SNT-6A, tape product
- xx: Output voltage value of regulator and detection voltage value of detector*2
  00 and 01 (two-digit numeric option code)
- x (third): Input type of RESX and ON / OFF pins*3
  A to H, J (one-digit alphabetical option code)
- x (second): Output type of VDOUT pin*4
  A to H, J (one-digit alphabetical option code)
- x (first): Product type*5
  A to H, J to N, P (one-digit alphabetical option code)

*1. Refer to the tape drawing.
*2. Refer to **Table 4** of **"2. Function list according to product type"**.
*3. Refer to **Table 3** of **"2. Function list according to product type"**.
*4. Refer to **Table 2** of **"2. Function list according to product type"**.
*5. Refer to **Table 1** of **"2. Function list according to product type"**.

2. Function list according to product type

Table 1 Product Types

Option Code	ON / OFF Pin Application	RESX Pin Application	Delay Type	Detector Monitor Voltage	Discharge Shunt Function	
					Control by ON / OFF Pin	Control by RESX Pin
A	ON / OFF	RESX	Internal	V_{OUT}	O	O
B	ON / OFF	RESX	Internal	V_{OUT}	O	×
C	ON / OFF	RESX	Internal	V_{OUT}	×	O
D	ON / OFF	RESX	Internal	V_{OUT}	×	×
E	ON / OFF	RESX	Internal	V_{IN}	O	O
F	ON / OFF	RESX	Internal	V_{IN}	O	×
G	ON / OFF	RESX	Internal	V_{IN}	×	O
H	ON / OFF	RESX	Internal	V_{IN}	×	×
J	ON / OFF	SENSE	Internal	V_{SENSE}	O	–
K	ON / OFF	SENSE	Internal	V_{SENSE}	×	–
L	ON / OFF	CD	External	V_{OUT}	O	–
M	ON / OFF	CD	External	V_{OUT}	×	–
N	ON / OFF	CD	External	V_{IN}	O	–
P	ON / OFF	CD	External	V_{IN}	×	–

Table 2 Output Types of VDOUT Pin

Option Code	Output Type	Hysteresis
A	Nch open drain output	5.0%
B	CMOS output (V_{OUT} drive)	5.0%
C	CMOS output (V_{IN} drive)	5.0%
D	Nch open drain output	2.5%
E	CMOS output (V_{OUT} drive)	2.5%
F	CMOS output (V_{IN} drive)	2.5%
G	Nch open drain output	None
H	CMOS output (V_{OUT} drive)	None
J	CMOS output (V_{IN} drive)	None

Table 3 Input Types of RESX and ON / OFF Pins

Option Code	RESX Pin	ON / OFF Pin
A	No pull-up/pull-down resistor	No pull-up/pull-down resistor
B	No pull-up/pull-down resistor	Pull-up
C	No pull-up/pull-down resistor	Pull-down
D	Pull-up	No pull-up/pull-down resistor
E	Pull-up	Pull-up
F	Pull-up	Pull-down
G	Pull-down	No pull-up/pull-down resistor
H	Pull-down	Pull-up
J	Pull-down	Pull-down

Table 4 Output Voltage Values of Regulator and Detection Voltage Values of Detector

Option Code	Output Voltage	Detection Voltage
00	3.1 V ±1.0%	2.75 V ±1.0%
01	3.1 V ±1.0%	2.60 V ±1.0%

Remark Please contact our sales office for products with an output voltage or detection voltage other than those specified above.

3. Package

Package Name	Drawing Code			
	Package	Tape	Reel	Land
SNT-6A	PG006-A-P-SD	PG006-A-C-SD	PG006-A-R-SD	PG006-A-L-SD

■ Pin Configuration

1. SNT-6A

Top view

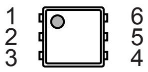


Figure 4

Table 5

Pin No.	Symbol	Description
1	VIN	Input voltage pin
2	ON / OFF	ON / OFF pin
3	RESX	External reset pin (S-1702Axx to Hxx)
	CD	External delay capacitor connection pin (S-1702Lxx to Nxx, Pxx)
	SENSE	Detector SENSE pin (S-1702Jxx, Kxx)
4	VSS	GND pin
5	VDOUT	Detector output voltage pin
6	VOUT	Regulator output voltage pin

■ Absolute Maximum Ratings

Table 6

(Ta = +25°C unless otherwise specified)

Item		Symbol	Absolute Maximum Rating	Unit
Input voltage		V_{IN}	V_{SS} − 0.3 to V_{SS} + 7.0	V
		$V_{ON / OFF}$	V_{SS} − 0.3 to V_{IN} + 0.3	V
		V_{RESX}	V_{SS} − 0.3 to V_{IN} + 0.3	V
		V_{CD}	V_{SS} − 0.3 to V_{IN} + 0.3	V
		V_{SENSE}	V_{SS} − 0.3 to V_{SS} + 7.0	V
Regulator output voltage		V_{OUT}	V_{SS} − 0.3 to V_{IN} + 0.3	V
Detector output voltage	Nch open drain output	V_{DOUT}	V_{SS} − 0.3 to V_{SS} + 7.0	V
	CMOS output		V_{SS} − 0.3 to V_{IN} + 0.3	V
Power dissipation		P_D	400*1	mW
Operation ambient temperature		T_{opr}	−40 to +85	°C
Storage temperature		T_{stg}	−40 to +125	°C

***1.** When mounted on board
[Mounted board]
(1) Board size : 114.3 mm × 76.2 mm × t1.6 mm
(2) Board name : JEDEC STANDARD51-7

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

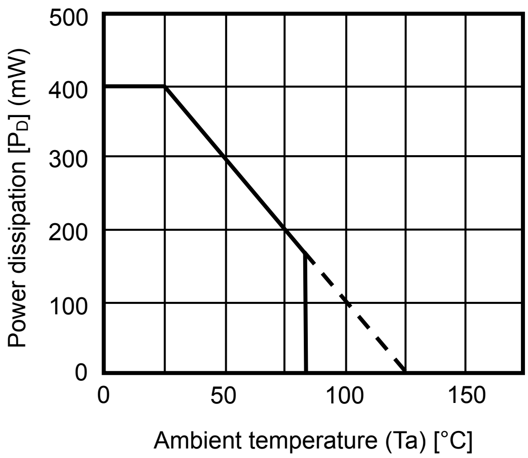


Figure 5 Power Dissipation of Package

■ Electrical Characteristics

1. Common to series (S-1702Axx to Hxx, Jxx to Nxx, Pxx)

Table 7 (1 / 2)

Entire circuit (Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Current consumption during operation*1	I_{SS}	$V_{IN} = V_{OUT(S)} + 1.0$ V	–	10	18	μA	2

