HIGH WITHSTAND-VOLTAGE VOLTAGE REGULATOR WITH RESET FUNCTION

S-87X Series

The S-87X is a series of low-power high withstand-voltage regulators with a reset function, which integrates high-precision voltage detection and voltage regulation circuits on a single chip. The S-87X Series has higher withstand-voltage characteristic and higher accuracy of detection voltage and output voltage, ±2.4% respectively. The S-87X Series has also lineups for lithium-ion battery packs.

■ Features

- Accuracy of output voltage: ±2.4%
  2.6V to 5.8V (0.1V step)
- Accuracy of detection voltage: ±2.4%
  (For the S-87XXXXF Series, the release voltage ±1.1%)
  2.1V to 11.3V (0.1V step)
- Low I/O voltage difference:
  0.15 V typ. at IOUT=30 mA, VOUT=5.0 V
  0.45 V typ. at IOUT=30 mA, VOUT=3.0 V
- Low current consumption: Operation: 8µA max.
  Power off : 3.5µA max. (Available for the S-87XXXXC/E/G Series)
- Wide operating voltage range: 24 V max.
- Wide operating temperature range:
  -40°C to +85°C
- Built-in delay circuit or power off circuit
- Small package: SOT-89-5
- Built-in short-circuit protection

■ Applications

- Constant voltage power supply or reset circuit of battery-powered equipment, VTR, camera, communications equipment and others.
- Lithium-ion secondary battery pack

■ Pin Assignment

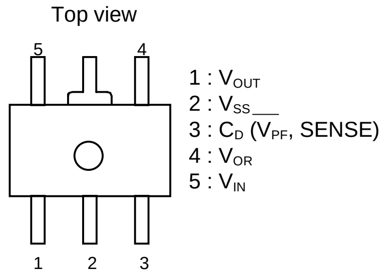


Figure 1 Pin Assignment

■ Pin Description

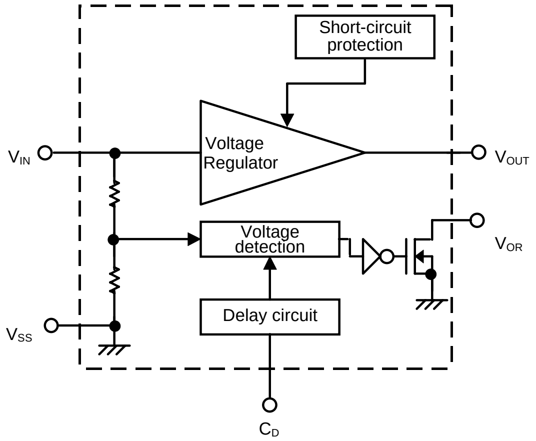
Table 1

Pin No.	Name	Description
1	V_{OUT}	Voltage output pin of voltage regulator
2	V_{SS}	Ground
3	C_D	Connection pin of external capacitor for delay of voltage detector
	$\overline{V_{PF}}$	Input pin of power off circuit
	SENSE	Voltage monitoring pin of voltage detector
4	V_{OR}	Output pin of voltage detector (Nch opendrain output)
5	V_{IN}	Positive power-supply

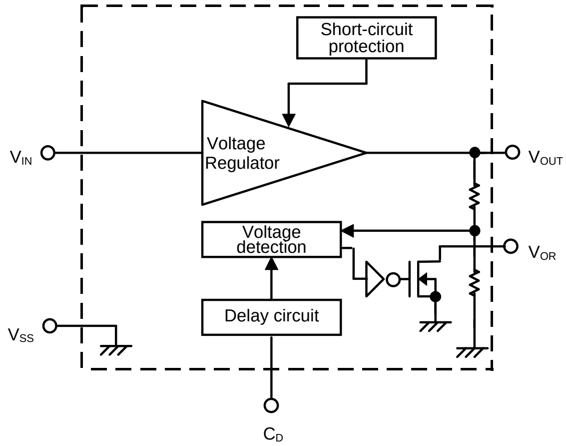
■ Block Diagram

1. Product Name

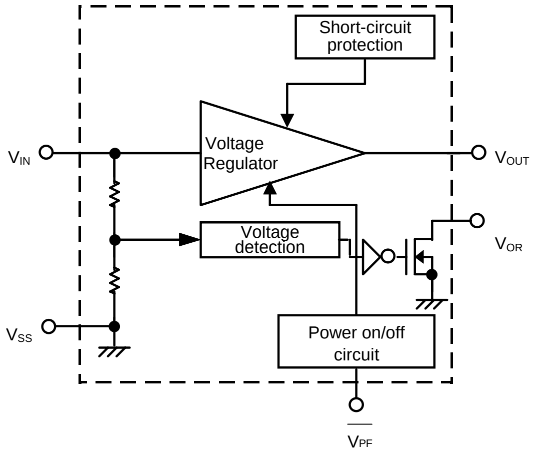
1) Built-in Delay Circuit, V_{IN} Detection
(S-87XXXXA/F Series)



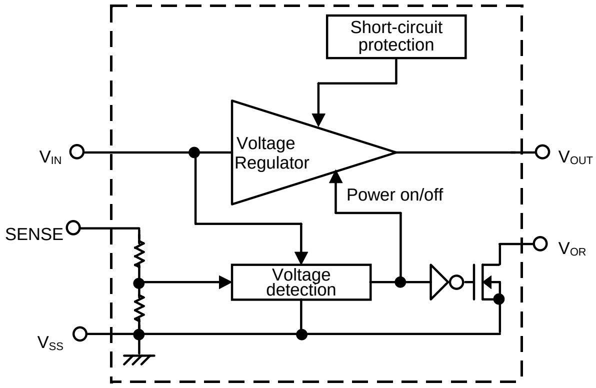
2) Built-in Delay Circuit, V_{OUT} Detection
(S-87XXXXB Series)



3) Built-in power off Circuit (for regulator)
V_{IN} Detection (S-87XXXXC Series)



4) Built-in Power ON/OFF (for regulator)
SENSE Detection (S-87XXXXE Series)



5) Built-in power off Circuit (for regulator)
V_{OUT} Detection (S-87XXXXG Series)

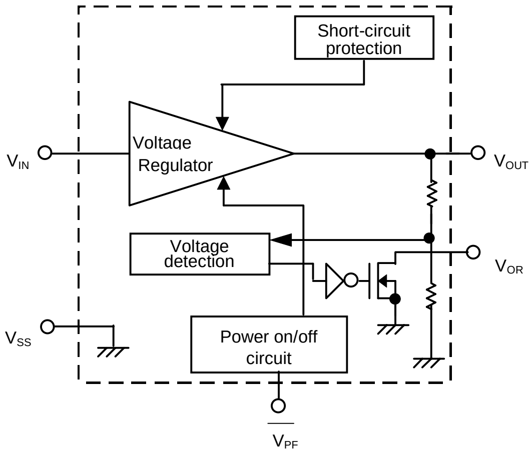


Figure 2 Block Diagram

■ Selection Guide

1. Series Selection

Table 2

Series name	Voltage detector (VD)	Detection voltage accuracy (%)	Release voltage accuracy (%)	Built-in delay circuit	Power off function	
					VR	VD
S-87XXXXA	Detects V_{IN}	±2.4	--	Yes	No	No
S-87XXXXB	Detects V_{OUT}	±2.4	--	Yes	No	No
S-87XXXXC	Detects V_{IN}	±2.4	--	No	Yes	No
S-87XXXXE	Detects SENSE	±2.4	--	No	Yes	No
S-87XXXXF	Detects V_{IN}	--	±1.1	Yes	No	No
S-87XXXXG	Detects V_{OUT}	±2.4	--	No	Yes	No

2. Product Name

Example:

S-875045BUP-AAA-T2

- T2: Taping
- AAA: Abbreviation (product marking)
- B: Function
- 45: Detection voltage of voltage detector x 10
- 50: Output voltage of voltage regulator x 10

3. Product List

Table 3

VR output voltage	VD detection voltage	S-87XXXXA Series	S-87XXXXB Series	S-87XXXXC Series	S-87XXXXG Series
5.6V	3.5V	--	S-875635BUP-AGA-T2	--	
5.2V	9.4V			S-875294CUP-AHC-T2	
5.2V	7.1V	--	--	S-875271CUP-AHA-T2	
5.2V	5.5V			S-875255CUP-AHB-T2	
5.0V	11.0V	--	--	S-8750B0CUP-ACG-T2	
5.0V	7.7V	--	--	S-875077CUP-ACF-T2	
5.0V	6.1V	--	--	S-875061CUP-ACH-T2	
5.0V	4.5V	S-875045AUP-AAA-T2	S-875045BUP-ABA-T2	S-875045CUP-ACA-T2	
5.0V	4.3V	S-875043AUP-AAB-T2	S-875043BUP-ABB-T2	S-875043CUP-ACB-T2	
5.0V	4.1V	S-875041AUP-AAC-T2	S-875041BUP-ABC-T2	S-875041CUP-ACC-T2	
5.0V	3.9V	S-875039AUP-AAD-T2	S-875039BUP-ABD-T2	S-875039CUP-ACD-T2	
5.0V	3.7V	S-875037AUP-AAE-T2	S-875037BUP-ABE-T2	S-875037CUP-ACE-T2	S-875037GUP-ANE-T2
3.3V	6.1V	--	--	S-873361CUP-AOH-T2	
3.3V	2.5V	--	S-873325BUP-ALA-T2	--	
3.0V	6.9V	--	--	S-873069CUP-AFF-T2	
3.0V	5.9V	--	--	S-873059CUP-AFG-T2	
3.0V	2.5V	S-873025AUP-ADA-T2	S-873025BUP-AEA-T2	S-873025CUP-AFA-T2	
3.0V	2.4V	S-873024AUP-ADB-T2	S-873024BUP-AEB-T2	S-873024CUP-AFB-T2	
3.0V	2.3V	S-873023AUP-ADC-T2	S-873023BUP-AEC-T2	S-873023CUP-AFC-T2	
3.0V	2.2V	S-873022AUP-ADD-T2	S-873022BUP-AED-T2	S-873022CUP-AFD-T2	
3.0V	2.1V	S-873021AUP-ADE-T2	S-873021BUP-AEE-T2	S-873021CUP-AFE-T2	

VR output voltage	VD detection voltage	S-87XXXXE Series
5.0V	7.7V	S-875077EUP-AJF-T2
5.0V	6.1V	S-875061EUP-AJH-T2
3.3V	3.0V	S-873330EUP-APB-T2
3.0V	8.2V	S-873082EUP-AMC-T2
3.0V	6.2V	S-873062EUP-AMB-T2

VR output voltage	VD detection voltage	S-87XXXXE Series
VR output voltage	VD detection voltage	S-87XXXXF Series
5.0V	8.7V	S-875087FUP-AKA-T2

Note In the S-87XXXXB/S-87XXXXG Series, When the output voltage of the voltage regulator is close to the detection voltage of the voltage detector, the transient response of the voltage regulator may cause false detection. Please take transient response into account when deciding voltages.

■ Absolute Maximum Ratings

Table 4

Parameter	Symbol	Ratings	Unit
Input voltage *	V_{IN}, V_{PF}	26	V
Output voltage	V_{OUT}	V_{IN}+0.3 to V_{SS}-0.3	V
Output voltage of voltage detector	V_{OR}	V_{SS}-0.3 to 26	V
Power dissipation	P_D	500	mW
Operating temperature	T_{opr}	-40 to +85	°C
Storage temperature	T_{stg}	-40 to +125	°C

* Even pulse (msec) noise exceeding the above input voltage (26 V) may damage the IC. Observe the rated input voltage (26 V).

■ Electrical Characteristics

1. S-8750XXA/B Series

Table 5

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions	Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator							
Output voltage	V_{OUT}	V_{IN}=7 V, I_{OUT}=30 mA	4.88	5.00	5.12	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA	--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6 to 24 V, I_{OUT}=30 mA	--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7 V, I_{OUT}=50 µA to 40 mA	--	15	50	mV	1
Input voltage	V_{IN}		--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7 V, I_{OUT}=30 mA, Ta=-40°C to +85°C	--	±0.38	±1.52	mV/°C	1
Voltage Detector							
Operating voltage	V_{SEN}		1.3	--	24	V	2
Delay time*1	t_{pd}	C_D=4.7 nF	15	27	41	ms	3
Temp. characteristic of $-V_{DET}$	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	--	±0.5	±2.0	mV/°C	2
Detection voltage	$-V_{DET}$	S-875045A/B	4.392	4.50	4.608	V	2
		S-875043A/B	4.196	4.30	4.404	V	2
		S-875041A/B	4.001	4.10	4.199	V	2
		S-875039A/B	3.806	3.90	3.994	V	2
		S-875037A/B	3.611	3.70	3.789	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V, V_{IN}=1.3 V	0.25	0.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=2.4 V	1.50	2.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V	--	--	0.1	µA	4
Hysteresis width	V_{HYS}	S-875045A/B	$-V_{DET}$ ×0.01	--	$-V_{DET}$ ×0.025	V	2
		S-875043A/B, 41A/B, 39A/B, 37A/B	$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current							
Current consumption*2	I_{SS}	V_{IN}=7 V, Unloaded	--	3	8	mA	5

*1 tpd (ms)=(3.18 min.,5.74 typ., 8.73 max.)×CD (nF)

*2 Excluding the charging current of CD

2. S-8730XXA/B Series

Table 6

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard			Unit	Test
				Min.	Typ.	Max.		cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=5 V, I_{OUT}=30 mA		2.928	3.000	3.072	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4 to 24 V I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5 V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.23	±0.92	mV/°C	1
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Delay time[*1]	t_{pd}	C_D=4.7 nF		15	27	41	ms	3
Temp. characteristic of $-V_{DET}$	$\frac{\Delta -V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C		--	±0.3	±1.2	mV/°C	2
Detection voltage	$-V_{DET}$	S-873025A/B		2.440	2.500	2.560	V	2
		S-873024A/B		2.342	2.400	2.458	V	2
		S-873023A/B		2.244	2.300	2.356	V	2
		S-873022A/B		2.147	2.200	2.253	V	2
		S-873021A/B		2.049	2.100	2.151	V	2
Sink current	I_{DOUT}	Nch	V_{IN}=1.3 V	0.25	0.60	--	mA	4
		V_{DS}=0.5 V	V_{IN}=2.4 V[*3]	1.50	2.60	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V		--	--	0.1	µA	4
Hysteresis width	V_{HYS}			$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current								
Current consumption[*2]	I_{SS}	V_{IN}=5 V, Unloaded		--	3	8	µA	5

*1 tpd (ms)=(3.18 min.,5.74 typ., 8.73 max.)×CD (nF)

*2 Excluding the charging current of CD

*3 S-873025A/B only

3. S-875635B

Table 7

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard			Unit	Test
				Min.	Typ.	Max.		cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=7.6 V, I_{OUT}=30 mA		5.465	5.60	5.735	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6.6 to 24 V I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7.6 V I_{OUT}=50 μA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7.6 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.43	±1.72	mV/°C	1
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Delay time[*1]	t_{pd}	C_D=4.7 nF		15	27	41	ms	3
Temp. characteristic of $-V_{DET}$	$\frac{\Delta -V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C		--	±0.3	±1.2	mV/°C	2
Detection voltage	$-V_{DET}$			3.416	3.50	3.584	V	2
Sink current	I_{DOUT}	Nch	V_{IN}=1.3 V	0.25	0.60	--	mA	4
		V_{DS}=0.5 V	V_{IN}=2.4 V	1.50	2.60	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V		--	--	0.1	μA	4
Hysteresis width	V_{HYS}			$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current								
Current consumption[*2]	I_{SS}	V_{IN}=7.6 V, Unloaded		--	4	8	μA	5

