VOLTAGE REGULATION STEP-UP CHARGE PUMP DC-DC CONVERTER

S-8821 Series

The S-8821 series is a CMOS step-up charge pump DC-DC converter with a voltage regulation function.
The S-8821 series consists of an oscillation circuit, a controller, a reference voltage circuit, an error amplifier circuit, and an output switching transistor, and can regulate the output voltage by PFM control.
Since small ceramic capacitors can be used for the pump capacitor, input capacitor, and output capacitor, the mounting area can be minimized.

■ Features

- Step-up PFM control CMOS charge pump
- Power supply voltage: 1.6 to 5.0 V
- Output voltage: 2.5 to 5.5 V, selectable in 0.1 V steps.
- Output voltage accuracy: ±2 % max.
- Built-in soft start circuit: 1.0 ms typ.
- Output current 25 mA (V_{IN}=($V_{OUT(S)}$ × 0.80) V)
- Oscillation frequency: 1.0 MHz typ.
- ON/OFF function: During standby: 1 μA max.
- Ultra-small package: SOT-23-6W, 6-Pin SNB(B), 6-Pin SON(A)

■ Applications

- Lithium ion battery driven applications
- Local power supply
- Power supply for white LED display backlights

■ Packages

Package Name	Drawing Code		
	Package	Tape	Reel
SOT-23-6W	MP006-B	MP006-B	MP006-B
6-Pin SNB(B)	BD006-A	BD006-A	BD006-A
6-Pin SON(A)	PB006-A	PB006-A	PB006-A

■ Block Diagram

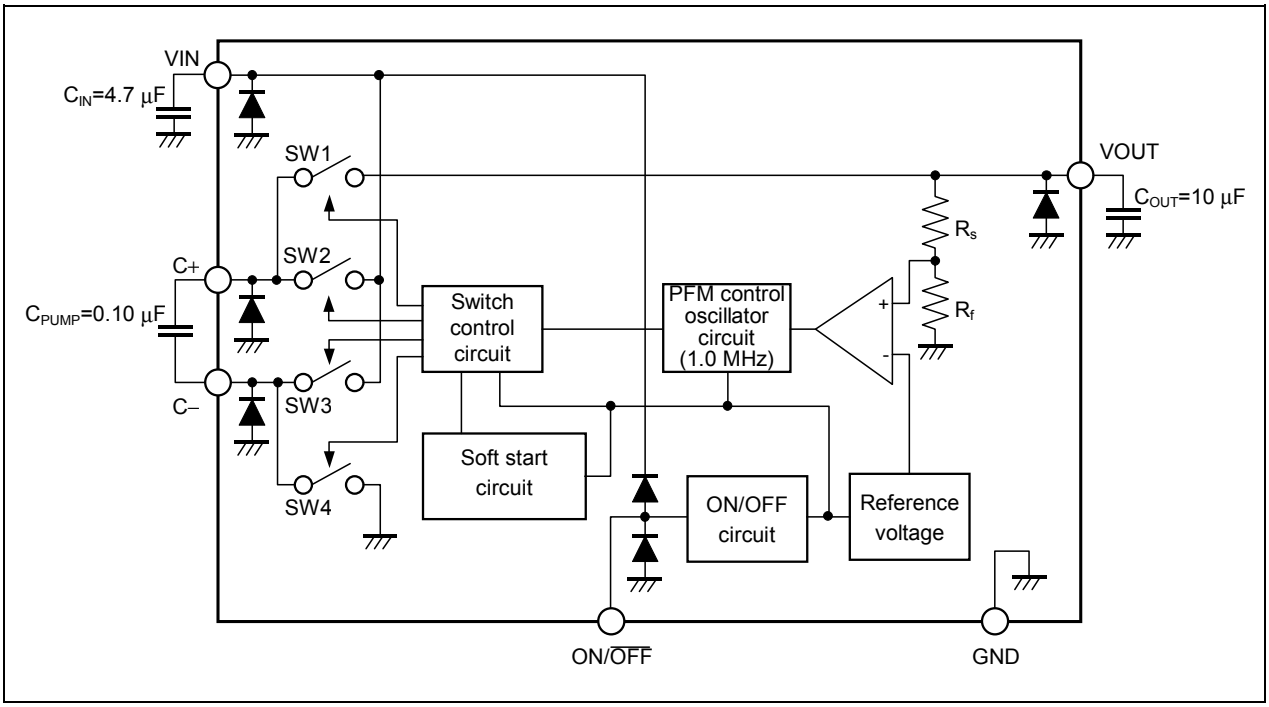


Figure 1

■ Selection Guide

- The output voltage and packages for the S-8821 Series can be selected at the user's request. Refer to the "Product name selection guide" for the meanings of the characters in the product name and "Product name list" for the full product names.

1. Product name selection guide

S-8821 xx A xx – xxx – TF

- TF: IC direction in tape specifications*1
- xxx: Product name (abbreviation)*2
- xx: Package name (abbreviation)
  - MH: SOT-23-6W
  - BD: 6-Pin SNB(B)
  - PB: 6-Pin SON(A)
- xx: Output voltage
  - 25 to 55
  - (E.g., when the output voltage is 2.5 V, it is expressed as 25.)

***1.** Refer to the taping specifications at the end of this book.
***2.** Refer to the product name list.

2. Product name list

Table 1

Output Voltage	SOT-23-6W	6-Pin SNB(B)	6-Pin SON(A)
3.0 V	S-882130AMH-M2F-TF	S-882130ABD-M2F-TF	S-882130APB-M2F-TF
3.3 V	S-882133AMH-M2I-TF	S-882133ABD-M2I-TF	S-882133APB-M2I-TF
3.6 V	S-882136AMH-M2L-TF	—	—
4.5 V	S-882145AMH-M2U-TF	—	—
5.0 V	S-882150AMH-M2Z-TF	S-882150ABD-M2Z-TF	S-882150APB-M2Z-TF
5.5 V	S-882155AMH-M3E-TF	—	—

Remark Contact the SII sales department for products with an output voltage other than those specified above.

■ Pin Configurations

SOT-23-6W
Top view

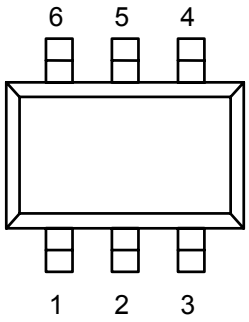
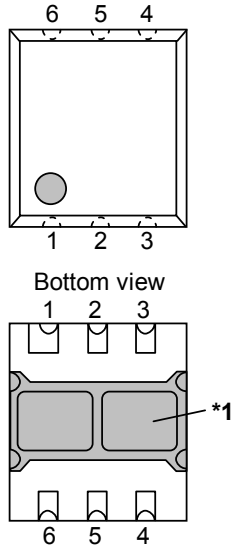


Figure 2

Table 2

Pin No.	Symbol	Pin Description
1	VIN	Voltage input pin
2	C+	Charge-pump pump capacitor connection pin (positive pin)
3	C–	Charge-pump pump capacitor connection pin (negative pin)
4	ON/$\overline{\text{OFF}}$	Shutdown pin High level (H): normal operation (step-up) Low level (L) : step-up halt (all circuit halt)
5	GND	GND pin
6	VOUT	Voltage output pin

6-Pin SNB(B)
Top view



***1.** Connect the heatsink of back side at shadowed area to the board, and set electric potential open or GND.
However, do not use it as the function of electrode.

Figure 3

Table 3

Pin No.	Symbol	Pin Description
1	VOUT	Voltage output pin
2	ON/$\overline{\text{OFF}}$	Shutdown pin High level (H): normal operation (step-up) Low level (L) : step-up halt (all circuit halt)
3	GND	GND pin
4	C–	Charge-pump pump capacitor connection pin (negative pin)
5	C+	Charge-pump pump capacitor connection pin (positive pin)
6	VIN	Voltage input pin

6-Pin SON(A)

Top view

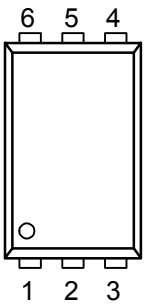


Figure 4

Table 4

Pin No.	Symbol	Pin Description
1	$\overline{\text{ON/OFF}}$	Shutdown pin High level (H): normal operation (step-up) Low level (L) : step-up halt (all circuit halt)
2	GND	GND pin
3	C−	Charge-pump pump capacitor connection pin (negative pin)
4	C+	Charge-pump pump capacitor connection pin (positive pin)
5	VIN	Voltage input pin
6	VOUT	Voltage output pin

■ Absolute Maximum Ratings

Table 5

(Ta=25°C unless otherwise specified)

Items	Symbols	Absolute Maximum Ratings		Units
C+ pin voltage	V_{C+}	V_{GND}–0.3 to V_{GND}+7.5		V
C– pin voltage	V_{C-}	V_{GND}–0.3 to V_{GND}+7		
VIN pin voltage	V_{IN}	V_{GND}–0.3 to V_{GND}+5.5		
VOUT pin voltage	V_{OUT}	V_{GND}–0.3 to V_{GND}+7		
ON/$\overline{OFF}$ pin voltage	$V_{ON/\overline{OFF}}$	V_{GND}–0.3 to V_{IN}+0.3		
Operating temperature range	T_{OPR}	–40 to +85		°C
Storage temperature range	T_{STG}	–40 to +125		
Power dissipation	P_{D1}	SOT-23-6W	300	mW
	P_{D2}	6-Pin SON(A)	200	
	P_{D3}	6-Pin SNB(B)	90	

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.

