HIGH RIPPLE-REJECTION LOW DROPOUT CMOS VOLTAGE REGULATOR

S-T111 Series

The S-T111 Series is a positive voltage regulator with a low dropout voltage, high output voltage accuracy, and low current consumption developed based on CMOS technology.
A built-in low on-resistance transistor provides a low dropout voltage and large output current, and a built-in overcurrent protector prevents the load current from exceeding the current capacitance of the output transistor. An ON/OFF circuit ensures a long battery life. Compared with the voltage regulators using the conventional CMOS process, a larger variety of capacitors are available, including small ceramic capacitors. A small SOT-23-5 package realizes high-density mounting.

■ Features

• Output voltage:	1.5 V to 5.5 V, selectable in 0.1 V steps.
• High-accuracy output voltage:	±1.0%
• Low dropout voltage:	190 mV typ. (3.0 V output product, I_{OUT} = 100 mA)
• Low current consumption:	During operation: 50 μA typ., 90 μA max. During shutdown: 0.1 μA typ., 1.0 μA max.
• High peak current capability:	150 mA output is possible (at $V_{IN} \geq V_{OUT(S)} + 1.0$ V)[*1]
• Built-in ON/OFF circuit:	Ensures long battery life.
• Low ESR capacitor can be used:	A ceramic capacitor of 0.1 μF or more can be used for the output capacitor.
• High ripple rejection:	80 dB typ. (at 1.0 kHz)
• Built-in overcurrent protector:	Overcurrent of output transistor can be restricted.
• Small package:	SOT-23-5
• Lead-free products	

***1.** Attention should be paid to the power dissipation of the package when the output current is large.

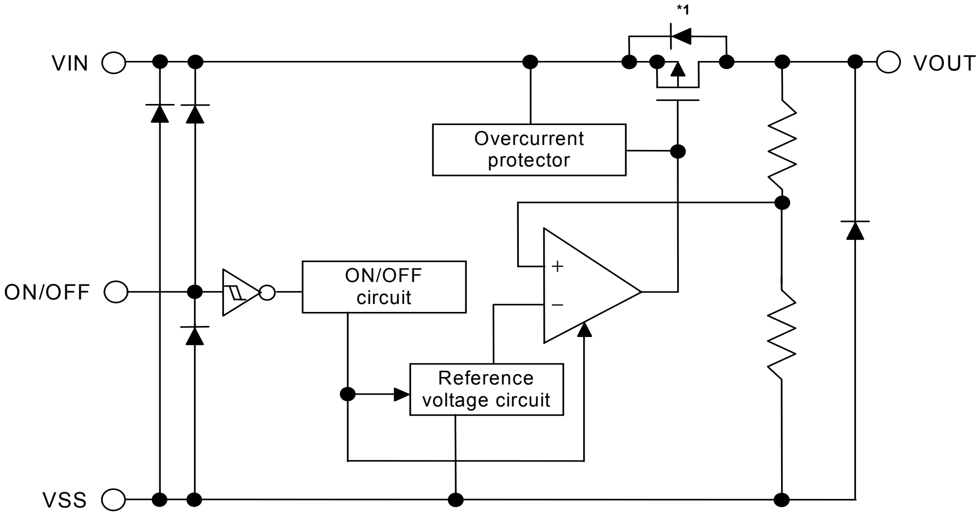
■ Applications

- Power supply for battery-powered devices
- Power supply for personal communication devices
- Power supply for home electric/electronic appliances
- Power supply for cellular phones

■ Package

Package Name	Drawing Code		
	Package	Tape	Reel
SOT-23-5	MP005-A	MP005-A	MP005-A

■ Block Diagram



***1.** Parasitic diode

Figure 1

■ Product Code Structure

- The product types and output voltage for the S-T111 Series can be selected at the user's request. Refer to the "Product name" for the meanings of the characters in the product name and "Product name list" for the full product names.

1. Product name

S-T111 x xx xx – xxx TF G

IC direction in tape specifications[*1]

Product name (abbreviation)[*2]

Package name (abbreviation)
MC: SOT-23-5

Output voltage
15 to 55
(e.g. when the output voltage is 1.5 V, it is expressed as 15.)

Product type[*3]
A: ON/OFF pin negative logic
B: ON/OFF pin positive logic

***1.** Refer to the taping specifications at the end of this book.
***2.** Refer to the product name list.
***3.** Refer to **3. Shutdown (ON/OFF pin)** in the "**■ Operation**".

2. Product name list

Table 1

Output Voltage	Product Name
1.5V±1.0%	S-T111B15MC-OGATFG
1.6V±1.0%	S-T111B16MC-OGBTFG
1.7V±1.0%	S-T111B17MC-OGCTFG
1.8V±1.0%	S-T111B18MC-OGDTFG
1.9V±1.0%	S-T111B19MC-OGETFG
2.0V±1.0%	S-T111B20MC-OGFTFG
2.1V±1.0%	S-T111B21MC-OGGTFG
2.2V±1.0%	S-T111B22MC-OGHTFG
2.3V±1.0%	S-T111B23MC-OGITFG
2.4V±1.0%	S-T111B24MC-OGJTFG
2.5V±1.0%	S-T111B25MC-OGKTFG
2.6V±1.0%	S-T111B26MC-OGLTFG
2.7V±1.0%	S-T111B27MC-OGMTFG
2.8V±1.0%	S-T111B28MC-OGNTFG
2.9V±1.0%	S-T111B29MC-OGOTFG
3.0V±1.0%	S-T111B30MC-OGPTFG
3.1V±1.0%	S-T111B31MC-OGQTFG
3.2V±1.0%	S-T111B32MC-OGRTFG
3.3V±1.0%	S-T111B33MC-OGSTFG
3.4V±1.0%	S-T111B34MC-OGTTFG
3.5V±1.0%	S-T111B35MC-OGUTFG
3.6V±1.0%	S-T111B36MC-OGVTFG
3.7V±1.0%	S-T111B37MC-OGWTFG
3.8V±1.0%	S-T111B38MC-OGXTFG
3.9V±1.0%	S-T111B39MC-OGYTFG
4.0V±1.0%	S-T111B40MC-OGZTFG
4.1V±1.0%	S-T111B41MC-OHATFG
4.2V±1.0%	S-T111B42MC-OHBTFG
4.3V±1.0%	S-T111B43MC-OHCTFG
4.4V±1.0%	S-T111B44MC-OHDTFG
4.5V±1.0%	S-T111B45MC-OHETFG
4.6V±1.0%	S-T111B46MC-OHFTFG
4.7V±1.0%	S-T111B47MC-OHGTFG
4.8V±1.0%	S-T111B48MC-OHHTFG
4.9V±1.0%	S-T111B49MC-OHITFG
5.0V±1.0%	S-T111B50MC-OHJTFG
5.1V±1.0%	S-T111B51MC-OHKTFG
5.2V±1.0%	S-T111B52MC-OHLTFG
5.3V±1.0%	S-T111B53MC-OHMTFG
5.4V±1.0%	S-T111B54MC-OHNTFG
5.5V±1.0%	S-T111B55MC-OHOTFG

Remark Please contact our sales office for products with type A.

