S-1165 Series

HIGH RIPPLE-REJECTION LOW DROPOUT CMOS VOLTAGE REGULATOR

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Rev.4.0_00

The S-1165 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, and 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: 140 mV typ. (3.0 V output product, I_{OUT} = 200 mA)
- Low current consumption: During operation: 35 μA typ., 65 μA max.
  During shutdown: 0.1 μA typ., 1.0 μA max.
- High peak current capability: 200 mA output is possible (at $V_{IN} \geq V_{OUT(S)} + 1.0$ V)*1
- Built-in ON/OFF circuit: Ensures long battery life.
- High ripple rejection: 70 dB typ. (at 1.0 kHz)
- Built-in overcurrent protector: Overcurrent of output transistor can be restricted.
- Lead-free, Sn 100%, halogen-free*2

***1.** Attention should be paid to the power dissipation of the package when the output current is large.
***2.** Refer to "■ **Product Name Structure**" for details.

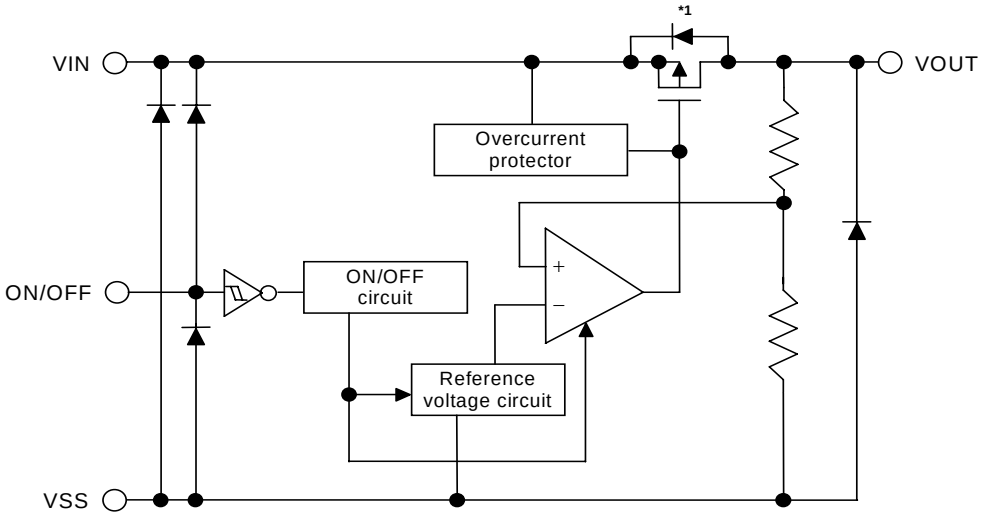
■ Applications

- 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

- SOT-23-5

■ Block Diagram



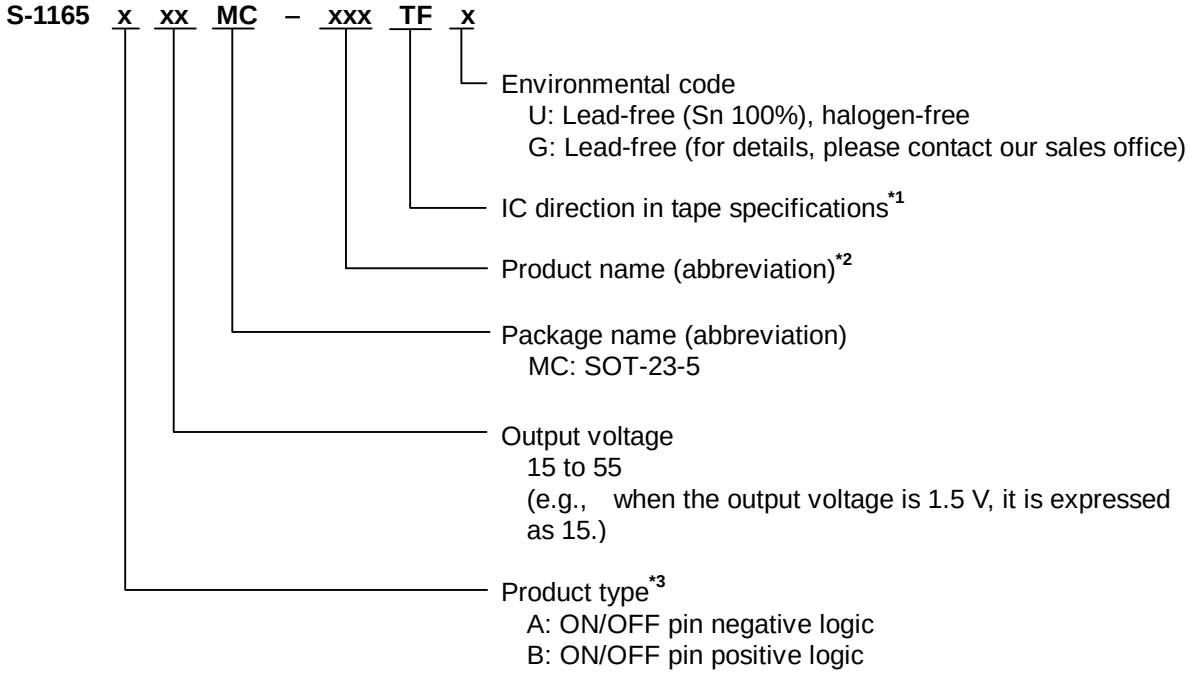
***1.** Parasitic diode

Figure 1

■ Product Name Structure

- The product types and output voltage for the S-1165 Series can be selected at the user's request. Refer to the "**1. Product name**" for the meanings of the characters in the product name, "**2. Package**" regarding the package drawings and "**3. Product name list**" for the full product names.