Regulator block

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
Output voltage*2	$V_{OUT(E)}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, $I_{OUT} = 30$ mA		$V_{OUT(S)}$ ×0.99	$V_{OUT(S)}$	$V_{OUT(S)}$ ×1.01	V	1
Output current*3	I_{OUT}	$V_{IN} > V_{OUT(S)} + 1.0$ V		150*8	–	–	mA	3
Dropout voltage*4	V_{drop}	$I_{OUT} = 100$ mA	$1.5\text{ V} < V_{OUT(S)} \le 2.0\text{ V}$	–	0.54	0.58	V	1
			$2.0\text{ V} < V_{OUT(S)} \le 2.5\text{ V}$	–	0.23	0.35	V	1
			$2.5\text{ V} < V_{OUT(S)} \le 3.0\text{ V}$	–	0.2	0.3	V	1
			$3.0\text{ V} < V_{OUT(S)} \le 3.3\text{ V}$	–	0.15	0.23	V	1
			$3.3\text{ V} < V_{OUT(S)} \le 5.5\text{ V}$	–	0.14	0.21	V	1
Line regulation	$\frac{\Delta V_{OUT1}}{\Delta V_{IN} \cdot V_{OUT}}$	$V_{OUT(S)} + 0.5\text{ V} < V_{IN} < 6.5$ V, $I_{OUT} = 30$ mA		–	0.05	0.2	%/V	1
Load regulation	ΔV_{OUT2}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $10\ \mu\text{A} < I_{OUT} < 100$ mA		–	20	40	mV	1
Output voltage temperature coefficient *5	$\frac{\Delta V_{OUT}}{\Delta Ta \cdot V_{OUT}}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, $I_{OUT} = 30$ mA, $-40°\text{C} \le Ta \le +85°\text{C}$*9		–	±100	±300	ppm/°C	1
Current consumption during operation*1	I_{SS1}	$V_{IN} = V_{OUT(S)} + 1.0$ V, RESX and ON / OFF pins enabled for operation, no load		–	9	16	μA	2
Input voltage	V_{IN}	–		2	–	6.5	V	–
ON / OFF pin input voltage "H"	V_{SH1}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $R_L = 1.0$ kΩ		1.2	–	–	V	4
ON / OFF pin input voltage "L"	V_{SL1}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $R_L = 1.0$ kΩ		–	–	0.3	V	4
ON / OFF pin input current "H"	I_{SH1}	$V_{IN} = 6.5$ V, $V_{ON / OFF} = 6.5$ V	S-1702xxA	−0.1	–	0.1	μA	4
			S-1702xxD	−0.1	–	0.1	μA	4
			S-1702xxG	−0.1	–	0.1	μA	4
ON / OFF pin input current "L"	I_{SL1}	$V_{IN} = 6.5$ V, $V_{ON / OFF} = 0$ V	S-1702xxA	−0.1	–	0.1	μA	4
			S-1702xxD	−0.1	–	0.1	μA	4
			S-1702xxG	−0.1	–	0.1	μA	4
Ripple rejection	$\lvert RR \rvert$	$V_{IN} = V_{OUT(S)} + 1.0$ V, f = 1.0 kHz, $\Delta V_{rip} = 0.5$ Vrms, $I_{OUT} = 30$ mA	$1.5\text{ V} \le V_{OUT(S)} < 3.1\text{ V}$	–	70	–	dB	5
			$3.1\text{ V} \le V_{OUT(S)} \le 5.5\text{ V}$	–	65	–	dB	5
Short-circuit current	I_{SHORT}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON / OFF pin enabled for operation, $V_{OUT} = 0$ V		–	300	–	mA	5

Table 7 (2 / 2)

Detector block (Ta = +25°C unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
Detection voltage*6	$-V_{DET}$	–		$-V_{DET(S)}$ ×0.99	$-V_{DET(S)}$	$-V_{DET(S)}$ ×1.01	V	6
Hysteresis width	V_{HYS}	S-1702xAx, S-1702xBx, S-1702xCx		$-V_{DET}$ ×0.035	$-V_{DET}$ ×0.05	$-V_{DET}$ ×0.065	V	6
		S-1702xDx, S-1702xEx, S-1702xFx		$-V_{DET}$ ×0.01	$-V_{DET}$ ×0.025	$-V_{DET}$ ×0.04	V	6
		S-1702xGx, S-1702xHx, S-1702xJx		–	0	$-V_{DET}$ ×0.015	V	6
Current consumption during operation*1	I_{SS2}	1.3 V ≤ $-V_{DET(S)}$ < 2.3 V	$V_{IN} = -V_{DET(S)} + 1.5$ V	–	2.4	4.0	μA	2
			V_{IN} = 5.5 V	–	2.6	4.5	μA	2
		2.3 V ≤ $-V_{DET(S)}$ < 5.2 V	$V_{IN} = -V_{DET(S)} + 1.5$ V	–	2.2	3.5	μA	2
			V_{IN} = 5.5 V	–	2.3	4.0	μA	2
Input voltage	V_{IN}	–		0.8	–	6.5	V	–
Detection voltage temperature coefficient*7	$\frac{\Delta -V_{DET}}{\Delta Ta \bullet -V_{DET}}$	Ta = –40°C to +85°C*9		–	±100	±400	ppm/°C	6

***1.** Excluding current flowing in pull-up and pull-down resistors connected to the ON / OFF or RESX pins

***2.** $V_{OUT(S)}$: Set output voltage
$V_{OUT(E)}$: Actual output voltage
Output voltage when fixing I_{OUT} (= 30 mA) and inputting $V_{OUT(S)}$ + 1.0 V

***3.** The output current at which the output voltage becomes 95% of $V_{OUT(E)}$ after gradually increasing the output current.

***4.** $V_{drop} = V_{IN1} - (V_{OUT3} \times 0.98)$
V_{OUT3} is the output voltage when $V_{IN} = V_{OUT(S)} + 1.0$ V and I_{OUT} = 100 mA.
V_{IN1} is the input voltage at which the output voltage becomes 98% of V_{OUT3} after gradually decreasing the input voltage.