*1 tpd (ms)=(3.18 min.,5.74 typ., 8.73 max.)×CD (nF)

*2 Excluding the charging current of CD

4. S-873325B

Table 8

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=5.3 V, I_{OUT}=30 mA		3.220	3.300	3.380	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4.3 to 24 V I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5.3 V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5.3 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.25	±1.00	mV/°C	1
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Delay time[*1]	t_{pd}	C_D=4.7 nF		15	27	41	ms	3
Temp. characteristic of $-V_{DET}$	$\frac{\Delta -V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C		--	±0.2	±0.8	mV/°C	2
Detection voltage	$-V_{DET}$			2.440	2.500	2.560	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V		--	--	0.1	µA	4
Hysteresis width	V_{HYS}			$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current								
Current consumption[*2]	I_{SS}	V_{IN}=5.3 V, Unloaded		--	4	8	µA	5

*1 tpd (ms)=(3.18 min.,5.74 typ., 8.73 max.)×CD (nF)

*2 Excluding the charging current of CD

5. S-875294C

Table 9

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions	Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator							
Output voltage	V_{OUT}	V_{IN}=14.4V, I_{OUT}=30 mA	5.075	5.20	5.325	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA	--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6 .2to 24 V I_{OUT}=30 mA	--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=14.4V I_{OUT}=50 µA to 40 mA	--	15	50	mV	1
Input voltage	V_{IN}		--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=14.4V, I_{OUT}=30 mA, Ta=-40°C to +85°C	--	±0.40	±1.60	mV/°C	1
Power off output voltage	V_{OUTOFF}	V_{IN}=14.4V, $\overline{V_{PF}}$=″L″ R_L=1 MΩ	--	--	0.1	V	6
Voltage Detector							
Operating voltage	V_{SEN}		1.3	--	24	V	2
Temp. characteristic of $-V_{DET}$	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	--	±0.7	±2.0	mV/°C	2
Detection voltage	$-V_{DET}$	S-875294C	9.174	9.40	9.626	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V, V_{IN}=1.3 V	0.25	0.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=2.4 V	1.50	2.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V	--	--	0.1	µA	4
Hysteresis width	V_{HYS}	S-875271C	$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current							
Current consumption	I_{SS}	V_{IN}=14.4V, Unloaded	--	4	9	µA	5
	Iof	$\overline{V_{PF}}$=″L″: Power off, V_{IN}=14.4V	--	1.5	4.7	µA	5
Input Voltage							
Power on/off input voltage	V_{IL}	$\overline{V_{PF}}$=″L″: Power off, V_{IN}=14.4V	--	--	0.4	V	6
	V_{IH}	$\overline{V_{PF}}$=″H″: Power on, V_{IN}=14.4V	2.6	--	--	V	6

6. S-8752XXC

Table 10

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard			Unit	Test
				Min.	Typ.	Max.		cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=7.2 V, I_{OUT}=30 mA		5.075	5.20	5.325	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6.2 to 24 V, I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7.2 V, I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7.2 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.40	±1.60	mV/°C	1
Power off output voltage	V_{OUTOFF}	V_{IN}=7.2V, $\overline{V_{PF}}$="L" R_L=1 MΩ		--	--	0.1	V	6
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Temp. characteristic of $-V_{DET}$	$\frac{\Delta -V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	S-875271C	--	±0.5	±2.0	mV/°C	2
			S-875255C	--	±0.4	±1.6	mV/°C	2
Detection voltage	$-V_{DET}$	S-875271C		6.929	7.10	7.271	V	2
		S-875255C		5.368	5.50	5.632	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
			V_{IN}=2.4 V	1.50	2.60	--	mA	4
			V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V		--	--	0.1	µA	4
Hysteresis width	V_{HYS}			$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current								
Current consumption	I_{SS}	V_{IN}=7.2 V, Unloaded		--	4	8	µA	5
	Iof	$\overline{V_{PF}}$="L": Power off, V_{IN}=7.2 V		--	1.5	3.5	µA	5
Input Voltage								
Power on/off input voltage	V_{IL}	$\overline{V_{PF}}$="L": Power off, V_{IN}=7.2 V		--	--	0.4	V	6
	V_{IH}	$\overline{V_{PF}}$="H": Power on, V_{IN}=7.2 V		2.0	--	--	V	6

7. S-8750XXC/G Series

Table 11

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=7 V, I_{OUT}=30 mA		4.88	5.00	5.12	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6 to 24 V, I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7 V, I_{OUT}=50 μA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.38	±1.52	mV/°C	1
Power off output voltage	V_{OUTOFF}	V_{IN}=7 V, $\overline{V_{PF}}$="L" R_L=1 MΩ		--	--	0.1	V	6
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Temp. characteristic of $-V_{DET}$	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	S-8750B0C	--	±0.8	±3.2	mV/°C	2
			S-875077C	--	±0.6	±2.4	mV/°C	2
			S-875061C,45C, 43C, 41C,39C,37C/G	--	±0.5	±2.0	mV/°C	2
Detection voltage	$-V_{DET}$	S-8750B0C		10.736	11.00	11.264	V	2
		S-875077C		7.515	7.70	7.885	V	2
		S-875061C		5.953	6.10	6.247	V	2
		S-875045C		4.392	4.50	4.608	V	2
		S-875043C		4.196	4.30	4.404	V	2
		S-875041C		4.001	4.10	4.199	V	2
		S-875039C		3.806	3.90	3.994	V	2
		S-875037C/G		3.611	3.70	3.789	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
			V_{IN}=2.4 V	1.50	2.60	--	mA	4
			V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V (S-8750B0C:V_{IN}=15 V)		--	--	0.1	μA	4
Hysteresis width	V_{HYS}	S-875045C		$-V_{DET}$ ×0.01	--	$-V_{DET}$ ×0.025	V	2
		S-875043C, 41C, 39C, 37C/G, B0C,77C,61C		$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current								
Current consumption	I_{SS}	V_{IN}=7 V Unloaded	S-8750B0C,77C,61C	--	4	8	μA	5
			S-875045C,43C, 41C,39C,37C/G	--	3	8	μA	5
	Iof	$\overline{V_{PF}}$="L": Power off, V_{IN}=7 V		--	1.5	3.5	μA	5
Input Voltage								
Power on/off input voltage	V_{IL}	$\overline{V_{PF}}$="L": Power off, V_{IN}=7 V		--	--	0.4	V	6
	V_{IH}	$\overline{V_{PF}}$="H": Power on, V_{IN}=7 V		2.0	--	--	V	6

8. S-873361C Series

Table 12

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions	Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator							
Output voltage	V_{OUT}	V_{IN}=5.3V, I_{OUT}=30 mA	3.220	3.300	3.380	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA	--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4.3Vto 24 V, I_{OUT}=30 mA	--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5.3V, I_{OUT}=50 μA to 40 mA	--	15	50	mV	1
Input voltage	V_{IN}		--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5.3V, I_{OUT}=30 mA, Ta=-40°C to +85°C	--	±0.25	±1.00	mV/°C	1
Power off output voltage	V_{OUTOFF}	V_{IN}=14.4V, $\overline{V_{PF}}$="L" R_L=1 MΩ	--	--	0.1	V	6
Voltage Detector							
Operating voltage	V_{SEN}		1.3	--	24	V	2
Temp. characteristic of $-V_{DET}$	$\frac{\Delta -V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	--	±0.5	±2.0	mV/°C	2
Detection voltage	$-V_{DET}$	S-873361C	5.953	6.100	6.247	V	2
Sink current	I_{DOUT}	Nch, V_{DS}=0.5 V, V_{IN}=1.3 V	0.25	0.60	--	mA	4
		Nch, V_{DS}=0.5 V, V_{IN}=2.4 V	1.50	2.60	--	mA	4
		Nch, V_{DS}=0.5 V, V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch, V_{DS}=24 V, V_{IN}=10 V	--	--	0.1	μA	4
Hysteresis width	V_{HYS}		$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current							
Current consumption	I_{SS}	V_{IN}=5.3V, Unloaded	--	4	8	μA	5
	Iof	$\overline{V_{PF}}$="L": Power off, V_{IN}=5.3V	--	1.5	3.5	μA	5
Input Voltage							
Power on/off input voltage	V_{IL}	$\overline{V_{PF}}$="L": Power off, V_{IN}=5.3V	--	--	0.4	V	6
	V_{IH}	$\overline{V_{PF}}$="H": Power on, V_{IN}=5.3V	2.0	--	--	V	6

9. S-8730XXC Series

Table 13

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions	Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator							
Output voltage	V_{OUT}	V_{IN}=5 V, I_{OUT}=30 mA	2.928	3.000	3.072	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA	--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4 to 24 V I_{OUT}=30 mA	--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5 V I_{OUT}=50 µA to 40 mA	--	15	50	mV	1
Input voltage	V_{IN}		--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5 V, I_{OUT}=30 mA, Ta=-40°C to +85°C	--	±0.23	±0.92	mV/°C	1
Power off output voltage	V_{OUTOFF}	V_{IN}=5 V, $\overline{V_{PF}}$="L" R_L=1 MΩ	--	--	0.1	V	6
Voltage Detector							
Operating voltage	V_{SEN}		1.3	--	24	V	2
Temp. characteristic of $-V_{DET}$	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta= -40°C to +85°C, S-873069C	--	±0.5	±2.0	mV/°C	2
		Ta= -40°C to +85°C, S-873025C, 24C,23C,22C, 21C,	--	±0.3	±1.2	mV/°C	2
Detection voltage	$-V_{DET}$	S-873069C	6.734	6.900	7.066	V	2
		S-873025C	2.440	2.500	2.560	V	2
		S-873024C	2.342	2.400	2.458	V	2
		S-873023C	2.244	2.300	2.356	V	2
		S-873022C	2.147	2.200	2.253	V	2
		S-873021C	2.049	2.100	2.151	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V, V_{IN}=1.3 V	0.25	0.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=2.4 V*	1.50	2.60	--	mA	4
		Nch V_{DS}=0.5 V, V_{IN}=3.6 V**	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=10 V	--	--	0.1	mA	4
Hysteresis width	V_{HYS}		$-V_{DET}$ ×0.03	--	$-V_{DET}$ ×0.08	V	2
Input Current							
Current consumption	I_{SS}	V_{IN}=5 V, Unloaded	--	3	8	mA	5
	Iof	$\overline{V_{PF}}$="L": Power off, V_{IN}=5 V	--	1.5	3.5	mA	5
Input Voltage							
Power on/off input voltage	V_{IL}	$\overline{V_{PF}}$="L": Power off, V_{IN}=5 V	--	--	0.4	V	6
	V_{IH}	$\overline{V_{PF}}$="H": Power on, V_{IN}=5 V	2.0	--	--	V	6

* For only S-873069C and S-873025C
** For only S-873069C

10. S-8750XXE Series

Table 14

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=7 V, I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		4.88	5.00	5.12	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA SENSE=-V_{DET} Typ.+2V		--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6 to 24 V I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7 V, SENSE=-V_{DET} Typ.+2V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7 V, I_{OUT}=30 mA, Ta=-40°C to +85°C, SENSE=-V_{DET} Typ.+2V		--	±0.38	±1.52	mV/°C	1
Output voltage during voltage detection	V_{OUTOFF}	V_{IN}=-V_{DET} Typ.-1V R_L=1 MΩ		--	--	0.1	V	6
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Temp. characteristic of -V_{DET}	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	S-875077E	--	±0.6	±2.4	mV/°C	2
			S-875061E	--	±0.5	±2.0	mV/°C	2
Detection voltage	-V_{DET}	S-875077E		7.515	7.70	7.885	V	2
		S-875061E		5.953	6.10	6.247	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
			V_{IN}=2.4 V	1.50	2.60	--	mA	4
			V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=-V_{DET} Typ.+2V		--	--	0.1	µA	4
SENSE pin input current	I_{SENSE}	V_{IN}=7V SENSE=-V_{DET} Typ.+2V	S-875077E	--	0.6	1.7	µA	7
			S-875061E	--	0.7	1.8	µA	7
Hysteresis width	V_{HYS}			-V_{DET} ×0.03	--	-V_{DET} ×0.08	V	2
Input Current								
Current consumption	I_{SS}	V_{IN}=-V_{DET} Typ.+2V Unloaded	S-875077E	--	4	8	µA	5
			S-875061E	--	4	9	µA	5
	Iof	V_{IN}=-V_{DET} Typ.-1V: Power off		--	1.5	3.5	µA	5

Unless otherwise specified, connect the SENSE pin to V_{IN}.

11. S-873330E Series

Table 15

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard			Unit	Test
				Min.	Typ.	Max.		cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=5.3 V, I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		3.220	3.300	3.380	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA SENSE=-V_{DET} Typ.+2V		--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4.3 to 24 V I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5.3 V, SENSE=-V_{DET} Typ.+2V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5.3 V, I_{OUT}=30 mA, Ta=-40°C to +85°C, SENSE=-V_{DET} Typ.+2V		--	±0.25	±1.00	mV/°C	1
Output voltage during voltage detection	V_{OUTOFF}	V_{IN}=-V_{DET} Typ.-1V R_L=1 MΩ		--	--	0.1	V	6
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Temp. characteristic of -V_{DET}	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C		--	±0.2	±0.8	mV/°C	2
Detection voltage	-V_{DET}			2.928	3.000	3.072	V	2
Sink current	I_{DOUT}	Nch	V_{IN}=1.3 V	0.25	0.60	--	mA	4
		V_{DS}=0.5 V	V_{IN}=2.4 V	1.50	2.60	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=-V_{DET} Typ.+2V		--	--	0.1	µA	4
SENSE pin input current	I_{SENSE}	V_{IN}=5.3V SENSE=-V_{DET} Typ.+2V		--	0.5	1.3	µA	7
Hysteresis width	V_{HYS}			-V_{DET} ×0.03	--	-V_{DET} ×0.08	V	2
Input Current								
Current consumption	I_{SS}	V_{IN}=-V_{DET} Typ.+2V Unloaded		--	4	8	µA	5
	Iof	V_{IN}=-V_{DET} Typ.-1V: Power off			1.5	3.5	µA	5

12. S-8730XXE Series

Table 16

(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=5 V, I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		2.928	3.000	3.072	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA SENSE=-V_{DET} Typ.+2V		--	0.45	0.70	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=4 to 24 V I_{OUT}=30 mA, SENSE=-V_{DET} Typ.+2V		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=5 V, SENSE=-V_{DET} Typ.+2V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp.coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=5 V, I_{OUT}=30 mA, Ta=-40°C to +85°C, SENSE=-V_{DET} Typ.+2V		--	±0.23	±0.92	mV/°C	1
Output voltage during voltage detection	V_{OUTOFF}	V_{IN}=-V_{DET} Typ.-1V R_L=1 MΩ		--	--	0.1	V	6
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Temp. characteristic of -V_{DET}	$\frac{\Delta\text{-}V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C	S-873082E	--	±0.6	±2.4	mV/°C	2
			S-873062E	--	±0.5	±2.0	mV/°C	2
Detection voltage	-V_{DET}	S-873082E		8.003	8.200	8.397	V	2
		S-873062E		6.051	6.200	6.349	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
			V_{IN}=2.4 V	1.50	2.60	--	mA	4
			V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=-V_{DET} Typ.+2V		--	--	0.1	µA	4
SENSE pin input current	I_{SENSE}	V_{IN}=5V SENSE=-V_{DET}Typ.+2V	S-873082E	--	0.6	1.7	µA	7
			S-873062E	--	0.6	1.8	µA	7
Hysteresis width	V_{HYS}			-V_{DET} ×0.03	--	-V_{DET} ×0.08	V	2
Input Current								
Current consumption	I_{SS}	V_{IN}=-V_{DET} Typ.+2V	Unloaded	--	4	8	µA	5
	Iof	V_{IN}=-V_{DET} Typ.-1V:	Power off	--	1.5	3.5	µA	5

Unless otherwise specified, connect the SENSE pin to V_{IN}.