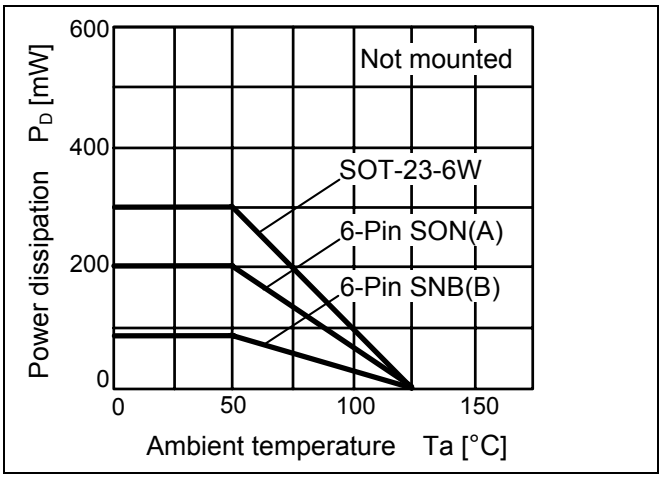


Figure 5 Power Dissipation of The Packages

■ Electrical Characteristics

Table 6

(V_{IN}=($V_{OUT(S)}$ × 0.60) V[*1], Ta=25°C unless otherwise specified)

Items	Symbols	Conditions	Min.	Typ.	Max.	Units	Test circuits
Operation input voltage	V_{IN}	$V_{OUT(S)}$ ≤ 2.9 V	1.6	—	5.0	V	2
		$V_{OUT(S)}$ > 2.9 V	$V_{OUT(S)}$ × 0.54	—	5.0		
Output voltage[*2]	$V_{OUT(E)}$	I_{OUT}=10 mA	$V_{OUT(S)}$ × 0.98	$V_{OUT(S)}$	$V_{OUT(S)}$ × 1.02		
Output current[*3]	I_{OUT}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6]	5	—	—	mA	
		V_{IN}=($V_{OUT(S)}$ × 0.60) V[*1]	15	—	—		
		V_{IN}=($V_{OUT(S)}$ × 0.80) V	25	—	—		
Line regulation	ΔV_{OUT1}	V_{IN}=($V_{OUT(S)}$ × 0.60) V[*1] to ($V_{OUT(S)}$ − 0.10) V, I_{OUT}=10 mA	—	50	100	mV	
Load regulation	ΔV_{OUT2}	I_{OUT}=0.1 mA to 10 mA	—	40	80		
Ripple voltage[*4]	V_{RIP}	I_{OUT}=10 mA	—	70	—	mV_{p-p}	
Maximum oscillation frequency	f_{osc}	V_{OUT}=($V_{OUT(S)}$ × 0.60) V, Measure waveform at C− pin	800	1000	1200	kHz	
Efficiency[*5]	η	V_{IN}=($V_{OUT(S)}$ × 0.54) V, $V_{OUT(S)}$ ≥ 3.0 V, I_{OUT}=5 mA	—	90	—	%	1
Operation consumption current	I_{SS1}	V_{IN}=$V_{OUT(S)}$, V_{OUT}=($V_{OUT(S)}$ + 0.5) V	—	35	60	μA	2
Standby consumption current	I_{SSS}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6] to 5.0 V, $V_{ON/\overline{OFF}}$=0 V	—	0.3	1.0		1
ON/$\overline{OFF}$ pin input voltage (high level)	V_{SH}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6] to 5.0 V	1.5	—	—	V	
ON/$\overline{OFF}$ pin input voltage (low level)	V_{SL}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6] to 5.0 V	—	—	0.3		
ON/$\overline{OFF}$ pin input current (high level)	I_{SH}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6] to 5.0 V	−0.1	—	0.1	μA	
ON/$\overline{OFF}$ pin input current (low level)	I_{SL}	V_{IN}=($V_{OUT(S)}$ × 0.54) V[*6] to 5.0 V	−0.1	—	0.1		
Soft start time	t_{SS}	I_{OUT}=10 mA	0.2	1.0	4.0	ms	

***1.** In case of V_{OUT} ≤ 3.3 V, V_{IN}=2.0 V

***2.** $V_{OUT(E)}$: Actual output voltage
$V_{OUT(S)}$: Specified output voltage

***3.** The output current at which the output voltage becomes 97 % of $V_{OUT(E)}$ after gradually increasing the output current.

***4.** Design assurance

***5.** The ideal efficiency is indicated by the following expression.
Efficiency (η)=(V_{OUT} × I_{OUT}) / (2.0 × V_{IN} × I_{OUT})

***6.** In case of V_{OUT} ≤ 2.9 V, V_{IN}=1.6 V

■ Test Circuits

1.

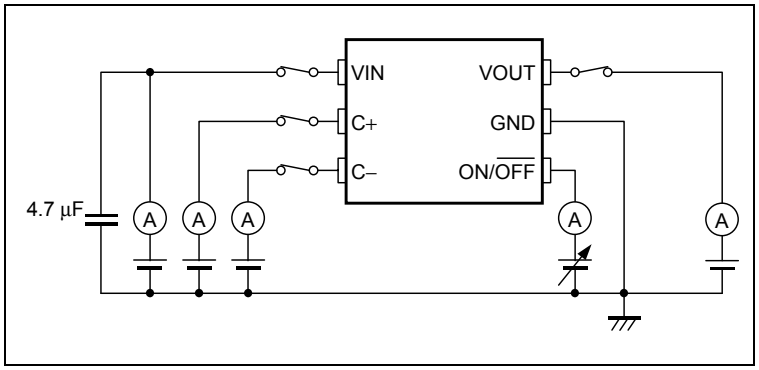


Figure 6

2.

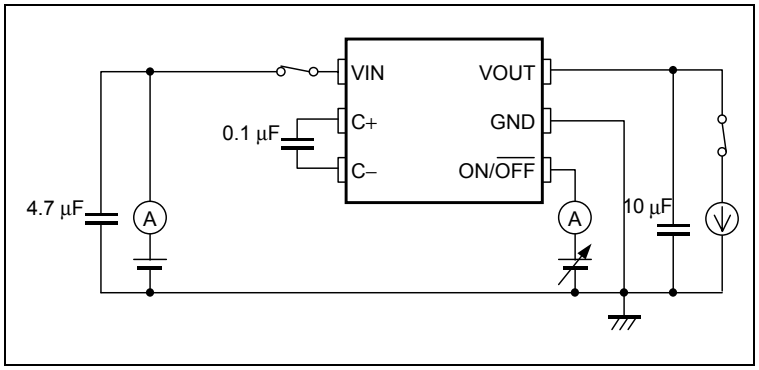


Figure 7

■ Operation

1. Basic operation

Figure 8 shows the block diagram of the S-8821 Series.
The S-8821 series controls the output voltage by using the pulse frequency modulation (PFM) method. The SW1 to SW4 switching transistors are switched ON/OFF with the clock generated by the internal oscillator circuit, and operates the step-up charge pump.
The output voltage is fed back and the voltage split by feedback resistances R_s and R_f and reference voltage (V_{ref}) are compared by a comparator. This comparator signal is used to modulate the oscillation pulse frequency in order to keep the output voltage constant.