***5.** A change in the temperature of the regulator output voltage [mV/°C] is calculated using the following equation.

$$\frac{\Delta V_{OUT}}{\Delta Ta}\ [\text{mV/°C}]^{*1} = V_{OUT(S)}\ [\text{V}]^{*2} \times \frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\ [\text{ppm/°C}]^{*3} \div 1000$$

***1.** Change in temperature of output voltage
***2.** Set output voltage
***3.** Output voltage temperature coefficient

***6.** $-V_{DET(S)}$: Set detection voltage
$-V_{DET}$: Actual detection voltage

***7.** A change in the temperature of the detector detection voltage [mV/°C] is calculated using the following equation.

$$\frac{\Delta -V_{DET}}{\Delta Ta}\ [\text{mV/°C}]^{*1} = -V_{DET(S)}\ (\text{Typ.})\ [\text{V}]^{*2} \times \frac{\Delta -V_{DET}}{\Delta Ta \bullet -V_{DET}}\ [\text{ppm/°C}]^{*3} \div 1000$$

***1.** Change in temperature of detection voltage
***2.** Set detection voltage
***3.** Detection voltage temperature coefficient

***8.** The output current can be at least this value.
Due to restrictions on the package power dissipation, this value may not be satisfied. Attention should be paid to the power dissipation of the package when the output current is large. This specification is guaranteed by design.

***9.** Since products are not screened at high and low temperatures, the specification for this temperature range is guaranteed by design, not tested in production.

2. Discharge shunt circuit (discharge shunt function) (S-1702Axx, Bxx, Cxx, Exx, Fxx, Gxx, Jxx, Lxx, Nxx)

Table 8

(Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
"L" output, Nch on resistor	R_{LOW}	V_{DS} = 0.5 V, V_{GS} = 6.5 V	–	100	–	Ω	3

3. Detector output circuit (VDOUT pin)

Table 9

Nch open drain output (S-1702xAx, xDx, xGx) (Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Output current	I_{DOUT1}	Output transistor: Nch, V_{DS} = 0.5 V, V_{DD} = 1.2 V	1.36	2.55	–	mA	7
Leakage current	I_{LEAK}	Output transistor: Nch, V_{DS} = 5.5 V, V_{DD} = 5.5 V	–	–	100	nA	7

CMOS output (S-1702xBx, xCx, xEx, xFx, xHx, xJx)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Output current	I_{DOUT2}	Output transistor: Nch, V_{DS} = 0.5 V, V_{IN} = 1.2 V	1.36	2.55	–	mA	7
	I_{DOUT3}	Output transistor: Pch, V_{DS} = 0.5 V, V_{IN} = 5.5 V	1.71	2.76	–	mA	8

4. RESX pin (S-1702Axx, Bxx, Cxx, Dxx, Exx, Fxx, Gxx, Hxx)

Table 10

(Ta = +25°C unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
RESX pin input voltage "H"*1	V_{SH2}	V_{IN} = $V_{OUT(S)}$ + 1.0 V, R_L = 1.0 kΩ		1.2	–	–	V	4
RESX pin input voltage "L"	V_{SL2}	V_{IN} = $V_{OUT(S)}$ + 1.0 V, R_L = 1.0 kΩ		–	–	0.3	V	4
RESX pin input current "H"	I_{SH2}	V_{IN} = 6.5 V, V_{RESX} = 6.5 V	S-1702xxA	−0.1	–	0.1	μA	4
			S-1702xxB	−0.1	–	0.1	μA	4
			S-1702xxC	−0.1	–	0.1	μA	4
RESX pin input current "L"	I_{SL2}	V_{IN} = 6.5 V, V_{RESX} = 0 V	S-1702xxA	−0.1	–	0.1	μA	4
			S-1702xxB	−0.1	–	0.1	μA	4
			S-1702xxC	−0.1	–	0.1	μA	4

***1.** $V_{OUT(S)}$: set output voltage value

5. Pull-up / pull-down resistor value of ON / OFF pin and RESX pin (S-1702xxB, xxC, xxD, xxE, xxF xxG, xxH, xxJ)

Table 11

(Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Pull-up / pull-down resistor	R_{PULL}	–	–	2.0	–	MΩ	4

6. Response time

Table 12

Internal delay type (S-1702Axx, Bxx, Cxx, Dxx, Exx, Fxx, Gxx, Hxx, Jxx, Kxx) (Ta = +25°C unless otherwise specified)

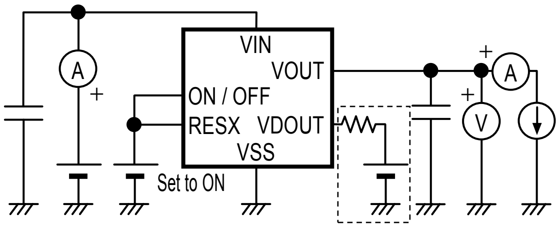
Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Response time	T_{PLH1}	–	–	–	90	μs	6

External delay type (S-1702Lxx, Mxx, Nxx, Pxx)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Response time	T_{PLH2}	C_D = 4.7 nF	–	30	–	ms	9

■ Test Circuits

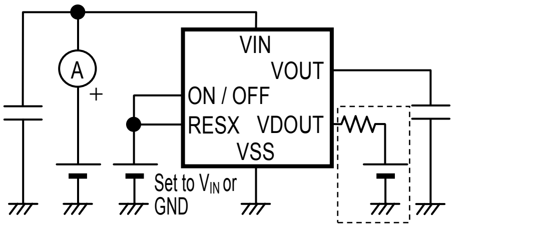
1.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 6

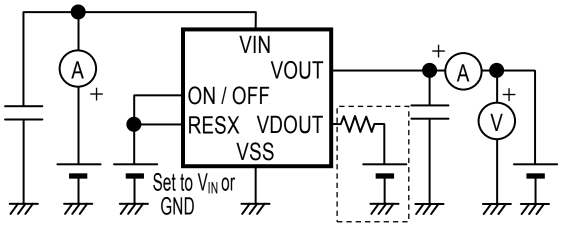
2.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 7

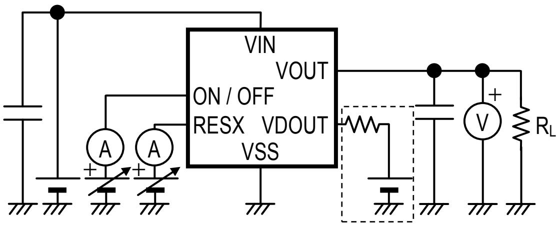
3.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 8

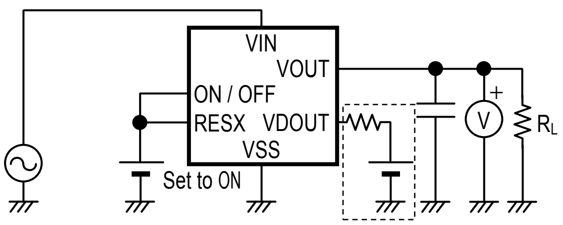
4.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 9

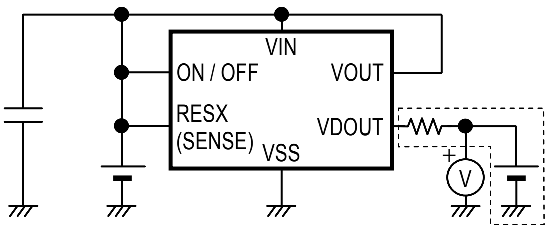
5.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 10

6.