13. S-875087F

Table 17

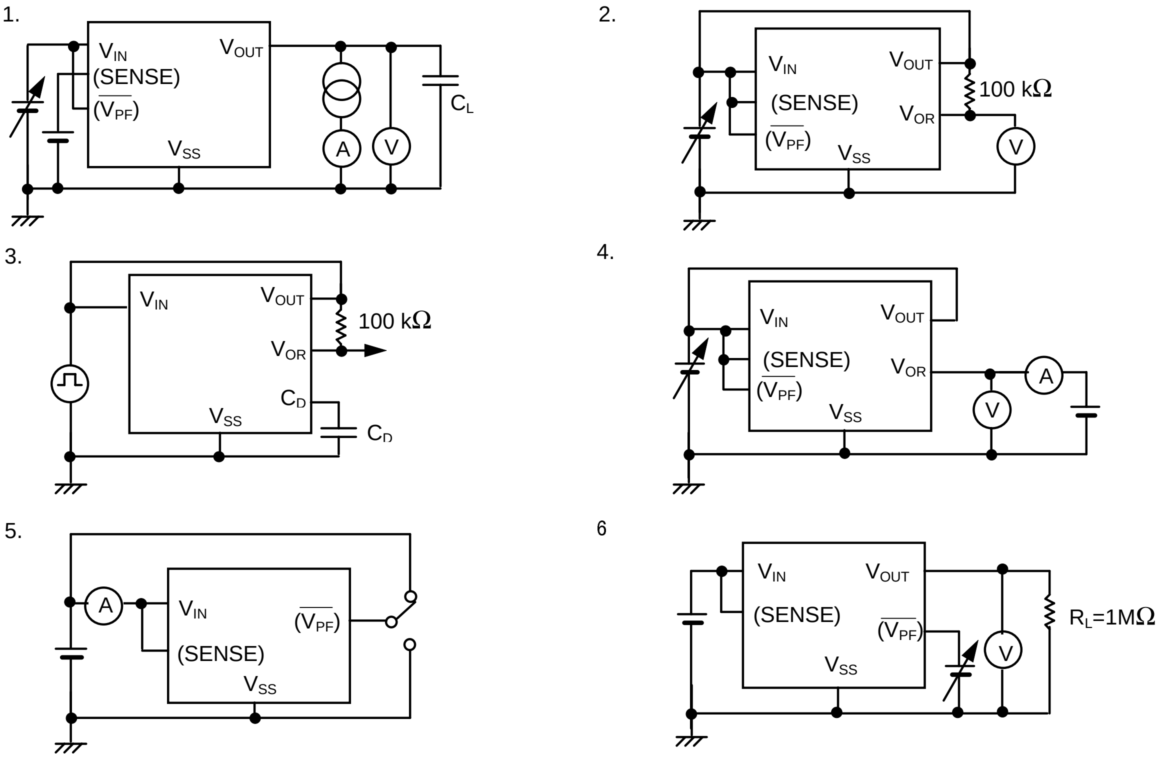
(Unless otherwise specified: Ta=25°C)

Parameter	Symbol	Conditions		Standard Min.	Standard Typ.	Standard Max.	Unit	Test cir.
Voltage Regulator								
Output voltage	V_{OUT}	V_{IN}=7 V, I_{OUT}=30 mA		4.88	5.00	5.12	V	1
I/O voltage difference	V_{dif}	I_{OUT}=30 mA		--	0.15	0.40	V	1
Line regulation	ΔV_{OUT1}	V_{IN}=6 to 24 V I_{OUT}=30 mA		--	15	50	mV	1
Load regulation	ΔV_{OUT2}	V_{IN}=7 V I_{OUT}=50 µA to 40 mA		--	15	50	mV	1
Input voltage	V_{IN}			--	--	24	V	1
Temp. coefficient of V_{OUT}	$\frac{\Delta V_{OUT}}{\Delta Ta}$	V_{IN}=7 V, I_{OUT}=30 mA, Ta=-40°C to +85°C		--	±0.38	±1.52	mV/°C	1
Voltage Detector								
Operating voltage	V_{SEN}			1.3	--	24	V	2
Delay time[*1]	t_{pd}	C_D=4.7 nF		15	27	41	ms	3
Release voltage vs Temperature	$\frac{\Delta +V_{DET}}{\Delta Ta}$	Ta=-40°C to +85°C		--	±0.7	±2.8	mV/°C	2
Release voltage (Overcharge detection voltage)	$+V_{DET}$			8.600	8.700	8.800	V	2
Sink current	I_{DOUT}	Nch V_{DS}=0.5 V	V_{IN}=1.3 V	0.25	0.60	--	mA	4
			V_{IN}=2.4 V	1.50	2.60	--	mA	4
			V_{IN}=3.6 V	3.00	4.50	--	mA	4
Leakage current	I_{LEAK}	Nch V_{DS}=24 V, V_{IN}=15 V		--	--	0.1	µA	4
Hysteresis width	V_{HYS}			0.085	--	0.215	V	2
Input Current								
Current consumption[*2]	I_{SS}	V_{IN}=7 V, Unloaded		--	4	8	µA	5

*1 tpd (ms)=(3.18 min.,5.74 typ., 8.73 max.)×CD (nF)

*2 Excluding the charging current of CD

■ Test Circuits



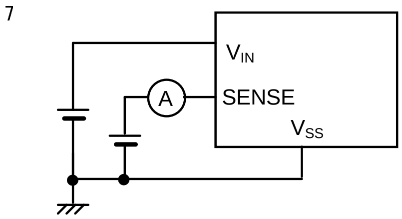


Figure 3 Test Circuits

■ Technical Terms

- I/O Voltage Difference (V_{dif})
  $V_{dif} = V_{IN1} - V_{OUT1}$
  V_{OUT1}: Initial output voltage
  V_{IN1}: Input voltage which generates an output voltage (V_{OUT2}) decreased by 5% from V_{OUT1}

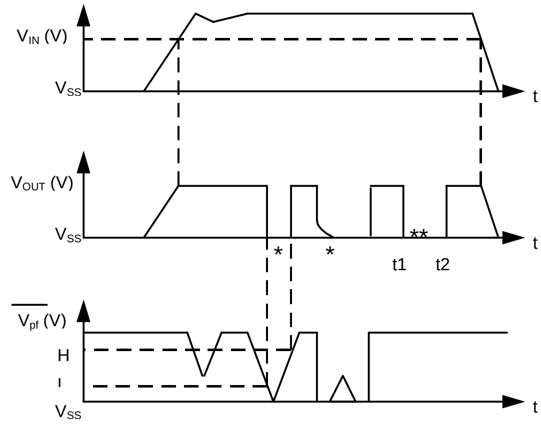
- Load Regulation (DV_{OUT2})
  $DV_{OUT2} = V_{OUT1} - V_{OUT2}$
  V_{OUT1}: Output voltage when I_{OUT} is 50 µA
  V_{OUT2}: Output voltage when I_{OUT} is 40 mA

- Line Regulation (ΔV_{OUT1})
  $\Delta V_{OUT1} = V_{OUT1} - V_{OUT2}$
  V_{OUT1}: Output voltage when V_{IN} is 24 V
  V_{OUT2}: Output voltage when V_{IN} is (V_{OUT}+1) V

- Hysteresis Width (V_{HYS})
  $V_{HYS} = (+V_{DET}) - (-V_{DET})$
  $+V_{DET}$: Release voltage
  $-V_{DET}$: Detection voltage

■ Operation Timing Charts

1. Voltage Regulator (S-87XXXXC/G Series)



* Indicates power off state. When the load current (I_{OUT}) is less than 1 µA, the V_{OUT} is not always V_{SS} level.
** When the V_{OUT} is shorted at t1, V_{OUT} becomes V_{SS} level. When the short of V_{OUT} is removed at t2, V_{OUT} returns to normal output.

Figure 4

2. Voltage Detector (S-87XXXXA/B/F Series)

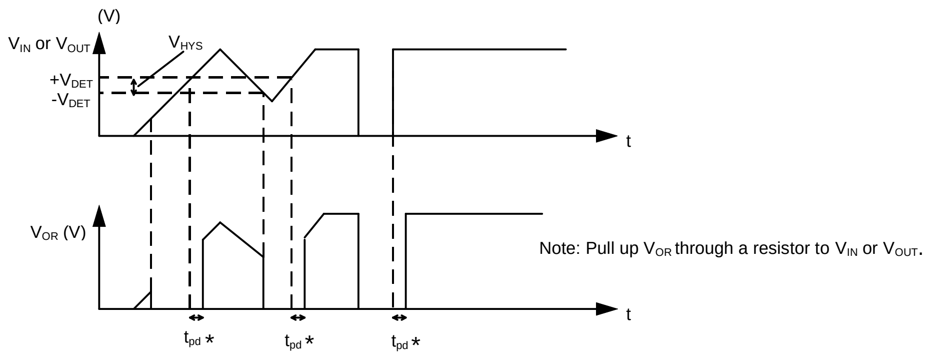
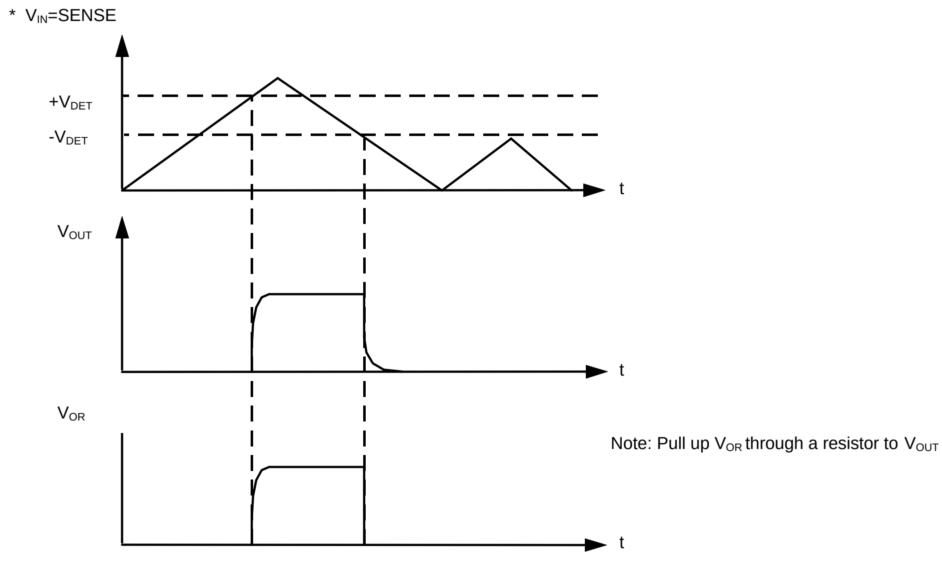


Figure 5

* Output delay time (tpd) of the voltage detector can be changed with an external capacitance value to CD pin.
** Delay circuit is not included in S-87XXXXC/G Series.

3. S-87XXXXE Series



* The SENSE is connected to V_{IN}.

Figure 6

■ Operation

1. Reference Voltage Circuit
   The reference voltage circuit operates all the time when the voltage is applied to V_{IN} and is not affected by the $\overline{V_{PF}}$ signal.

2. Voltage Regulator
   Figure 7 shows the voltage regulator circuit. The S-87X Series has a Pch MOS transistor as the output control transistor.

   Reverse current may break IC if V_{OUT} potential is higher than V_{IN}, because a parasitic diode is formed between V_{IN} and V_{OUT} due to the structure of the control transistor. Therefore, keep V_{OUT} lower than V_{IN}+0.3 V.

   The output voltage of the voltage regulator can be selected as follows :

   2.6V to 5.8V ±2.4% (0.1V step)

   Note For an application with a load current of less than 1 μA, the leakage current of the control transistor M1 increases the output voltage.

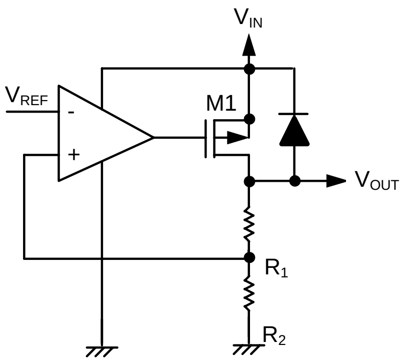


Figure 7 Voltage Regulator

3. Short-circuit Protection Circuit
   The S-87X Series has a built-in short-circuit protection circuit to protect the element from break caused by a large current in case of a short circuit. The output short current is internally limited to approx. 70 mA. Short-circuit protection circuit has three kinds characteristics according to VIN (input voltage) as shown in Figure 8.

At 5-V Output:

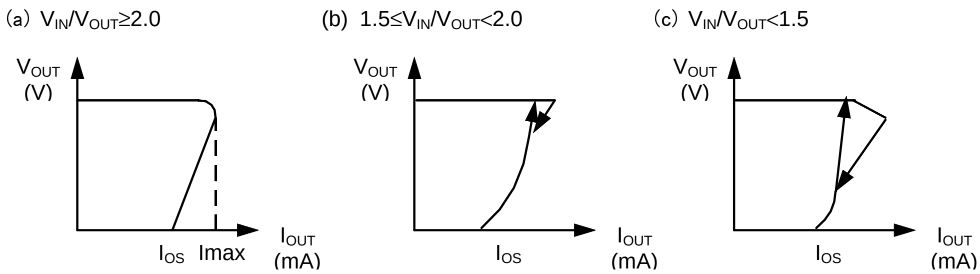


Figure 8

Note: Use a voltage regulator under the specified power dissipation of the package.

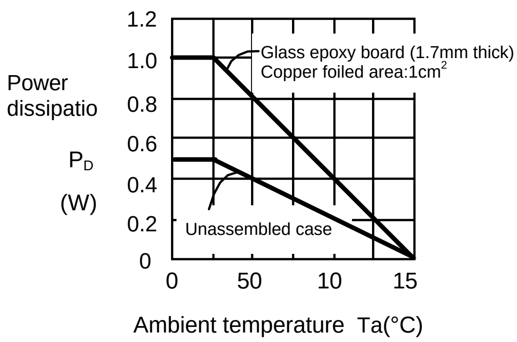


Figure 9 Power Dissipation of Package

4. Delay Circuit

The delay circuit outputs voltage detector output (V_{OR}) with delay after the voltage at V_{IN} pin has become release voltage ($+V_{DET}$) at the rising of V_{IN} pin.