■ Pin Configuration

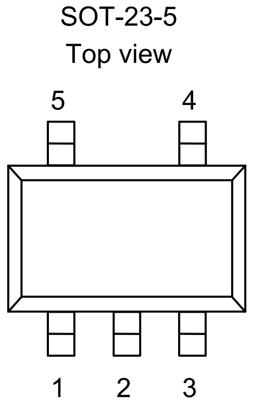


Figure 2

Table 2

Pin No.	Symbol	Description
1	ON/OFF	Shutdown pin
2	VSS	GND pin
3	NC[*1]	No connection
4	VOUT	Output voltage pin
5	VIN	Input voltage pin

***1.** The NC pin is electrically open.
The NC pin can be connected to VIN or VSS.

■ Absolute Maximum Ratings

Table 3

(Ta = 25°C unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
Input voltage	V_{IN}	V_{SS} – 0.3 to V_{SS} + 7	V
	$V_{ON/OFF}$	V_{SS} – 0.3 to V_{IN} + 0.3	V
Output voltage	V_{OUT}	V_{SS} – 0.3 to V_{IN} + 0.3	V
Power dissipation	P_D	300	mW
Operating ambient temperature	T_{opr}	–40 to +85	°C
Storage temperature	T_{stg}	–40 to +125	°C

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.

■ Electrical Characteristics

Table 4

(Ta = 25°C unless otherwise specified)

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
Output voltage[*1]	$V_{OUT(E)}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, $I_{OUT} = 30$ mA		$V_{OUT(S)} \times 0.99$	$V_{OUT(S)}$	$V_{OUT(S)} \times 1.01$	V	1
Output current[*2]	I_{OUT}	$V_{IN} \geq V_{OUT(S)} + 1.0$ V		150[*5]	—	—	mA	3
Dropout voltage[*3]	V_{drop}	$I_{OUT} = 50$ mA	$1.5 \text{ V} \leq V_{OUT(S)} \leq 2.7$ V	Not specified			V	1
			$2.8 \text{ V} \leq V_{OUT(S)} \leq 5.5$ V	—	0.08	0.14	V	1
		$I_{OUT} = 100$ mA	$1.5 \text{ V} \leq V_{OUT(S)} \leq 1.6$ V	—	0.32	0.55	V	1
			$1.7 \text{ V} \leq V_{OUT(S)} \leq 1.8$ V	—	0.28	0.47	V	1
			$1.9 \text{ V} \leq V_{OUT(S)} \leq 2.3$ V	—	0.25	0.35	V	1
			$2.4 \text{ V} \leq V_{OUT(S)} \leq 2.7$ V	—	0.20	0.29	V	1
			$2.8 \text{ V} \leq V_{OUT(S)} \leq 5.5$ V	—	0.19	0.26	V	1
Line regulation	$\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}$	$V_{OUT(S)} + 0.5 \text{ V} \leq V_{IN} \leq 6.5$ V, $I_{OUT} = 30$ mA		—	0.05	0.2	% / V	1
Load regulation	ΔV_{OUT2}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $1.0 \text{ mA} \leq I_{OUT} \leq 80$ mA		—	12	40	mV	1
Output voltage temperature coefficient[*4]	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	$V_{IN} = V_{OUT(S)} + 1.0$ V, $I_{OUT} = 10$ mA, $-40°C \leq Ta \leq 85°C$		—	±100	—	ppm /°C	1
Current consumption during operation	I_{SS1}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = ON, no load		—	50	90	μA	2
Current consumption during shutdown	I_{SS2}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = OFF, no load		—	0.1	1.0	μA	2
Input voltage	V_{IN}	—		2.0	—	6.5	V	—
Shutdown pin input voltage "H"	V_{SH}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $R_L = 1.0$ kΩ		1.5	—	—	V	4
Shutdown pin input voltage "L"	V_{SL}	$V_{IN} = V_{OUT(S)} + 1.0$ V, $R_L = 1.0$ kΩ		—	—	0.3	V	4
Shutdown pin input current "H"	I_{SH}	$V_{IN} = 6.5$ V, $V_{ON/OFF} = 6.5$ V		−0.1	—	0.1	μA	4
Shutdown pin input current "L"	I_{SL}	$V_{IN} = 6.5$ V, $V_{ON/OFF} = 0$ V		−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		—	80	—	dB	5
Short-circuit current	I_{short}	$V_{IN} = V_{OUT(S)} + 1.0$ V, ON/OFF pin = ON, $V_{OUT} = 0$ V		—	200	—	mA	3

***1.** $V_{OUT(S)}$: Specified output voltage
$V_{OUT(E)}$: Actual output voltage at the fixed load
The output voltage when fixing I_{OUT}(= 30 mA) and inputting $V_{OUT(S)} + 1.0$ V

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

***3.** $V_{drop} = V_{IN1} - (V_{OUT3} \times 0.98)$
V_{OUT3} is the output voltage when $V_{IN} = V_{OUT(S)} + 1.0$ V and $I_{OUT} = 50$ mA or $I_{OUT} = 100$ mA.
V_{IN1} is the input voltage at which the output voltage becomes 98% of V_{OUT3} after gradually decreasing the input voltage.

***4.** The change in temperature [mV/°C] is calculated using the following equation.

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

***1.** The change in temperature of the output voltage
***2.** Specified output voltage
***3.** Output voltage temperature coefficient

***5.** 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.

■ Test Circuits

1.

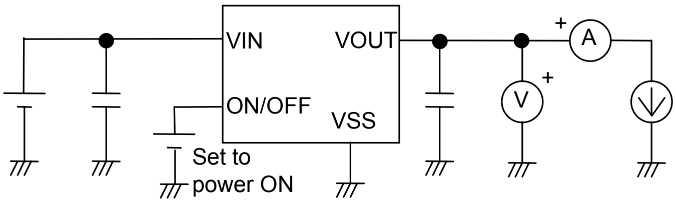


Figure 3

2.

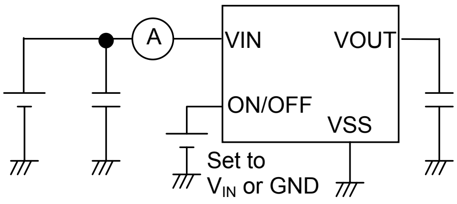


Figure 4

3.