1. Product name



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

2. Package

Package Name	Drawing Code		
	Package	Tape	Reel
SOT-23-5	MP005-A-P-SD	MP005-A-C-SD	MP005-A-R-SD

3. Product name list

Table 1

Output Voltage	Product Name
1.5V±1.0%	S-1165B15MC-N6ATFx
1.6V±1.0%	S-1165B16MC-N6BTFx
1.7V±1.0%	S-1165B17MC-N6CTFx
1.8V±1.0%	S-1165B18MC-N6DTFx
1.9V±1.0%	S-1165B19MC-N6ETFx
2.0V±1.0%	S-1165B20MC-N6FTFx
2.1V±1.0%	S-1165B21MC-N6GTFx
2.2V±1.0%	S-1165B22MC-N6HTFx
2.3V±1.0%	S-1165B23MC-N6ITFx
2.4V±1.0%	S-1165B24MC-N6JTFx
2.5V±1.0%	S-1165B25MC-N6KTFx
2.6V±1.0%	S-1165B26MC-N6LTFx
2.7V±1.0%	S-1165B27MC-N6MTFx
2.8V±1.0%	S-1165B28MC-N6NTFx
2.9V±1.0%	S-1165B29MC-N6OTFx
3.0V±1.0%	S-1165B30MC-N6PTFx
3.1V±1.0%	S-1165B31MC-N6QTFx
3.2V±1.0%	S-1165B32MC-N6RTFx
3.3V±1.0%	S-1165B33MC-N6STFx
3.4V±1.0%	S-1165B34MC-N6TTFx
3.5V±1.0%	S-1165B35MC-N6UTFx
3.6V±1.0%	S-1165B36MC-N6VTFx
3.7V±1.0%	S-1165B37MC-N6WTFx
3.8V±1.0%	S-1165B38MC-N6XTFx
3.9V±1.0%	S-1165B39MC-N6YTFx
4.0V±1.0%	S-1165B40MC-N6ZTFx
4.1V±1.0%	S-1165B41MC-N7ATFx
4.2V±1.0%	S-1165B42MC-N7BTFx
4.3V±1.0%	S-1165B43MC-N7CTFx
4.4V±1.0%	S-1165B44MC-N7DTFx
4.5V±1.0%	S-1165B45MC-N7ETFx
4.6V±1.0%	S-1165B46MC-N7FTFx
4.7V±1.0%	S-1165B47MC-N7GTFx
4.8V±1.0%	S-1165B48MC-N7HTFx
4.9V±1.0%	S-1165B49MC-N7ITFx
5.0V±1.0%	S-1165B50MC-N7JTFx
5.1V±1.0%	S-1165B51MC-N7KTFx
5.2V±1.0%	S-1165B52MC-N7LTFx
5.3V±1.0%	S-1165B53MC-N7MTFx
5.4V±1.0%	S-1165B54MC-N7NTFx
5.5V±1.0%	S-1165B55MC-N7OTFx

Remark 1. Please contact the SII marketing department for type A products.
2. x: G or U
3. Please select products of environmental code = U for Sn 100%, halogen-free products.

■ Pin Configuration

SOT-23-5
Top view

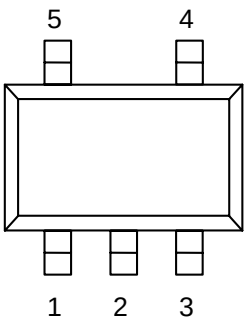


Figure 2

Table 2

Pin No.	Symbol	Description
1	VIN	Input voltage pin
2	VSS	GND pin
3	ON/OFF	Shutdown pin
4	NC*1	No connection
5	VOUT	Output 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	
Output voltage	V_{OUT}	V_{SS} − 0.3 to V_{IN} + 0.3	
Power dissipation	P_D	300 (When not mounted on board)	mW
		600[*1]	mW
Operating ambient temperature	T_{opr}	−40 to +85	°C
Storage temperature	T_{stg}	−40 to +125	

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

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

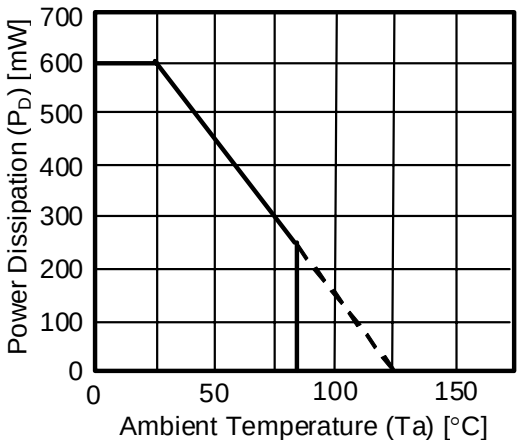


Figure 3 Power Dissipation of Package (When Mounted on Board)

■ Electrical Characteristics

Table 4

(Ta = 25°C unless otherwise specified)

Item	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
Output voltage*1	VOUT(E)	VIN = VOUT(S) + 1.0 V, IOUT = 30 mA		VOUT(S) × 0.99	VOUT(S)	VOUT(S) × 1.01	V	1
Output current*2	IOUT	VIN ≥ VOUT(S) + 1.0 V		200*5	—	—	mA	3
Dropout voltage*3	Vdrop	IOUT = 200 mA	1.5 V ≤ VOUT(S) ≤ 2.5 V	—	0.20	0.30	V	1
			2.6 V ≤ VOUT(S) ≤ 5.5 V	—	0.14	0.20		
Line regulation	$\frac{\Delta V_{OUT1}}{\Delta V_{IN} \bullet V_{OUT}}$	VOUT(S) + 0.5 V ≤ VIN ≤ 6.5 V, IOUT = 30 mA		—	0.05	0.2	% / V	
Load regulation	ΔVOUT2	VIN = VOUT(S) + 1.0 V, 1.0 mA ≤ IOUT ≤ 200 mA		—	20	40	mV	
Output voltage temperature coefficient*4	$\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}$	VIN = VOUT(S) + 1.0 V, IOUT = 30 mA, −40°C ≤ Ta ≤ 85°C		—	±100	—	ppm / °C	
Current consumption during operation	ISS1	VIN = VOUT(S) + 1.0 V, ON/OFF pin = ON, no load		—	35	65	μA	2
Current consumption during shutdown	ISS2	VIN = VOUT(S) + 1.0 V, ON/OFF pin = OFF, no load		—	0.1	1.0		
Input voltage	VIN	—		2.0	—	6.5	V	—
Shutdown pin input voltage "H"	VSH	VIN = VOUT(S) + 1.0 V, RL = 1.0 kΩ		1.5	—	—		4
Shutdown pin input voltage "L"	VSL	VIN = VOUT(S) + 1.0 V, RL = 1.0 kΩ		—	—	0.3		
Shutdown pin input current "H"	ISH	VIN = 6.5 V, VON/OFF = 6.5 V		−0.1	—	0.1	μA	
Shutdown pin input current "L"	ISL	VIN = 6.5 V, VON/OFF = 0 V		−0.1	—	0.1		
Ripple rejection	|RR|	VIN = VOUT(S) + 1.0 V, f = 1.0 kHz, ΔVrip = 0.5 Vrms, IOUT = 30 mA		—	70	—	dB	5
Short-circuit current	Ishort	VIN = VOUT(S) + 1.0 V, ON/OFF pin = ON, VOUT = 0 V		—	350	—	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 $I_{OUT} = 200$ 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.