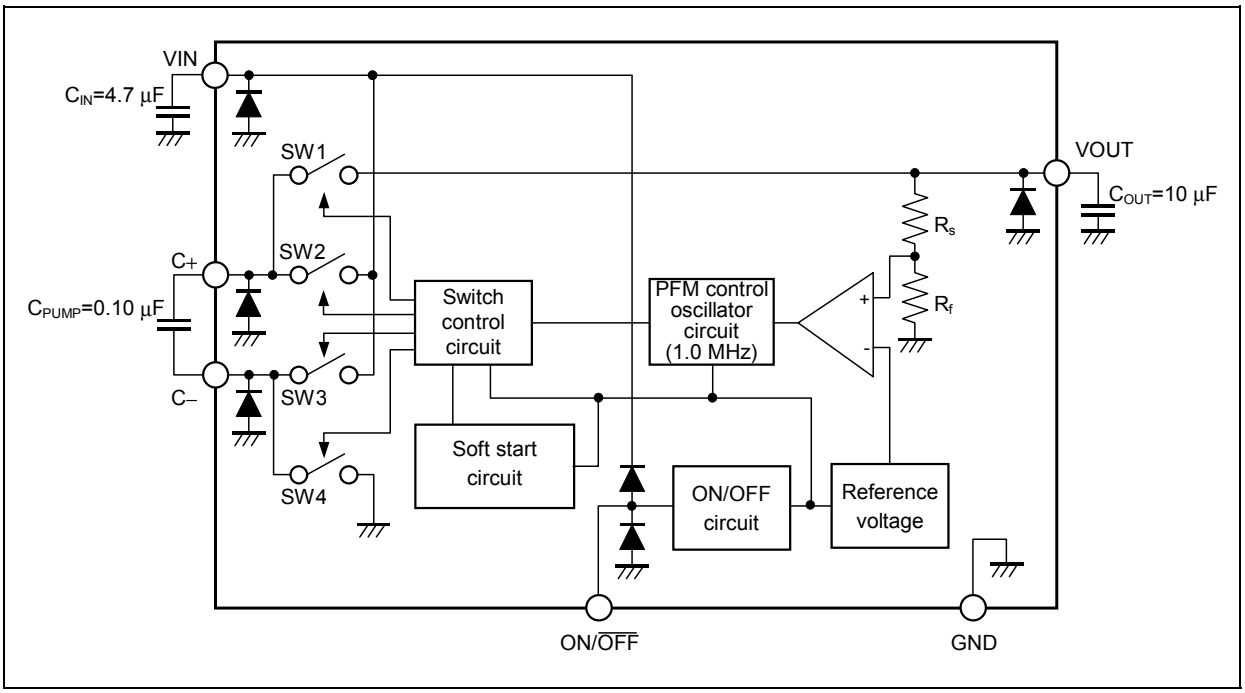


Figure 8

2. Step-up Charge Pump

The step-up charge pump steps up the voltage by switching ON/OFF of the SW1 to SW4 switching transistors.
First, in order to charge the pump capacitance (C_{PUMP}), set SW1 to OFF, SW2 to ON, SW3 to OFF, and SW4 to ON (charge cycle). Following charging the electricity, in order to discharge the charged electricity to the output capacitance (C_{OUT}), SW1 set the switches as to ON, SW2 to OFF, SW3 to ON, and SW4 to OFF (discharge cycle).
The input voltage can be stepped up to a constant voltage value by repeating this charge cycle and discharge cycle.
Figure 9 shows the charge cycle, and **Figure 10** shows the discharge cycle.

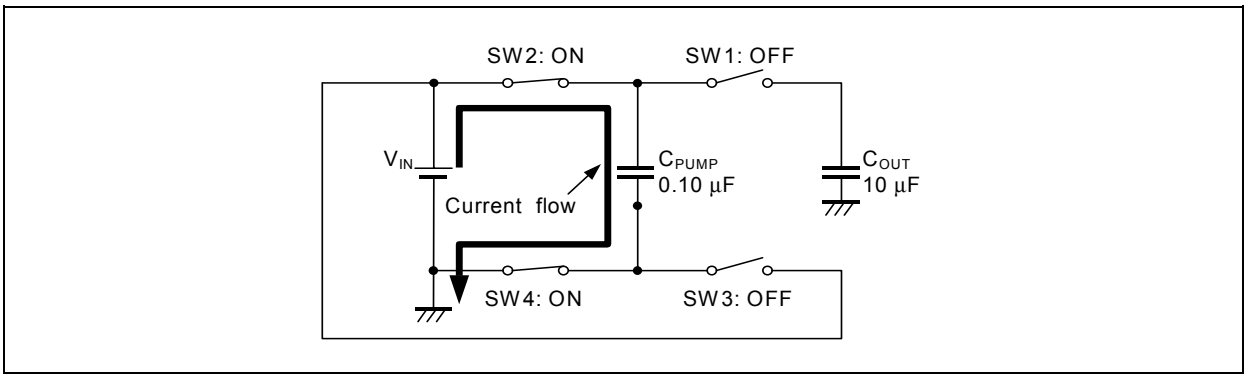


Figure 9

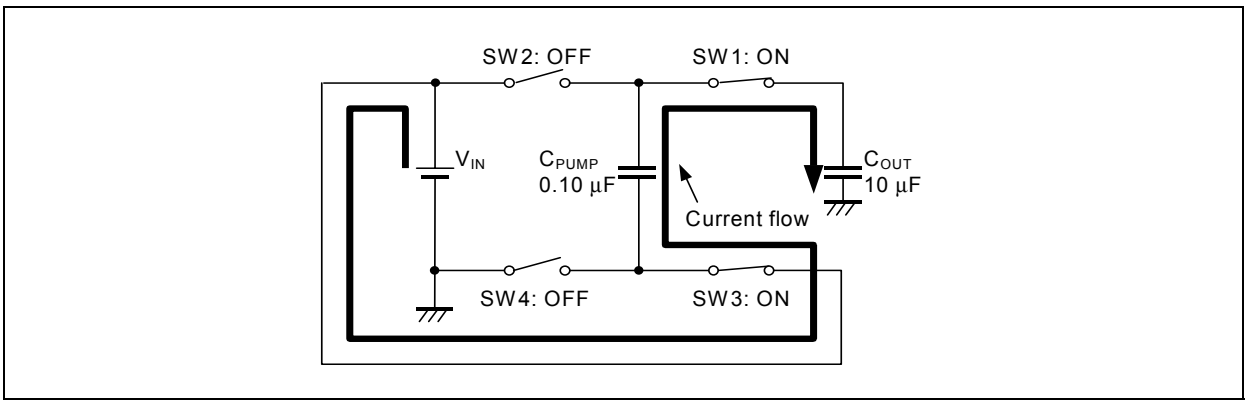


Figure 10

3. Shutdown Pin (ON/$\overline{\text{OFF}}$ Pin)

Setting the ON/$\overline{\text{OFF}}$ pin to the Low level ("L") causes the voltage of the VOUT pin to change to the GND level and simultaneously the operation of all the internal circuit to stop. At this time, the consumption current is largely reduced, to a level of approximately 0.3 μA.
The structure of the ON/$\overline{\text{OFF}}$ pin is as shown in **Figure 11**. Since the ON/$\overline{\text{OFF}}$ pin is neither pulled down nor pulled up internally, do not use it in the floating state.
When the ON/$\overline{\text{OFF}}$ pin is not used, connect it to the VIN pin.

Table 7

ON/$\overline{\text{OFF}}$ pin	Internal circuit	VOUT pin voltage
"H": Power on	Operating	Set value
"L": Power off	Stop	V_{GND} level

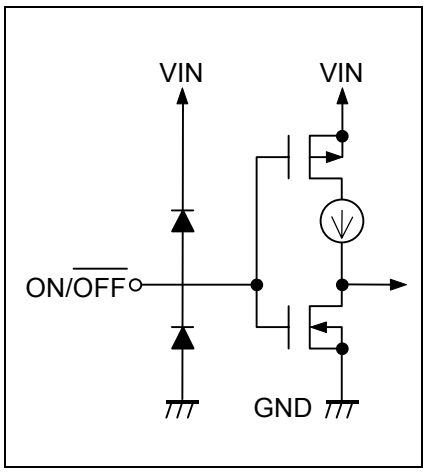


Figure 11

4. Soft Start Function

The S-8821 Series features a built-in soft start circuit. Upon power application or when the ON/$\overline{\text{OFF}}$ pin is switched from "L" to "H", the output voltage gradually rises over the soft start time, and the output current is gradually output as a result. This soft start function reduces the input current rush.

■ External Capacitor Selection

1. Input and Output Capacitors (C_{IN}, C_{OUT})

The input capacitor (C_{IN}) lowers the power supply impedance and averages the input current.
The C_{IN} value is selected according to the impedance of the power supply that is used. Select a ceramic capacitor with a small equivalent series resistance (ESR). Although this figure varies according to the impedance of the power supply that is used as well as the load current value, it is generally in the range of 4.7 μF to 10 μF.
For the output capacitor (C_{OUT}), select a ceramic capacitor with a small ESR for smoothing the ripple voltage. A value of 10 μF is recommended for the capacitance value. Use of a capacitor with a capacitance lower than 10 μF results in a larger ripple voltage. Conversely, use of a capacitor with a capacitance greater than 10 μF results in the output voltage not being able to rise up to setting value and the impossibility to obtain the desired output current.

2. Pump Capacitor (C_{PUMP})

The pump capacitor (C_{PUMP}) is required for stepping up the voltage. Select a ceramic capacitor with a small ESR. A capacitance value of 0.10 μF is recommended. Use of a capacitor with a capacitance greater than 0.10 μF results in a larger ripple voltage. Conversely, use of a capacitor with a capacitance lower than 0.10 μF results in the output voltage not being able to raise up to setting value and the impossibility to obtain the desired output current.