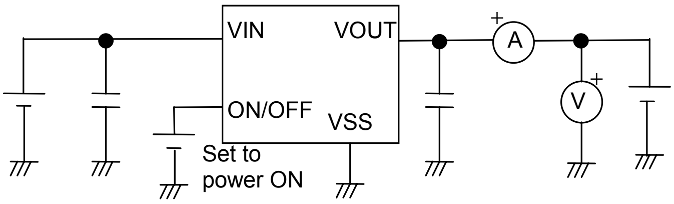


Figure 5

4.

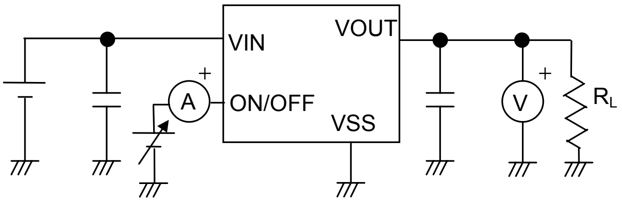


Figure 6

5.

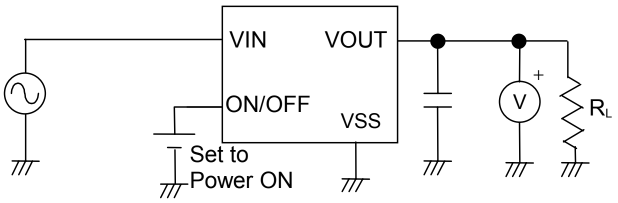
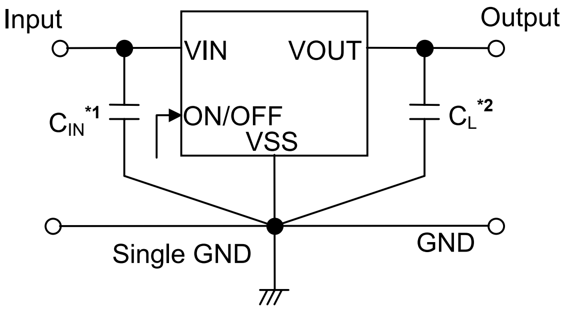


Figure 7

■ Standard Circuit



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A ceramic capacitor of 0.1 μF or more can be used for C_L.

Figure 8

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

■ Application Conditions

Input capacitor (C_{IN}):	0.1 μF or more
Output capacitor (C_L):	0.1 μF or more
ESR of output capacitor:	10 Ω or less

Caution A general series regulator may oscillate, depending on the external components selected. Check that no oscillation occurs with the application using the above capacitor.

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

The S-T111 Series requires an output capacitor between the VOUT and VSS pins for phase compensation. Operation is stabilized by a ceramic capacitor with an output capacitance of 0.1 μF or more in the entire temperature range. However, when using an OS capacitor, tantalum capacitor, or aluminum electrolytic capacitor, a ceramic capacitor with a capacitance of 0.1 μF or more and an ESR of 10 Ω or less is required.
The value of the output overshoot or undershoot transient response varies depending on the value of the output capacitor. The required capacitance of the input capacitor differs depending on the application.
The recommended value for an application is 1.0 μF or more for C_{IN} and 0.47 μF or more for C_L; however, when selecting the output capacitor, perform sufficient evaluation, including evaluation of temperature characteristics, on the actual device.

■ Explanation of Terms

1. Low dropout voltage regulator

The low dropout voltage regulator is a voltage regulator whose dropout voltage is low due to its built-in low on-resistance transistor.

2. Low ESR

A capacitor whose ESR (Equivalent Series Resistance) is low. The S-T111 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.

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. Please see the "Electrical Characteristics" and attached characteristics data for details.

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.

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.

6. Dropout voltage (V_{drop})

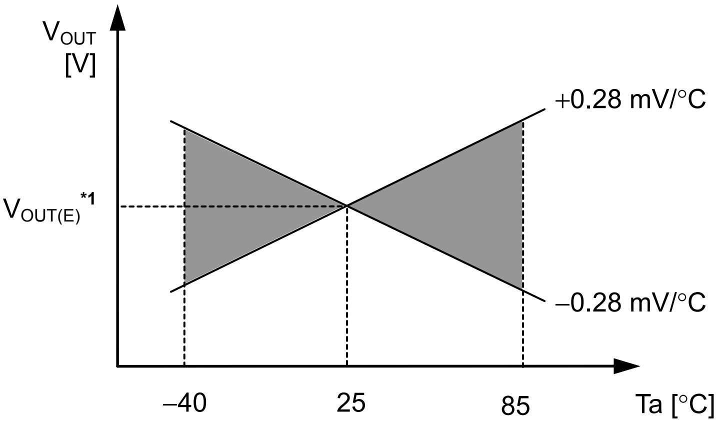
Indicates the difference between the input voltage V_{IN1}, which is the input voltage (V_{IN}) at the point where the output voltage has fallen to 98% of the output voltage value V_{OUT3} after V_{IN} was gradually decreased from $V_{IN} = V_{OUT(S)} + 1.0$ V, and the output voltage at that point ($V_{OUT3} \times 0.98$).

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

7. Temperature Coefficient of Output Voltage $\left(\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\right)$

The shadowed area in **Figure 9** is the range where V_{OUT} varies in the operating temperature range when the temperature coefficient of the output voltage is ±100 ppm/°C.

Ex. S-T111B28 Typ.



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

Figure 9

A change in the temperature of the 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.** Specified output voltage
***3.** Output voltage temperature coefficient

■ Operation

1. Basic operation

Figure 10 shows the block diagram of the S-T111 Series.

The error amplifier compares the reference voltage (V_{ref}) with V_{fb}, which is the output voltage resistance-divided by feedback resistors R_s and R_f. It supplies the output transistor with the gate voltage necessary to ensure a certain output voltage free of any fluctuations of input voltage and temperature.

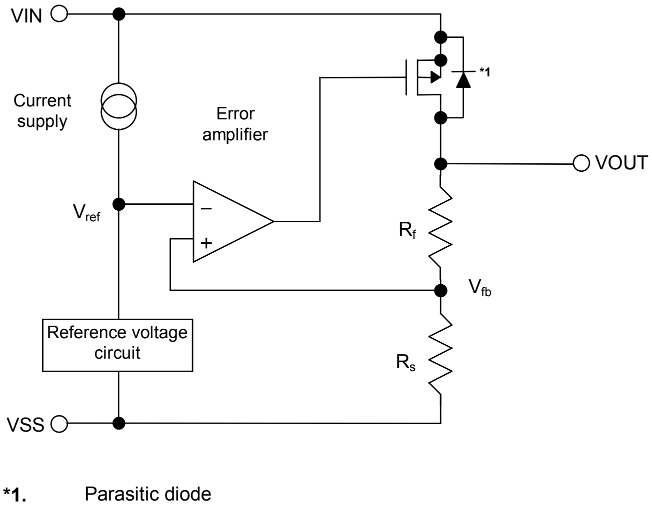


Figure 10

2. Output transistor

The S-T111 Series uses a low on-resistance P-channel MOS FET as the output transistor.
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.