In Fig. 9, when Vcd exceeds the reference voltage (Vref), the output voltage pin V_{OR} changes from low to high level, providing delay output. When the voltage at V_{IN} pin falls under the detection voltage ($-V_{DET}$), the N_2 transistor turns ON, therefore the charge of C_D is rapidly discharged and the voltage detector output (V_{OR}) changes from high to low level without delay.

The external capacitor (C_D) is charged with constant current, and is practically independent of V_{IN} voltage. Its delay time (t_{pd}) is expressed by the following equation:

t_{pd} (ms)=Delay coefficient (3.18 min., 5.74 typ., 8.73 max.)×C_D (nF)

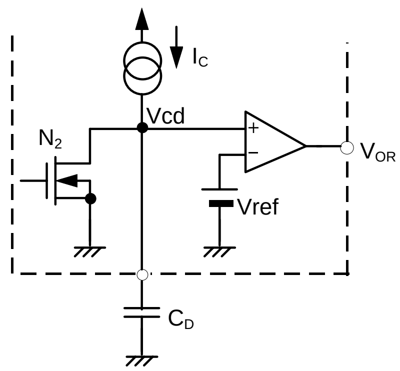


Figure 10 Delay

Note · Unless an output delay is needed, keep C_D pin open. Do not apply external voltage other than ground potential to C_D pins, which may cause IC breakdown.

· When designing your printed-circuit board layout, take care that no leakage current flows to the external capacitor (C_D), otherwise the correct delay time may not be obtained. Because the value of the constant current source I_C is only 195 nA, C_D to impedance is high.

5. Voltage Detection Circuit

The built-in voltage detection circuit (Nch opendrain type) is equivalent to our S-808/809 Series voltage detectors. A pull-up resistor of about 100 kΩ is required for output. Since the comparator power of this circuit is supplied from V_{IN} pin, this circuit operates while voltage is applied to V_{IN} pin.

The detection voltage of the voltage detector can be selected as follows :

2.1 V to 11.3 V ±2.4% (0.1V step)

In the S-87XXXXF Series, the release voltage ($+V_{DET}$) accuracy is±1.1%. So, it responds to the application for overcharge detection of lithium-ion battery packs.

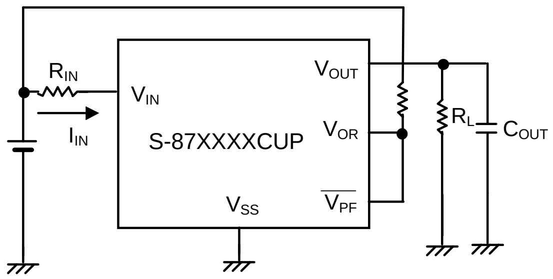
In the S-87XXXXE Series, the input voltage monitoring pin of the voltage detector is externally connected as the SENSE pin. Because this pin is configured by a resistor only, temporary current such as a through-type current does not flow. Consequently, even when resistor R_{IN} is inserted between input power supply and V_{IN} pin, the input power voltage can be accurately monitored by connecting the SENSE pin to the input power supply. Also, when a drop in the SENSE pin input voltage is detected, the voltage detector generates a reset signal. At the same time, it powers off the voltage regulator.

Notes: · As shown in Figure 11, when connecting V_{OR} output to $\overline{V_{PF}}$ pin in the S-87XXXXC Series or connecting SENSE pin to V_{IN} pin in the S-87XXXXE Series, the following phenomena occur if R_{IN} is connected between input voltage and V_{IN} pin. Be careful.

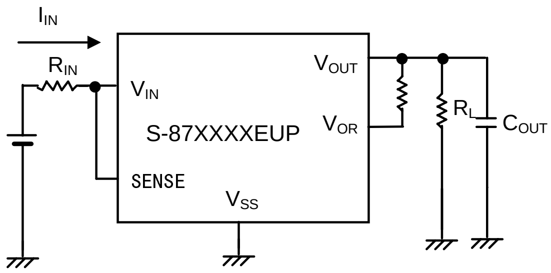
① At the time of voltage detection, the voltage regulator is shutdown and load current is cut. Therefore, V_{IN} voltage increases by $\Delta V_{IN}= I_{IN}\times R_{IN}$, where the current flowing into R_{IN} is set to I_{IN}. Hence, if ΔV_{IN} exceeds hysterisis width Vhys, oscillation starts immediately after detection and continues. It is necessary to set ΔV_{IN} less than Vhys.

② At the time of voltage release, the voltage regulator is powered on and load current flows. Therefore, if ΔV_{IN} exceeds hysterisis width Vhys, oscillation starts immediately after release and continues. It is necessary to set ΔV_{IN} less than Vhys. Also at the time of voltage release, the rush current to charge output capacitor Cout flows. Hence, oscillation momentarily starts until the output of regulator V_{out} rises high enough even though ΔV_{IN} is set less than Vhys. But Short-circuit protection circuit controls the rush current less than Imax on fig.8. If this momentary oscillation is a problem in your applicaion, setting R_{IN} less than Vhys/Imax prevents oscillation.

[Attention1]



[Attention2]



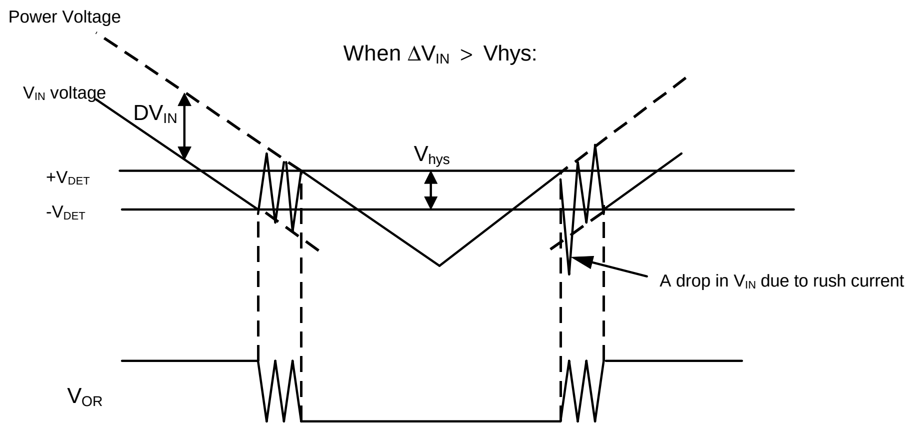


Figure 11

- In the S-87XXXXE series, the minimum operating voltage becomes 2.0 V as V_{IN} voltage. If a drop in V_{IN} voltage occurs due to load current or rush current to be charged to the output capacitor when load current or the voltage regulator is powered on at the time of release, set V_{IN} to 2.0 V or more.
- Also, in the S-87XXXXE Series, when sharply increasing only V_{IN} pin voltage at 1 ms/V or less, with the SENSE pin fixed to $-V_{DET} \geq V_{SENSE} \geq -V_{DET}$-2V, a release pulse is output to the output pin of voltage detector. Be careful. In this case, this release pulse is removed by setting the time constant of V_{OR} pin 20ms or more with capacitance and pull-up resistance. In addition, when the voltage of SENSE pin is fixed to between the detection voltage and the release voltage at the detect condition, if sharply increasing only V_{IN} pin voltage at 1 ms/V or less, the output of the detector turns to the release condition. If this action is a problem in your system, please connect SENSE pin to V_{IN} pin.

6. Power off Circuit (S-87XXXXC/E/G Series)

When $\overline{V_{PF}}$ pin goes low (0.4 V or less) in the S-87XXXXC/G Series or at the time of voltage detection in the S-87XXXXE series, current for the voltage regulator is shut down, the current consumption (excluding the current which flows through the pull-up resistor) lowers to 3.5 μA or less.

During power off, the M1 transistor in the voltage regulator shown in the Figure 6 is off and V_{OUT} pin is pulled down by R1 and R2, whose value (R1+R2) is 5MΩ to 10MΩ. Input current of V_{PF} pin is 0.1μA or less.

Notes · The output voltage may not become 0 V when the load which makes I_{OUT} under 1μA is connected during power off.

- DO NOT keep $\overline{V_{PF}}$ pin floating state or medium potential (between low and high levels). Otherwise through-type current flows.

■ Transient Response

An undershoot or an overshoot may occur in the output voltage of the voltage regulator if input voltage or load current fluctuates transiently. If an undershoot is large, the voltage detector operates to output reset signal in the S-87XXXXB Series in which the voltage detector detects the output voltage of the regulator. If an overshoot is large, the load circuit is adversely affected. Therefore it is important to determine the capacitor value so as to minimize undershoot and overshoot.

1. Line Transient Response due to Input Voltage Ffluctuation

Input voltage fluctuation differs depending on the types of the signal applied: type I which is a rectangular wave between (V_{OUT} + 1) V and 10 V, and type II which is a rectangular wave from 0 V to 10 V (see Figure 12). The ringing waveforms and parameter dependency of each type are described below. The measuring circuit is shown in Figure 13 for reference, .

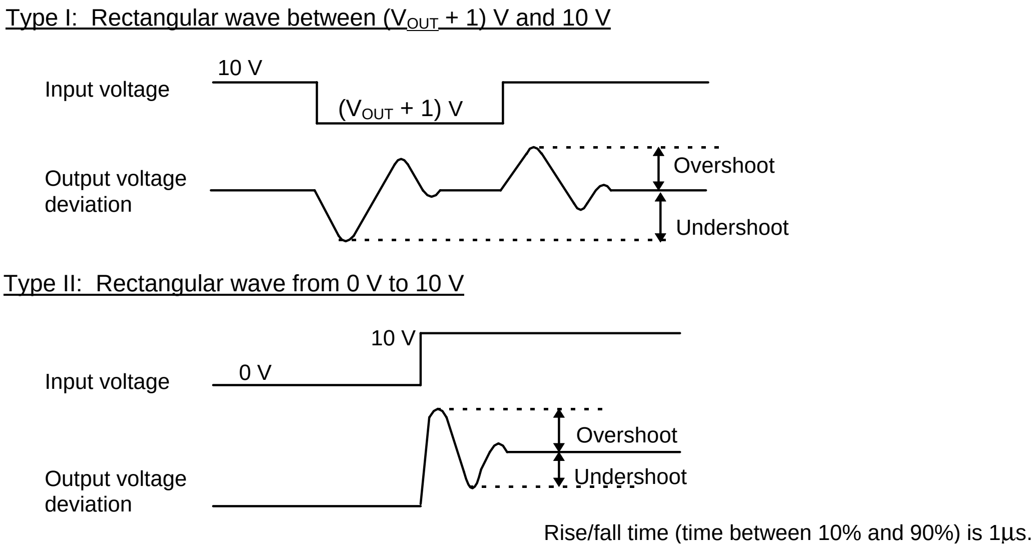


Figure 12

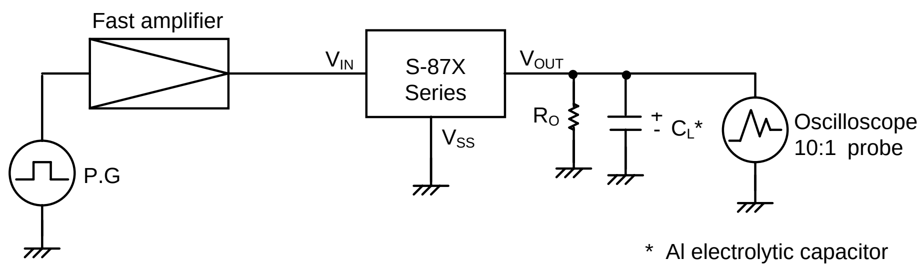


Figure 13 Measuring Circuit

Type I

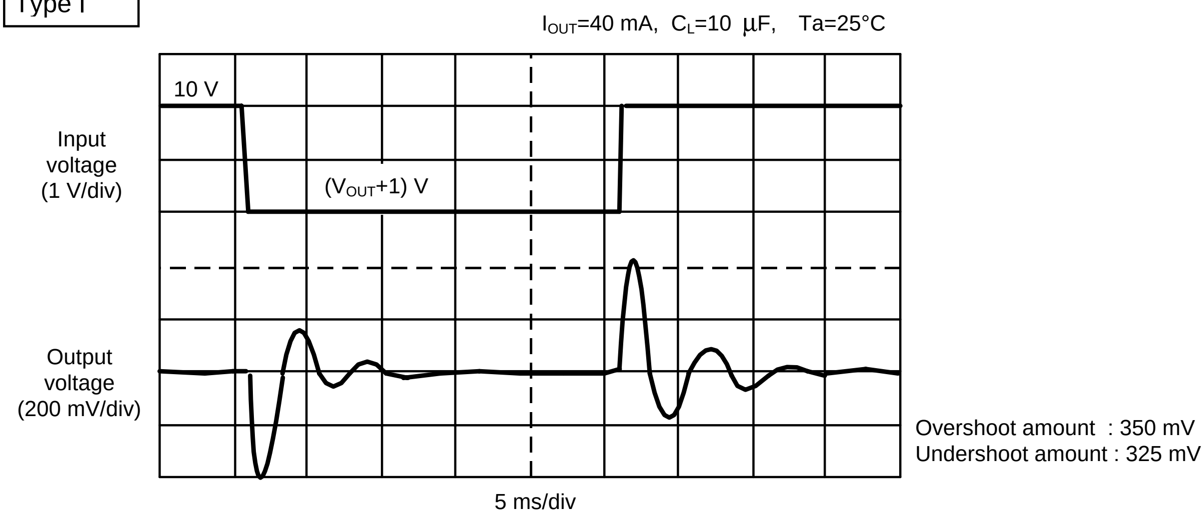


Figure 14 Type I Ringing Waveform

Table 18 Type I Parameter Dependency

Series	Parameter		Conditions	Method to decrease overshoot	Method to decrease undershoot
S-8750XXX	Load current	I_{OUT}	10 to 60 mA, C_L=10µF	Decrease	Decrease
	Load capacitance	C_L	1 to 47 µF, I_{OUT}=40 mA	Increase	Increase
	Input fluctuation	ΔV_{IN}*	2 to 4 V	Decrease	Decrease
			4 to 18 V	Increase	Decrease
	Temperature	Ta	-40 °C to +85 °C	Low temperature	Low temperature
S-8730XXX	Load current	I_{OUT}	10 to 60 mA, C_L=10µF	Increase	Decrease
	Load capacitance	C_L	1 to 47 µF, I_{OUT}=40 mA	Increase	Increase
	Input fluctuation	ΔV_{IN}*	4 to 20 V	Increase	Decrease
	Temperature	Ta	-40 °C to +85 °C	Low temperature	Low temperature