■ Precautions

- Regarding the wiring to the VIN pin, VOUT pin, C+ pin, C– pin and GND pin, be careful to perform pattern wiring so as to obtain low impedance.

- Always connect a capacitor to the VOUT pin, C+ pin, and C– pin.

- Connect C_{IN} and C_{OUT} in the vicinity of the IC and sufficiently strengthen the wiring for GND pin and VIN pin in order to lower the impedance of the wiring resistance, etc. High impedance may cause unstable operation.
  Moreover, in selecting C_{IN} and C_{OUT}, perform a full evaluation of the actual usage conditions.

- Connect C_{PUMP} in the vicinity of the IC and sufficiently strengthen the wiring for the C+ pin and C– pin in order to lower the impedance of the wiring resistance, etc. High impedance may cause instable operation.
  Moreover, in selecting C_{PUMP}, perform a full evaluation of the actual usage conditions.

- The ON/$\overline{\text{OFF}}$ pin is configured as shown in **Figure 11** and is neither pulled up or down internally, so do not use this pin in a floating state. When not using the ON/$\overline{\text{OFF}}$ pin, connect it to the VIN pin.
  Moreover, please do not apply voltage higher than VIN + 0.3 V to an ON/$\overline{\text{OFF}}$ pin. Current flows for a VIN pin through the protection diode inside IC.

- Since this IC consists of double step-up circuits, it cannot set more than twice voltage of V_{IN} to $V_{OUT(S)}$.

- Be careful about the usage conditions for the input/output voltages and output current to make sure that dissipation within the IC does not exceed the allowable power dissipation of the package.
  For reference, the calculation of the power consumption in this IC is shown below.
  $P_D=(V_{IN} \times 2.0 - V_{OUT}) \times (I_{OUT})$

  Reference: V_{IN}=4.2 V, V_{OUT}=5.5 V, I_{OUT}=10 mA
  $P_D=(4.2 \times 2.0 - 5.5) \times 0.010$=29 mW

- Since the information described herein is subject to change without notice, confirm that this is the latest one before using.

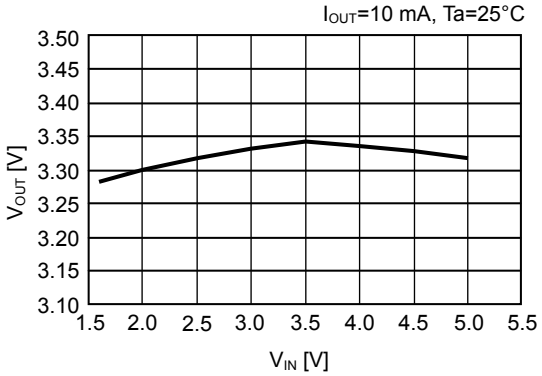
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

- SII claims no responsibility for any and all disputes arising out of or in connection with any infringement of the products including this IC upon patents owned by a third party.

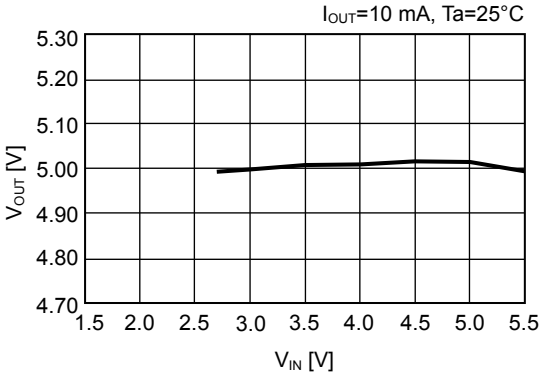
■ Typical Characteristics

(1) Output voltage vs. Operation input voltage

S-882133A



S-882150A



(2) Output voltage vs. Output current

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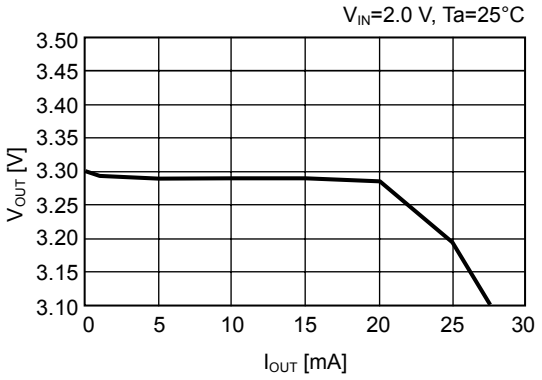

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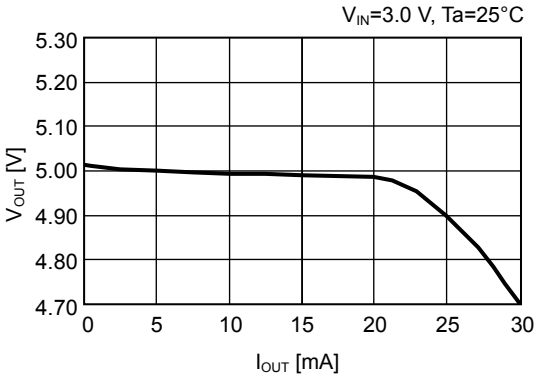
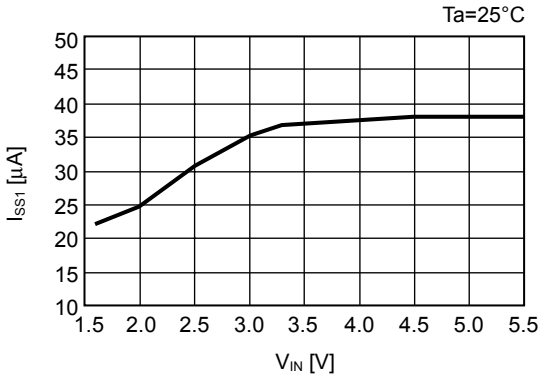


(3) Operation consumption vs. Operation input voltage

S-882133A



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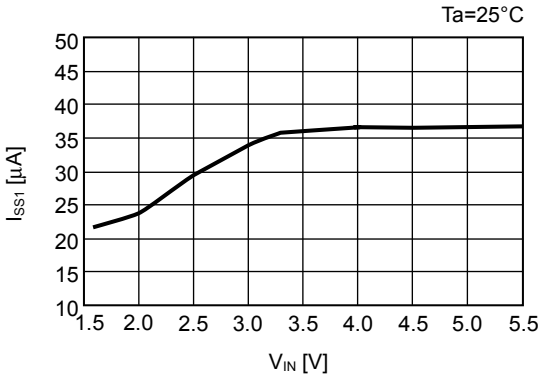

(4) Ripple voltage vs. Operation input voltage

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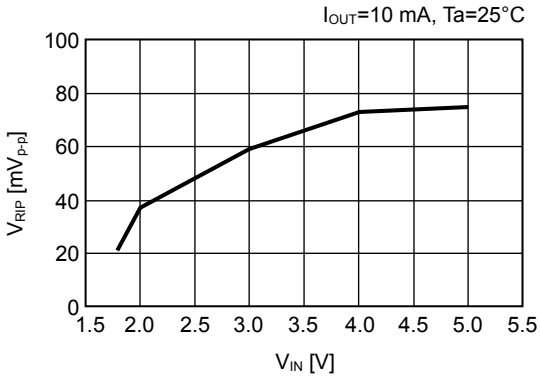

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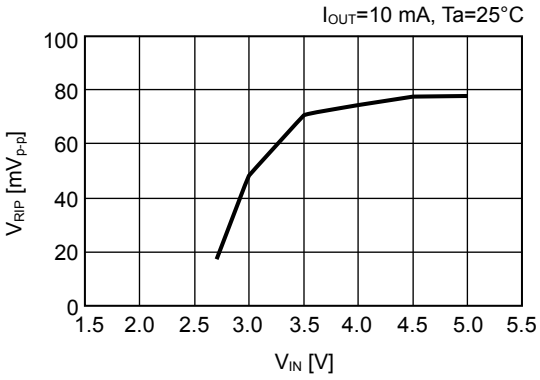

(5) Efficiency[*1] vs. Operation input voltage

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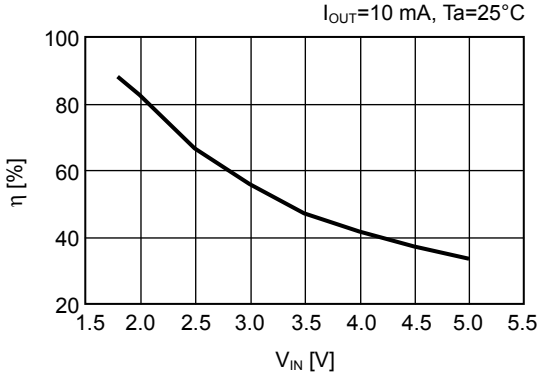