3. Shutdown pin (ON/OFF pin)

This pin starts and stops the regulator.

When the ON/OFF pin is set to the shutdown level, the operation of all internal circuits stops, and the built-in P-channel MOS FET output transistor between the VIN pin and VOUT pin is turned off to substantially reduce the current consumption. The VOUT pin becomes the V_{SS} level due to the internally divided resistance of several MΩ between the VOUT pin and VSS pin.
The structure of the ON/OFF pin is as shown in **Figure 11**. Since the ON/OFF pin is neither pulled down nor pulled up internally, do not use it in the floating state. In addition, note that the current consumption increases if a voltage of 0.3 V to V_{IN} – 0.3 V is applied to the ON/OFF pin. When the ON/OFF pin is not used, connect it to the VSS pin if the logic type is “A” and to the VIN pin if it is “B”.

Table 5

Logic Type	ON/OFF Pin	Internal Circuits	VOUT Pin Voltage	Current Consumption
A	“L”: Power on	Operating	Set value	I_{SS1}
A	“H”: Power off	Stopped	V_{SS} level	I_{SS2}
B	“L”: Power off	Stopped	V_{SS} level	I_{SS2}
B	“H”: Power on	Operating	Set value	I_{SS1}

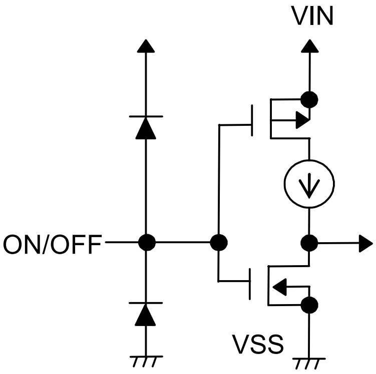


Figure 11

■ Precautions

- Wiring patterns for the VIN, VOUT and GND pins should be designed so that the impedance is low. When mounting an output capacitor between the VOUT and VSS pins (C_L) and a capacitor for stabilizing the input between VIN and VSS pins (C_{IN}), the distance from the capacitors to these pins should be as short as possible.
- Note that the output voltage may increase when a series regulator is used at low load current (1.0 mA or less).
- Generally a series regulator may cause oscillation, depending on the selection of external parts. The following conditions are recommended for this IC. However, be sure to perform sufficient evaluation under the actual usage conditions for selection, including evaluation of temperature characteristics.

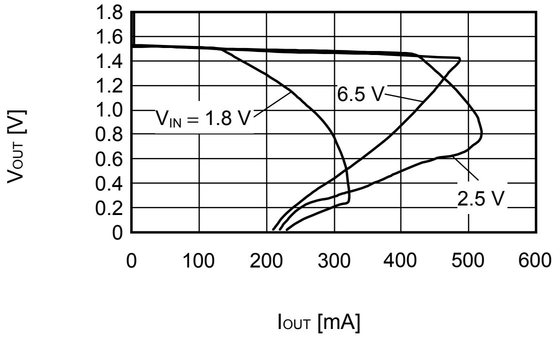
Input capacitor (C_{IN}):	1.0 μF or more
Output capacitor (C_L):	0.47 μF or more
Equivalent series resistance (ESR):	10 Ω or less

- The voltage regulator may oscillate when the impedance of the power supply is high and the input capacitor is small or an input capacitor is not connected.
- The application conditions for the input voltage, output voltage, and load current should not exceed the package power dissipation.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- In determining the output current, attention should be paid to the output current value specified in **Table 4** in the "**■ Electrical Characteristics**" and footnote ***5** of the table.
- SII claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

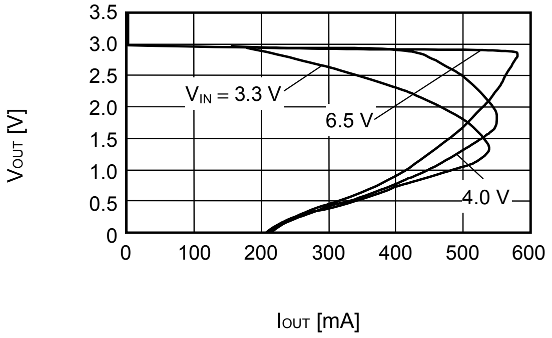
■ Typical Characteristics

(1) Output Voltage vs. Output current (when load current increases)

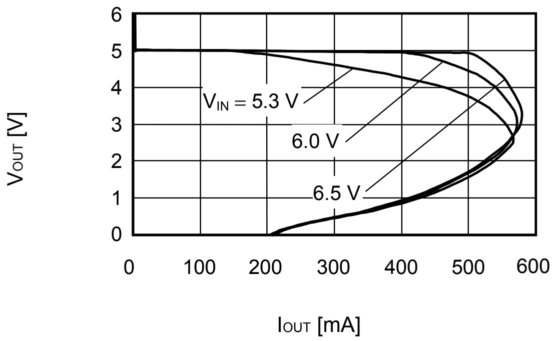
S-T111B15 (Ta = 25°C)



S-T111B30 (Ta = 25°C)



S-T111B50 (Ta = 25°C)

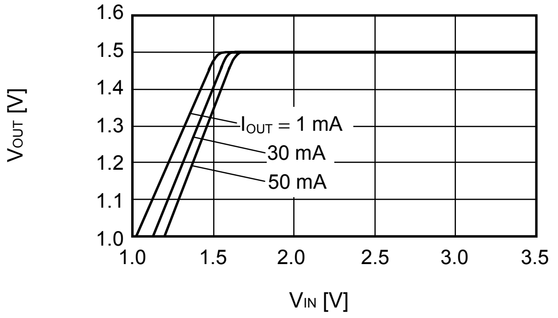


Remark In determining the output current, attention should be paid to the following.

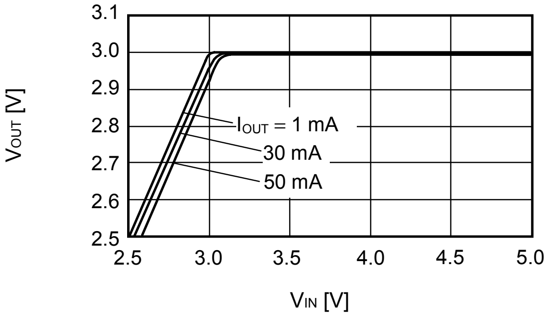
1) The minimum output current value and footnote ***5** in the "■ **Electrical Characteristics**"
2) The package power dissipation

(2) Output voltage vs. Input voltage

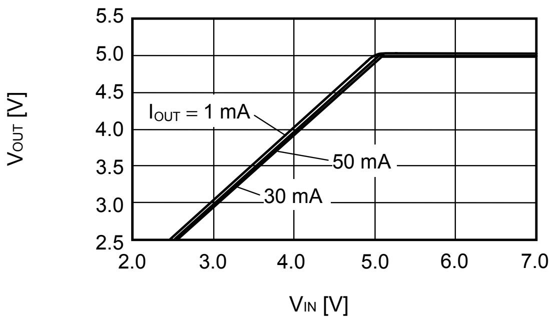
S-T111B15 (Ta = 25°C)