The portion enclosed by dotted lines is not required for CMOS output products.

Figure 11

7.

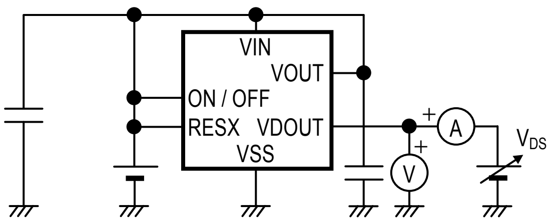


Figure 12

8.

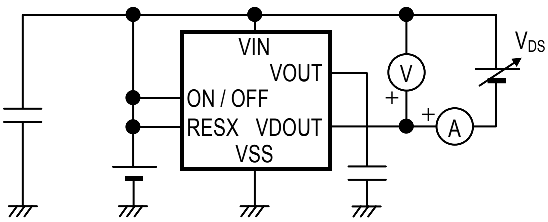
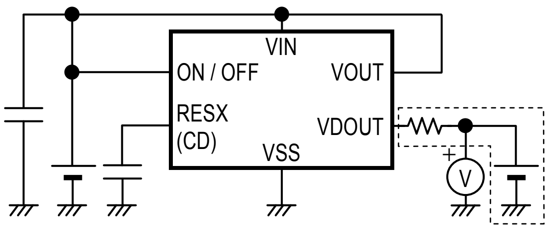


Figure 13

9.

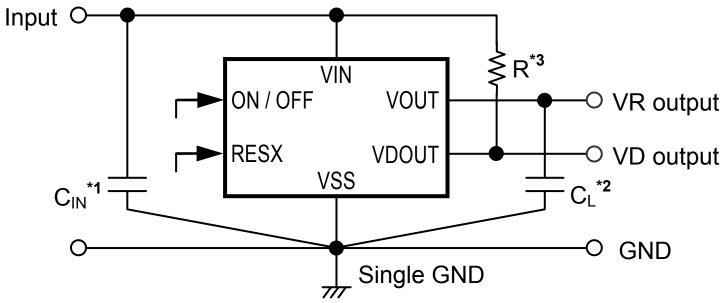


The portion enclosed by dotted lines is not required for CMOS output products.

Figure 14

■ Standard Circuits

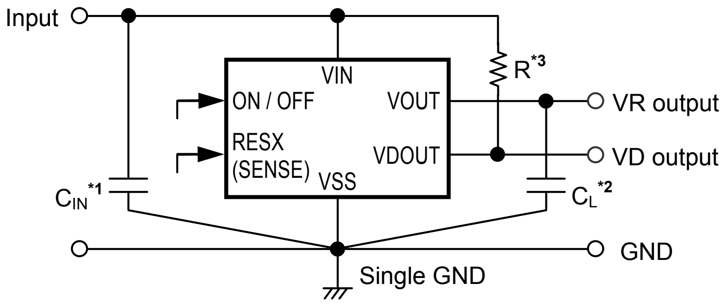
1. S-1702Axx, Bxx, Cxx, Dxx, Exx, Fxx, Gxx, Hxx



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A ceramic capacitor of 1.0 μF or more can be used for C_L.
***3.** R is not required for a CMOS output product.

Figure 15

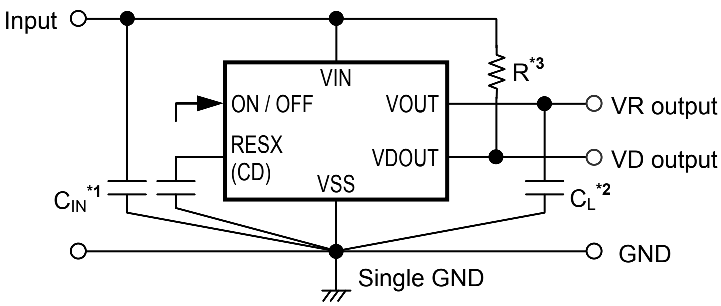
2. S-1702Jxx, Kxx



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A ceramic capacitor of 1.0 μF or more can be used for C_L.
***3.** R is not required for a CMOS output product.

Figure 16

3. S-1702Lxx, Mxx, Nxx, Pxx



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A ceramic capacitor of 1.0 μF or more can be used for C_L.
***3.** R is not required for a CMOS output product.

Figure 17

Caution The above connection diagrams and constants will not guarantee successful operation. Perform thorough evaluation using the actual application to set the constants.

■ Condition of Application

Input capacitor (C_{IN}):	1.0 μF or more
Output capacitor (C_L):	1.0 μF or more
ESR of output capacitor:	10 Ω or less

Caution Generally a series regulator may cause oscillation, depending on the selection of external parts. Confirm that no oscillation occurs in the application for which the above capacitors are used.

■ Selection of VIN Input and VOUT Output Capacitors (C_{IN}, C_L)

The S-1702 Series requires an output capacitor (C_L) between the VOUT and VSS pins for phase compensation. A ceramic capacitor with a capacitance of 1.0 μF or more provides a stable operation in all temperature ranges. When using an OS capacitor, a tantalum capacitor, or an aluminum electrolytic capacitor, a capacitance must be 1.0 μF or more, and the ESR must be 10 Ω or less.
The output overshoot and undershoot values, which are transient response characteristics, vary depending on the output capacitor value. The required capacitance value for the input capacitor differs depending on the application.
The recommended application values are $C_{IN} \geq 1.0$ μF and $C_L \geq 1.0$ μF; however, perform thorough evaluation using the actual device, including evaluation of temperature characteristics.

■ Explanation of Terms

1. Regulator block

1. 1 Low dropout voltage regulator

This voltage regulator has the low dropout voltage due to its built-in low on-resistance transistor.

1. 2 Low ESR

A capacitor whose ESR (Equivalent Series Resistance) is low. The S-1702 Series enables use of a low ESR capacitor, such as a ceramic capacitor, for the output-side capacitor (C_L). A capacitor whose ESR is 10 Ω or less can be used.

1. 3 Output voltage (V_{OUT})

The accuracy of the output voltage is ensured at ±1.0% under the specified conditions of fixed input voltage*1, fixed output current, and fixed temperature.