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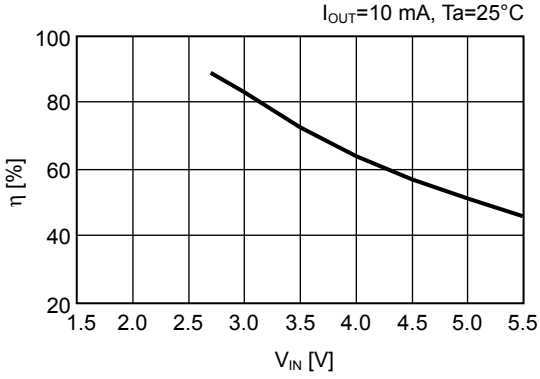
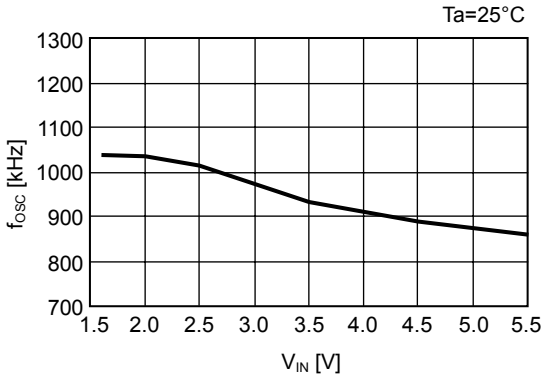


***1.** The ideal efficiency is indicated by the following expression.
Efficiency (η)=($V_{OUT} \times I_{OUT}$) / ($2.0 \times V_{IN} \times I_{OUT}$)

(6) Maximum oscillation frequency vs. Operation input voltage

S-882133A



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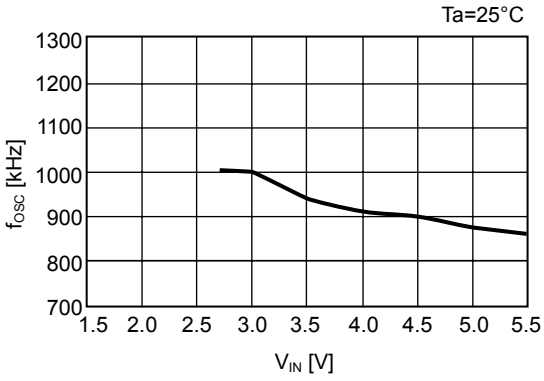
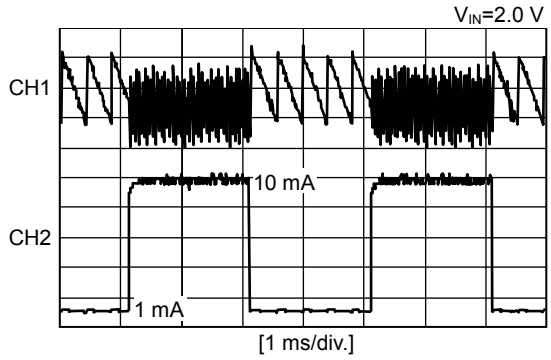


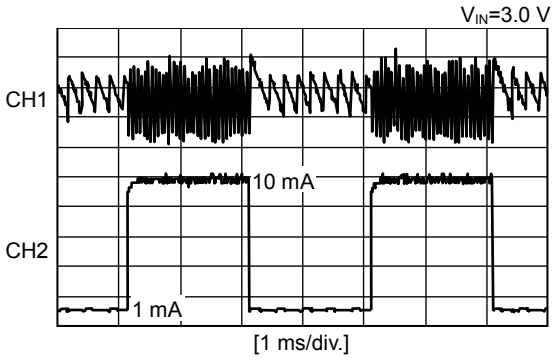
(7) Load fluctuation

S-882133A



CH1: V_{OUT} [20 mV/div.]
CH2: I_{OUT} [2 mA/div.]

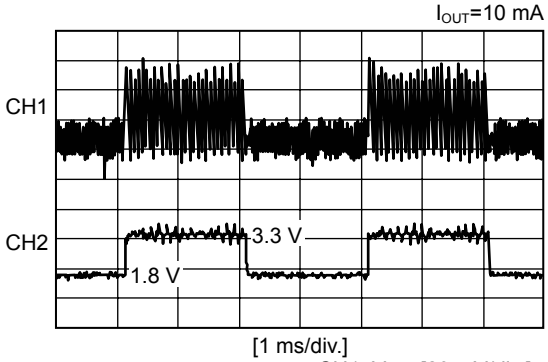
S-882150A



CH1: V_{OUT} [20 mV/div.]
CH2: I_{OUT} [2 mA/div.]

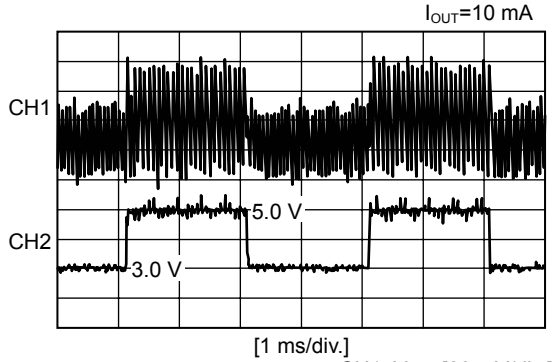
(8) Input voltage fluctuation

S-882133A

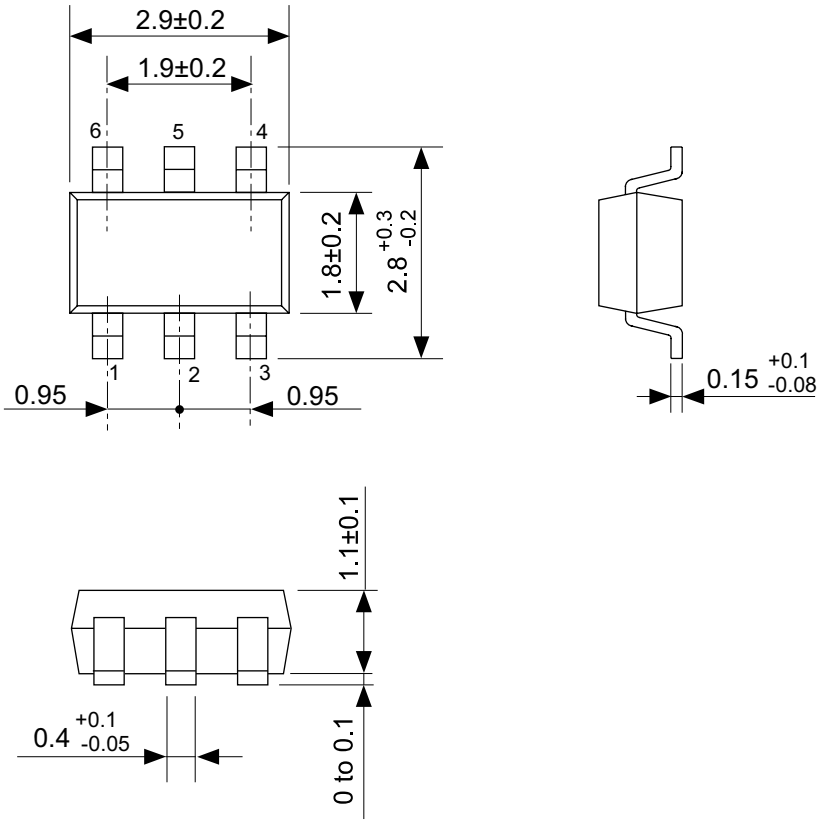


CH1: V_{OUT} [20 mV/div.]
CH2: V_{IN} [1 V/div.]