S-T111B30 (Ta = 25°C)

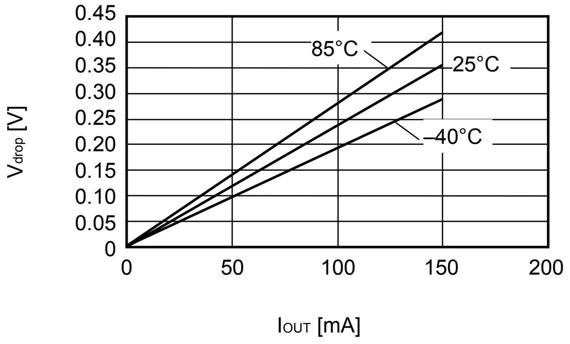


S-T111B50 (Ta = 25°C)

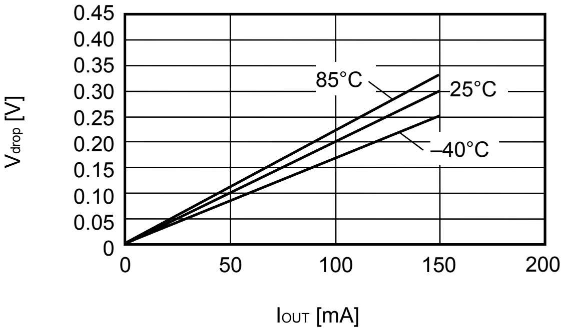


(3) Dropout voltage vs. Output current

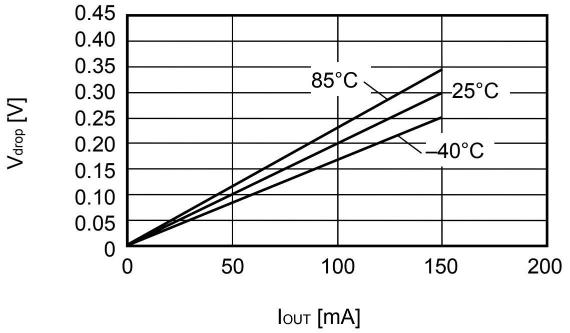
S-T111B15



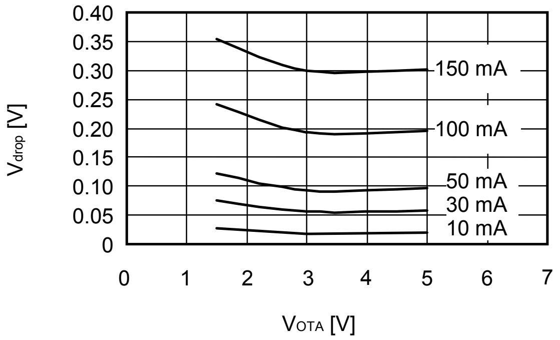
S-T111B30



S-T111B50

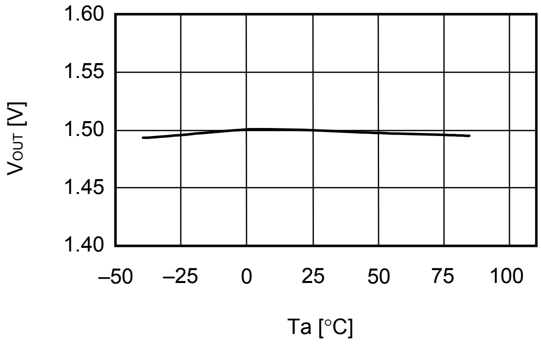


(4) Dropout voltage vs. Set output voltage

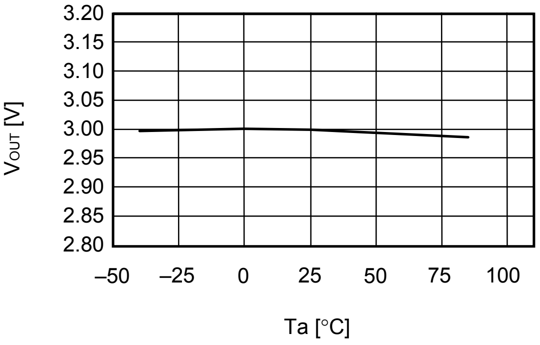


(5) Output voltage vs. Ambient temperature

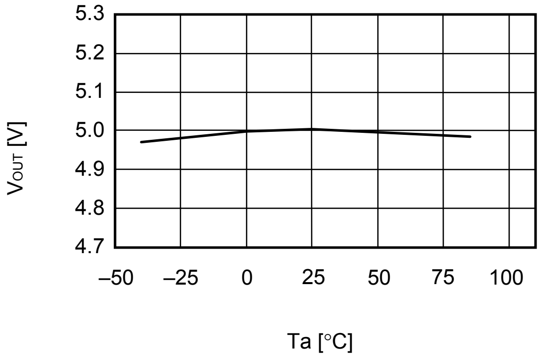
S-T111B15



S-T111B30

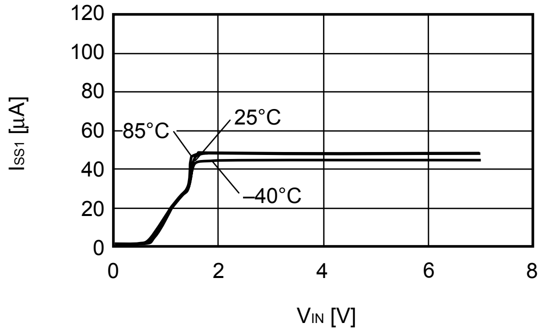


S-T111B50

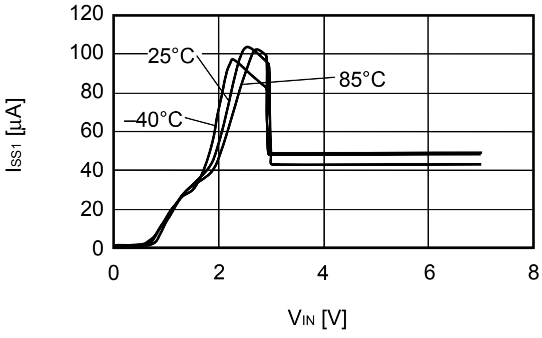


(6) Current consumption vs. Input voltage

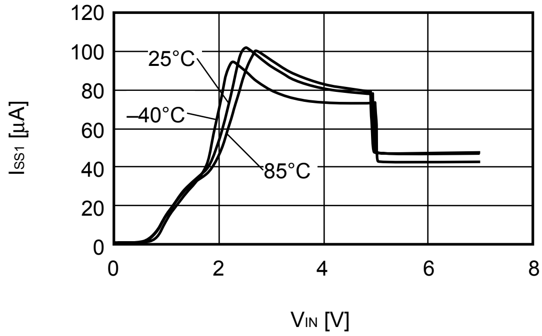
S-T111B15



S-T111B30

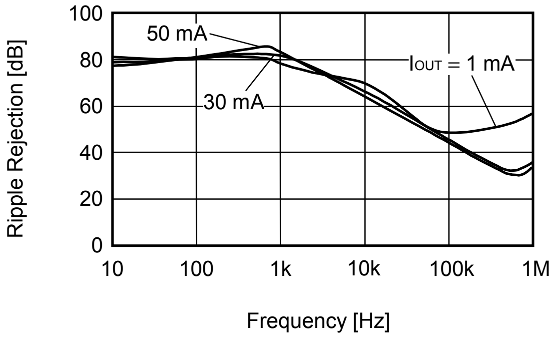


S-T111B50

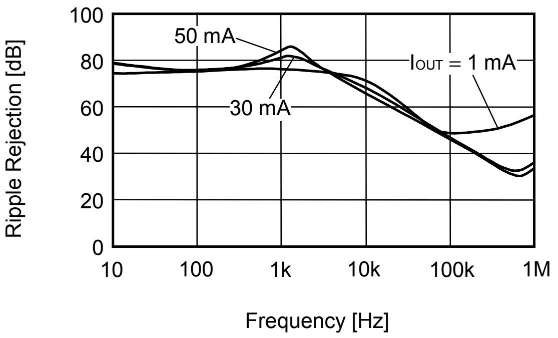


(7) Ripple rejection