***1.** Differs depending on the product.

Caution If the above conditions change, the output voltage value may vary and exceed the accuracy range of the output voltage. Refer to "■ Electrical Characteristics" and "■ Characteristics (Typical Data)" for details.

1. 4 Line regulation $\left(\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}\right)$

Indicates the dependency of the output voltage on the input voltage. That is, the values show how much the output voltage changes due to a change in the input voltage with the output current remaining unchanged.

1. 5 Load regulation (ΔV_{OUT2})

Indicates the dependency of the output voltage on the output current. That is, the values show how much the output voltage changes due to a change in the output current with the input voltage remaining unchanged.

1. 6 Dropout voltage (V_{drop})

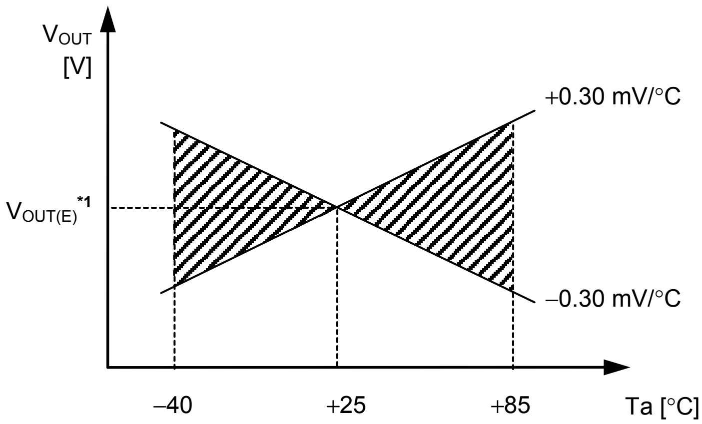
Indicates the difference between input voltage (V_{IN1}) and the output voltage when; decreasing input voltage (V_{IN}) gradually until the output voltage has dropped out to the value of 98% of output voltage (V_{OUT3}), which is at $V_{IN} = V_{OUT(S)} + 1.0$ V.

$V_{drop} = V_{IN1} - (V_{OUT3} \times 0.98)$

1. 7 Output voltage temperature coefficient $\left(\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\right)$

The shaded area in **Figure 18** is the range where V_{OUT} varies in the operation temperature range when the output voltage temperature coefficient is ±100 ppm/°C (Refer to ***5** of **Table 7** for how to calculate the temperature change of the output voltage [mV/°C]).

Example of V_{OUT} = 3.0 V typ. product



***1.** $V_{OUT(E)}$ is the value of the output voltage measured at Ta = +25°C.

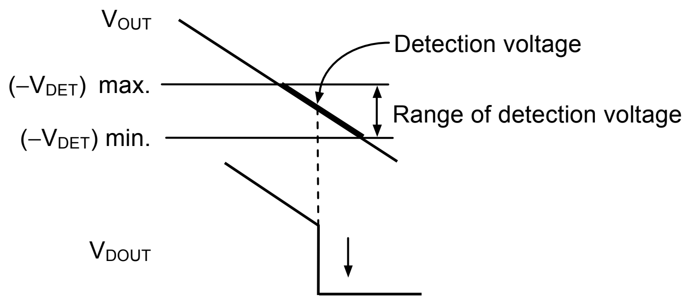
Figure 18

2. Detector block

2. 1 Detection voltage ($-V_{DET}$)

The detection voltage ($-V_{DET}$) is a voltage when the detector output voltage (V_{DOUT}) switches to low. This detection voltage varies slightly depending on products even having the same specification. The range between the minimum ($-V_{DET}$) value and the maximum ($-V_{DET}$) value due to variation is called the range of detection voltage (refer to **Figure 19**).

e.g. In a product with $-V_{DET}$ = 3.0 V, the detection voltage is a value in the range of 2.97 V ≤ ($-V_{DET}$) ≤ 3.03 V. This means that some products have 2.97 V for $-V_{DET}$ and some have 3.03 V.



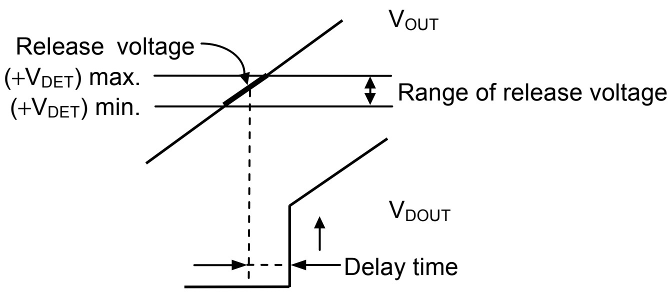
Remark This is the case when the regulator output voltage (V_{OUT}) is monitored by the detector.

Figure 19 Detection Voltage ($-V_{DET}$)

2. 2 Release voltage ($+V_{DET}$)

The release voltage ($+V_{DET}$) is a voltage when the detector output voltage (V_{DOUT}) switches to high. This release voltage varies slightly depending on products even having the same specification. The range between the minimum ($+V_{DET}$) value and the maximum ($+V_{DET}$) value due to variation is called the range of release voltage (refer to **Figure 20**).

e.g. In a product with $-V_{DET}$ = 3.0 V and hysteresis width of 5%, the release voltage is a value in the range of 3.074 V ≤ ($+V_{DET}$) ≤ 3.227 V.
This means that some products have 3.074 V for $+V_{DET}$ and some have 3.227 V.



Remark This is the case when the regulator output voltage (V_{OUT}) is monitored by the detector.

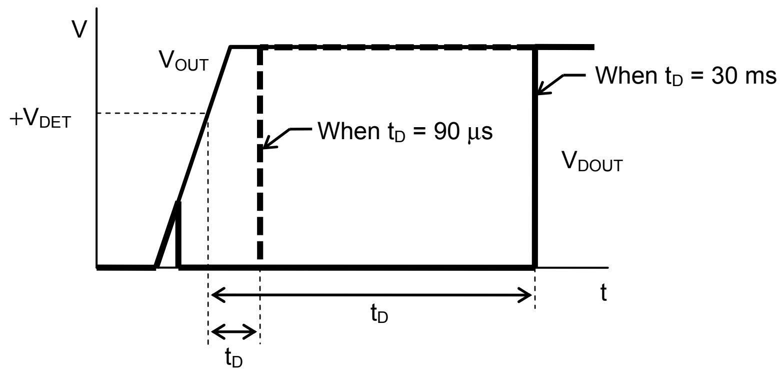
Figure 20 Release Voltage ($+V_{DET}$)

2. 3 Hysteresis width (V_{HYS})

The hysteresis width is the difference between the detection voltage and the release voltage. Setting the hysteresis width prevents malfunction caused by noise on the input voltage. The hysteresis width is internally fixed and varies depending on the product type for details, refer to **"Table 2 Output Types of VDOUT Pin"**.