S-882150A

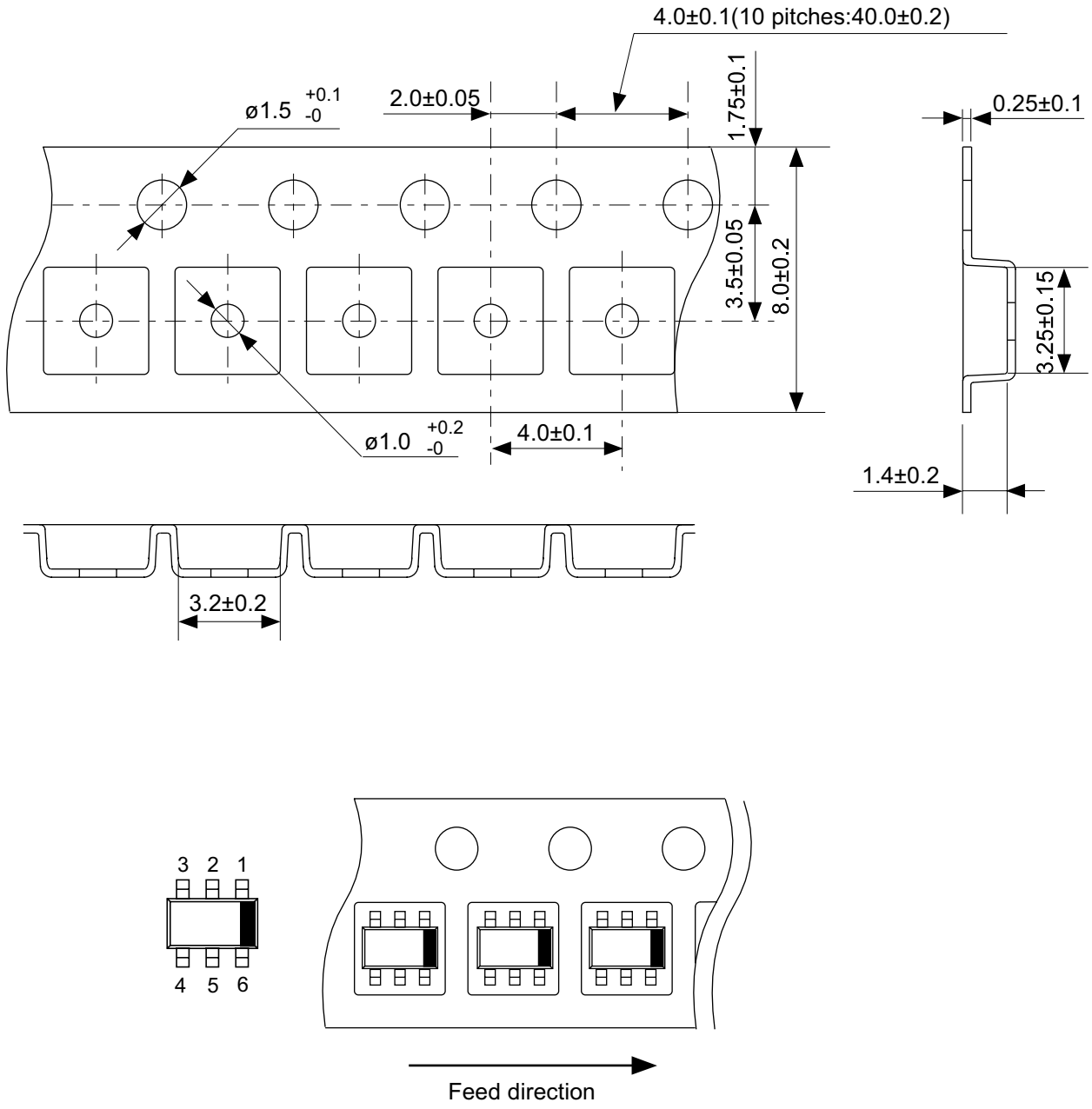


CH1: V_{OUT} [20 mV/div.]
CH2: V_{IN} [1 V/div.]



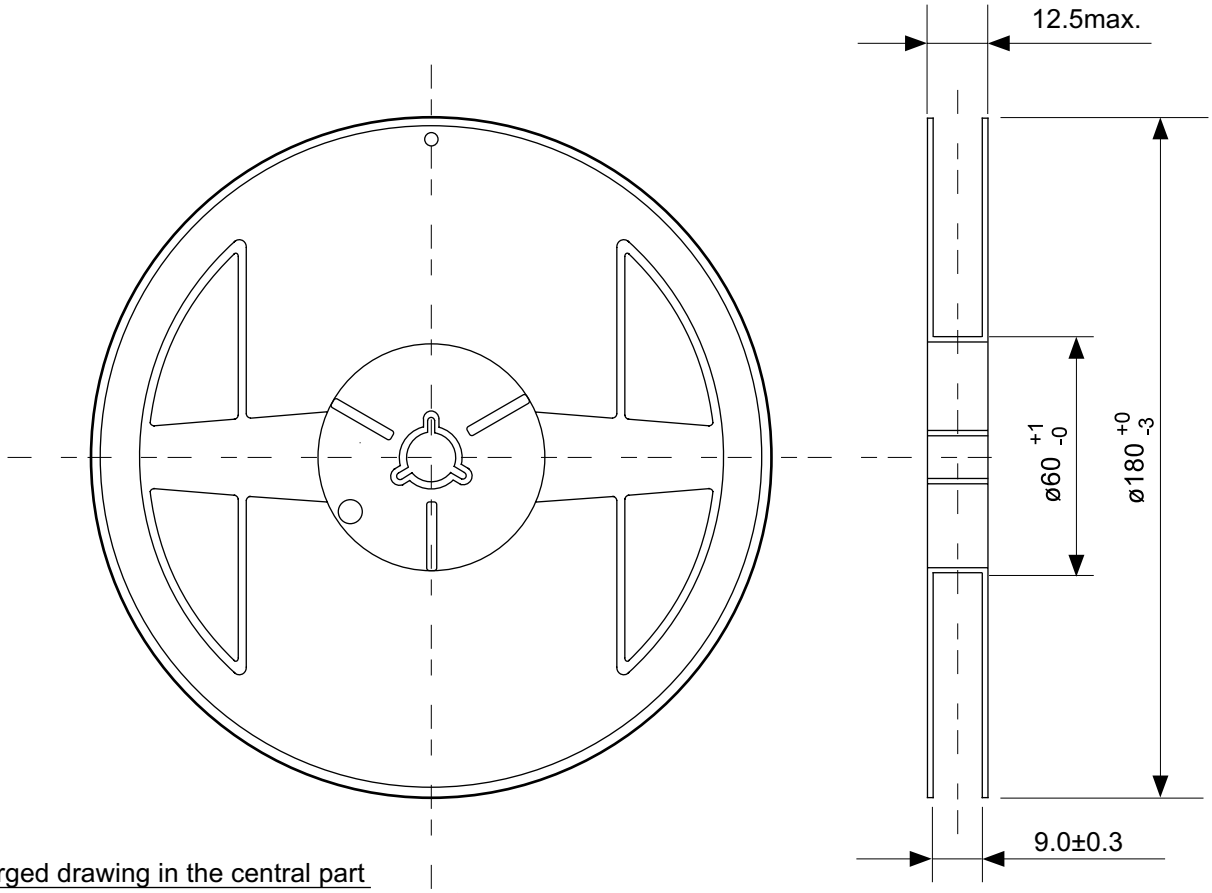
No. MP006-B-P-SD-1.0

TITLE	SOT236-B-PKG Dimensions
No	MP006-B-P-SD-1.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	

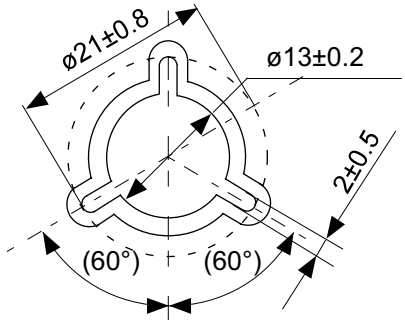


No. MP006-B-C-SD-1.0

TITLE	SOT236-B-Carrier Tape
No	MP006-B-C-SD-1.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	

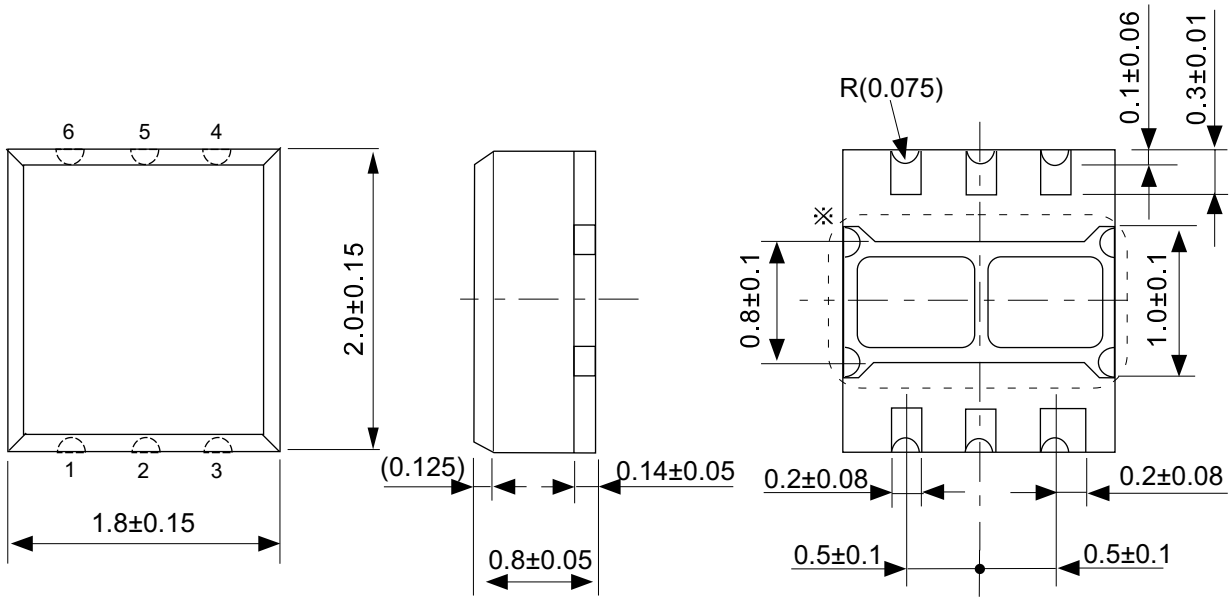


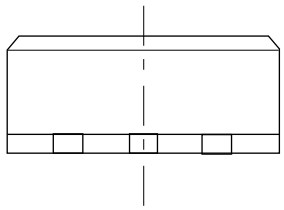
Enlarged drawing in the central part



No. MP006-B-R-SD-1.0

TITLE	SOT236-B-Reel		
No	MP006-B-R-SD-1.0		
SCALE		QTY	3,000
UNIT	mm		
Seiko Instruments Inc.			