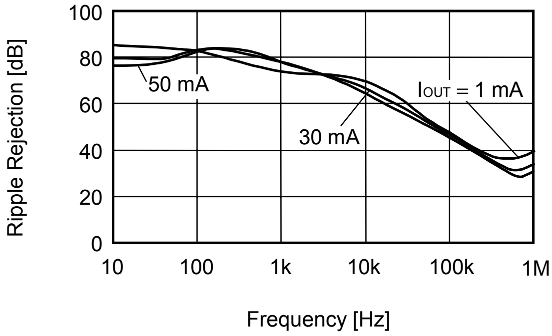
S-T111B15 (Ta = 25°C)
V_{IN} = 2.5 V, C_{OUT} = 0.47 μF



S-T111B30 (Ta = 25°C)
V_{IN} = 4.0 V, C_{OUT} = 0.47 μF



S-T111B50 (Ta = 25°C)
V_{IN} = 6.0 V, C_{OUT} = 0.47 μF

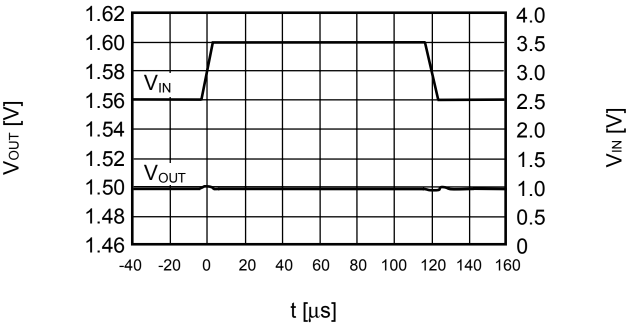


■ Reference Data

(1) Input transient response characteristics

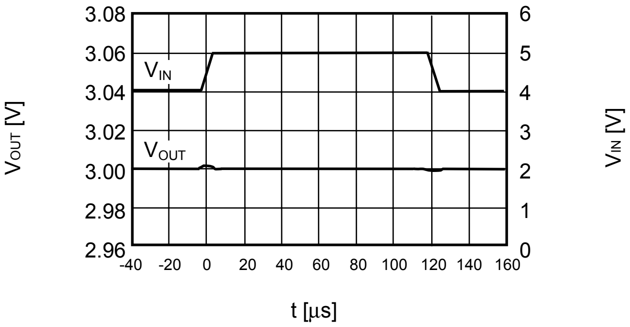
S-T111B15 (Ta = 25°C)

I_{OUT} = 30 mA, tr = tf = 5.0 µs, C_{OUT} = 0.47 µF, C_{IN} = 0 µF



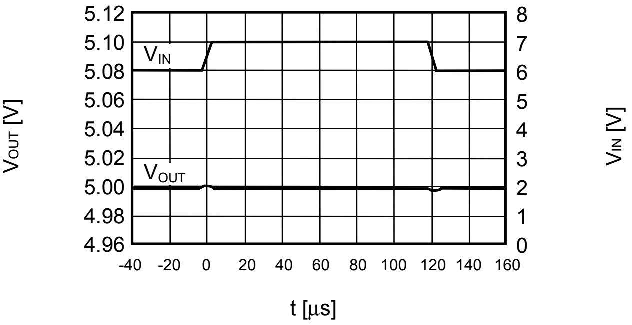
S-T111B30 (Ta = 25°C)

I_{OUT} = 30 mA, tr = tf = 5.0 µs, C_{OUT} = 0.47 µF, C_{IN} = 0 µF



S-T111B50 (Ta = 25°C)

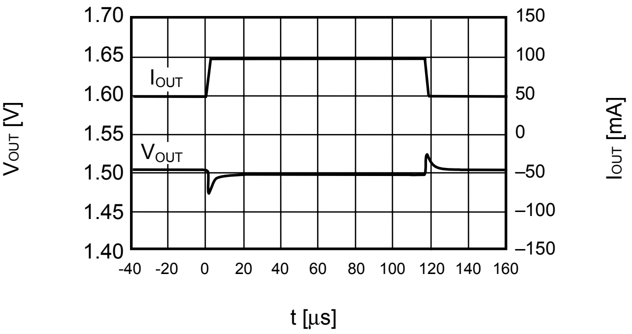
I_{OUT} = 30 mA, tr = tf = 5.0 µs, C_{OUT} = 0.47 µF, C_{IN} = 0 µF



(2) Load transient response characteristics

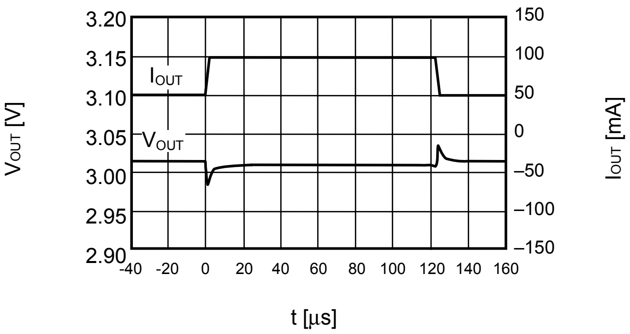
S-T111B15 (Ta = 25°C)