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

***1.** 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.

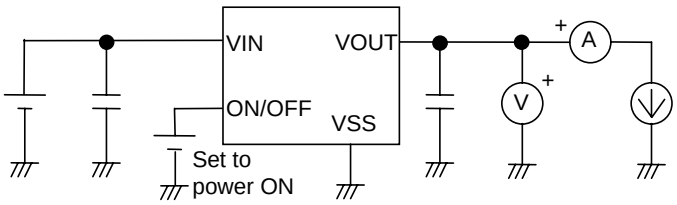


Figure 4

2.

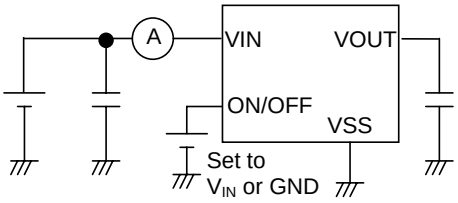


Figure 5

3.

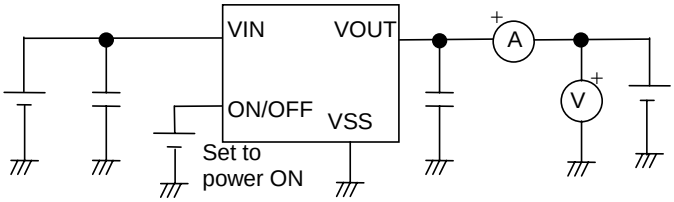


Figure 6

4.

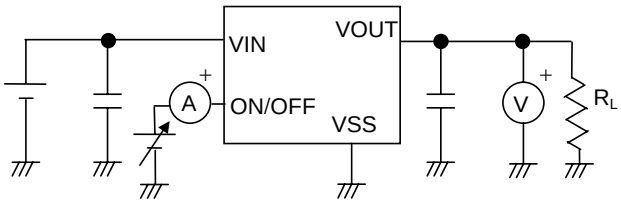


Figure 7

5.

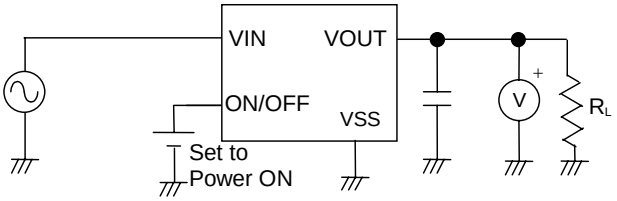
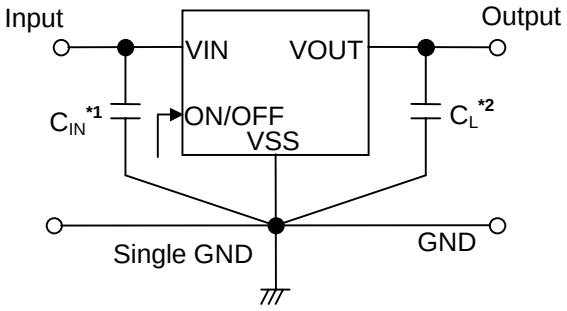


Figure 8

■ Standard Circuit



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** A tantalum capacitor (2.2 μF or more) can be used.

Figure 9

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}): 1.0 μF or more
Output capacitor (C_L): 2.2 μF or more (tantalum capacitor)

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.

■ 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. 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 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.

3. 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 value shows how much the output voltage changes due to a change in the input voltage with the output current remaining unchanged.

4. Load regulation (ΔV_{OUT2})

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

5. Dropout voltage (V_{drop})

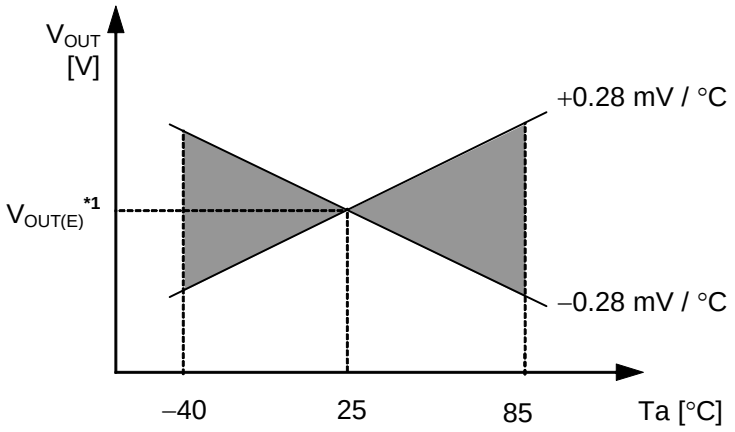
   Indicates the difference between the input voltage V_{IN1}, which is the input voltage (V_{IN}) at the point where the output voltage has fallen to 98% of the output voltage value V_{OUT3} after V_{IN} was gradually decreased from $V_{IN} = V_{OUT(S)} + 1.0$ V, and the output voltage at that point ($V_{OUT3}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

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

6. Temperature coefficient of output voltage $\left(\frac{\Delta V_{OUT}}{\Delta Ta \bullet V_{OUT}}\right)$

The shadowed area in **Figure 10** 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-1165B28 Typ.



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

Figure 10

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

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

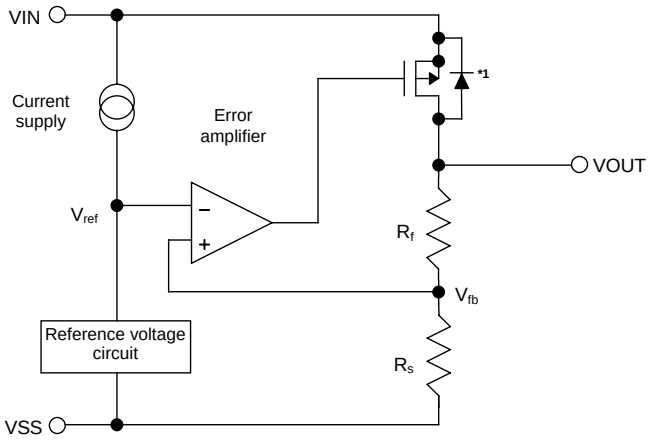
***1.** Change in temperature of output voltage
***2.** Specified output voltage
***3.** Output voltage temperature coefficient

■ Operation

1. Basic operation

Figure 11 shows the block diagram of the S-1165 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.