2. 4 Delay time (t_D)

The delay time (t_D) is a period from the input voltage flowing to the detector block has exceeded the release voltage ($+V_{DET}$), until the detector output voltage (V_{DOUT}) inverts.
The internal delay type products (S-1702Axx, Bxx, Cxx, Dxx, Exx, Fxx, Gxx, Hxx, Jxx, Kxx) have delay time which is internally fixed.
In external delay type products (S-1702Lxx, Mxx, Nxx, Pxx), the delay time (t_D) can be changed by controlling the capacitance value of the capacitor (C_D) connected between the CD (RESX) and VSS pins.
For how to set the delay time (t_D), refer to **"3. 2 Delay circuit"** in **"3. Detector block" in "■ Operation"**.



Remark This is the case when the regulator output voltage (V_{OUT}) is monitored by the detector.

Figure 21

2. 5 Through-type current

This is the current that flows instantaneously when the voltage detector detects and releases a voltage.
A large through-type current flows in CMOS output products (S-1702xBx, xCx, xEx, xFx, xHx, xJx).
A small through-type current flows in Nch open drain products (S-1702xAx, xDx, xGx).

2. 6 Oscillation

In applications where a resistor is connected to the input side (**Figure 22**), the through-type current which is generated when the detector output voltage (V_{DOUT}) goes from low to high (release) causes a voltage drop equal to Through-type current × Input resistance across the resistor. When the input voltage drops below the detection voltage as a result, the detector output voltage (V_{DOUT}) goes from high to low. In this state, the through-type current stops, its resultant voltage drop disappears, and the detector output voltage (V_{DOUT}) goes from low to high. The through-type current is then generated again, a voltage drop appears, and repeating the process finally induces oscillation.

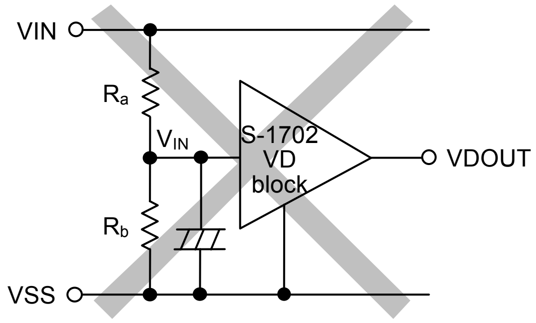


Figure 22 Example of Bad Implementation of Detection Voltage Changer

2. 7 Detection voltage temperature characteristics

The shaded area in **Figure 23** is the range where $-V_{DET}$ varies within the operation temperature range when the detection voltage temperature coefficient is ±100 ppm/°C (Refer to ***7** of **Table 7** for how to calculate the temperature change of the detection voltage [mV/°C]).

Example of $-V_{DET}$ = 3.0 V typ. product

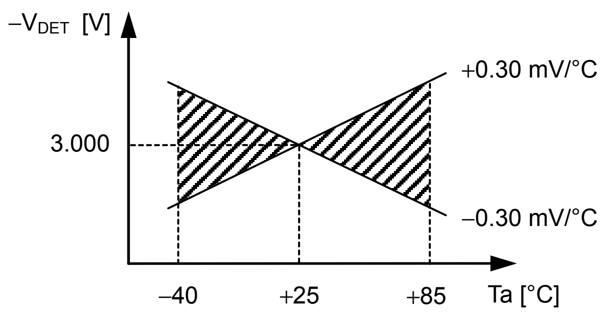


Figure 23

2. 8 Release voltage temperature characteristics

The temperature change $\frac{\Delta +V_{DET}}{\Delta Ta}$ of the release voltage is calculated by the temperature change $\frac{\Delta -V_{DET}}{\Delta Ta}$ of the detection voltage as follows:

$$\frac{\Delta +V_{DET}}{\Delta Ta} = \frac{+V_{DET}}{-V_{DET}} \times \frac{\Delta -V_{DET}}{\Delta Ta}$$

The temperature changes of the release voltage and the detection voltage consequently have the same sign.

2. 9 Hysteresis voltage temperature characteristics

The temperature change of the hysteresis voltage is expressed as $\frac{\Delta +V_{DET}}{\Delta Ta} - \frac{\Delta -V_{DET}}{\Delta Ta}$ and is calculated as follows:

$$\frac{\Delta +V_{DET}}{\Delta Ta} - \frac{\Delta -V_{DET}}{\Delta Ta} = \frac{V_{HYS}}{-V_{DET}} \times \frac{\Delta -V_{DET}}{\Delta Ta}$$

■ Operation

1. Control of S-1702 Series by using ON / OFF and RESX pins

1. 1 Starting and stopping regulator block

The regulator block can be started and stopped according to the combination of the ON / OFF and RESX pins.
The regulator block switches off the output transistor between the VIN pin and VOUT pin and reduces current consumption significantly.
The detector block is operating during this period, so only the amount of current consumed by the detector block flows in the S-1702 Series.

1. 2 Regulator output (V_{OUT}) control: discharge shunt function [*1]

The regulator output (V_{OUT}) can be controlled by combining the ON / OFF and RESX pins.
In the product types having a discharge shunt circuit[*1] (Axx, Bxx, Cxx, Exx, Fxx, Gxx, Jxx, Lxx, Nxx), this circuit forcibly sets the regulator output (V_{OUT}) the V_{SS} level[*1].
In the product types that do not have a discharge shunt circuit[*1] (Dxx, Hxx, Kxx, Mxx, Pxx), the regulator output (V_{OUT}) is set at the V_{SS} level by a division resistor of several MΩ between the VOUT pin and VSS pin.

***1.** For details of a discharge shunt circuit, refer to **"2. 2. 2 Discharge shunt function"** in **"2. Regulator Block"**.

1. 3 Detector output voltage (V_{DOUT}) control: forcible assertion function

The detector output voltage (V_{DOUT}) is forcibly asserted to the V_{SS} level by combining the ON / OFF and RESX pins.
When the forcible assertion function is not being used, the result of detection by the detector (release status: "H", detection status: "L") is output from the VDOUT pin.

1. 4 Operation of each function according to ON / OFF and RESX pins

The following shows the operation of each function according to the combination of the ON / OFF and RESX pin.