V_{IN} = 2.5 V, C_{OUT} = 0.47 µF, C_{IN} = 1.0 µF, I_{OUT} = 50↔100 mA



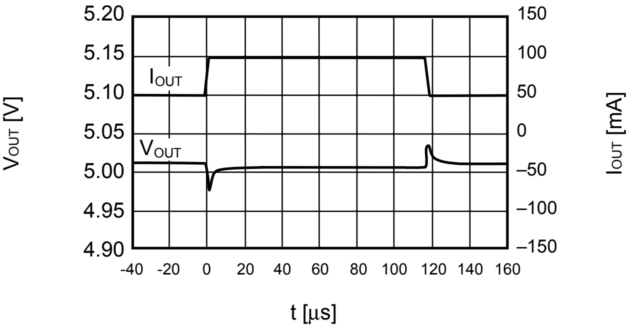
S-T111B30 (Ta = 25°C)

V_{IN} = 4.0 V, C_{OUT} = 0.47 µF, C_{IN} = 1.0 µF, I_{OUT} = 50↔100 mA



S-T111B50 (Ta = 25°C)

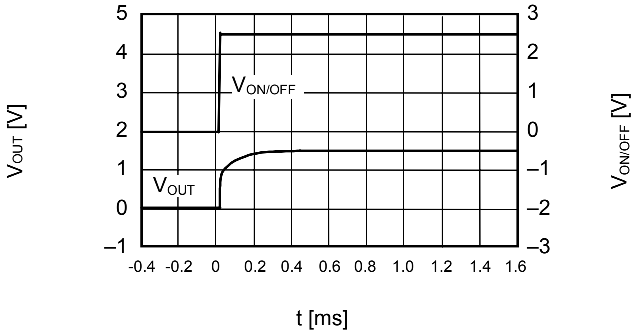
V_{IN} = 6.0 V, C_{OUT} = 0.47 µF, C_{IN} = 1.0 µF, I_{OUT} = 50↔100 mA



(3) Shutdown pin transient response characteristics

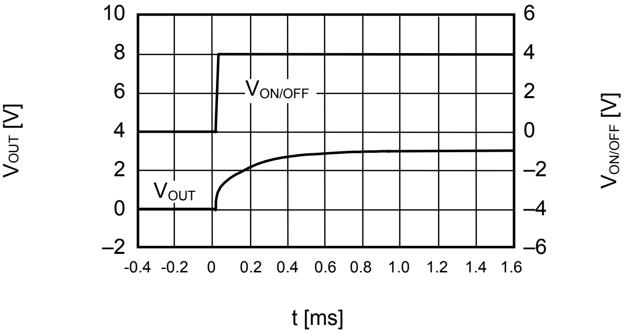
S-T111B15 (Ta = 25°C)

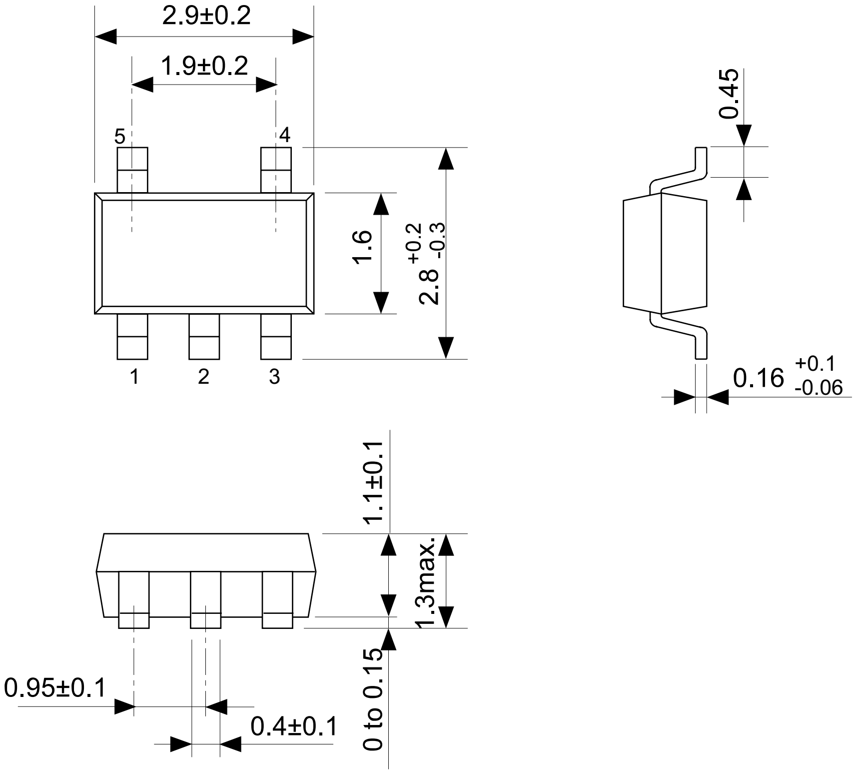
V_{IN} = 2.5 V, C_{OUT} = 0.47 µF, C_{IN} = 1.0 µF, I_{OUT} = 100 mA



S-T111B30 (Ta = 25°C)