1. Parasitic diode

Figure 11

2. Output transistor

The S-1165 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 VOUT pin through a parasitic diode to 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 hundreds kΩ between the VOUT pin and VSS pin.
The structure of the ON/OFF pin is as shown in **Figure 12**. 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}

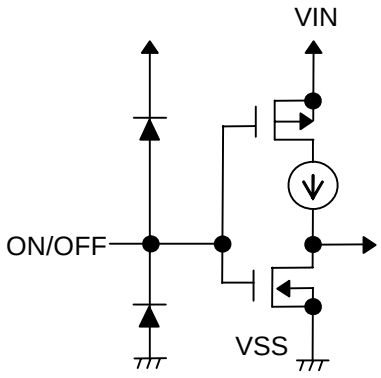


Figure 12

■ Selection of Output Capacitor (C_L)

The S-1165 Series performs phase compensation using the internal phase compensator in the IC and the ESR (Equivalent Series Resistance) of the output capacitor to enable stable operation independent of changes in the output load. Therefore, always place a capacitor (C_L) of 2.2 μF or more between VOUT and VSS pins.
For stable operation of the S-1165 Series, it is essential to employ a capacitor whose ESR is within an optimum range. Using a capacitor whose ESR is outside the optimum range (approximately 0.5 to 5 Ω), whether larger or smaller, may cause an unstable output, resulting in oscillation. For this reason, a tantalum electrolytic capacitor is recommended.
When a ceramic capacitor or an OS capacitor with a low ESR is used, it is necessary to connect an additional resistor that serves as the ESR in series with the output capacitor. The required resistance value is approximately 0.5 to 5 Ω, which varies depending on the usage conditions, so perform sufficient evaluation for selection. Ordinarily, around 1.0 Ω is recommended.
Note that an aluminum electrolytic capacitor may increase the ESR at a low temperature, causing oscillation. When using this kind of capacitor, perform thorough evaluation, including evaluation of temperature characteristics.

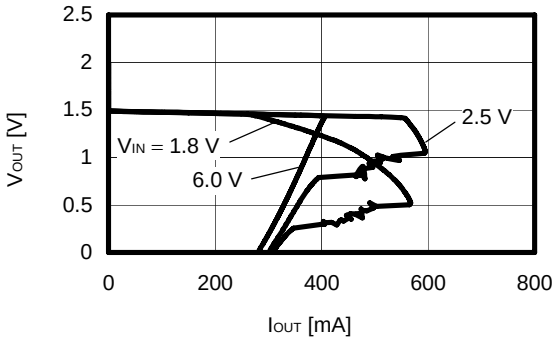
■ Precautions

- 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).
- This IC performs phase compensation by using an internal phase compensator and the ESR of an output capacitor. Therefore, always place a capacitor of 2.2 μF or more between VOUT and VSS pins. A tantalum type capacitor is recommended. Moreover, to secure stable operation of the S-1165 Series, it is necessary to employ a capacitor with an ESR within an optimum range (0.5 to 5 Ω). Using a capacitor whose ESR is outside the optimum range (approximately 0.5 to 5 Ω), whether larger or smaller, may cause an unstable output, resulting in oscillation. Perform sufficient evaluation under the actual usage conditions for selection, including evaluation of temperature characteristics.
- 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.

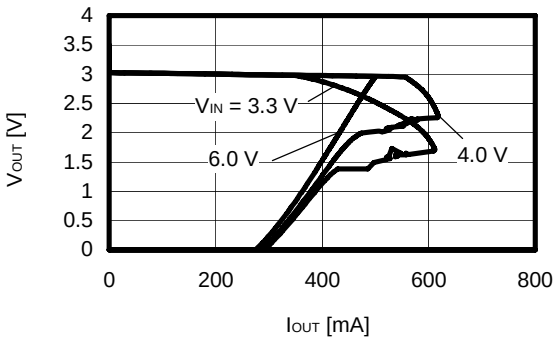
■ Typical Characteristics

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

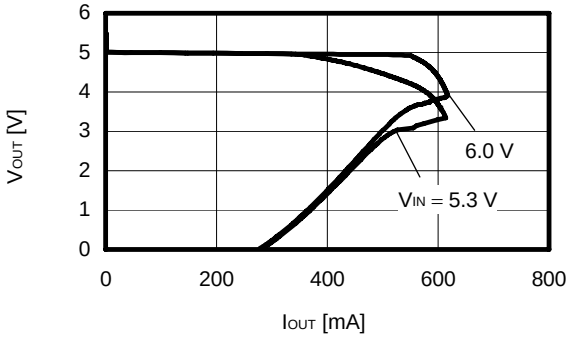
S-1165B15 (Ta = 25°C)



S-1165B30 (Ta = 25°C)



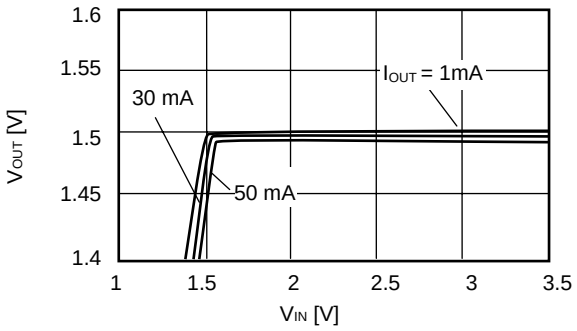
S-1165B50 (Ta = 25°C)



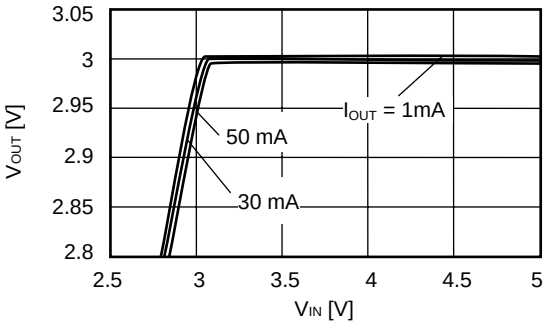
Remark In determining the output current, attention should be paid to the following.
1) The minimum output current value and footnote *5 in the electrical characteristics
2) The package power dissipation

(2) Output voltage vs. Input voltage

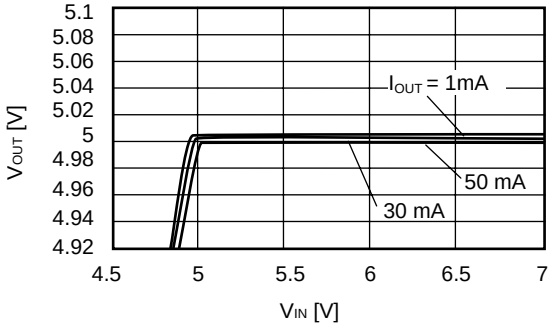
S-1165B15 (Ta = 25°C)