* ΔV_{IN} : High voltage value - low voltage value

Type II

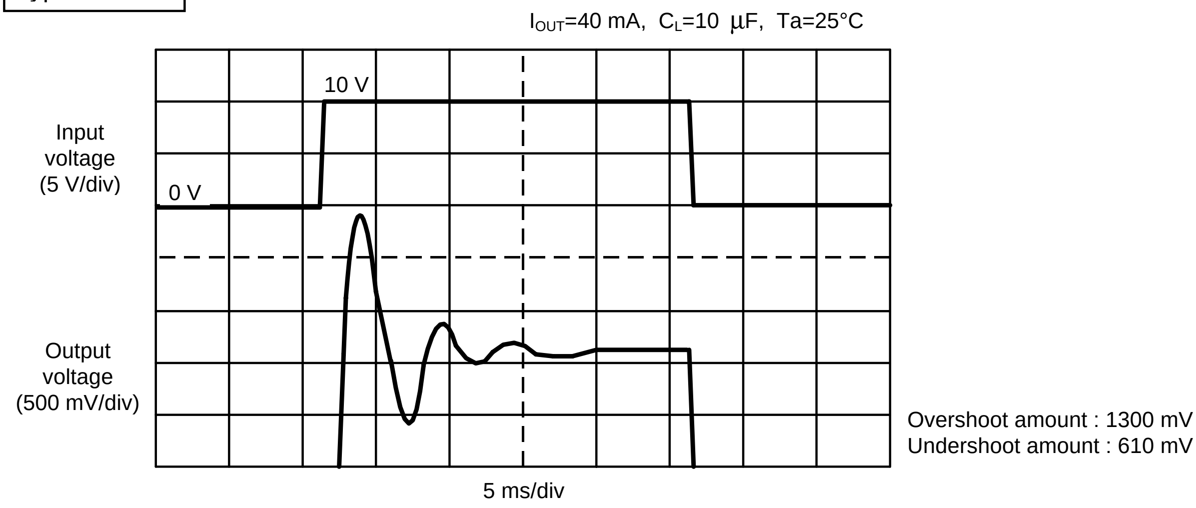


Figure 15 Type II Ringing Waveform

Table 19 Type II Parameter Dependency

Series	Parameter		Conditions	Method to decrease overshoot	Method to decrease undershoot
S-8750XXX	Load current	I_{OUT}	10 to 60 mA, C_L=10µF	Increase	Increase
	Load capacitance	C_L	1 to 47 µF, I_{OUT}=40 mA	Decrease	Decrease
	Input fluctuation	ΔV_{IN}*	3 to 19 V	Increase	Increase
	Temperature	Ta	-40 °C to +85 °C	Low temperature	Low temperature
S-8730XXX	Load current	I_{OUT}	10 to 60 mA, C_L=10µF	Increase	Increase
	Load capacitance	C_L	1 to 47 µF, I_{OUT}=40 mA	Decrease	Decrease
	Input fluctuation	ΔV_{IN}*	5 to 21 V	Increase	Increase
	Temperature	Ta	-40 °C to +85 °C	Low temperature	Low temperature

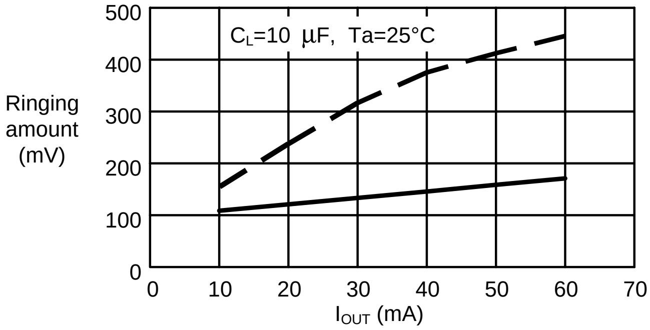
* ΔV_{IN}: High voltage value - low voltage value

For reference, the following pages describe the ringing in V_{OUT} measured using the output load current (I_{OUT}), output load capacitance (C_L), input fluctuation width (ΔV_{IN}), and temperature as parameters.

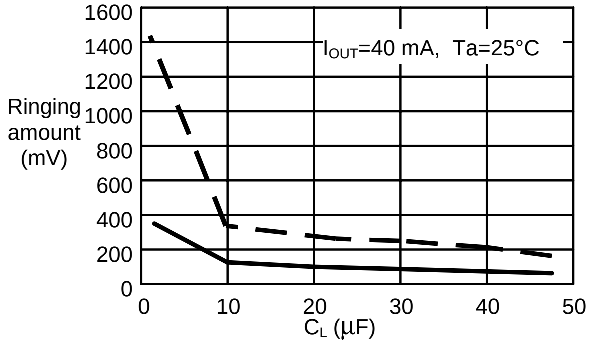
Reference Data: Type I

S-8750XXX Series

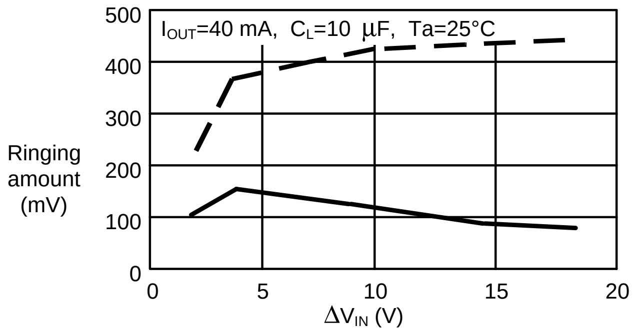
1. I_{OUT} Dependency



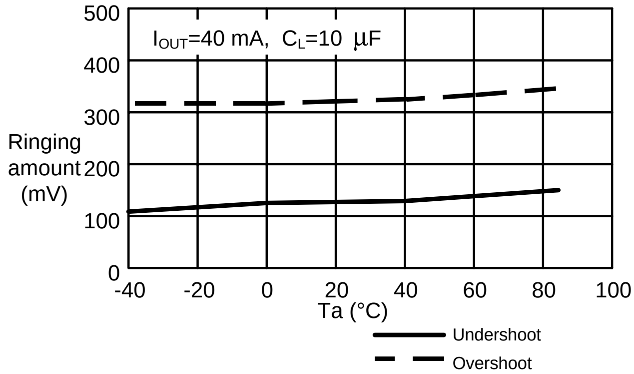
2. C_L Dependency



3. ΔV_{IN} Dependency
The lower voltage is fixed at (V_{OUT}+1).



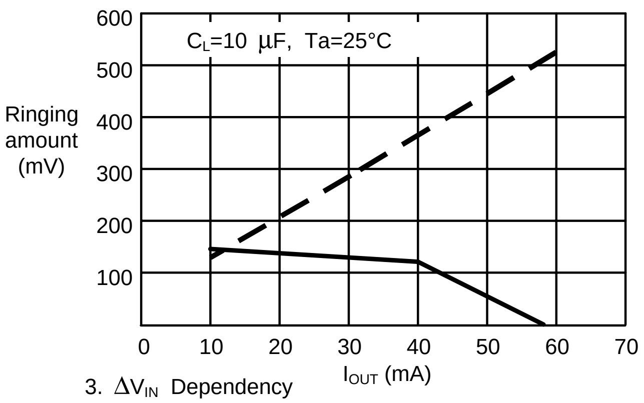
4. Temperature Dependency



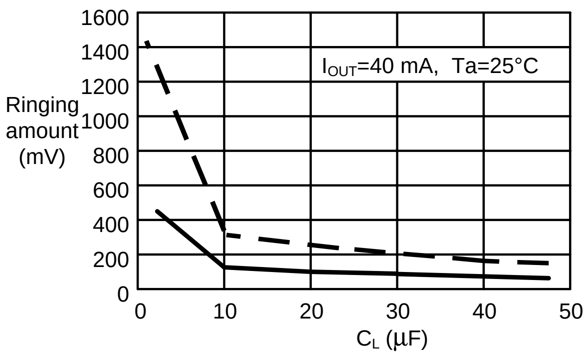
Reference Data: TypeI

S-8730XXX Series

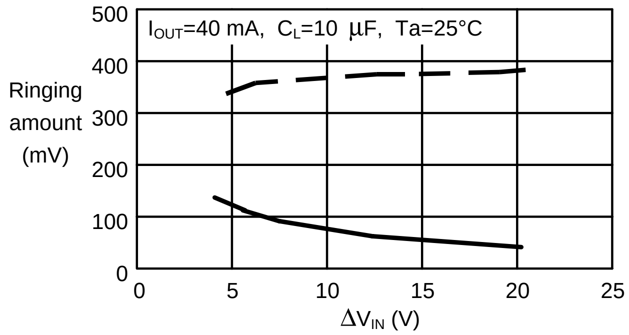
1. I_{OUT} Dependency



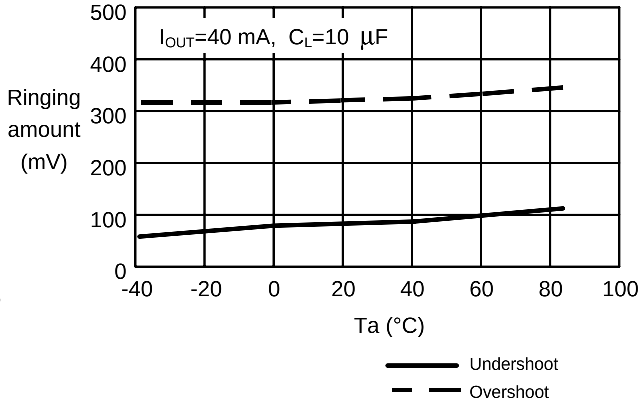
2. C_L Dependency



3. ΔV_{IN} Dependency
The lower voltage is fixed at (V_{OUT}+1).

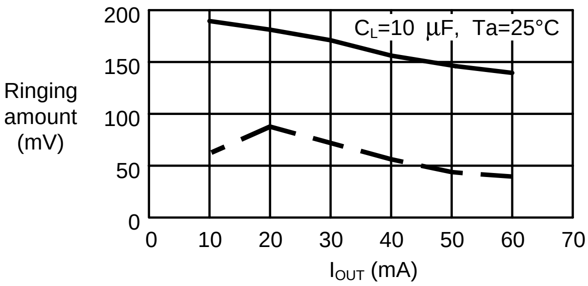


4. Temperature Dependency

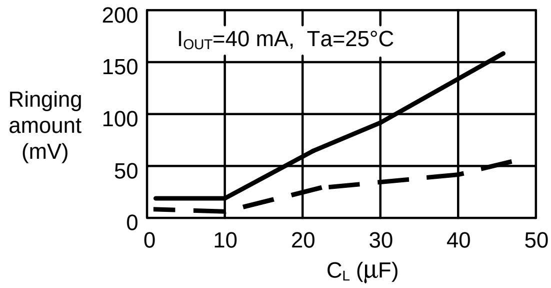


Reference Data: TypeII S-8750XXX Series

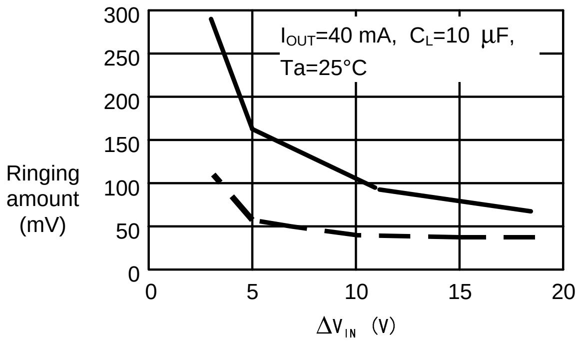
1. I_{OUT} Dependency



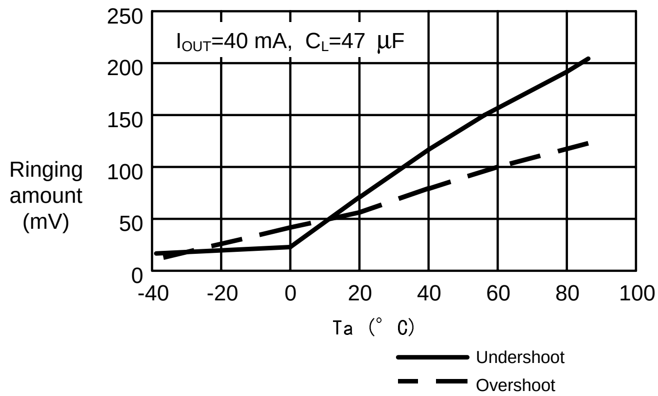
2. C_L Dependency



3. ΔV_{IN} Dependency
The lower voltage is fixed at (V_{OUT}+1).

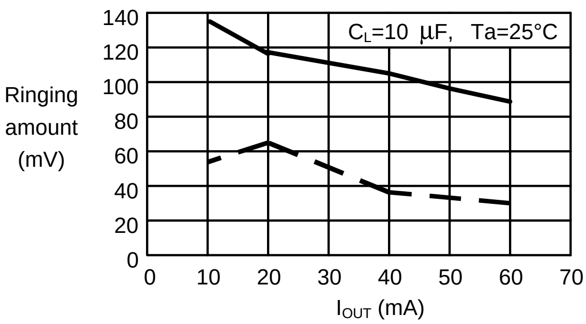


4. Temperature Dependency

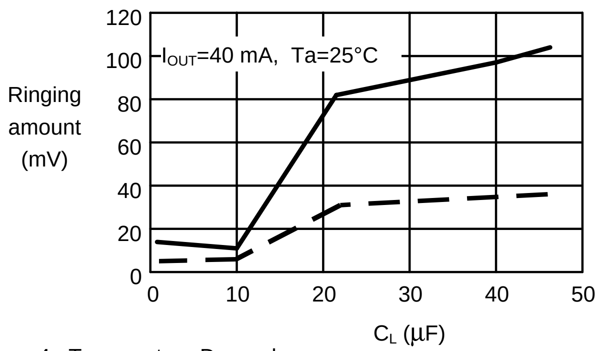


Reference Data: TypeII S-8730XXX Series

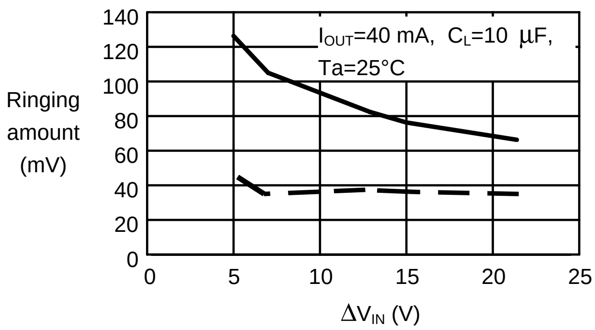
1. I_{OUT} Dependency



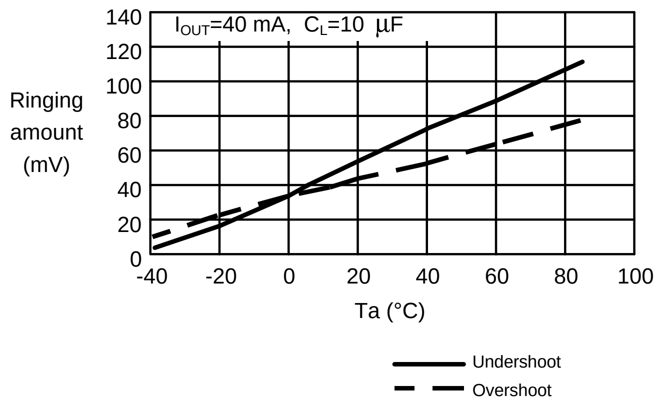
2. C_L Dependency



3. ΔV_{IN} Dependency
The lower voltage is fixed at (V_{OUT}+1).



4. Temperature Dependency



2. Load Transient Response due to Load Current Fluctuation

An overshoot and an undershoot are caused in the output voltage if the load current is changed from 50 µA to 40 mA while the input voltage is kept constant. Figure 16 shows the output voltage fluctuation due to a change in the load current. The measuring circuit is shown in Figure 17 for reference. The latter half of this section describes ringing waveform and parameter dependency.