V_{IN} = 4.0 V, C_{OUT} = 0.47 µF, C_{IN} = 1.0 µF, I_{OUT} = 100 mA





No. MP005-A-P-SD-1.2

TITLE	SOT235-A-PKG Dimensions
No.	MP005-A-P-SD-1.2
SCALE	
UNIT	mm

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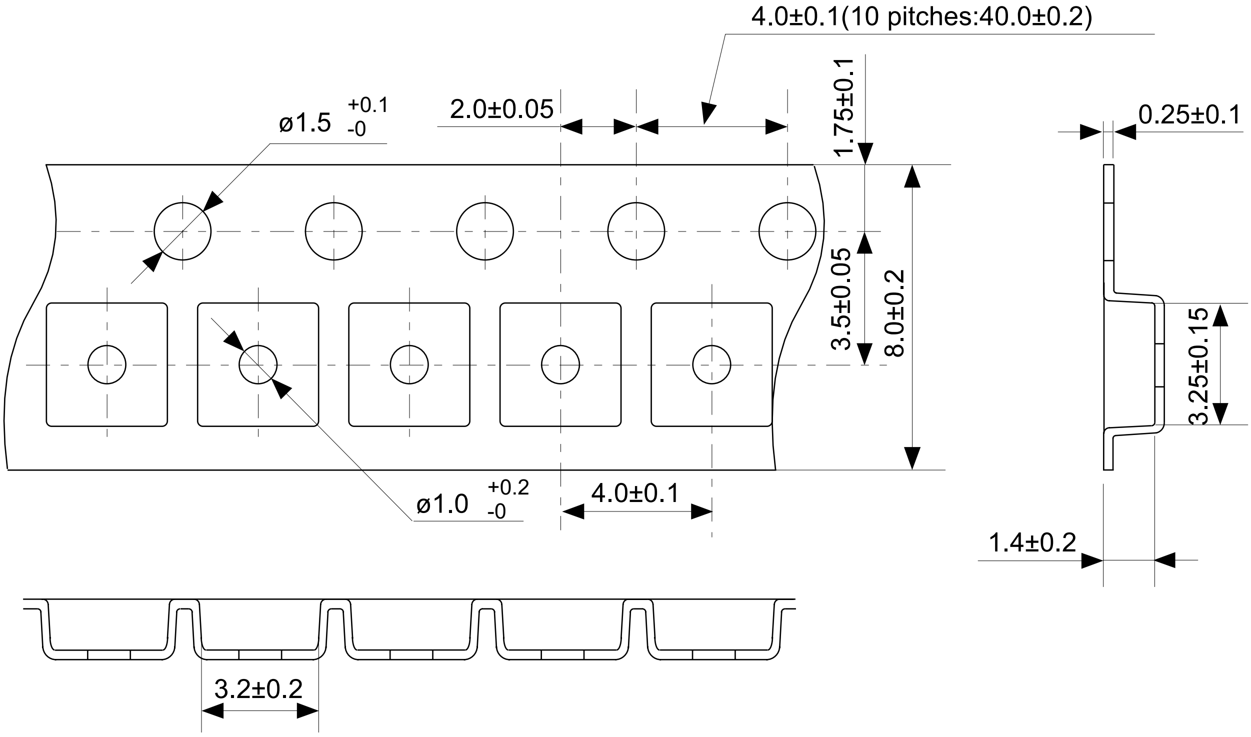
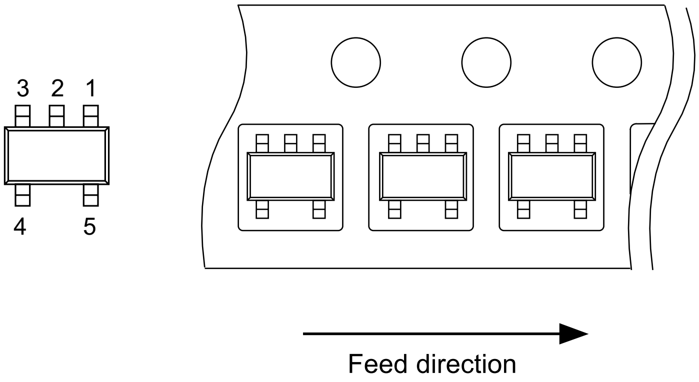
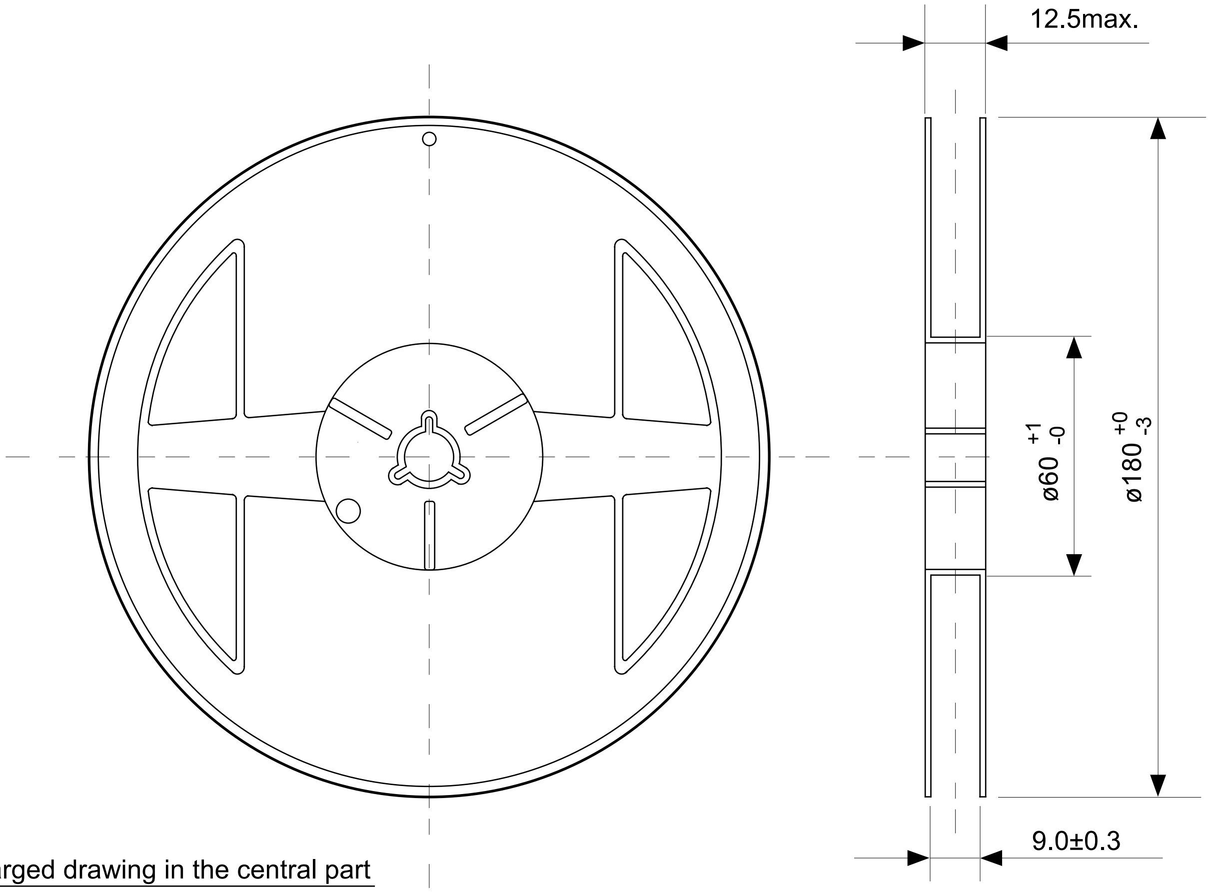




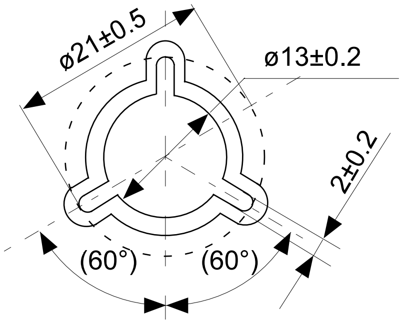
No. MP005-A-C-SD-2.1

TITLE	SOT235-A-Carrier Tape
No.	MP005-A-C-SD-2.1
SCALE	
UNIT	mm

Seiko Instruments Inc.



Enlarged drawing in the central part



No. MP005-A-R-SD-1.1

TITLE	SOT235-A-Reel		
No.	MP005-A-R-SD-1.1		
SCALE		QTY.	3,000
UNIT	mm		

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