S-1165B30 (Ta = 25°C)

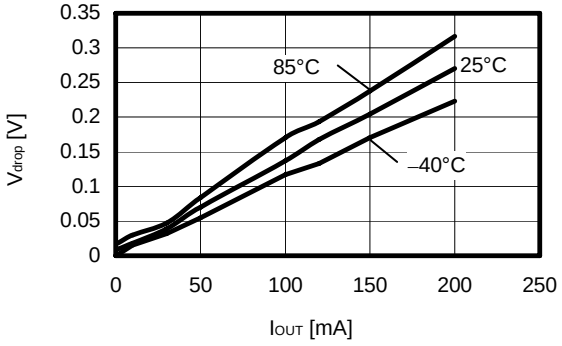


S-1165B50 (Ta = 25°C)

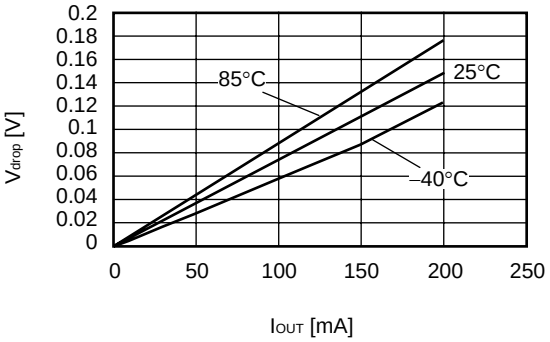


(3) Dropout voltage vs. Output current

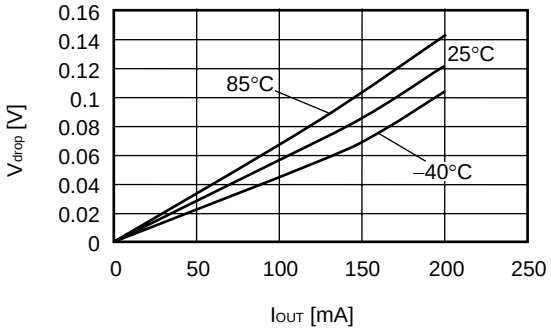
S-1165B15



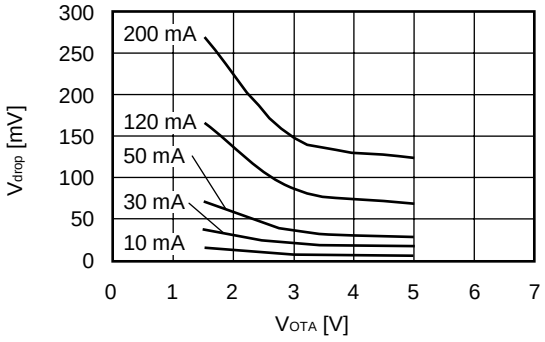
S-1165B30



S-1165B50

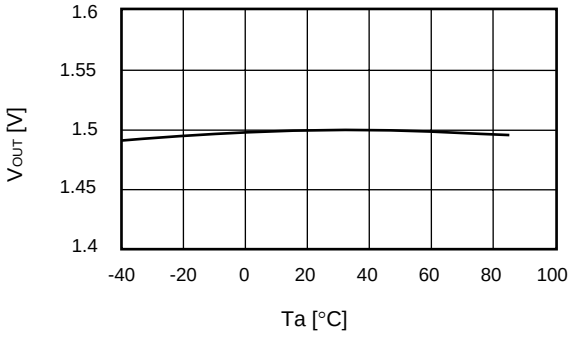


(4) Dropout voltage vs. Set output voltage

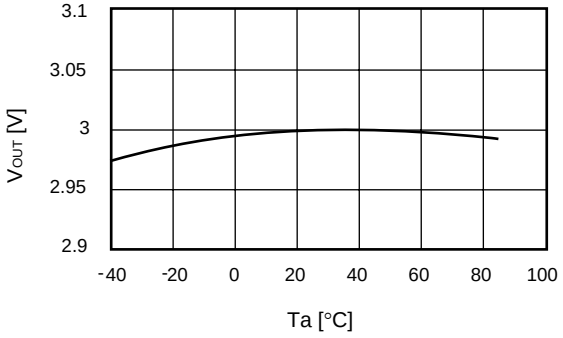


(5) Output voltage vs. Ambient temperature

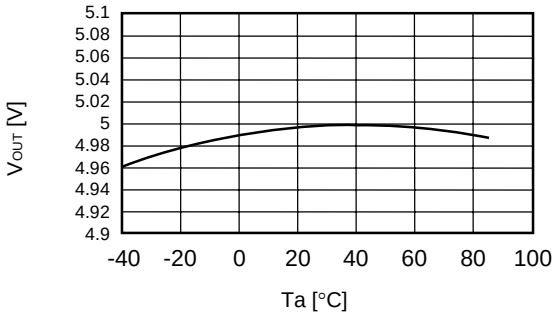
S-1165B15



S-1165B30

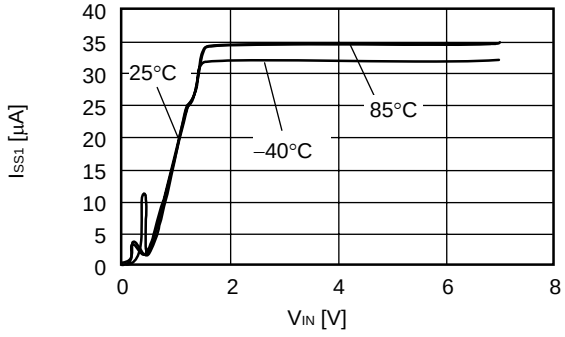