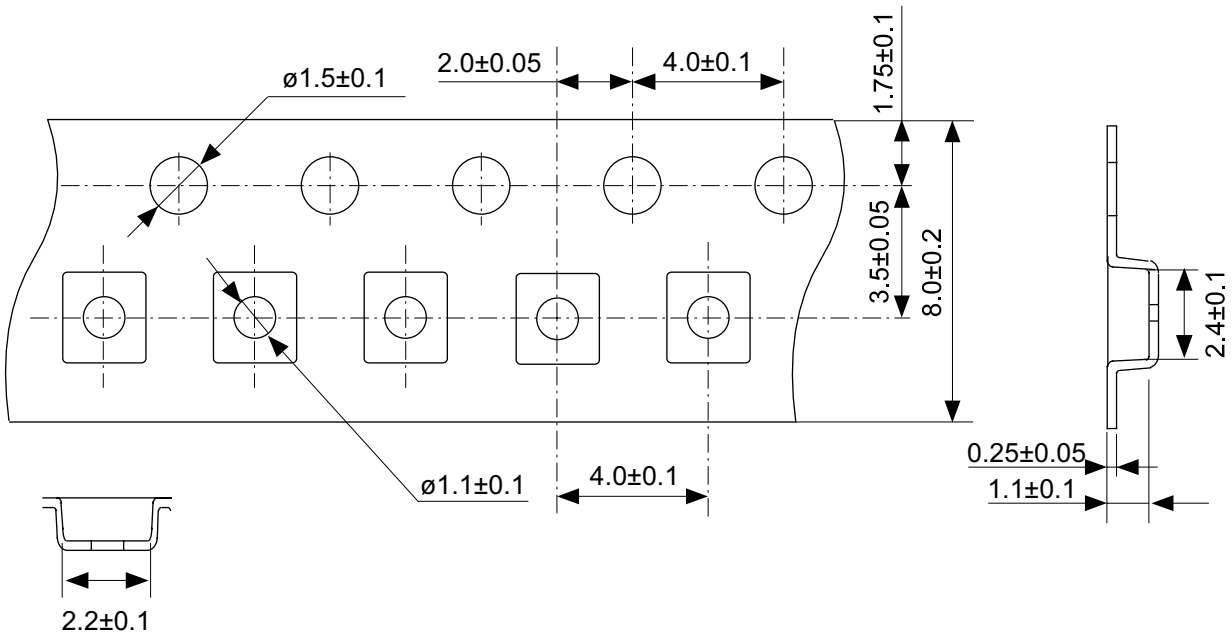


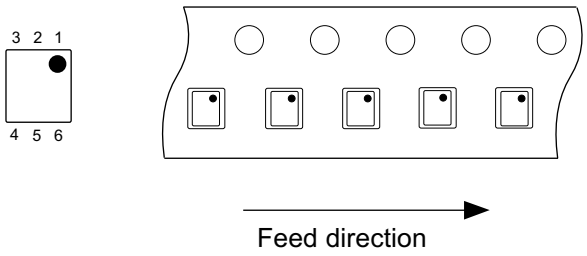


※ The heatsink of back side has different electric potential depending on the product.
Confirm specifications of each product.
Do not use it as the function of electrode.

No. BD006-A-P-SD-3.0

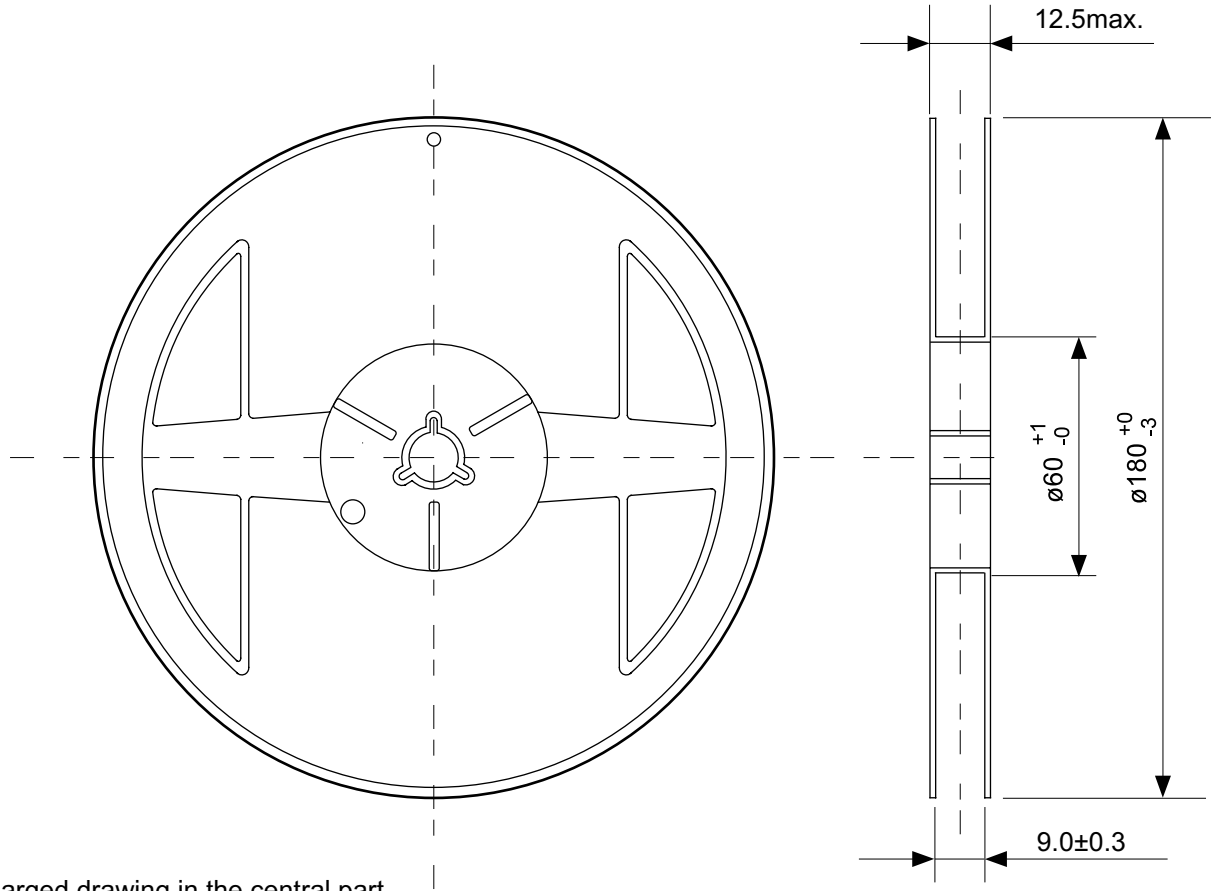
TITLE	SNB6B-A-PKG Dimensions
No.	BD006-A-P-SD-3.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	



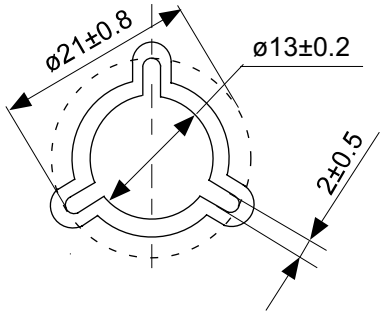


No. BD006-A-C-SD-2.1

TITLE	SNB6B-A-Carrier Tape
No.	BD006-A-C-SD-2.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	