Table 13

S-1702Axx, Exx

ON / OFF Pin	RESX Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	"L"	Stops	Forcibly discharged	V_{SS} potential
"L"	"H"	Stops	Forcibly discharged	V_{SS} potential
"H"	"L"	Stops	Forcibly discharged	V_{SS} potential
"H"	"H"	Starts	Set value	"H" or "L"

S-1702Bxx, Fxx

ON / OFF Pin	RESX Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	"L"	Stops	Forcibly discharged	V_{SS} potential
"L"	"H"	Stops	Forcibly discharged	V_{SS} potential
"H"	"L"	Starts	Set value	V_{SS} potential
"H"	"H"	Starts	Set value	"H" or "L"

S-1702Cxx, Gxx

ON / OFF Pin	RESX Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	"L"	Stops	Forcibly discharged	V_{SS} potential
"L"	"H"	Stops	Not forcibly discharged	"H" or "L"
"H"	"L"	Stops	Forcibly discharged	V_{SS} potential
"H"	"H"	Starts	Set value	"H" or "L"

S-1702Dxx, Hxx

ON / OFF Pin	RESX Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	"L"	Stops	Not forcibly discharged	V_{SS} potential
"L"	"H"	Stops	Not forcibly discharged	"H" or "L"
"H"	"L"	Starts	Set value	V_{SS} potential
"H"	"H"	Starts	Set value	"H" or "L"

S-1702Jxx, Lxx, Nxx

ON / OFF Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	Stops	Forcibly discharged	V_{SS} potential
"H"	Starts	Set value	"H" or "L"

S-1702Kxx, Mxx, Pxx

ON / OFF Pin	Regulator Block	Regulator Output (V_{OUT})	Detector Output (V_{DOUT})
"L"	Stops	Not forcibly discharged	"H" or "L"
"H"	Starts	Set value	"H" or "L"

1. 5 Equivalent circuits of ON / OFF and RESX pins

The ON / OFF and RESX pins are internally fixed to any one of three states; pulled-up (via a pull-up resistor), pulled-down (via a pull-down resistor), or neither pulled-up nor pulled-down (no down pull-up / pull-down resistor). For details, refer to "**Table 3 Input Types of RESX and ON / OFF Pins**". The equivalent circuits are shown below.

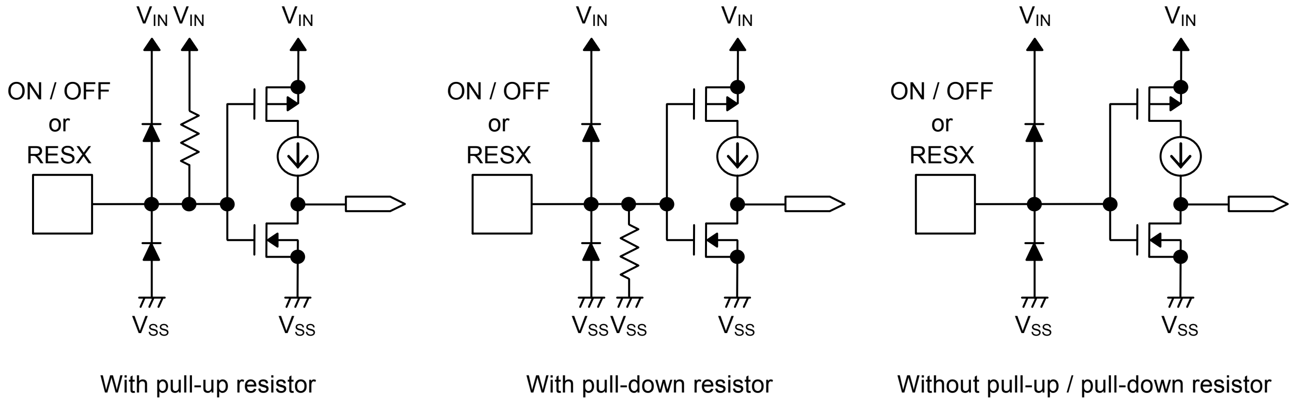


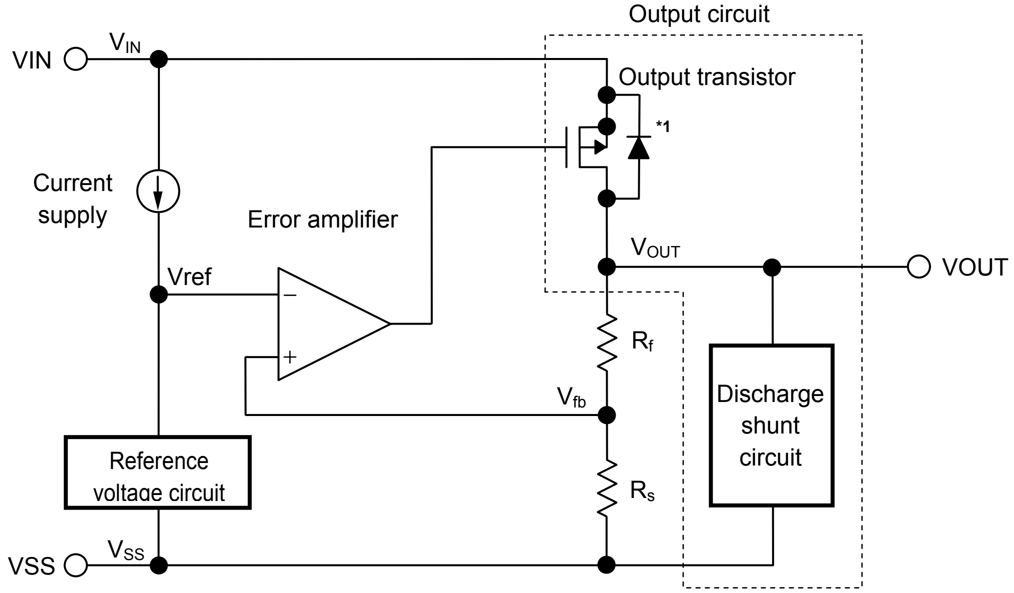
Figure 24 Equivalent Circuits of ON / OFF and RESX Pins

Caution In product without pull-up / pull-down resistor, do not use the ON / OFF and RESX pins in a floating status.
Note that applying voltage of 0.3 V to 1.2 V may increase current consumption.

2. Regulator block

2. 1 Basic operation

Figure 25 shows a block diagram of the regulator block.
The error amplifier compares the reference voltage (V_{ref}) with feedback voltage (V_{fb}), which is the output voltage resistance-divided by feedback resistors (R_s and R_f). It supplies the gate voltage necessary to maintain the constant output voltage which is not influenced by the input voltage and temperature change, to the output transistor.
The regulator output voltage (V_{OUT}) of the S-1702 Series can be selected from a value between 1.5 V and 5.5 V.