S-1165B50

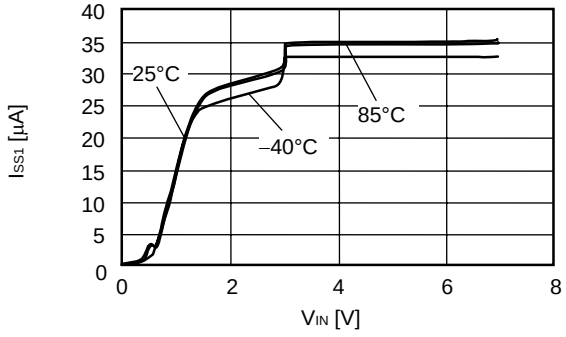


(6) Current consumption vs. Input voltage

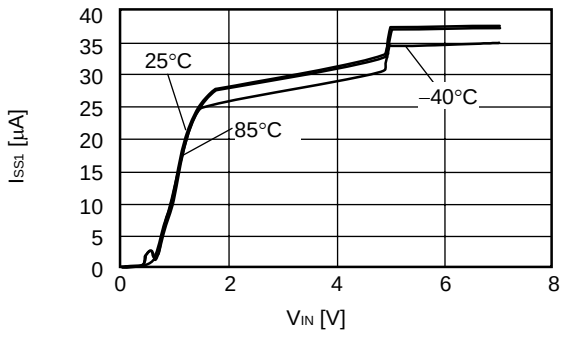
S-1165B15



S-1165B30

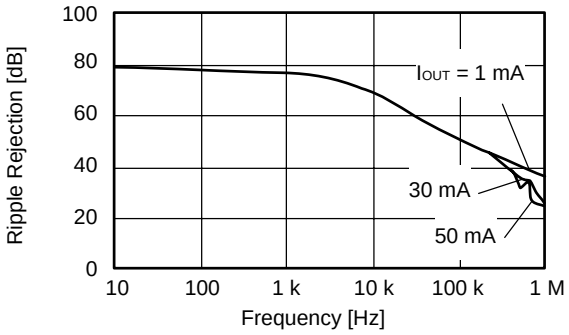


S-1165B50

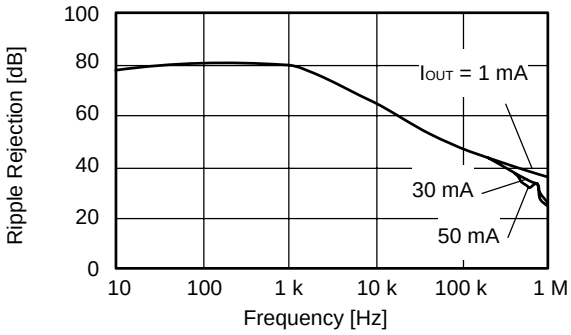


(7) Ripple rejection

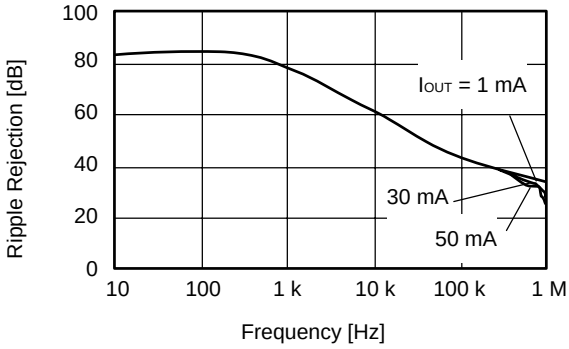
S-1165B15 (Ta = 25°C)
V_{IN} = 2.5 V, C_{OUT} = 2.2 µF



S-1165B30 (Ta = 25°C)
V_{IN} = 4.0 V, C_{OUT} = 2.2 µF



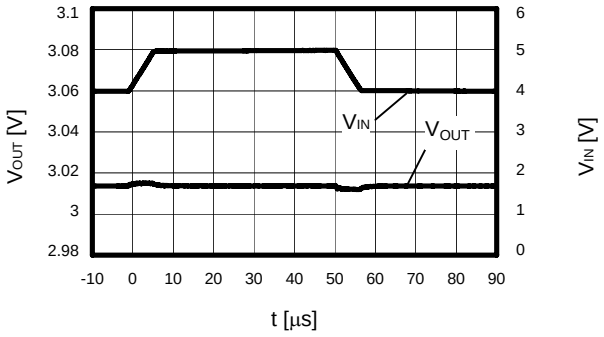
S-1165B50 (Ta = 25°C)
V_{IN} = 6.0 V, C_{OUT} = 2.2 µF