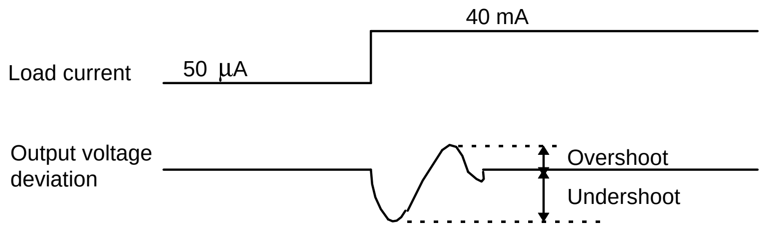
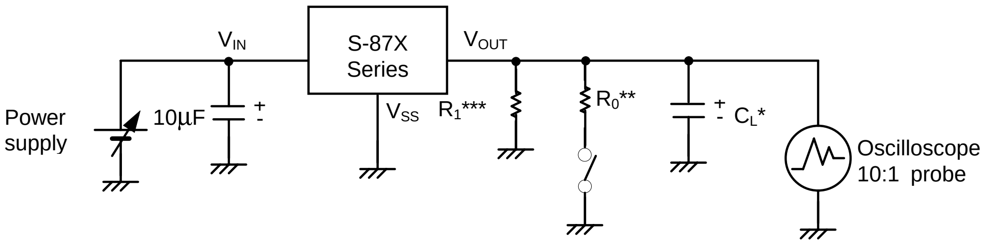


Figure 16



* Al electrolytic capacitor

** $R_0 = \frac{V_{OUT}\,[V]}{40\ mA}$ [Ω]

*** $R_1 = \frac{V_{OUT}\,[V]}{50\ \mu A}$ [Ω]

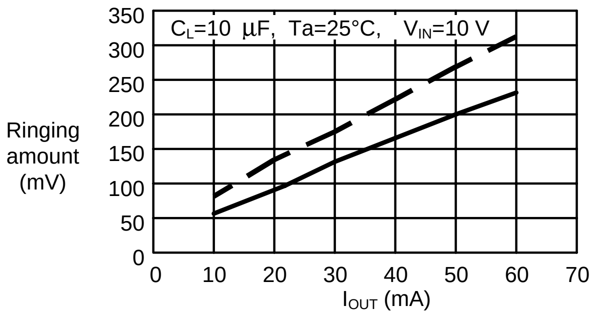
Figure 17 Measuring Circuit

Table 20 Parameter Dependency due to Load Current Fluctuation

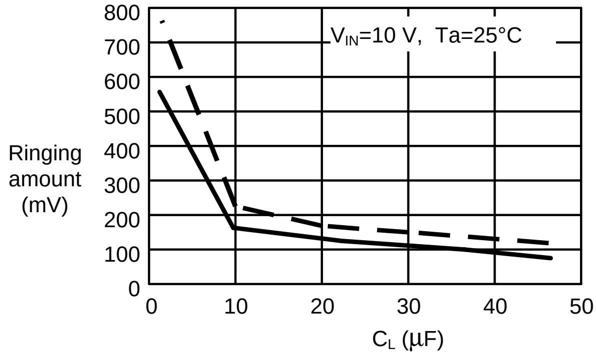
Series	Parameter	Conditions	Method to decrease overshoot	Method to decrease undershoot
S-8750XXX S-8730XXX	Load current I_{OUT}	10 to 60 mA, C_L=10µF	Decrease	Decrease
	Load capacitance C_L	1 to 47µF, I_{OUT}=40 mA	Increase	Increase
	Power supply voltage V_{IN}	(V_{OUT}+1) to 24 V	Increase	Increase
	Temperature Ta	-40°C to +85°C	Low temperature	Low temperature

Reference Data S-8750XXX Series

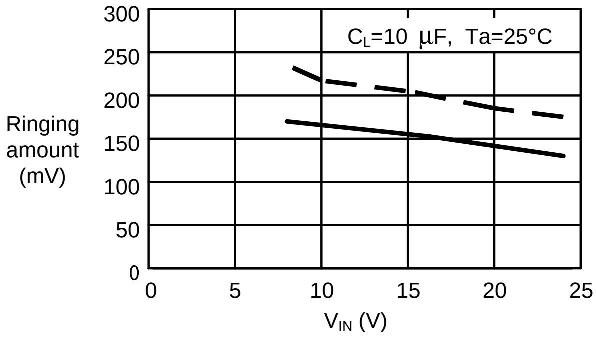
1. I_{OUT} Dependency



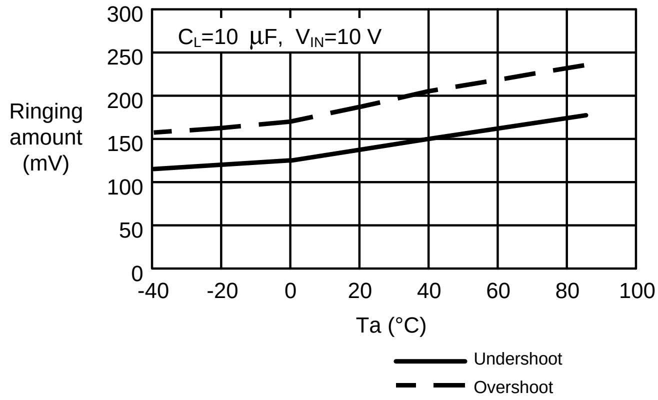
2. C_L Dpendency



3. V_{IN} Dependency

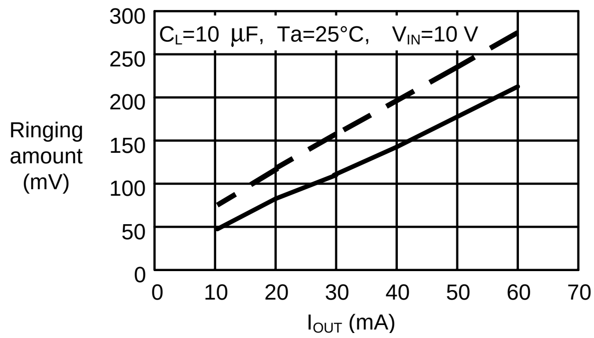


4. Temperature Dependency

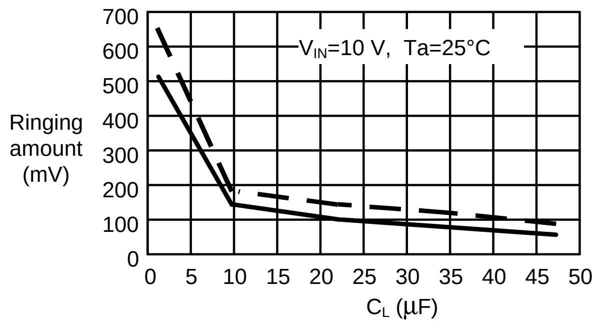


Reference S-8730XXX

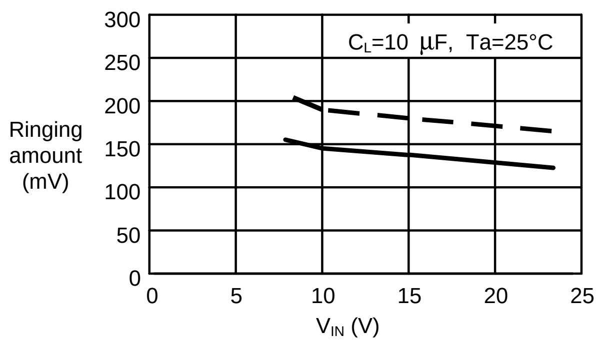
1. I_{OUT} Dependency



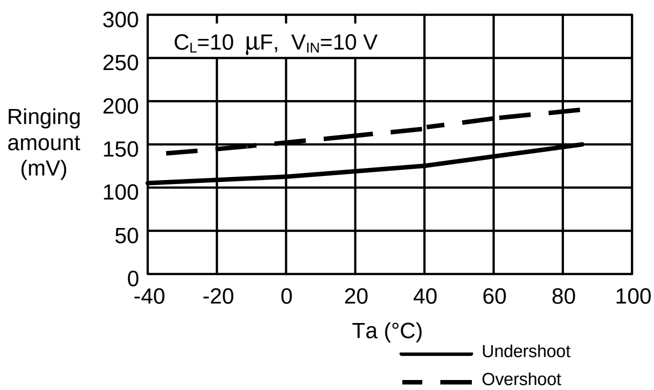
2. C_L Dependency



3. V_{IN} Dependency



4. Temperature Dependency



■ Standard Circuits

1. S-87XXXXA/B/F
2. S-87XXXXC/E/G

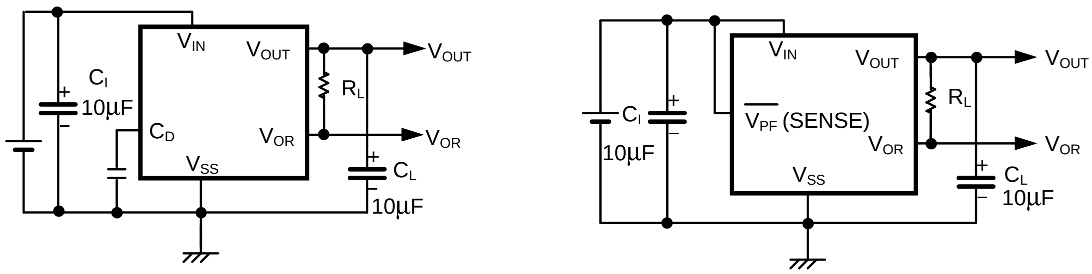


Figure 18

■ Application Circuits

1. Microcomputer Power Supply and Reset Circuit

To construct a microcomputer power supply and a reset circuit using conventional ICs, a voltage regulator IC, a voltage detector IC, a delay time generation circuit and others are required. The S-87XXXXA/B Series allows you to make these circuits without these ICs, and the delay time is variable.

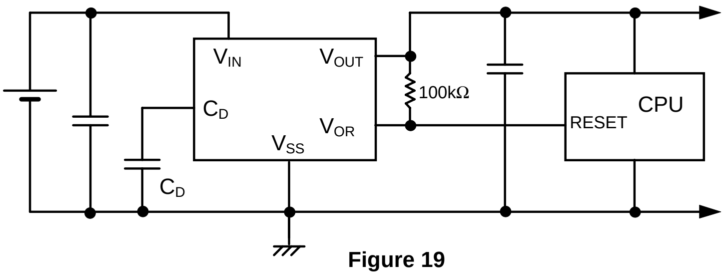


Figure 19

2. Output Current Boost Circuit

A PNP transistor is used to increase the output current.

(1) S-87XXXXA/B

(2) S-87XXXXC/G

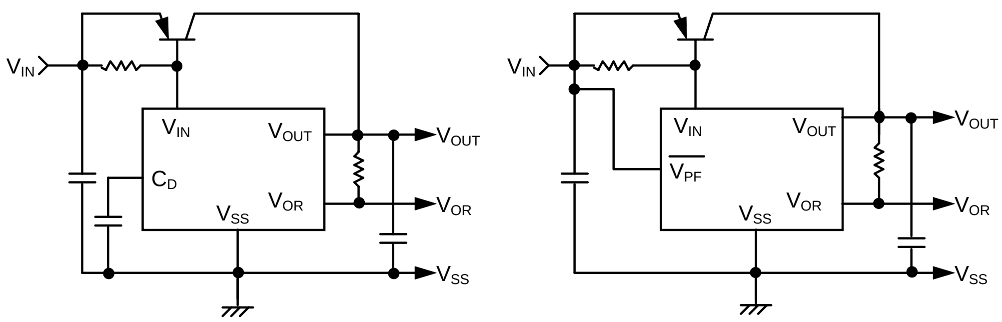


Figure 20

3. Power Supply for Lithium-Ion Battery Pack

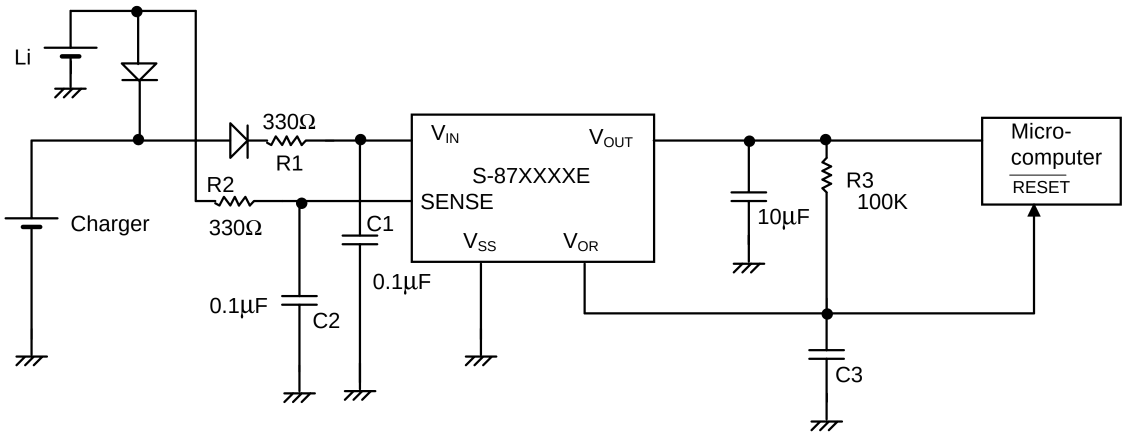
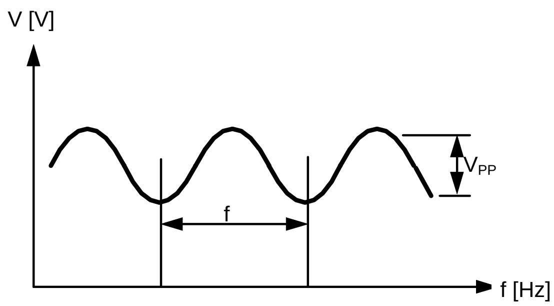


Figure 21

When the lithium-ion battery goes down to the overdischarge voltage, the built-in voltage detector powers OFF the voltage regulator, and at the same time it transmits the RESET signal to the microcomputer. R1, C1, R2 and C2 are attached to eliminate the voltage exceeding the absolute maximum ratings of charger. C3 is attached to give a delay and to release the RESET signal after power supply voltage for microcomputer(V_{OUT}) rises high enough.

■ Notes

- DO NOT apply a ripple voltage of the conditions below to V_{IN} pin.



$V_{PP} \geq 0.5V$
$f \geq 1000Hz$

Figure 22

- When connecting the voltage regulator output pin to another power supply, insert a diode to protect the IC.