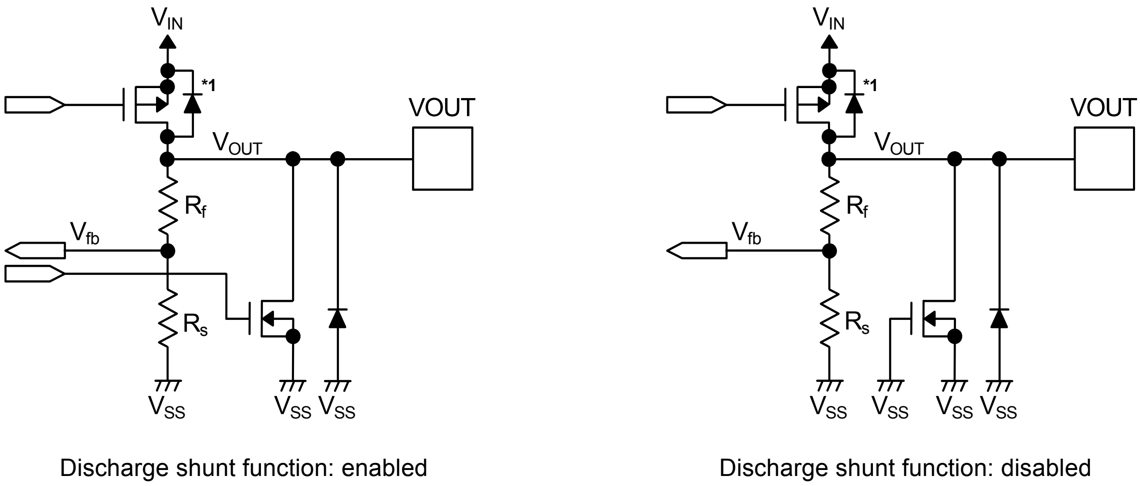


***1.** Parasitic diode

Figure 25

2. 2 Output circuit

The output circuit of the regulator block consists of an output transistor and a discharge shunt circuit.
The discharge shunt function is enabled or disabled for the VOUT pin. Refer to **"Table 1 Product Types"** for details. The equivalent circuits are shown below.



***1.** Parasitic diode

Figure 26 Equivalent Circuits of VOUT Pin

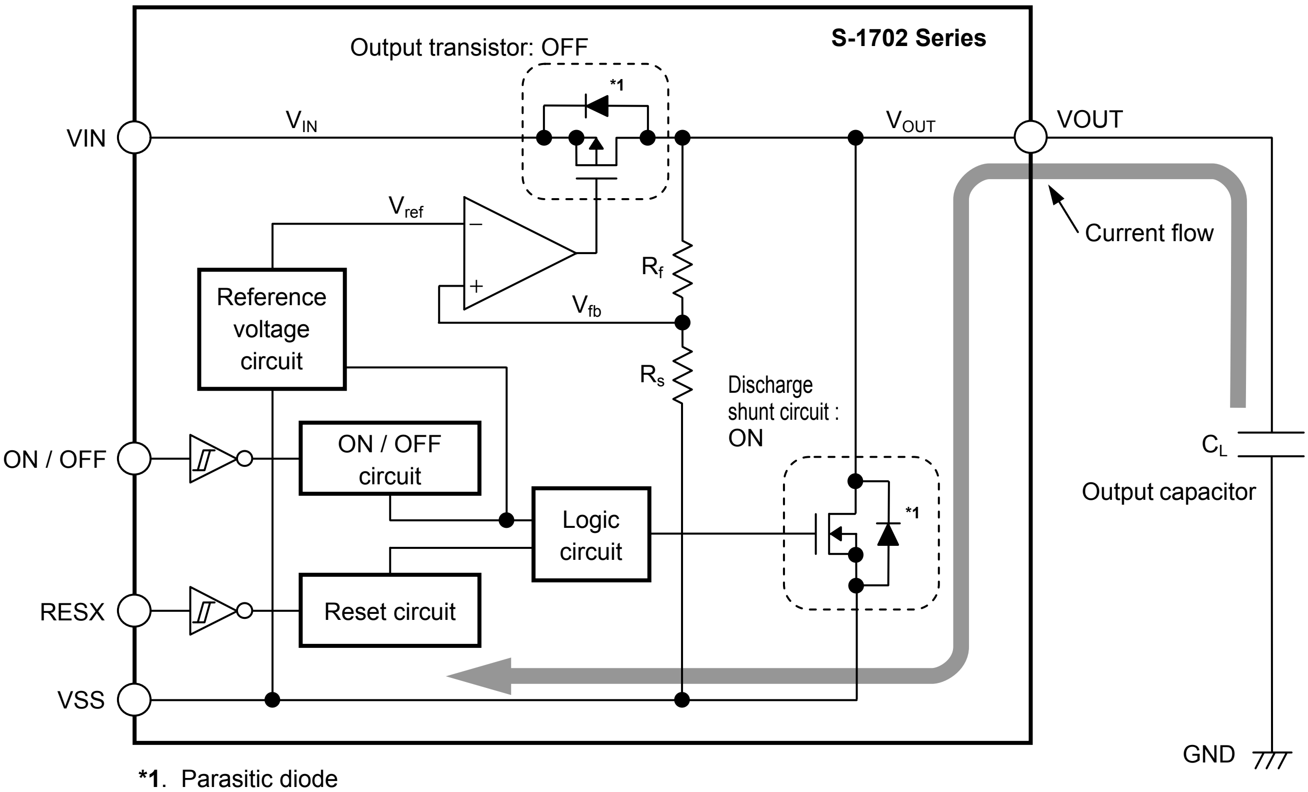
2. 2. 1 Output transistor

The S-1702 Series regulator block uses a low on-resistance Pch MOS FET transistor as the output transistor.

Caution Be sure that V_{OUT} does not exceed V_{IN} + 0.3 V to prevent the voltage regulator from being damaged due to inverse current flowing from the VOUT pin through a parasitic diode to the VIN pin, when the potential of V_{OUT} became higher than V_{IN}.

2. 2. 2 Discharge shunt function

The discharge shunt function is enabled in the S-1702Axx, Bxx, Cxx, Exx, Fxx, Gxx, Jxx, Lxx, and Nxx.
When the regulator block is stopped, the output transistor is turned off and the discharge shunt circuit is turned on according to the combination of the ON / OFF and the RESX pins.
This operation causes the charge in the output capacitor (C_L) to be discharged, and forcibly sets the VOUT pin the V_{SS} level.
The VOUT pin is set at the V_{SS} level in a shorter time than the S-1702Dxx, Hxx, Kxx, Mxx, and Pxx, because they disable the discharge shunt function.



*1. Parasitic diode

Figure 27 Discharge Shunt Function