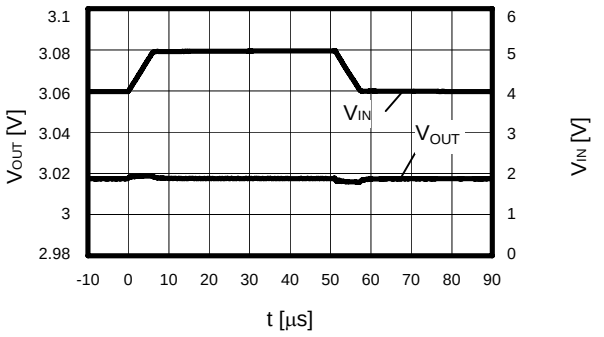
■ Reference Data

(1) Input transient response characteristics

I_{OUT} = 30 mA, tr = tf = 5.0 µs, C_{OUT} = 2.2 µF, C_{IN} = 0 µF

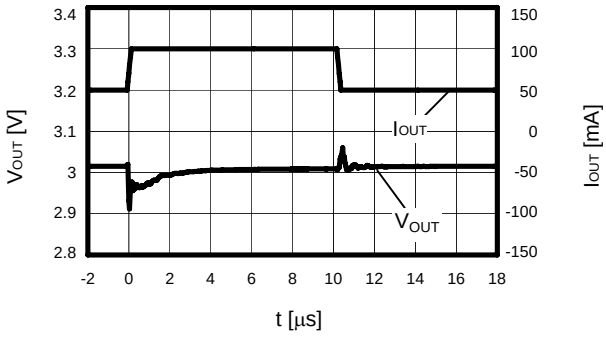


I_{OUT} = 30 mA, tr = tf = 5.0 µs, C_{OUT} = 4.7 µF, C_{IN} = 0 µF

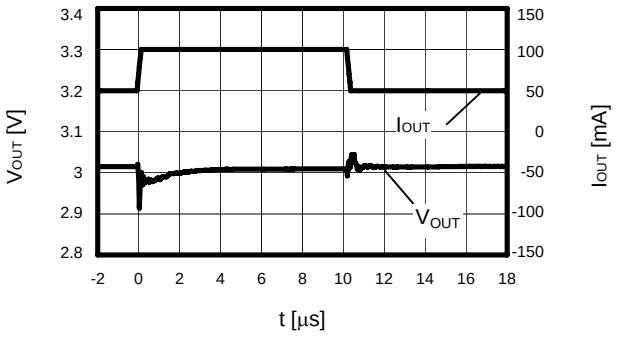


(2) Load transient response characteristics

V_{IN} = 4.0 V, C_{OUT} = 2.2 µF, C_{IN} = 1.0 µF,
I_{OUT} = 50↔100 mA



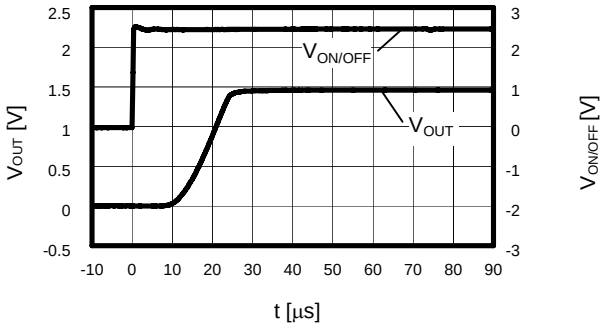
V_{IN} = 4.0 V, C_{OUT} = 4.7 µF, C_{IN} = 1.0 µF,
I_{OUT} = 50↔100 mA



(3) Shutdown pin transient response characteristics

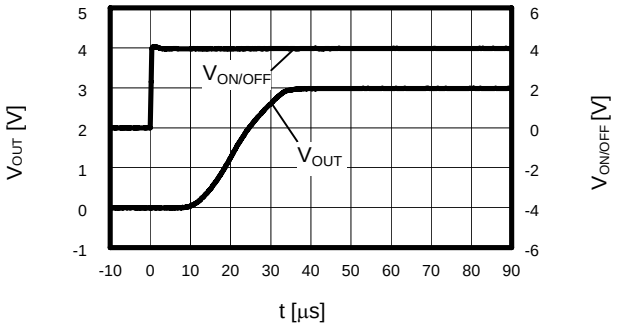
S-1165B15 (Ta = 25°C)

V_{IN} = 2.5 V, C_{OUT} = 2.2 µF, C_{IN} = 1.0 µF



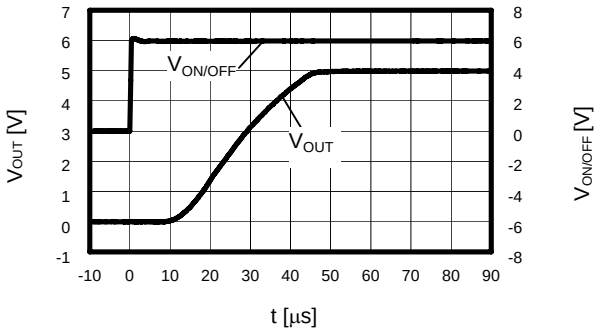
S-1165B30 (Ta = 25°C)

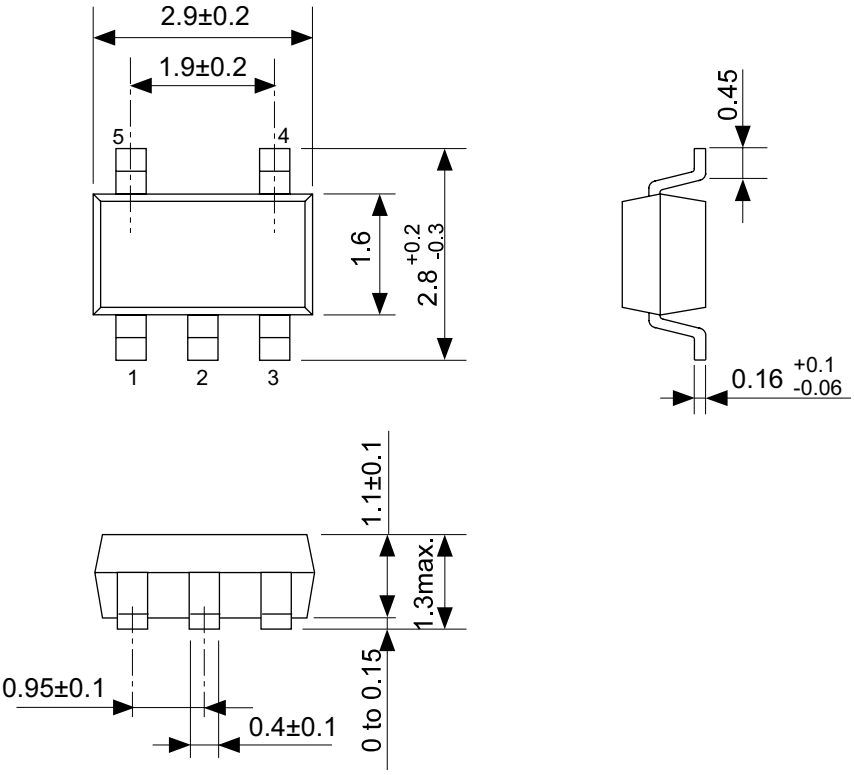
V_{IN} = 4.0 V, C_{OUT} = 2.2 µF, C_{IN} = 1.0 µF



S-1165B50 (Ta = 25°C)