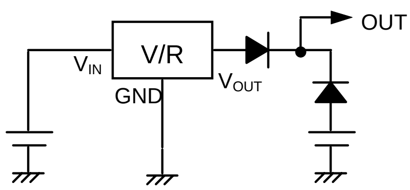
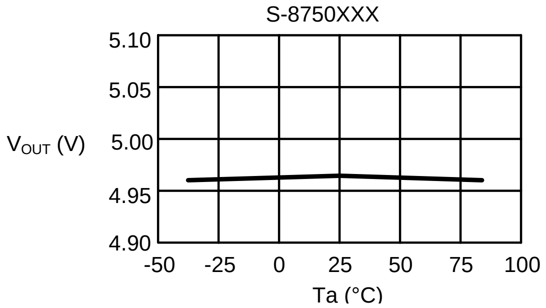


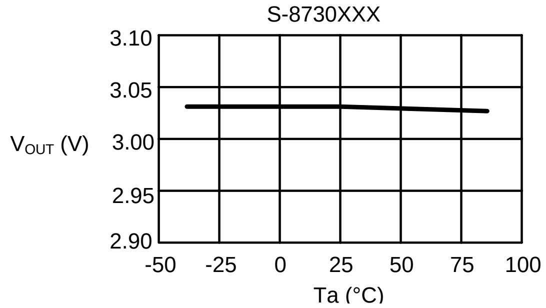
Figure 23

■ Characteristics

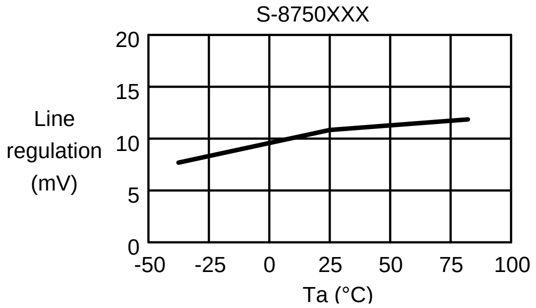
1. Voltage Regulator

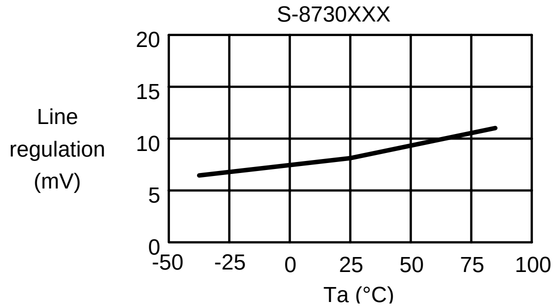
(1) Output Voltage (V_{OUT}) -Temperature (Ta)



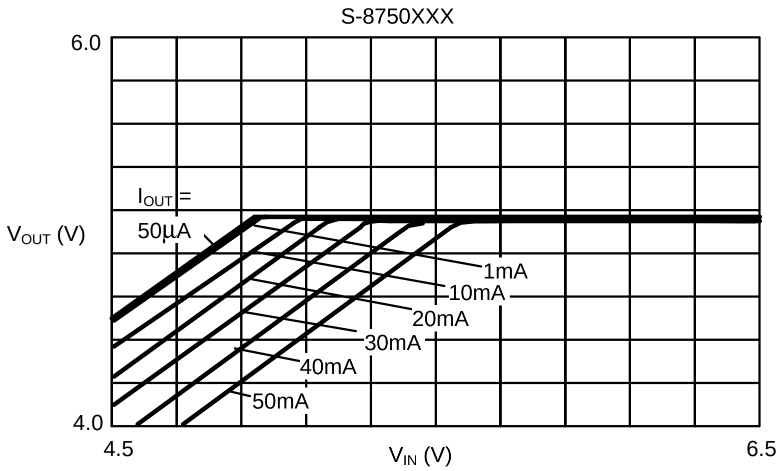


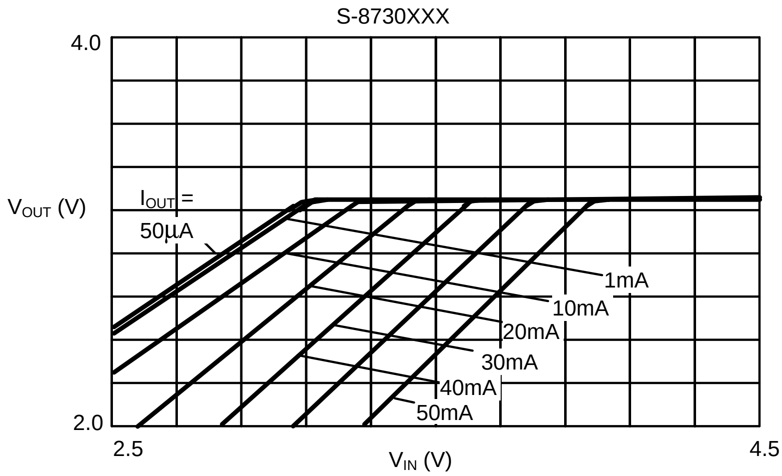
(2) Line Regulation -Temperature (Ta)





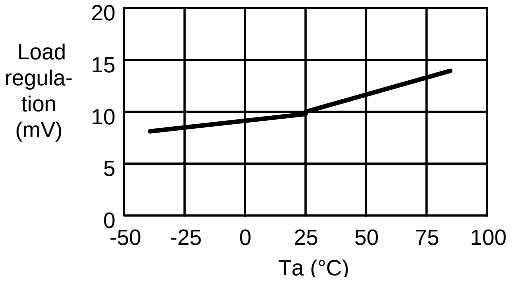
(3) Input Voltage (V_{IN}) - Output voltage (V_{OUT})



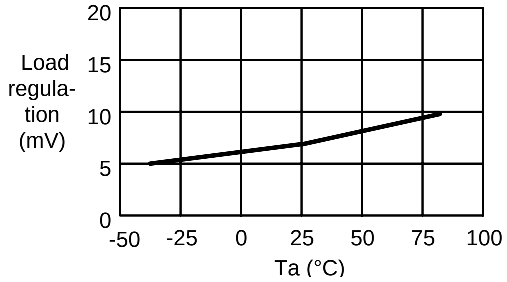


(4) Load Regulation - Temperature (Ta)

S-8750XXX

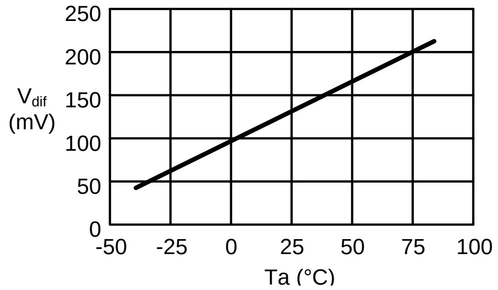


S-8730XXX

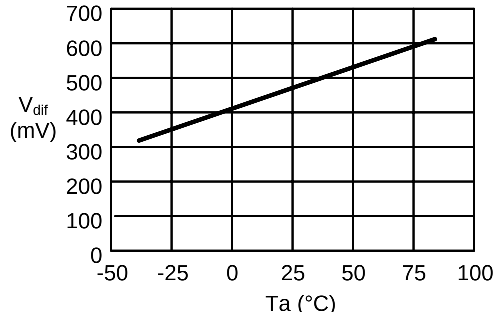


(5) I/O Voltage Difference (V_{dif})- Temperature (Ta)

S-8750XXX



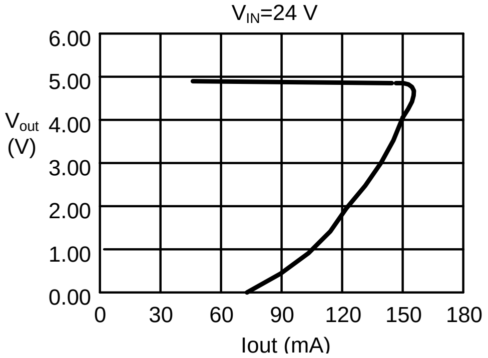
S-8730XXX



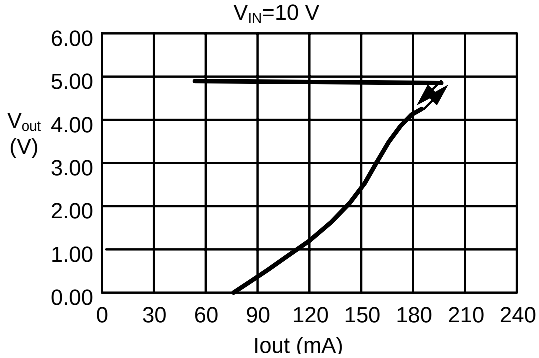
(6) Short-Circuit Protection Circuit

S-8750XXX Series Ta=25°C

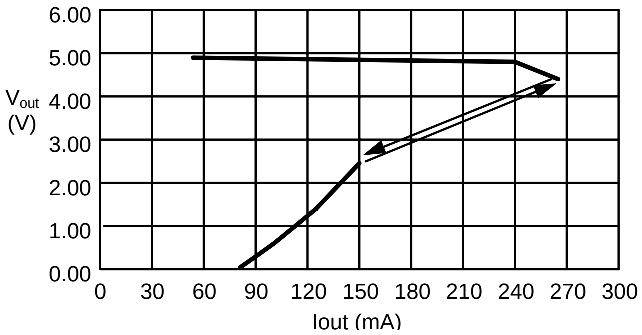
V_{IN}=24 V



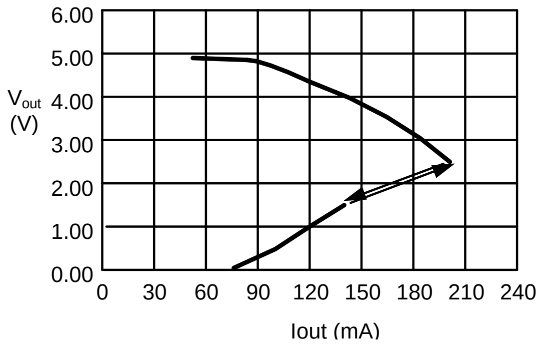
V_{IN}=10 V



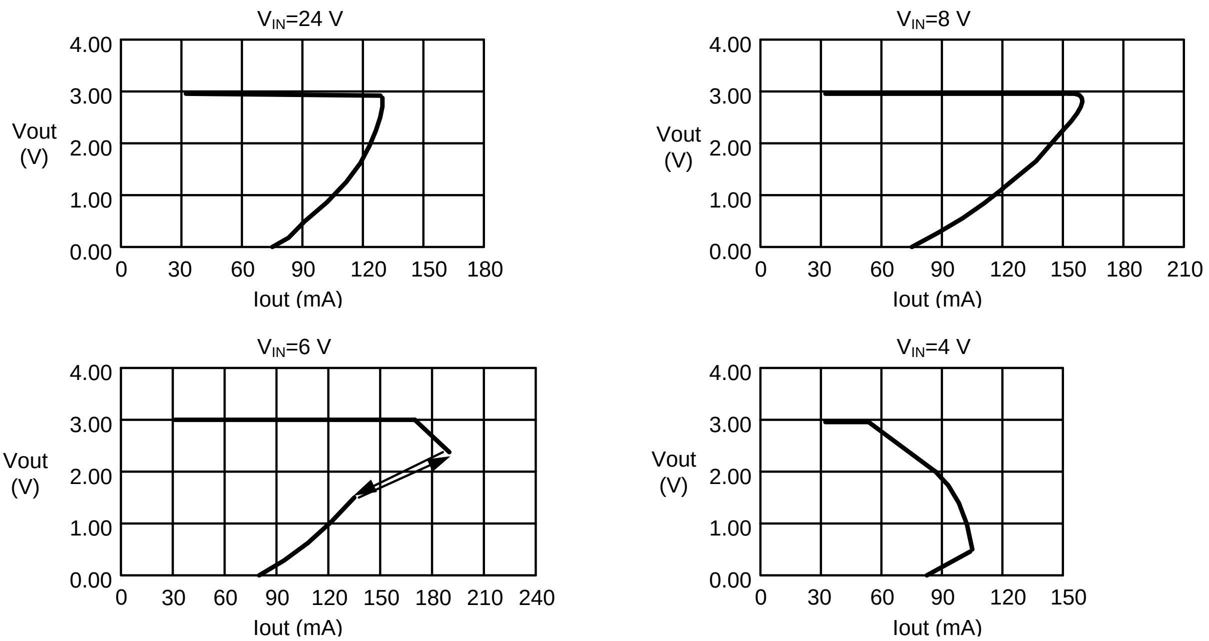
V_{IN}=8 V



V_{IN}=6 V

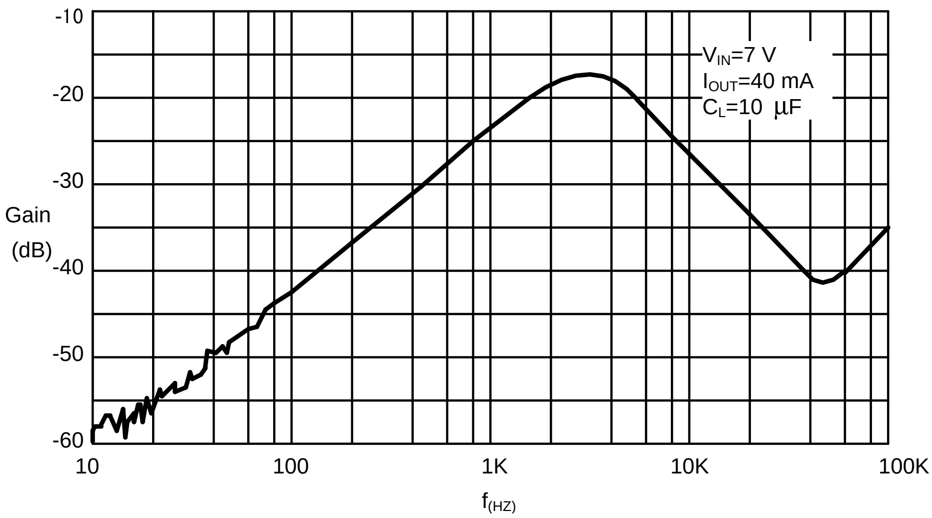


S-8730XXX Series Ta=25°C

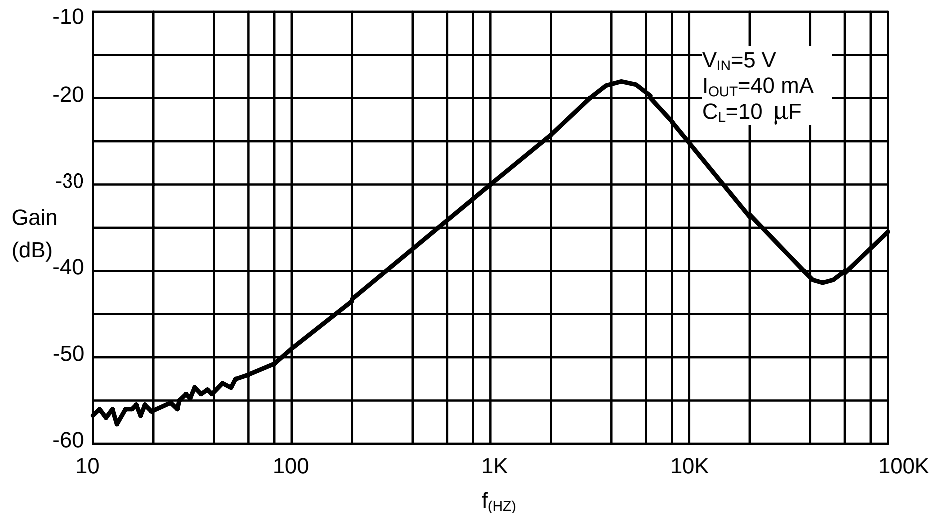


(7) Ripple rejection

S-8750XXX Series



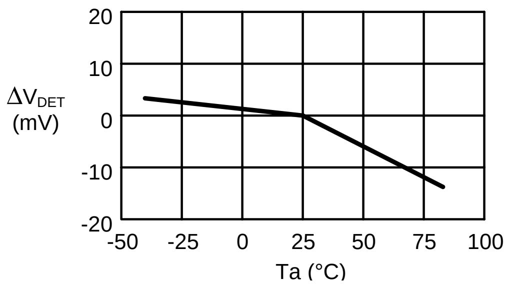
S-8730XXX Series



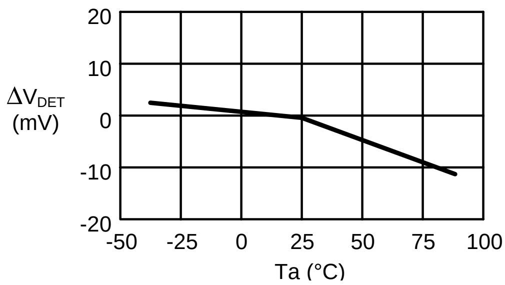
2. Voltage Detector

(1) Detection Voltage (V_{DET}) - Temperature (Ta)