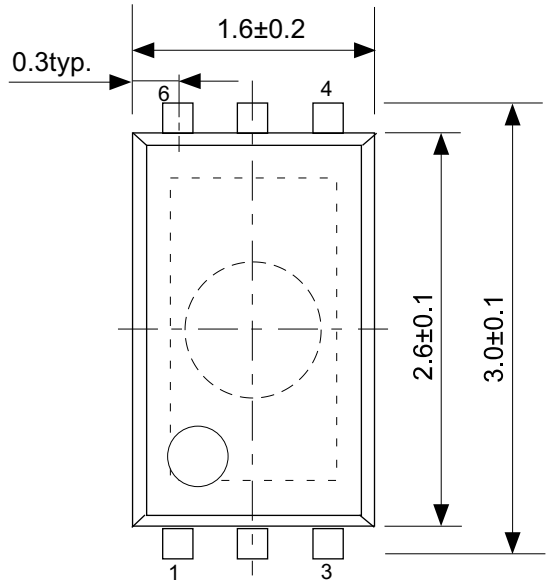


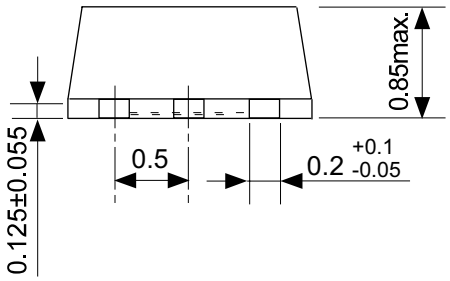
Enlarged drawing in the central part

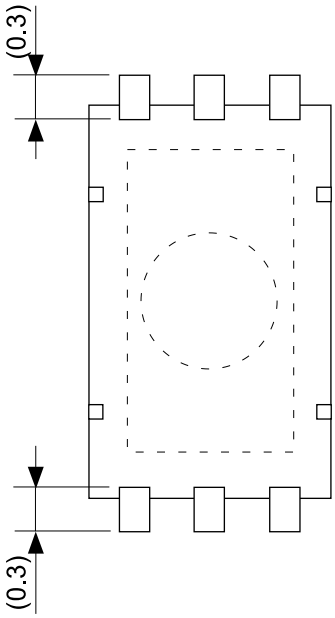


No. BD006-A-R-SD-1.1

TITLE	SNB6B-A-Reel		
No.	BD006-A-R-SD-1.1		
SCALE		QTY.	3,000
UNIT	mm		
Seiko Instruments Inc.			

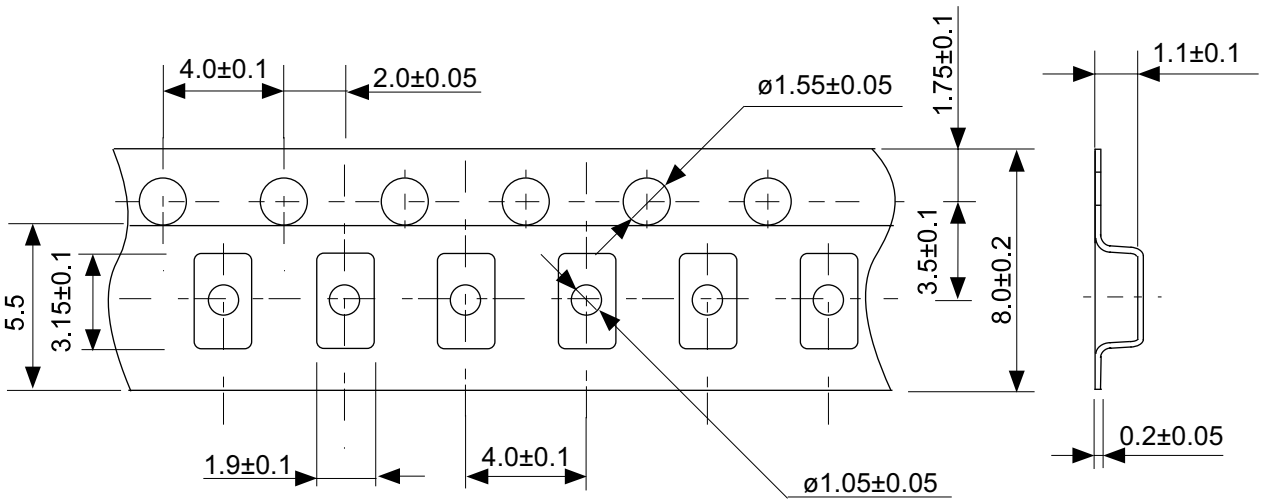


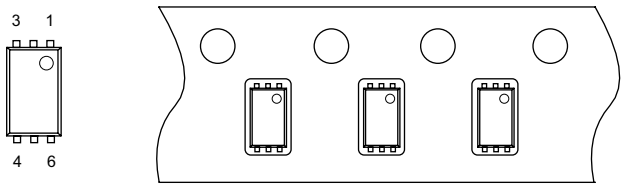




No. PB006-A-P-SD-1.0

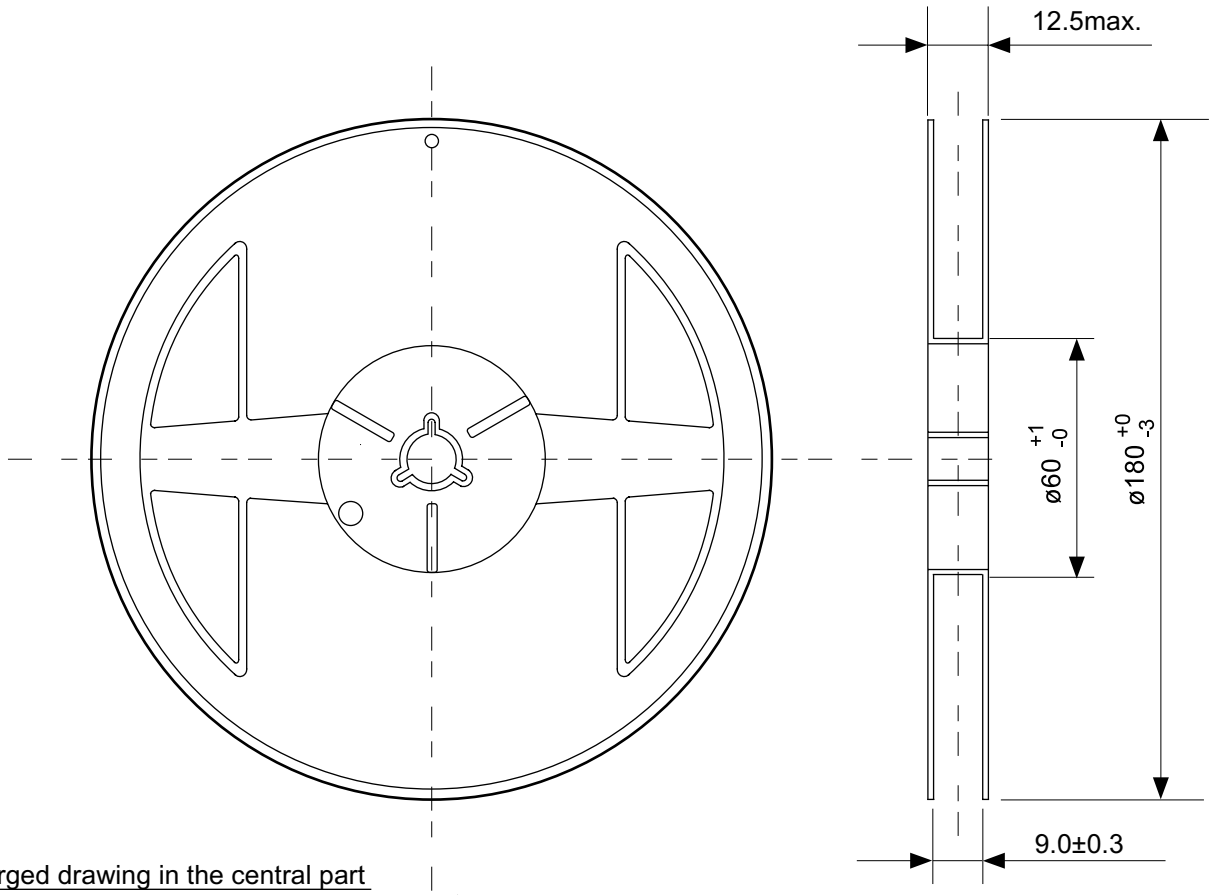
TITLE	SON6A-A-PKG Dimensions
No.	PB006-A-P-SD-1.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	



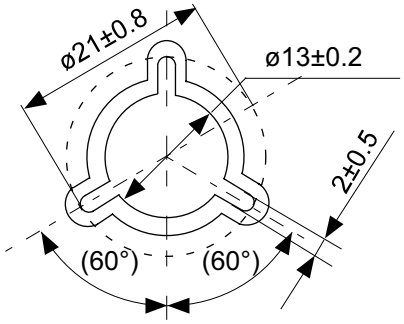


No. PB006-A-C-SD-1.0

TITLE	SON6A-A-Carrier Tape
No.	PB006-A-C-SD-1.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	



Enlarged drawing in the central part



No. PB006-A-R-SD-1.0

TITLE	SON6A-A-Reel		
No.	PB006-A-R-SD-1.0		
SCALE		QTY.	3000
UNIT	mm		
Seiko Instruments Inc.			

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