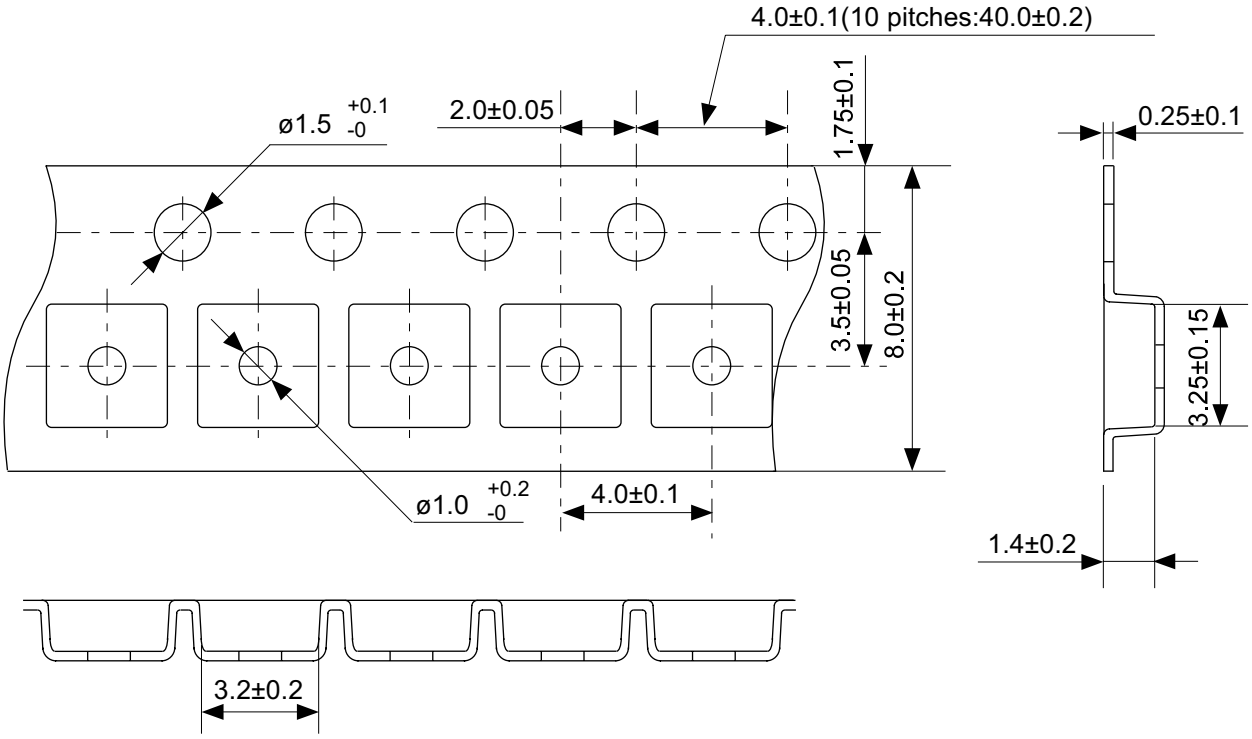
V_{IN} = 6.0 V, C_{OUT} = 2.2 µF, C_{IN} = 1.0 µF

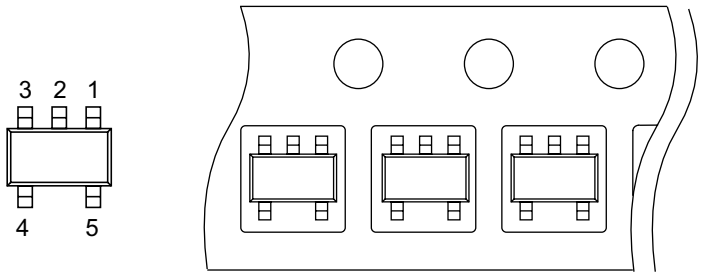




No. MP005-A-P-SD-1.2

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

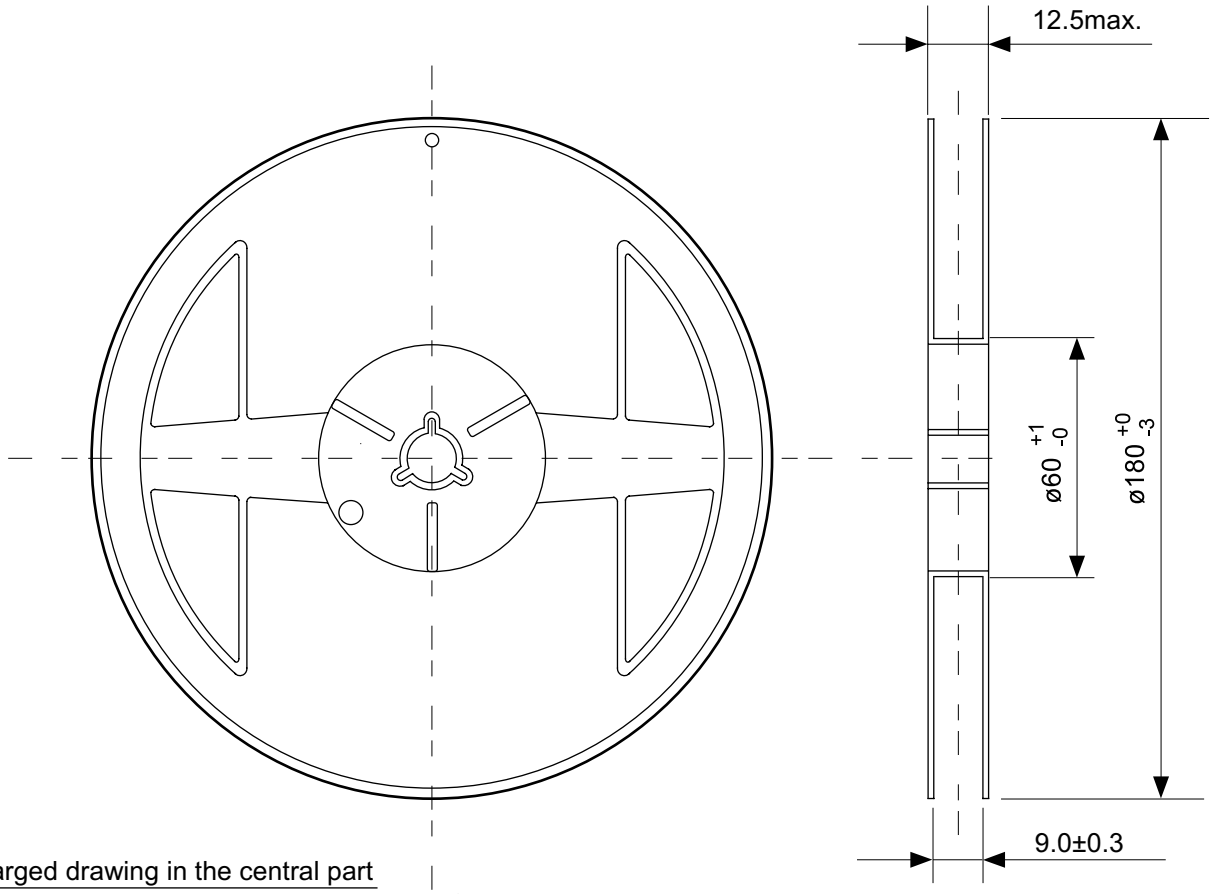




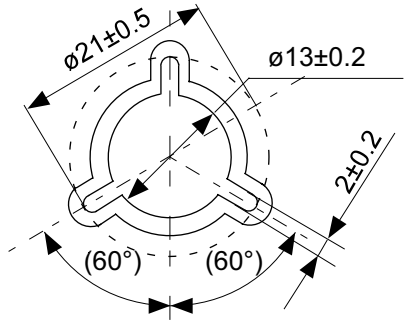
Feed direction

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		
Seiko Instruments Inc.			

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- *Подбор аналогов.*
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- *Входной контроль качества.*
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Тел: +7 (812) 336 43 04 (многоканальный)
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