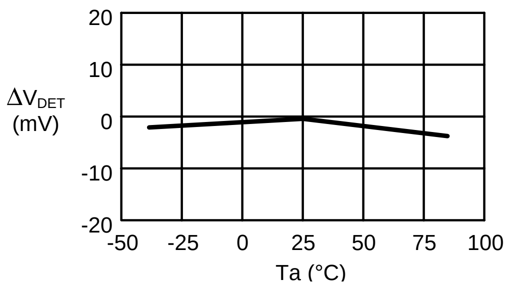
S-875045



S-875043

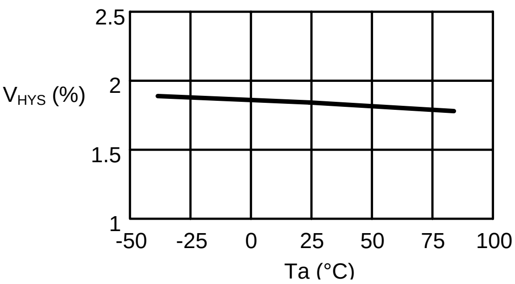


S-873023

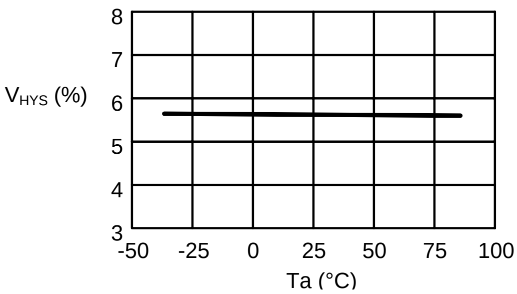


(2) Hysteresis Width (V_{HYS}) - Temperature (Ta)

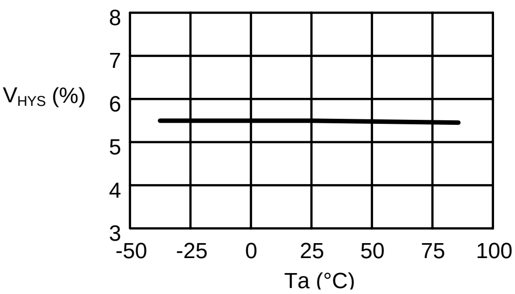
S-875045



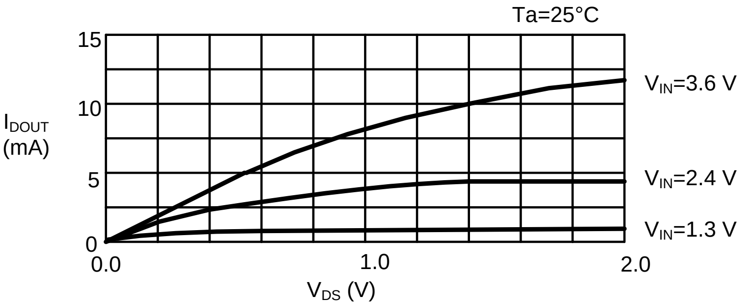
S-875043



S-873023

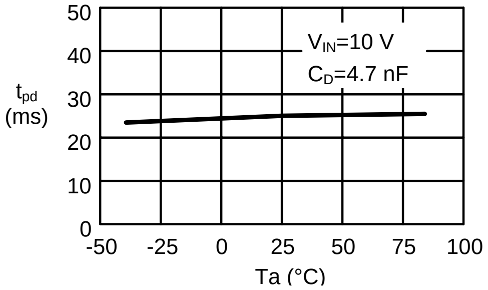


(3) Nch Transistor Output Current (I_{DOUT})



(4) Delay Time (tpd)

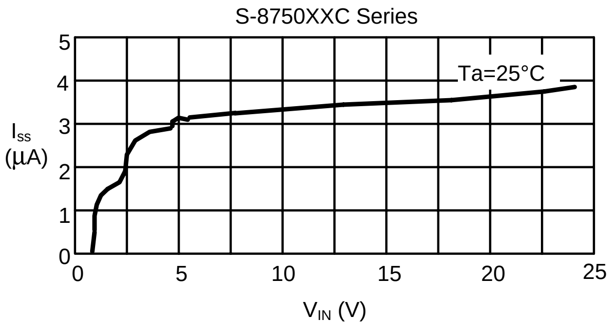
(a) Delay Time (tpd) - Temperature (Ta)

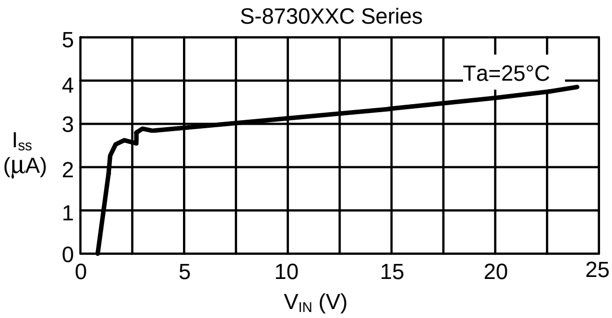


3. Total

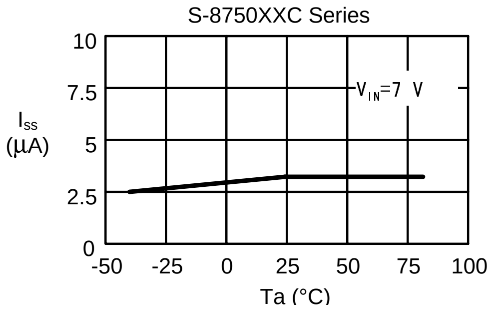
(1) Current Consumption (Iss)

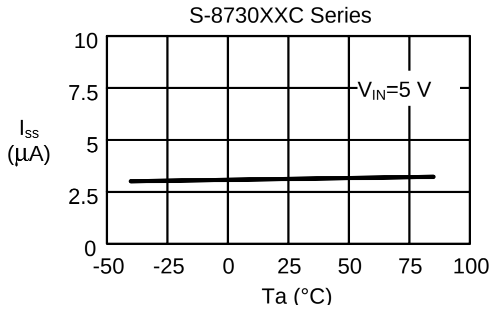
(a) Input Voltage(V_{IN})





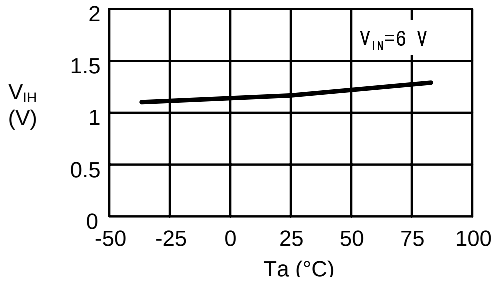
(b) Current Consumption (Iss) - Temperature (Ta)



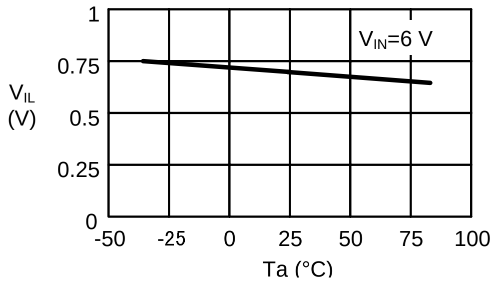


(2) Input Voltage of Shutdown Sircuit

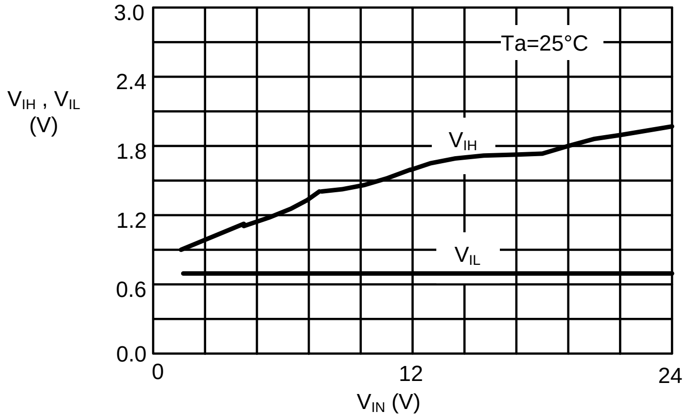
(a) High Level Input Voltage (V_{IH}) - Temperature (Ta)



(b) Low Level Input Voltage (V_{IL}) - Temperature (Ta)



(c) V_{IH} , V_{IL} - Power Supply Voltage Dependency

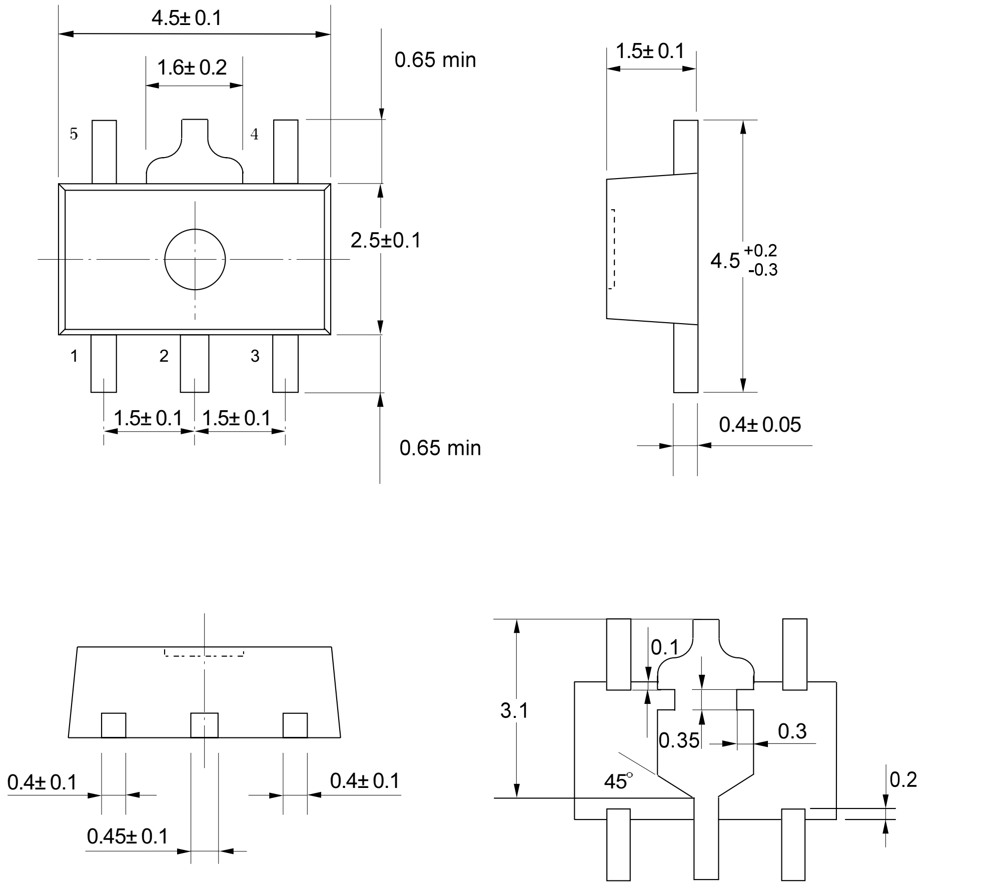


■ SOT-89-5

UP005-A 990531

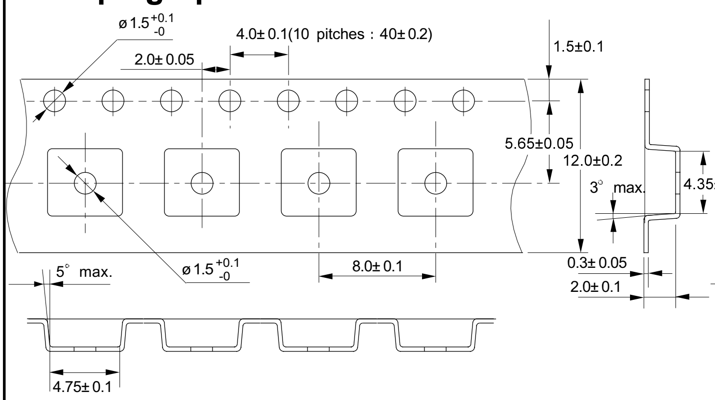
Unit : mm

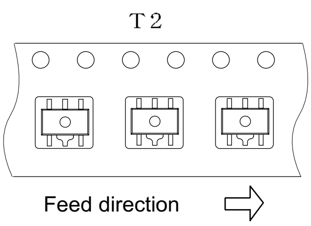
● Dimensions



No. : UP005-A-P-SD-1. 1

● Taping Specifications

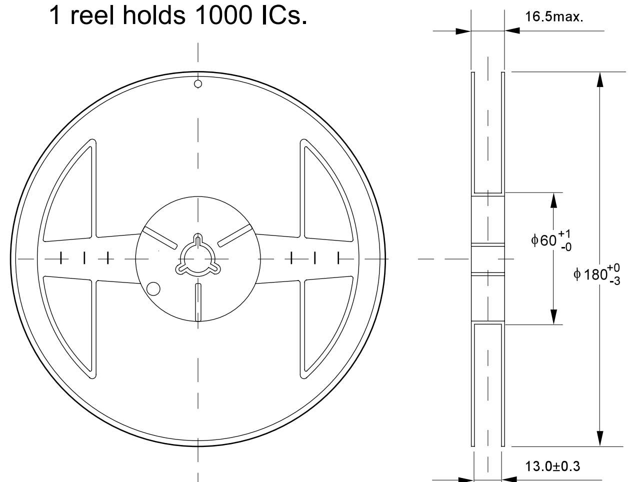




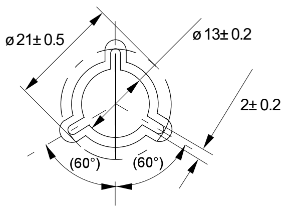
No. : UP005-A-C-SD-1. 0

● Reel Specifications

1 reel holds 1000 ICs.



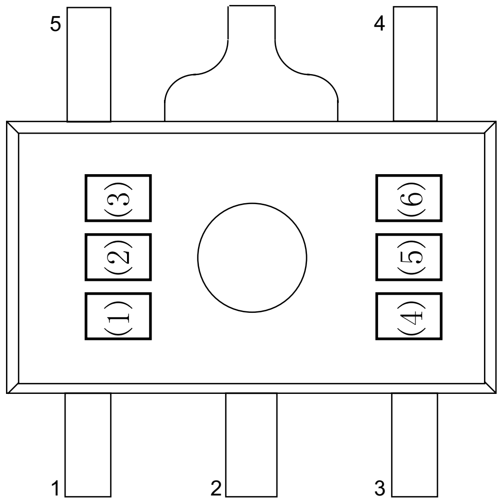
Winding core



No. : UP005-A-R-SD-1. 0

■Markings

● **SOT-89-5**



（1） to （3） : Product name (abbreviation)

（4） : Year of assembly

（5） : Month of assembly

（6） : Week of assembly